GEOLOGY FOR PLANNING IN BOONE AND WINNEBAGO COUNTIES

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Geology for planning in Boone and Winnebago Counties / Richard C. Berg, John P. Kempton, Amy N. Stecyk with contributions by Jonathan H. Goodwin. bedrock resources, Randall E. Hughes. clay resources, John M. Masters. sand, gravel, and peat resources, Christopher J. Stohr. geology for construction.
(Illinois—Geological Survey. Circular ; 531)


Graphic artist: Craig Ronto
Editor: Mary Glockner
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CIRCULAR 531
1984
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This study was conducted under the auspices of the Boone and Winnebago County Boards, funded proportionately by each county, and administered through the University of Illinois. James G. Cannell and Lawrence E. Ralston were chairmen of the Boone and Winnebago County Boards when the project was initiated, and the project continued under the chairmanships of LeRoy Schroeder (Boone) and L. D. Worden (Winnebago). Jeb Kresge and Paul G. Schriever, administrators of Boone and Winnebago Counties, and Thomas Cozzi, Winnebago County purchasing director, helped coordinate the contract drilling program.

Technical aid and helpful suggestions were provided by Dennis McKenna, Winnebago County Soil and Water Conservation District; Raymond Ontiveros, Belvidere and Boone County Regional Planning Commission; J. Maichle Bacon, Winnebago County Health Department; Russell Petrote, Rockford-Winnebago County Planning Commission; and Richard B. Mohaupt, Winnebago County Public Works Department. Many other people from both counties provided help during the study.

Many individual landowners, quarry and pit operators, and members of public and private organizations provided data or access to their property for test drilling and geologic observations, and water well drilling contractors supplied logs of water wells used in this study. We appreciate their cooperation.

Illinois State Geological Survey staff members who contributed to this project were: Keros Cartwright and Thomas Johnson, hydrogeology; Jonathan H. Goodwin, sandstone and dolomite resources; Dennis R. Kolata, bedrock stratigraphy and maps of the subdrift bedrock; John M. Masters, sand and gravel and peat resources; Christopher J. Stohr, construction conditions; Randall E. Hughes, clay resources; Herbert D. Glass, interpretations of x-ray diffraction data for the glacial deposits; Leon R. Follmer, glacial stratigraphic problems and the relationship of soils to geology.

Rebecca Roeppe supervised the grain size analyses of the glacial tills and Edna M. Yeargin supervised the typing and clerical work. Craig Ronto drafted the maps and figures and designed the cover; Walter J. Morse, William G. Dixon, and Michael L. Sargent assisted with the sampling and geophysical logging of the contract test holes. Robert J. Krumm operated the Survey drilling equipment.
ABSTRACT

This report provides comprehensive information on the geology, hydrogeology, and mineral resources of Boone and Winnebago Counties for use in resource-based land-use planning and development. Data on the composition, thickness, and regional distribution of glacial drift and bedrock materials were used to construct maps of: geologic materials to a depth of 20 feet; bedrock topography; drift thickness; major terranes; and glacial drift aquifers.

Because contamination of aquifers is a serious concern in some areas of the two counties, a major focus of this study is on interpreting data critical to the selection of suitable areas for municipal waste disposal and prevention of contamination from existing municipal landfills and septic systems. Interpretive maps accompanying the text (1) rate geological sequences on their capacity to protect aquifers and surface water from contamination by land burial of municipal wastes, septic system disposal, and surface spreading of wastes and agricultural chemicals; (2) rate geologic sequences on their suitability for general construction; and (3) delineate resources of sand, gravel, peat, and dolomite.

Areas in which aquifer contamination from waste disposal and other land-use practices is most likely to occur are those in which sand and gravel and/or permeable creviced bedrock are at or near the surface. Areas having the lowest contamination potential are underlain by thick (20 feet or more) deposits of fine-grained glacial till.

Areas most favorable for general construction are well-drained locations in major river valleys and terrace outwash plains; areas least favorable for construction are scattered throughout both counties on poorly drained land having low bearing capacities and on uplands and slopes in northwestern Winnebago County where the drift is thin over the bedrock.

Extensive deposits of sand and gravel occur in the major bedrock valleys. Dolomite deposits underlie all the uplands of Winnebago County and most of Boone County, but extraction costs are prohibitive where overburden is thick. High-grade dolomite with relatively thin overburden is found in eastern Winnebago County and southwestern Boone County.

INTRODUCTION

The geologic framework of Boone and Winnebago Counties has provided all the necessary conditions for the development of a diversified, prosperous economy in the two-county area. The glacial deposits and the underlying bedrock provide abundant groundwater for domestic, industrial, and municipal uses, mineral resources (sand and gravel and dolomite) conveniently close to highway and construction sites, and rich soil in which crops flourish.

Large quantities of groundwater can be obtained everywhere in both counties, usually within 500 to 2000 feet of land surface; in many places, groundwater can be found 20 to 40 feet below the surface. However, the shallow, water-yielding earth materials can be rapidly infiltrated by contaminants resulting from improper waste disposal practices and overapplication of agricultural chemicals; the very characteristics that make these geologic materials so useful also make them particularly susceptible to abuse. Aquifer contamination is a serious problem in the counties.

PURPOSE AND SCOPE OF STUDY

This study was initiated primarily to provide geological information to help county agencies locate suitable landfill sites, prevent contamination from existing disposal sites, and cope with problems arising from large concentrations of individual septic tanks in rapidly growing communities. Although the major focus of this investigation was on geology related to the protection of water resources, the overall study objective was to collect, summarize, and interpret data on the geology, hydrogeology, and mineral resources of the area to facilitate public and private planning and resource development.

In addition to technical information presented in the text, this report provides:

Basic maps
- Geological stack-unit map showing areal and vertical distribution of surficial deposits to a depth of 20 feet (includes physical and mineralogical data for each deposit).
- Bedrock topography map, showing elevation of the bedrock surface.
- Drift thickness map, showing thickness of materials above the bedrock surface.
- Major terranes map, combining topographic and geologic data.

Interpretive maps
- Glacial drift aquifer map, delineating groundwater availability in surficial materials.
- Classification of geological materials for municipal land burial of wastes.
- Classification of geological materials for septic tank waste disposal and surface application of wastes and agricultural chemicals.
- Geologic conditions affecting general construction.
- Sand and gravel and peat resources.
- Dolomite resources.
An informal geology-for-planning study was begun in 1970 concurrently with USDA soil mapping of both counties. Between 1970 and 1974, Survey staff collected data and completed some preliminary mapping, building on the work of Anderson (1967). In 1979 the Boone and Winnebago County Boards agreed that the study should be accelerated, and the State Geological Survey made a formal proposal to (1) compile basic information on the characteristics and distribution of geologic materials and (2) prepare interpretive maps that could help resolve certain land-use and resource problems.

CULTURAL SETTING
Located in north-central Illinois, Winnebago and Boone Counties are bordered by Wisconsin on the north and by four Illinois counties: Stephenson to the west, Ogle and De Kalb to the south, and McHenry to the east (fig. 1).

Figure 1. Location map and summary of surface elevations in Boone and Winnebago Counties.
Rockford, the county seat of Winnebago County, is about 80 miles northwest of Chicago; Belvidere, the county seat of Boone County, is about 12 miles east of Rockford. Each county consists of a complex of urban and suburban residential and commercial areas, industrial regions, and rural areas. Boone County covers an area of 283 square miles, Winnebago County an area of 520 square miles. In 1980 the population of Boone County was 28,630 and the population of Winnebago County was 250,884. Between 1970 and 1980 the population in Winnebago County increased by just 4,261, but shifted away from the Rockford area to the northeastern and southeastern suburbs. Rockford Township lost more than 12,800 people, while Cherry Valley, Harlem, and Roscoe Townships gained more than 14,000 people (Rockford-Winnebago County Planning Commission, 1979, 1981). In the same decade the population in Boone County increased by 3,200 but shifted away from Belvidere to suburban areas west and northwest of Belvidere (Belvidere-Boone County Regional Planning Commission, 1980). The metropolitan areas of Rockford and Belvidere are separated by a rapidly closing narrow rural corridor.

PHYSICAL SETTING

The two counties lie within the Rock River Hill Country physiographic province of Illinois (Leighton, Ekblaw, and Horberg, 1948). The Rock River flows from north to south through Winnebago County; its major tributaries, the Pecatonica and the Kishwaukee Rivers, enter from the west and east, respectively. The rolling topography partly reflects erosional drainage flows flowing toward the Rock River and its tributaries. The Kishwaukee River and its principal tributaries, Piscasaw Creek and Beaver Creek, drain most of Boone County.

As glaciers advanced and retreated, the landscape was eroded, reshaped, and modified many times. Much of southern Boone County and western Winnebago County has been subjected to considerable glacial erosion by ice and meltwater, which accounts for the patchy, irregularly exposed glacial deposits and shallow bedrock (fig. 2). The topography in this area is controlled primarily by the bedrock. In northern Boone County and northeastern Winnebago County, glacial drift on the uplands is often more than 100 feet thick, and the topography is primarily controlled by erosion. Drift thickness exceeds 300 feet in much of northeastern Boone County over the Troy Bedrock Valley that trends northeast through Boone County; drift thickness exceeds 200 feet in the Rock Bedrock Valley, which roughly parallels the present-day Rock River (fig. 2).

Land surface elevations range from more than 1000 feet in northern Boone County to just below 700 feet along the Rock and Kishwaukee Rivers in southern Winnebago County (fig. 1). Elevations of more than 800 feet predominate over most of the two-county area, except within the valleys of the Rock, Pecatonica, and Kishwaukee Rivers and some of their tributaries.
Figure 3. Examples of preliminary maps prepared during construction of a geologic materials map.

A. Soils map
22, 728 - Paleosol in till soils
102, 570 - Colluvial soils
123, 152, 776 - Alluvial soils
290, 354, 387, 783, 939 - Outwash soils
361, 363 - Till soils
504, 561, 768 - Bedrock soils

B. Topographic map
10 ft contour interval

C. Drift thickness

D. Cross section A-A'

E. Completed surficial map
  c - alluvium
  hm - sand and gravel
  Og - bedrock
  pl - sand
  py - sandy colluvium
  wia - till
  zu - paleosol

ISGS 1981
MAPPING PROCEDURES

The basic mapping for this project began with construction of a stack-unit map of the Boone-Winnebago region showing the areal and vertical distribution of geological materials to a depth of 20 feet (plate 1). (Each stack-unit on the map represents a unique succession of mappable rock-stratigraphic/soil-stratigraphic units down to the specified depth limit.) We used this map as the basis for the preparation of a set of interpretive maps tailored to specific land-use and resource development purposes.

In constructing the stack-unit map we used—with slight modification—procedures developed by Kempton (1981) and Bogner, Cartwright, and Kempton (1976) and followed these steps specifically for conditions in the two-county area:

1. Determined the uppermost 5 feet of materials by grouping the 82 soil series identified on USDA Soil Conservation Service soil survey maps (Grantham, 1980) into 19 soil-parent material groups (fig. 3a). These groups were differentiated on the basis of their compositions and on their geomorphic position on the landscape (fig. 3b).
2. Determined materials below the 5-foot limit of soil surveying by analyzing 1800 samples (from 308 locations) from field, engineering, and construction borings and 29 other test borings (13 test borings were geophysically logged), and by analyzing data from 5000 water wells to provide information on drift thickness and relationships between aquifers and geologic materials. Test drilling specifically for this study provided additional information on thickness of glacial deposits and elevation of bedrock surface. Figure 4 shows the location of all test holes; table 1 indicates the legal description of each location, and gives depth statistics and number of samples taken at each of the 29 test holes.
3. Plotted all data onto base map and constructed cross

![Figure 4](image-url)
sections (fig. 3d) to illustrate the continuity and thickness of subsurface geologic units and their stratigraphic relationships.

- Combined surficial geologic information with subsurface data and constructed the preliminary stack-unit map (fig. 3e). A 20-foot depth limit was selected because most land-use activity occurs within this interval and because adequate data are available to this depth.
- Reduced the map scale from 1:24,000 (topographic map scale) to 1:62,500 to accommodate the 2-county area on one map.
- Made further groupings (mandated by the reduction and the complexity of units) of soil-parent materials and subsurface geologic materials.

These conventions and compromises were adopted in preparing the final stack unit map:
- Geologic units less than 2 feet thick were not mapped.
- Thin, irregularly distributed units and units unverifiable because of lack of data were put in parentheses.

Parentheses in the surficial unit suggest that the underlying material is the principal map unit. Parentheses in the lowest unit suggest that the unit may or may not be present within 20 feet of the surface but is generally present at or just below 20 feet. (In creviced bedrock areas the drift thickness may considerably exceed 20 feet within narrow valleys, but is less than 20 feet thick on bedrock interfluves.) Parentheses were also used for combining adjacent map areas of nearly equal size with and without a paleosol. Large, less complex areas with a definite presence or absence of a paleosol were mapped accordingly.

We assumed that there is at least a 75 percent chance that a geologic unit mapped is present (fig. 5a); about a 25 to 75 percent chance that a unit enclosed in parentheses will be present (fig. 5b); and probably less than a 25 percent chance that units not mapped are present (fig. 5c). On sand and gravel terraces, alluvial bottomlands, and peat and muck areas, the stack symbol for any given unit is nearly 100 percent accurate. The stack symbol is less

### TABLE 1. Test hole locations.

<table>
<thead>
<tr>
<th>Test hole</th>
<th>Land owner</th>
<th>Location</th>
<th>Depth of hole (ft)</th>
<th>No. of split spoon samples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BOONE COUNTY</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BNE-1</td>
<td>Hullah</td>
<td>SE NE SW 24, 46N-3E</td>
<td>200</td>
<td>18</td>
</tr>
<tr>
<td>BNE-2</td>
<td>Nelson</td>
<td>NE NE SW 3, 45N-4E</td>
<td>303.5</td>
<td>23</td>
</tr>
<tr>
<td>BNE-3</td>
<td>Watkins</td>
<td>SE SW SE 36, 45N-4E</td>
<td>302</td>
<td>25</td>
</tr>
<tr>
<td>BNE-4</td>
<td>Caledonia Elem. School</td>
<td>SW SE NW 21, 45N-3E</td>
<td>163.5</td>
<td>13</td>
</tr>
<tr>
<td>BNE-5</td>
<td>K &amp; B Farms</td>
<td>NW NW NW 6, 43N-4E</td>
<td>132</td>
<td>12</td>
</tr>
<tr>
<td>BNE-6</td>
<td>Vowles</td>
<td>NE NE SE 33, 43N-3E</td>
<td>57.5</td>
<td>6</td>
</tr>
<tr>
<td>ISGS-1</td>
<td>County</td>
<td>NW NW NW 27, 43N-4E</td>
<td>31</td>
<td>6</td>
</tr>
<tr>
<td>ISGS-2</td>
<td>County</td>
<td>NE NE NE 22, 43N-3E</td>
<td>51.5</td>
<td>20</td>
</tr>
<tr>
<td>ISGS-6</td>
<td>Mueller</td>
<td>NE SW SE 15, 43N-4E</td>
<td>55.5</td>
<td>20</td>
</tr>
<tr>
<td>ISGS-7</td>
<td>County</td>
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<td>33</td>
<td>12</td>
</tr>
<tr>
<td>ISGS-8</td>
<td>County</td>
<td>NW NE NE 26, 44N-3E</td>
<td>33</td>
<td>11</td>
</tr>
<tr>
<td>ISGS-9</td>
<td>Daniels</td>
<td>SE SW NE 21, 44N-4E</td>
<td>51</td>
<td>12</td>
</tr>
<tr>
<td>ISGS-10</td>
<td>Salberg</td>
<td>NW NE NW 30, 45N-3E</td>
<td>39</td>
<td>12</td>
</tr>
<tr>
<td>ISGS-13</td>
<td>State</td>
<td>SW SE NE 11, 44N-3E</td>
<td>23</td>
<td>12</td>
</tr>
<tr>
<td>ISGS-15</td>
<td>County</td>
<td>SW SE SE 10, 46N-3E</td>
<td>52</td>
<td>14</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td><strong>1527.5</strong></td>
<td><strong>216</strong></td>
</tr>
</tbody>
</table>

| **WINNEBAGO COUNTY** | | | | |
| WIN-1     | Porter  | SE NE SW 33, 46N-2E | 242.5            | 20                        |
| WIN-2     | Gummow  | SE NW SE 15, 46N-1E | 240               | 20                        |
| WIN-3     | Gasaske | SW NE NW 16, 45N-2E | 245               | 18                        |
| WIN-4     | Borg-Warner | SW SW SE 31, 45N-2E | 245               | 21                        |
| WIN-5     | Rockford Blacktop | NW SE NE 10, 43N-1E | 285               | 21                        |
| WIN-6     | Hochstatter | NW NE SE 34, 43N-1E | 240               | 21                        |
| WIN-7     | Rockford School of Medicine | NE SW SW 18, 44N-2E | 274.5            | 21                        |
| ISGS-3     | Langhoff | SW SE NE 15, 26N-10E | 55                | 14                        |
| ISGS-4     | County   | NW SE NW 9, 43N-1E | 26                 | 10                        |
| ISGS-5     | Brower   | SW NW NE 33, 26N-11E | 26                | 6                         |
| ISGS-11    | County   | SW NW NE 33, 27N-10E | 51                | 14                        |
| ISGS-12    | County   | SW SW NE 10, 27N-10E | 52                | 12                        |
| ISGS-14    | County   | NE SE NW 7, 45N-2E | 9                  | 4                         |
| ISGS-16    | Realtor  | SE SW NE 34, 45N-2E | 32                 | 9                         |
| **TOTAL** |             |                   | **2022**           | **211**                   |

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The succession of geologic materials that constitutes the framework of Boone and Winnebago Counties (fig. 6) can be generally categorized as (1) the Precambrian granite that forms the basement rocks; (2) the sedimentary rock succession (shale, sandstone, dolomite) of the Cambrian, Ordovician, and Silurian Systems; and (3) the Quaternary material (pebbly clays and sand and gravel). The granite and sedimentary rocks are commonly called bedrock; the Quaternary glacial deposits are often referred to as overburden, unconsolidated materials, or drift.

The succession of bedrock units generally dips in a southeastward direction; the youngest rocks are found at the bedrock surface in southeastern Boone County. Although a complete succession of all rock units shown on figure 6 once covered the entire area, erosion has removed most of the younger Silurian and Maquoketa rocks. The sedimentary rocks are as much as 2700 feet thick in southeastern Boone County and about 2000 feet thick in northwestern Winnebago County.

The long period of erosion of the bedrock prior to deposition of the glacial deposits left a series of deep valley systems carved into the bedrock. Partly because of this extremely uneven bedrock surface and partly because of concurrent and subsequent erosion, the glacial drift is unevenly distributed throughout the two counties. The drift thickness varies from more than 450 feet in north-eastern Boone County and about 300 feet under parts of Rockford to only a thin veneer (0 to 20 feet) throughout much of western Winnebago County and southern Boone County.

The glacial deposits consist primarily of: (1) till—pebbly clay, silt, and sand, deposited directly from melting glaciers; (2) outwash—mostly sand and gravel, deposited by the rapidly flowing meltwater rivers; (3) lacustrine deposits—silt and clay that settled out in quiet-water lakes and ponds; and (4) loess—windblown sand and silt. Glacial till and outwash are the most prevalent of these materials. The surficial glacial tills can be further differentiated on the basis of their dominant matrix characteristics. In areas of thicker drift, several tills—as well as outwash and lacustrine deposits—may be present. Ice-contact deposits (sand and gravel), river deposits (alluvium), slope wash (colluvium), and peat and muck are also present.

### BEDROCK GEOLOGY

The bedrock formations (fig. 6) are important sources of groundwater; those at or near land surface are current or potential sources of rock and mineral products.

Most of the information on bedrock geology (fig. 7) has been derived from logs and samples from water wells and test holes provided by drilling contractors. Although only a few wells have penetrated to or near the base of the sedimentary rocks, thousands have been finished in the upper units. Fewer than 40 wells or test holes in the two counties enter the Mt. Simon Sandstone, and only a few penetrate the entire unit.

In this section we will describe the bedrock units of Boone and Winnebago Counties, generally by formation and group, and note the groundwater resource potential of each of these units.

#### Precambrian rocks

Precambrian rocks, commonly referred to as basement rocks, have been reached by two test wells in Boone and Winnebago Counties. In Boone County (Sec. 28, T. 43 N., R. 3 E.), the Northern Oil and Gas Company Taylor well No. 1 penetrated the top of granite at a depth of 2925 feet (Grogan, 1949; Hackett, 1960). In Winnebago County, the Ivan A. Seele et al. oil test well No. 1 (Sec. 24, T. 44 N., R. 2 E.) reached granite at a depth of 2656 feet. Between these two wells the elevation of the Precambrian surface drops 320 feet to the southeast. The Precambrian surface at South Beloit is probably about 1200 feet below sea level, or about 1950 feet below land surface. Twenty-one test wells have reached the Precambrian in Illinois. In southern Illinois, the rocks are about 14,000 feet beneath the surface (Bradbury and Atherton, 1965).

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**Figure 5.** Mapping generalizations used in constructing a stack-unit map.
Cambrian System
The rocks of Boone and Winnebago Counties above the Precambrian are marine sediments deposited about 520 to 400 million years ago during the Cambrian, Ordovician, and Silurian Periods of the Paleozoic Era. The rocks consist of sandstones, dolomites, and shales. The Cambrian System comprises six formations (fig. 6): Mt. Simon Sandstone, Eau Claire Formation, Ironton and Galesville Sandstones, Franconia Formation, and Potosi Dolomite.

Mt. Simon Sandstone. The Mt. Simon Sandstone is generally a poorly sorted, very fine- to very coarse-grained, white to red, silty, friable sandstone. It is locally conglomeratic, with thin beds of shale (Hackett, 1960). Numerous wells have penetrated the Mt. Simon Sandstone. In southern Boone County and southeastern Winnebago County, the Mt. Simon attains a maximum thickness of about 1600 feet. At South Beloit, the Wisconsin Power and Light Company well No. 3 (Sec. 5, T. 46 N., R. 2E.) penetrated 275 feet of the sandstone below a depth of 915 feet; its thickness in the northern part of the counties is estimated to be at least 1000 feet.

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>GROUP</th>
<th>FORMATION &amp; THICKNESS</th>
<th>GRAPHIC COLUMN</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUATERNARY</td>
<td>0-0.7 m.y. B.P.</td>
<td>0 - 450 ft</td>
<td></td>
</tr>
<tr>
<td>SILURIAN</td>
<td>405-440 m.y. B.P.</td>
<td>50 ft</td>
<td></td>
</tr>
<tr>
<td>ORDOVICIAN</td>
<td>480-560 m.y. B.P.</td>
<td>Maquoketa 150 - 200 ft</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Galena 250 ft</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Platteville 100 ft</td>
<td>Glenwood 5 - 80 ft</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ancell St. Peter 200 - 400 ft</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Potosi 50 - 100 ft</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Franconia 50 - 100 ft</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ironton - Galesville 75 - 170 ft</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eau Claire 350 - 450 ft</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mt. Simon 1000 - 1600 ft</td>
<td></td>
</tr>
<tr>
<td>PRECAMBRIAN</td>
<td>GRANITE</td>
<td>8071 ft</td>
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</tr>
</tbody>
</table>

Figure 6. Stratigraphic column for Boone and Winnebago Counties (not to vertical scale).

Zones of coarse-grained sandstone in the Mt. Simon are permeable and yield most of the water withdrawn from the formation. About 40 percent of the Mt. Simon consists of this coarse-grained material, most of which occurs below a depth of about 1800 feet. Although the water-yielding potential of the Mt. Simon is considerable, little information is available on water quality and temperature.

Eau Claire Formation. The Eau Claire Formation consists primarily of dolomite (buff to gray) and argillaceous sandstone ranging in thickness from about 350 to 450 feet (fig. 6). It is easily recognized because it overlies the relatively clean Mt. Simon Sandstone and underlies the clean Galesville Sandstone. Three members of the Eau Claire Formation are recognized (Templeton, 1952; Willman et al., 1975): the Elmhurst Sandstone at the base, the Lombard Dolomite in the middle, and the Proviso Siltstone at the top. The Elmhurst Sandstone, about 130 feet thick, contains beds of clean, medium-to-coarse sandstone. The Elmhurst and the Mt. Simon together provide significant quantities of groundwater. Much of the water obtained from wells drilled into the Mt. Simon comes from the basal Elmhurst Sandstone Member of the Eau Claire.

The Lombard Dolomite is a sandy dolomite averaging about 160 feet; although less permeable than the Elmhurst Sandstone Member, it yields some water from thin beds of sandstone occurring throughout the member. The uppermost member of the Eau Claire, the Proviso Siltstone, is a dolomitic, sandy siltstone commonly containing beds of shale. This member is the least permeable portion of the Eau Claire and is not considered a water-yielding unit. The Lombard Dolomite and Proviso Siltstone Members, where present, separate the Elmhurst and Mt. Simon Sandstones from the overlying sandstones of the Ironton-Galesville and restrict the vertical movement of water between these two important water-yielding units.

Ironton-Galesville Sandstone. The Ironton-Galesville Sandstone lies between the Eau Claire and Franconia Formations. The Galesville Sandstone is a clean, fine- to medium-grained, well-sorted sandstone overlain by the Ironton Sandstone, an often dolomitic and relatively coarse-grained sandstone. Because it is often difficult to separate the Ironton and Galesville Formations in the subsurface, they are commonly combined to form a single hydrogeologic unit—the Ironton-Galesville Sandstone (Hackett, 1960). Samples from numerous wells suggest that the Ironton-Galesville maintains a relatively consistent thickness (an average 135 ft) throughout Boone and Winnebago Counties (fig. 8a), but thicknesses slightly northward. The elevation of the top of the Ironton-Galesville (fig. 8b) ranges from sea level in extreme southeastern Boone County, to more than 300 feet above sea level in northern Boone and Winnebago Counties.

The clean, well-sorted sandstone of the Ironton-Galesville forms a primary aquifer in Boone and Winnebago Counties. A rough estimate of the depth to the top of the Ironton Sandstone can be determined by subtracting the elevation of the top of the Ironton (fig. 8b) from land surface elevation (fig. 1).
Franconia Formation. The Franconia Formation, which overlies the Ironton-Galesville, consists primarily of sandstone, interbedded siltstone and shale, and some dolomite. The sandstones are generally fine-grained, dolomitic and compact, whereas dolomite beds, found near the base or top of the formation, are sandy or silty. In Boone and Winnebago Counties, the Franconia Formation ranges in thickness from 50 to 100 feet. The unit is not considered an important aquifer.

Potosi Formation. The Potosi Formation is composed of finely crystalline dolomite containing variable amounts of clay, silt, and sand. In Boone and Winnebago Counties the Potosi is only about 50 to 100 feet thick, but in some
The St. Peter Sandstone is a widely used aquifer in Boone and Winnebago Counties. The hydrogeologic characteristics of the sandstone depend upon its thickness, on the amount of interstitial fine-grained sediments present, and on the thickness and character of the basal, less permeable cherty zone. Wells finished in the Ironton-Galesville Sandstone are frequently left uncased and open to the hydrologically similar St. Peter Sandstone.

Glenwood Formation. The Glenwood Formation is a relatively thin unit (5 to 60 ft thick) overlying the St. Peter Sandstone (fig. 6). It consists of interbedded dolomite, sandstone, and shale. The dolomites are commonly gray or buff, argillaceous, and silty or sandy, and the sandstone and shale beds are often gray-green. The lowermost beds of the Glenwood are generally more sandy than the upper beds and are often difficult to distinguish from the underlying St. Peter Sandstone. The lowermost sandstone portion of the Glenwood may provide some water to the underlying St. Peter Sandstone; however, because the Glenwood is thin and absent in some places it is relatively insignificant as a source of groundwater.

Galena and Platteville Groups. The uppermost bedrock units over most of Boone and Winnebago Counties are dolomites of the Galena and Platteville Groups (fig. 7). The Platteville Group, which stratigraphically overlies the Glenwood Formation, is a finely crystalline, dense, and partly argillaceous dolomite. Its upper part is often cherty, its lower part often sandy. The Galena Group is a medium- to coarse-grained, partly cherty dolomite. In general, Platteville formations are finer grained and thinner bedded than are the overlying Galena formations and are gray rather than brown; however, some Platteville formations resemble the Galena (Willman and Kolata, 1978). The boundary between the Galena and Platteville Groups is shown on figure 7. The Platteville is the surficial bedrock in parts of northwestern Winnebago County and along major bedrock valley walls. Because these groups are often diffi-
cult to separate in driller's logs and because their hydrogeological characteristics are similar, they were combined for mapping purpose in this study.

The groups have a combined maximum thickness of more than 380 feet. The Platteville is as much as 137 feet thick at Rockford, and the Galena is about 250 feet thick in southeastern Boone County, where it is overlain and protected from erosion by the Maquoketa Shale Group (Willman and Kolata, 1978). The original thickness of the Galena has been reduced significantly by erosion outside the Maquoketa boundary. An exceptional exposure of more than 100 feet of Galena can be seen at the Nimtz Quarry (Sec. 33, T. 45 N., R. 2 E.), northeast of Rockford, where the Wise Lake and the Dunleith Formations have been described (Willman and Kolata, 1978).

The best exposure of the Platteville is along State Road 70, 4 1/2 miles southwest of Durand (Sec. 36, T. 28 N., R. 10 E.); here, more than 50 feet of section, including the Quimbys Mill, Nachusa, Grand Detour, and Mifflin Formations, can be seen. In a quarry half a mile north of Durand (Sec. 10, T. 28 N., R. 10 E.) a 41-foot section of the Grand Detour, Mifflin, and Pecatonica Formations is exposed.

The dolomites of the Galena and Platteville Groups are generally a dependable source of groundwater. Joints, bedding planes, fractures, and solution openings normally provide adequate water for farmsteads or other residences.

**Maquoketa Shale Group.** Rocks of the Maquoketa Shale Group occur in southeastern Boone County (fig. 7) and consist mostly of shale with dolomite stringers. The Maquoketa Group overlies dolomite of the Galena Group (Willman et al., 1975). In the subsurface the Maquoketa often contains beds of siltstone and, in some places, limestone or dolomite. The shale attains a maximum thickness of about 110 feet in Boone County; its average thickness in this county is 50 feet. However, thicknesses up to 200 feet are reported in neighboring counties. The best outcrop of Maquoketa (Sec. 14, T. 43 N., R. 3 E.) exposes the Brainard Formation, which is a greenish-gray shale, partly dolomitic, locally silty, and highly fossiliferous. Because of the tightly packed nature of shale, the Maquoketa is not considered a reliable groundwater source, although small quantities can be obtained in some places. The shale of the Maquoketa is a hydrogeologic barrier between the shallower and deeper permeable formations.

**Silurian System**

Silurian rocks, probably of the Wilhelmi Formation, occur as the upper bedrock (overlying the Maquoketa Shale) in three restricted locations in southern and eastern Boone County (fig. 7). Their maximum thickness is about 20 feet. The rocks are characterized as argillaceous, yellowish-gray to light olive-gray dolomites and dolomitic shales; their lower portions are often more argillaceous than are the upper portions, and less likely to contain chert. Because of their limited extent, these rocks are not a groundwater resource in Boone and Winnebago Counties, although they are a major source of groundwater to the east.

**BEDROCK TOPOGRAPHY/DRIFT THICKNESS**

During the long interval between the deposition of the bedrock formations and the advance of the continental glaciers over the region, stream erosion dissected and removed much of the succession of younger rocks. By early glacial time this erosion had carved most of the major topographic features of the present bedrock surface, and subsequent action by glaciers or by streams during the melting of the glaciers further eroded the bedrock surface. This eroded surface is now largely buried or masked by glacial deposits. The amount of glacial debris deposited, the amount of subsequent erosion of these deposits, and the irregularities in the bedrock surface are the primary controls determining the total thickness of drift. Erosion continues to lower the bedrock surface elevation (where bedrock is exposed) and reduce the thickness of drift in some areas, and alluviation and colluviation continue to add to the total thickness of drift elsewhere.

The bedrock topography and drift thickness maps (figs. 10, 11) were derived from several new sources of data. Shallow bedrock (less than 5 ft) and associated thin drift were determined by noting bedrock exposures and by consulting soil maps of the two counties (Grantham, 1980). Drift thickness and bedrock elevation were determined primarily by evaluating and plotting more than 5000 water well logs, 150 engineering, highway, and foundation borings, and 29 test holes. Figures 10 and 11 were updated from earlier maps showing the bedrock topography and drift thickness of the counties (Horberg, 1950; Hackett, 1960; McGinnis, Kempton, and Heigold, 1963; and Piskin and Bergstrom, 1975).

**The bedrock valleys**

The bedrock topography of Boone and Winnebago Counties is dominated by two major bedrock valleys carved into the uplands—the Rock and Troy Bedrock Valleys and the Rock's two main tributaries, the Pecatonica and Sugar Bedrock Valleys; in these ancient valleys the thickest drift has been deposited. The Troy Bedrock Valley, approximately 2 to 3 miles wide and up to 400 feet below the adjacent bedrock uplands, enters Boone County from McHenry County approximately 2 miles south of the Wisconsin state line; it trends south-southwest, entering Winnebago County at Section 13, T. 43 N., R. 2 E., and leaving Winnebago County near the southeast corner of Section 36, T. 43 N., R. 2 E. Along the main channel of the Troy Bedrock Valley, the bedrock surface elevation ranges from just below 500 feet in the northeastern corner of Boone County to less than 450 feet in the southeastern corner of Winnebago County. The associated drift in the Troy Bedrock Valley is more than 450 feet in northeastern Boone County and more than 300 feet in southeastern Winnebago County.

The Rock Bedrock Valley, approximately 1 1/2 to 2 1/2 miles wide and 200 to 300 feet below the bedrock uplands, enters Winnebago County from Rock County, Wisconsin, approximately 4 miles west of the Boone-Winnebago County line, and trends southward into Ogle County, leaving Winnebago County in Section 35, T. 43 N., R. 1 E.
Figure 10. Topography of the bedrock surface of Boone and Winnebago Counties.
Figure 11. Drift thickness of Boone and Winnebago Counties.
Along the deepest part of the Rock Bedrock Valley, the bedrock surface elevation ranges from about 500 feet in the north to 450 feet in the south; the associated drift thickness is between 200 and 250 feet in the north and 250 feet in the south. Although the Troy and Rock Bedrock Valleys have similar bedrock surface elevations, the drift is considerably thicker over most of the Troy Bedrock Valley (fig. 11) because younger glacial deposits are present above the Troy Bedrock Valley and are absent over most of the Rock Bedrock Valley. The topography above the Troy Bedrock Valley is predominantly uplands underlain by glacial till, except where the modern Kishwaukee River follows the position of the Troy Bedrock Valley in southern Boone County and southeastern Winnebago County. The Rock Bedrock Valley is filled primarily with silt and sand and gravel deposits. The modern Rock River generally flows in the same valley as the ancient Rock River, with two notable exceptions. The present river flows along the west edge of the bedrock valley at Rockford, across an area of high bedrock. In this area, the axis of the bedrock valley lies just to the east beneath the till upland. At the southern edge of Winnebago County, the present river turns south-westward away from the ancient bedrock valley. The elevation of the modern surface of the valley above the Rock Bedrock Valley ranges from 780 feet in the north to 680 feet in the south.

The ancient Pecatonica-Sugar Bedrock Valley, a major east-trending tributary of the Rock Bedrock Valley, is approximately 1 to 2 miles wide and 150 to 250 feet deep, and is filled by thick deposits of silt and sand and gravel. The Pecatonica Bedrock Valley enters Winnebago County from Stephenson County at Section 19, T. 27 N., R. 10 E., and trends east-northeast. The Sugar Bedrock Valley enters Winnebago County from Rock County, Wisconsin at Section 6, T. 29 N., R. 11 E., trends south-southeast, and enters the Pecatonica Bedrock Valley at Section 14, T. 29 N., R. 11 E. The Pecatonica-Sugar Bedrock Valley then trends east and enters the Rock Bedrock Valley at Section 18, T. 46 N., R. 2 E. The modern Sugar and Pecatonica Rivers flow over the ancestral Pecatonica and Sugar Bedrock Valleys. The elevation of the bedrock surface along the ancient Pecatonica and Sugar Bedrock Valleys ranges from less than 600 feet in upstream positions to 500 feet where the Pecatonica Bedrock Valley joins the Rock Bedrock Valley. The drift also thickens to the east, ranging from 150 feet in upvalley positions where the bedrock valley floor is higher to more than 250 feet at the joining of the Pecatonica and Rock Bedrock Valleys, where the bedrock valley floor is 100 feet lower. Backwater sedimentation filled the ancient valleys and constructed a relatively flat modern topography.

The bedrock uplands

The bedrock valleys separate the bedrock uplands into four regions: the uplands southeast of the Troy Bedrock Valley; the uplands between the Troy and Rock Bedrock Valleys; the uplands west of the Rock Bedrock Valley and south of the Pecatonica Bedrock Valley; and the uplands west of the Rock Bedrock Valley and north of the Pecatonica Bedrock Valley. The bedrock surface elevation southeast of the Troy Bedrock Valley is generally between 750 and 800 feet and rarely more than 850 feet in southern Boone County. The drift thickness in this upland region is usually between 50 and 100 feet; however, in a few restricted areas it is less than 20 feet thick, and where small tributary valleys have been filled in, up to 150 feet thick.

The bedrock surface elevation of the uplands between the Troy and Rock Bedrock Valleys is commonly more than 850 feet, but rarely more than 900 feet, in the north; in the south it is generally greater than 800 feet, but rarely more than 850 feet. The drift thickness of this upland area is also quite variable: usually between 50 and 150 feet, rarely less than 20 feet. The variability of drift thickness characteristic of this upland region results from variations in bedrock topography due to preglacial bedrock dissection, and from variations in drift erosion. Bedrock is exposed where the Kishwaukee River has cut into the ancient bedrock upland surface; relatively recent postglacial erosion and stream dissection have probably modified the bedrock surface in some places.

Much of the upland area of western Winnebago County is characterized by bedrock outcrops or by thin drift over bedrock; the present topography is therefore controlled by the ancient bedrock topography. West of the Rock Bedrock Valley and south of the Pecatonica Bedrock Valley, the bedrock surface elevation is generally greater than 800 feet, often more than 850 feet, but rarely 900 feet. In this region a variable bedrock surface topography is mantled by a thin drift cover usually less than 20 feet thick. In a few small localities the drift is up to 100 feet thick where the modern upland surface overlies a small ancient tributary valley cut into the bedrock.

The elevation of the bedrock surface west of the Rock Bedrock Valley and north of the Pecatonica Bedrock Valley is generally more than 850 feet, often more than 900 feet, and occasionally more than 950 feet. Bedrock exposures are numerous in this area, and in areas where bedrock does not outcrop, the drift is less than 20 feet thick and frequently less than 5 feet. As in the area south of the Pecatonica River valley, the modern topography parallels the bedrock surface topography.

SURFICIAL DEPOSITS

General distribution and characteristics

Figure 12 shows the succession of glacial and other surficial drift units in Boone and Winnebago Counties. Revised, detailed stratigraphic nomenclature appears in Kempton et al., in preparation. Figure 13a-f shows cross sections through various parts of the counties. Lines of cross section are shown in figure 4. All identified geologic materials to a depth of 20 feet are shown on the stack-unit map (plate 1). Figure 14, derived directly from the geologic stack-unit map, summarizes the distribution of principal surficial units. Descriptions, locations, and stratigraphic relationships of specific borings, exposures, and mapping units are summarized in the appendix.

Since 13 glacial tills are identified in the two counties, it is reasonable to assume that glaciers covered all or part of the areas at least 13 times. Although each till has some unique diagnostic characteristics, several tills are very similar in texture and color and have not been differentiated until the present study.
<table>
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<tr>
<td>Kellerville Till</td>
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</table>

*All Winnebago Formation tills might be of Illinoian rather than Wisconsinan age.

Figure 12. Stratigraphic classification of Quaternary deposits in Boone and Winnebago Counties.

The composition of tills results from the incorporation of distinctive materials into the glacial ice as it traversed a particular land surface, the distance the materials have been transported, and the mixing of the materials within the glacial ice. Because tills have unique, relatively uniform compositions, they are the most predictable glacial materials in Boone and Winnebago Counties and therefore, the basic units for geologic mapping of the surficial deposits.
Glacial tills. The most extensive deposits in Boone and Winnebago Counties are tills. The thickest till deposits occur over the Troy Bedrock Valley where they are interbedded with outwash and lacustrine materials (fig. 13b). The major tills mapped in Boone and Winnebago Counties are sandy tills: the Capron-sandy (wic-s), Clinton (wicl), Argyle (wia), Nimtz (win), Oregon (gor), Fairdale (gf), and Ogle (go) (fig. 14). Slight differences in texture, clay mineralogy, and stratigraphic position provide the basis for the definition of units.

Loamy and silt loam tills—the Capron (wic), Belvidere (gbl), and Creston (gc)—are the principal surficial materials on uplands in eastern and southeastern Boone County (figs. 13c, 14). A layer of loess cover or a paleosol overlies these tills. A loamy Ogle Till (go-1) occurs in a few places in west-central and north-central Winnebago County.

The only extensive silty clay till is the Esmond (ge), the principal surficial unit in southwestern Boone County and extreme southeastern Winnebago County (fig. 13c). The Esmond Till is also present over a much more extensive area to the south. The Creston is frequently a silty clay loam till occurring locally.

Outwash sand and gravel. The principal coarse-textured materials in Boone and Winnebago Counties are the outwash sands and gravels of the Henry Formation, Mackinaw Member (hm) in the Rock, Sugar, and Kishwaukee Rivers and Pecasaw Creek. Figures 13d-f indicate 100 feet of Henry Formation sands and gravels and an underlying thick sequence of sand and gravel outwash associated with earlier glaciations. These materials were deposited by glacial meltwaters originating from the north and east.

Some outwash sand and gravel is exposed at the surface (g-o) (fig. 13e); some is interbedded with tills. Most of the exposed outwash deposits are found along the lower reaches of Beaver Creek and on the east side of the Rock River valley. These deposits apparently underlie the Nimtz Till.

Ice-contact deposits. Sand and gravel of the Henry Formation, Wasco Member (hw) deposited directly adjacent to melting glaciers occurs extensively in southern Boone County and southwestern Winnebago County adjacent to the Rock and Kishwaukee River valleys and is also found on the uplands of southern Boone County as a series of northwest-southeast linear ridges. In southwestern Winnebago County and along the south side of the Kishwaukee River valley the ice-contact deposits may be marking the boundary of the ice that deposited the Nimtz Till. The linear ridges of sand and gravel in southern Boone County seem to separate the Esmond Till from the Belvidere Till.

Eolian and colluvial material. Other surficial deposits in Boone and Winnebago Counties are windblown silt (loess), sand, or colluviated silt or sand. Loess (more than 2 feet thick) is the uppermost surficial unit on about 30 percent of the two-county area. Deposits of Peoria Loess and Roxana Silt (pr, pr5) or Peoria Loess (p) are thickest (up to 9 feet) on the uplands in northern Boone County, in southwestern Winnebago County, on the west side of the Rock River valley in Winnebago County, and in the Kishwaukee valley. These deposits apparently underlie the Nimtz Till.

River-Pecasaw Creek valleys. A complex of Peoria Loess and Cahokia Alluvium (pc) is present on terraces of the Pecatonica River and Otter Creek. Loess is noticeably absent in southern and southeastern Boone County; in central, north-central, and extreme southeastern Winnebago County; and adjacent to the east side of the Rock River valley in Winnebago County. In extreme northwestern Winnebago County where the loess did not erode, ridgetops characteristically are covered with 2 to 5 feet of loess.

Windblown (eolian) sand, called Parkland Sand (pl), was deposited primarily on terraces of the Rock, Sugar, and Kishwaukee Rivers. Sand dunes are present locally southwest, west, and northwest of Rockton. Extensive sand deposits have blown up onto the uplands (1) east of the Rock River valley, (2) along Route 20, and (3) in north-central Winnebago County.

Peyton Colluvium (py, py-s) was deposited primarily by slope wash from ridgetops to toe slopes; this material (mostly loess, sand, and till) was eroded and subsequently redeposited. The thickest and most extensive deposits of colluvium are found in northern Boone County. Because a distinction could not be made between the thick loess and the colluvium, they were combined to form a complex (ppr). Thick colluvium also exists on the north sides of Otter Creek and the Pecatonica River in Winnebago County. In other areas, a distinction was made between silty colluvium (py) and sandy colluvium (py-s). For the most part, silty colluvium is associated with thick loess areas and sandy colluvium is associated with Parkland Sand or eroded areas where a sandy till is the primary surficial unit.

Legend for figures 13a-f. Generalized cross sections.
**Figure 13a.** Generalized W-E cross section across Boone and Winnebago Counties.

**Figure 13b.** SW-NE cross section along lowest part of Troy Bedrock Valley from northern DeKalb County to northwest McHenry County. See figure 4 for locations of cross sections.
Figure 13c. N-S cross section through Boone County.

Figure 13d. N-S cross section along Rock River valley.
Figure 13e. W-E cross section across Rock River valley at Loves Park.

Figure 13f. W-E cross section across Rock River valley at Roscoe.

GEOLOGY FOR PLANNING IN BOONE AND WINNEBAGO COUNTIES
### FORMATION

<table>
<thead>
<tr>
<th>Member</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>CAHOKIA ALLUVIUM</td>
<td>(c) sand, silt and clay deposited by modern rivers and streams</td>
</tr>
<tr>
<td>GRAYSLAKE PEAT</td>
<td>(gl) peat and muck often interbedded with silt and clay</td>
</tr>
<tr>
<td>EQUITY</td>
<td>(ec) silt and clay deposited in glacial lakes</td>
</tr>
<tr>
<td>HENRY</td>
<td>(ed) medium-to-coarse sand deposited in former glacial lakes</td>
</tr>
<tr>
<td>WINNEBAGO</td>
<td>(hm) thick deposits of sand and gravel in major river valleys</td>
</tr>
<tr>
<td>GLASFORD</td>
<td>(hw) near ice deposits of poorly sorted sand and gravel</td>
</tr>
<tr>
<td></td>
<td>(wic) pinkish-brown friable silt loam till</td>
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<td></td>
<td>(wicl) yellowish-tan, very friable, very sandy till</td>
</tr>
<tr>
<td></td>
<td>(wia) pinkish- or buff-tan often friable sandy till</td>
</tr>
<tr>
<td></td>
<td>(win) gray-brown or buff often compact sandy or sandy loam till</td>
</tr>
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<td>(g-o) sand and gravel deposit overlying Belvidere Till</td>
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<td>(gc) pinkish-brown silt clay loam till</td>
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### Figure 14
Summary map of principal surficial geologic materials.

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Paleosols (old buried soils). The Sangamon Soil (zs, zs-ag) or an undifferentiated paleosol (zu, zu-ag) is present either at the surface or beneath eolian deposits on the uplands of the two counties. Paleosols are almost totally absent in southern and southeastern Boone County and extreme southeastern Winnebago County; apparently they were removed along with the loess by glacial meltwater. However, where loess was eroded in central Winnebago County, the lower part of the paleosol remained relatively intact and is the surficial unit over much of the area. In places where loess or colluvium is more than 5 feet thick, it is assumed that an underlying paleosol is present.

Lake deposits. Fine-grained lacustrine sediments of the Equality Formation, Carmi Member (ec) occur extensively as surficial slackwater deposits on terraces of the Pecatonica River and Otter Creek. During periods of peak meltwater flow down the Rock River, water apparently backed up the Pecatonica River and Otter Creek, creating a lake. The lake eventually drained, leaving a terrace throughout the valleys. Fine-grained lacustrine deposits also occur in small stream valleys adjacent to the Rock River valley and in channels connecting Piscasaw Creek and the Kishwaukee River. The only other significant lacustrine materials mapped were deposited in a glacial lake in southwestern Winnebago County.

Deposits of rather coarse sand and silty sand of the Equality Formation, Dolton Member (ed) are also associated with glacial lakes. The most extensive deposits occur in extreme southeastern Boone County; they are generally thin, and underlain by Belvidere Till.

Old lake deposits occur in the deep bedrock valleys (figs. 13a-f). Quiet-water lakes formed when glacial ice blocked the valleys, and fine-grained materials were deposited in the lakes. Coarse-grained buried materials suggest periods of outwash flow. The valleys have obviously been blocked numerous times by glacial events.

Bedrock. Dolomite of the Galena and Platteville Groups (Og) is the principal surficial material on the uplands of northwestern Winnebago County. It is also within or near 20 feet of the surface beneath thin deposits of till on most of the uplands west of the Rock River, and is a significant unit in southeastern and northeastern Winnebago County, where it has been extensively quarried. St. Peter Sandstone (Oa) is exposed in extreme northwestern Winnebago County; it is the bedrock unit that lies directly beneath glacial drift in the Rock and Pecatonica Bedrock Valleys and beneath part of the Troy Bedrock Valley. The Maquoketa Shale Group (Om) is exposed in some places at the surface and is within 20 feet of the surface locally in southern Boone County. Silurian dolomite (S) occurs within 20 feet of the surface at three restricted locations in southeastern and south-central Boone County.

Other materials. Other deposits include Grayslake Peat (gl), Plano Silt (wip), and Cahokia Alluvium (c). Alluvium is the principal surficial unit on the uplands along small stream drainageways, and in bottomlands adjacent to major rivers (fig. 14). Peat occurs in restricted depressions throughout both counties. The largest peat areas are in northeastern Boone County (fig. 14). The Plano Silt Member occurs in a small area south of Rock Cut State Park in east-central Winnebago County.

Geology/soil relationships

The most accurate maps of surficial materials are produced through coordinated mapping of geology and soils (McComas, Hinckley, and Kempton, 1969). Soil Conservation Service soil scientists in Boone and Winnebago Counties and ISGS geologists cooperated on a soil survey of the two counties (Grantham, 1980). The resulting soil survey maps were used during the preparation of basic geologic maps for the current study.

Bedrock soils such as Palsgrove, Ashdale, and Whalan and New Glarius are capped by up to 5 feet of loess over bedrock. Other bedrock soils such as Sogn, Dunbarton, and Edmund are characterized by thin residuum or loess over bedrock.

Outwash soils generally consist of a surficial cover of loess and/or eolian sand and are underlain by sand or sand and gravel. Waupecan, Ockley, and Wea characteristically consist of up to 5 feet of loess or loam over sand and gravel. Warsaw, Fox, Will, Kane, and Hononega consist of about 2 to 3 feet of eolian material over sand and gravel. Hoopeston, Billet, Hayfield, Marshall, and Flagger consist of up to about 4 feet of eolian sand or fine material over mostly outwash sand with some gravel. The Dakota soil contains a thin loess cover over sand and gravel.

Soils over much of the uplands are developed in loess over till. These soils indicate differences in loess thickness and in the composition of the underlying till. Elliot, Varna, and Andres soils generally have less than 2 feet of loess over the silty clay or clay loam Esmond Till. Miami, Parr, Odell, Lisbon, Saybrook, and Herbert soils have less than about 3 1/2 feet of loess and formed in the loamy Capron, Belvidere, and Ogle Tills. Ringwood, McHenry, Griswold, and Kidder soils formed in up to about 2 feet of loess and underlying sand or sandy loam till. Pecatonica, Argyle, Ogle, Flagg, Elco, and Assumption are soils developed in loess over a paleosol formed in till.

The thick loess soils include Tama, Muscatine, Atterberry, Sable, Stronghurst, Rozetta, Fayette, and Downs, which are all developed in loess more than 5 feet thick. Virgil, Drummer, Elburn, Plano, Kendall, and St. Charles soils are characterized by 3 to 5 feet of loess or silty coluvium overlying either outwash or till. LaHogue, Beardstown, Jasper, and Martinsville soils are characterized by a thin silty loess or a loam over a sandy material and often occur at the base of slopes as colluvium. Although a sandy basal unit is indicated, the colluvial material may overlie till, bedrock, or outwash. Chelsea, Grellton, and Friesland soils are developed on eolian sand that overlies sand and gravel, till, or lacustrine deposits of clay loam or silt. In some instances the sand lies directly on bedrock.

Selma, Sawmill, Troxel, Lawson, Millington, Comfrey, Orion, Juneau, and Riverwash are alluvial soils composed of both fine and coarse components overlying silty material or sand and gravel. Palms, Houghton, and Adrian are organic soils composed of organics and a sandy material; these materials are generally thinner than alluvial materials.

The Rodman soil and Rodman-Warsaw complex...
characteristically indicate terrace breaks in slope or upland deposits of sand and gravel in kames and eskers. If capped by loess or eolian sand, the soils are classified as one of the outwash soils discussed earlier.

Soil drainage

Soil drainage conditions are an important factor in planning and development decisions in Boone and Winnebago Counties—particularly those involving waste disposal sites (plates 2, 3). Poor soil drainage conditions do not always pose a major problem, but are locally present throughout both counties. Where pertinent, they have been considered in the preparation of several of the interpretive maps. Several factors affect soil drainage: depth to, and fluctuations of, the top of the zone of saturation (water table); hydraulic conductivity of the underlying materials; local and regional slope characteristics; and the position of a site with respect to local and regional groundwater flow systems and surface water drainageways. Soil drainage characteristics can be changed by constructing ponds or promoting drainage by the use of agricultural tile. Sometimes when agricultural tile systems are disrupted by construction operations an area may revert back to its natural poorly-drained condition.

The shaded area on plate 3 shows areas of soils subject to flooding or seasonally high water tables, as interpreted from the latest USDA Soil Conservation Service soil survey maps (Grantham, 1980). The shaded areas include all soils that are poorly, somewhat poorly, and moderately well drained. Areas that are naturally poorly drained have developed specific mappable characteristics, including mottling developed in the solum. Areas mapped on plate 3 as poorly drained, somewhat poorly drained, or moderately well-drained include those in which: (1) the soil parent materials are peat or organic sediments; (2) the parent materials are largely inorganic sediments formed in small shallow depressions; and (3) the soils composed of relatively impermeable sediments have developed on nearly flat surfaces with limited surface drainage. In the latter two areas, shallow water table conditions during wet years and periods of intense rainfall may cause standing water in low areas; during dry years, however, these areas may give no surface indication of poor drainage.

The areas of poorly drained soils also include many small and large drainageways, most of which are local or regional discharge areas that are subject to periodic flooding. Such areas are shown on USGS Flood Hazard Maps and (in more detail) on Federal Flood Insurance Program maps.

PRINCIPAL TERRANES

In order to combine on one map both geologic materials and topography as related to resource and land-use characteristics, "terrain" analysis similar to that used by Hackett and McComas (1969) was applied to the Boone and Winnebago County region. However, for this report, a terrain is defined as a physiographic (topographic) feature, such as a major valley or upland area, that has a specific position and characteristic differentiating it from other features of the landscape. In contrast, a terrane is a mapping unit consisting of a topographic feature considered together with the sequence of geologic materials of which it is composed. Using physiographic analysis as well as detailed geologic mapping (plate 1), we mapped terrane units (fig. 15) to provide the basis for differentiating areas in which the conditions for a variety of land-use and resource interpretations are likely to be similar.

In Boone and Winnebago Counties, the uplands and lowlands were subdivided into the following terrains:

**Uplands**

(U1): *High uplands*, generally more than 100 feet above major valley areas (lowlands); mostly rolling topography with slopes predominantly 2 to 5 percent; may be either erosional remnants or constructional features.

(U2): *Intermediate uplands*, generally less than 100 feet above major lowlands; may be gradational to lowlands; slopes predominantly 2 to 5 percent.

(U3): *Steeply sloping uplands*, including some steeply sloping depositional features of high and intermediate uplands; slopes predominantly greater than 5 percent; includes steep valley sides along numerous small drainageways.

**Lowlands**

(L1): *Upland valleys*, including upland basins and relatively sizable valleys tributary to major lowland valleys but generally more than 50 feet above lowlands; valley bottoms contain areas of slopes less than 2 percent.

(L2): *Major valley areas*, generally the lowest elevations of the landscape, containing widespread flat areas with slopes less than 2 percent; usually associated with the principal streams.

Generalized slope characteristics were derived from topographic maps and compared with slopes shown for soils on Soil Conservation Service (USDA) maps (Grantham, 1980).

To construct the terrane map, we outlined these categories of uplands and lowlands on a 1:62,500 base map (1 inch = 1 mile), using a preliminary designation for each category (e.g., U1, U2, U3, L1, and L2). Then we placed this map over the stack-unit map (plate 1) in order to combine information on the physiography with information about the geologic materials. The boundary between the uplands and major valley lowlands was the most obvious match; it was drawn by using the separations between sand and gravel or lacustrine materials in the valleys and till or bedrock of the uplands. Where minor tributary valleys are carved into the upland the division between the lowland and upland terranes is somewhat arbitrary. Where valleys are less pronounced topographically, and less than one-half mile wide, they were included within upland terrane areas.

Additional subdivisions of the upland and lowland terranes were established, and each was assigned a numbered terrane unit (fig. 15). In general, there was remarkable agreement between physiographic boundaries and material changes; only minor adjustments to the physiographic boundaries were necessary in order for them to coincide.

Six categories of upland terranes and three categories of lowland terranes were established (fig. 15). High or intermediate uplands separated into relatively flat areas (area 1, 2, or 3) or dissected (more steeply sloping) areas (area 4 or 5) with either dolomite (area 1 or 4) or till (area 2, 3, or 5) as the principal underlying material.
The upland till areas were further separated into two major textural groups: sandy to sandy loam materials (areas 2 and 5) and silt loam to silty clay loam materials (area 3). Only relatively small areas of sand or sand and gravel are found in the uplands, but there are some significant local deposits, particularly in southern Boone County. A separate terrane unit is used to indicate these materials (area 6). The physiographic distinction between high and intermediate uplands appeared to be a relatively insignificant discriminator between material types and could not be used consistently; therefore, the distinction was not attempted.

The lowland was separated into map units: those underlain predominantly by sand and gravel (area 8) and those underlain mostly by fine-textured, lacustrine sediments (area 9). Only two areas were mapped as upland valleys (area 7): the headwaters of Beaver Creek in northeastern Boone County; and a relatively large "basin," the headwaters of Grover Creek in southwestern Winnebago County.

The distribution of terranes and the characteristics of the terrane materials determine the groundwater gradient and hydraulic conductivity. Therefore, the terrane map can be used to suggest the potential of a given area for natural recharge to shallow aquifers and the potential for pollution in a given area. Other land-use and resource characteristics can also be identified with specific terranes.

**HYDROGEOLOGIC PRINCIPLES**

In northern Illinois, groundwater is derived from precipitation that falls primarily as rainfall and seeps into the ground. The water infiltrates through loose particles of the soil and percolates downward through the soil. Below the water table (the top of the zone of saturation) almost all openings (pores) in the earth materials are filled with water. Above the water table the pore spaces are filled with water and air. This definition of water table is independent of the character of earth materials, and therefore is not related to the availability of groundwater to wells.

In the zone of saturation groundwater is stored in openings ranging in size from tiny pores between particles of clay and silt, to larger pores in sand and gravel, to large crevices in dolomite and limestone. The porosity of an earth material is expressed quantitatively as the percentage of the bulk volume of the rock or sediment that is occupied by its pore space. The size and interconnection of the pores determine the hydraulic conductivity of the material—the relative ease with which it transmits water under a pressure gradient. Permeability refers to the capacity of an earth material to transmit any fluid; hydraulic conductivity refers to the rate at which the water flows through the material (Domenico, 1972).

In northern Illinois, the water table roughly parallels the surface topography, rising under the uplands and intersecting the ground surface along perennial streams, lakes, swamps, and springs. At these points of intersection, groundwater is discharged to surface water bodies by gravity flow from adjacent areas where the water table is higher (fig. 16 a, b). The position of the water table and the amount of discharge of groundwater to streams fluctuate from season to season and from year to year. Although the water table can be reached in any of the surficial materials found in northern Illinois, the groundwater present in these materials is not necessarily available to a well. Water will be available only after it encounters material with sufficient hydraulic conductivity to transmit.
Figure 15.- Terranes of Boone and Winnebago Counties.

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it to a well. A large excavation below the water table will fill with water—very slowly—even in materials having very low hydraulic conductivity.

An aquifer is a natural material having interconnected openings large enough to transmit water readily to a spring or to a well in sufficient quantity to satisfy the need for which the well was drilled. An aquifer that produces sufficient water to supply a well for a single residence might not yield enough to serve as an aquifer for a municipal well. (In this report, we use the term aquifer to refer to earth materials capable of supplying water to at least several residences.)

Aquifers may be classified as unconfined or confined, depending on the presence or absence of a water table (fig. 17) within the aquifer. In an unconfined aquifer the water table is within the material that yields water to wells. In an artesian aquifer, the groundwater is confined under pressure greater than atmospheric pressure by overlying, relatively impermeable materials, which causes the water to rise in a well above the top of the aquifer (fig. 17). Both types of aquifers are present in Boone and Winnebago Counties.

In some places, a material above the top of the water table can become saturated for all or part of the year; this results in a perched water table. In Boone and Winnebago Counties, perched water tables frequently occur in areas where 3 to 7 feet of loess overlies a clay-rich paleosol developed in till. Since water generally moves somewhat more rapidly through silt than through the clayey paleosol, the material directly above the paleosol becomes saturated. Small areas containing relatively thin sand and gravel layers

Figure 16a. Local and regional flow systems (from Cartwright and Sherman, 1969).

Figure 16b. Details of flow systems (modified from Hughes, Landon, and Farvolden, 1971).
Figure 17. Relationship between water table and piezometric surface (modified from Cartwright and Hunt, 1981).

between loess and clay-rich till and within the zone of perched water might be considered as perched aquifers. Perched aquifers rarely yield enough water for a sufficient length of time to be considered even as a source of a small household supply; however, they often cause problems such as wet basements, soft foundations, and septic tank failures.

The addition or replenishment of water to the groundwater reservoir is called recharge. A groundwater flow system describes the progressive movement of water through the earth from recharge areas to discharge areas. The driving force for groundwater movement is gravity; the direction of groundwater movement is a function of potential (energy). The path that groundwater follows vertically and horizontally through the earth from the recharge to the discharge area can be thought of as imaginary lines of flow (fig. 16b).

Any complete regional flow system is composed of small, local systems superimposed on larger systems. A small, local flow system might include only a small pond, which acts as a discharge area. Adjacent uplands act as the local recharge area. This small system could, in turn, be superimposed on a secondary system that finally discharges into a major stream such as the Kishwaukee River or the Rock River (fig. 16a, b).

Recharge is diffuse over large areas and does not come from a point source or even from small local areas. In relatively humid areas such as northern Illinois, streams that flow perennially or for most of the year are groundwater discharge areas. The entire interstream area, therefore, forms the recharge area.

GROUNDWATER AND TERRANES
The eventual destination of all precipitation that falls on north-central Illinois—other than that which evaporates or is transpired by vegetation—is the Mississippi River, via the Kishwaukee and Rock Rivers. Less than half the water that enters these streams will be direct surface runoff. About 10 percent of the precipitation enters the groundwater system. Recharge occurs only after the rain that enters the ground saturates the soil; the rest moves into the groundwater reservoir.

Regionally, the interrelationship of surface soils, the underlying geologic materials, and the terrain configuration determines the amount of water entering the groundwater reservoir, the rate of recharge, and the direction of groundwater movement. Climatic factors (including temperature and rainfall frequency and intensity) and type and distribution of vegetation are also important. Storm sewers in urban areas and field tile in agricultural areas may also considerably alter natural drainage and recharge characteristics.

Since the rate of groundwater movement is directly related to both hydraulic conductivity and hydraulic gradient, relatively rapid infiltration and groundwater movement will occur in uplands directly underlain by dolomite or sand and gravel. On the other hand, surface runoff may be greater, and infiltration rates and groundwater movement generally slower, in uplands directly underlain by silty, clayey till having a considerably lower hydraulic conductivity. Thus, over a given period of time, till terranes generally provide considerably less recharge to a given area than do terranes composed of sand and gravel or dolomite at or near land surface.

The distribution pattern of terranes also affects the direction of groundwater movement. Since groundwater moves under the influence of gravity from the place of intake to a lower place of discharge, movement of groundwater is from the uplands toward the lowlands. It is likely that more water will enter the deeper portions of the shallow aquifer system (sand and gravel within the drift and underlying dolomite) from upland terranes than from lowland terranes; this occurs because the distance to regional
zones of discharge is greater. Only a very small amount of this water will actually move downward through the Maquoketa Shale Group or the Galena and Platteville Dolomite Groups into the Cambrian and Ordovician aquifers (Walton, 1965, p. 3-6). Nearly all of the water that infiltrates to the groundwater reservoir in the lowland terranes adjacent to the principal zones of discharge (e.g., the Rock River), will move directly toward the rivers and enter the surface water system.

NATURAL RECHARGE
Natural recharge depends upon soil moisture conditions, soil permeability, precipitation intensity, and location within the groundwater flow system. Some recharge occurs in almost all areas except in the discharge zones themselves. In the past, designation of prime natural recharge areas has often been made on the basis of the characteristics of the surficial materials, without consideration of the relative hydrogeologic position of the materials. The regional terrane map (fig. 15) is an intermediate step in producing a hydrogeologic appraisal that can provide the basis for evaluating the regional shallow groundwater system. By evaluating both the surficial materials and regional topography we can establish the relative natural recharge potential of various parts of the landscape.

Relative rates and highly generalized directions of groundwater movement were determined in order to show the relative amounts of recharge over a given area and period of time. Long-term water level records for wells penetrating the glacial drift and shallow bedrock aquifers were generally not available, and even when records were available, the local and regional flow systems in the shallow aquifers were too complex to be mapped. Walton (1965) indicates that approximately 65 percent of the flow of the Rock River is groundwater discharge. Groundwater recharge in the carbonate terranes (thin drift over fractured dolomite as in western Winnebago County) is about 265,000 gallons per day (97 million gallons per year). In the till terranes, recharge is about 155,000 gallons per day (56 million gallons per year).

In Boone and Winnebago Counties the relatively flat upland terranes (fig. 15, map areas 1, 2, 3) probably provide the greatest amount of recharge to the shallow aquifers of the region; they also provide recharge to the deeper aquifers (Suter et al., 1959), particularly in western Winnebago County. The sloping or dissected terranes (map areas 4, 5) provide at least local recharge to the shallow dolomite aquifers where the drift is thin (map area 4). Since only small areas of upland sand and gravel may be present (map area 6) these areas probably contribute only minor amounts of local recharge to the shallow aquifer system, even though infiltration rates probably are relatively high.

Although the lowland areas (fig. 15, map areas 7, 8, 9) are considered local or regional discharge areas, they provide for some local recharge to the shallow aquifer systems, particularly in map area 8. However, the water is of little significance to water resource development unless it is intercepted by wells before it reaches the discharge zone (e.g., the Rock or Kishwaukee Rivers).

Significant recharge to the shallow aquifer system occurs throughout nearly all of Boone and Winnebago Counties. Although rates may be very slow throughout the portions of the region underlain by tills, very substantial amounts of water eventually move into the shallow aquifers through these materials.

It seems likely that increasing urbanization in parts of northern Illinois has significantly altered the natural recharge to the shallow aquifer system. According to Savini and Kammerer (1961), urbanization (subdividing) on a relatively small scale may sometimes enhance local recharge. Additional water is channeled to lawns by rainfall draining from roofs, by heavy watering of lawns, and occasionally by outflow from septic systems. When this additional water, often imported to these areas, is added to the normal, evenly distributed rainfall, it is likely that the soil will become saturated and the hydraulic pressure will drive water downward into the groundwater system. Obviously, in areas of intensive urbanization where most of the land is either paved or covered with buildings, and where storm sewers are installed, recharge may be very limited.

Agricultural practices (using field tile to drain large fields or removing natural vegetation) may affect natural recharge. Some agricultural practices actually promote surface runoff and thus decrease the amount of water available for infiltration.

GEOLOGY AND LAND USE

WASTE DISPOSAL AND LAND TREATMENT
Plate 2 rates geologic materials according to their capacity to protect aquifers from contamination by land burial of municipal wastes; plate 3 rates geologic materials according to their capacity to protect aquifers from contamination by septic systems and surface spreading of wastes and chemicals. (On these two plates, the term groundwater is synonymous with aquifer.) These maps indicate the probability of finding suitable sites within a given area and provide preliminary data for reevaluating existing sites; however, the maps cannot be used as a substitute for individual site evaluations.

Detailed investigation of all proposed waste disposal sites is necessary because of variations in earth conditions, limitations of mapping scale, and the uneven distribution of available data. Individual site evaluations should always include consideration of the following factors, which cannot be evaluated regionally: (1) composition of the waste material; (2) distance from waste to nearby wells; (3) number of nearby wells; (4) frost depth; (5) depth to seasonal water table; (6) minor slope variations; (7) nature and availability of cover material; (8) position of site with respect to the groundwater flow system; (9) areas at or near mapped material boundaries; and (10) the density of disposal sites in a given area.

In some places where geologic materials are generally considered unsuitable for waste disposal sites the hydrogeologic system may play a mitigating role by providing extremely large dilution ratios. For example, waste disposal sites along major rivers would normally be considered unsuitable because the underlying materials are generally coarse grained and have moderately high hydraulic conductivities and low cation exchange capacities (CECs). However, flow paths in such areas are predictable, and a leachate-
producing waste disposal operation would probably produce only a limited zone of contamination between the waste disposal site and the major river, a regional discharge area. Important considerations with respect to such sites are: (1) whether this zone of contamination, which will exist in a finite space for a finite time, is acceptable (under present Illinois Pollution Control Board Standards, it is not); and (2) whether there are, or may be, pumping wells nearby that could cause leachate to migrate outside the predictable "zone." Hughes, Landon, and Farvolden (1971) suggest that, when properly located, spaced, constructed, and monitored, such sites may not significantly degrade the quality of the surface water body. Such sites must be evaluated individually and carefully monitored during and after waste disposal operations, and are not generally considered desirable; therefore such areas were purposely excluded from this study.

**General criteria for mapping**

In evaluating materials for their suitability for waste disposal, prime consideration must be given to their porosity, hydraulic conductivity, and attenuation capacity.

**Porosity and hydraulic conductivity** (permeability) are related to the grain size, mineralogy, and sedimentation history of the earth materials (Todd, 1959); however, grain size has the most influence on porosity and hydraulic conductivity because of its variability over the region. Generally, the larger the grain size, the greater the hydraulic conductivity. Materials having low hydraulic conductivities transmit water at a rate of about $1 \times 10^{-5}$ cm/sec or less; materials with high hydraulic conductivities have values about $1 \times 10^{-2}$ cm/sec or greater.

**Attenuation capacity** is the capacity of earth materials to remove contaminants from the water as it passes through them. This is a complex physical-chemical relationship involving two major factors: cation exchange capacity (CEC) and chemical precipitation of insoluble compounds resulting from pH changes and other chemical reactions. CEC and chemical precipitation occur more or less independently of each other. CEC, the more important factor, is an exchange phenomenon that results in the capture of a pollutant and release of the natural ion present in the clay. In northern Illinois, the ion released is generally calcium, but occasionally sodium.

Naturally-occurring clays consist mostly of clay minerals (such as illite, chlorite, vermiculite, and montmorillonite) and small amounts of associated nonclay minerals such as quartz, dolomite, and calcite. Clay minerals have a distinctive layered structure in which the number and type of layers are generally fixed, but the number and type of ions (positive and negative charges) within and between layers vary. Places where ions (usually the positively charged cations) fit into the clay mineral structure are called exchange sites; the number of available cation exchange sites in a particular clay mineral determines its cation exchange capacity. Some clay minerals hold their ions more loosely than others and have a high cation exchange capacity. Some stable clay minerals are characterized by an increasing CEC as they weather and become less stable.

The cation exchange capacity of a specific geologic material is a measure of its potential to release or adsorb cations as the groundwater moves through it. If the groundwater contains objectional cations derived from industrial, domestic, or agricultural waste products, the CEC of the geologic materials has a direct bearing on problems of waste disposal. In such instances the CEC is a reasonable direct estimate of the attenuation capacity of the geologic materials; geologic materials having high CEC values are likely to attenuate at least some of the contaminants.

The range in CEC values is generally related to the clay and organic content of the earth materials: materials having a higher percentage of clay and organic matter usually have higher CEC values. Clays are prevalent in shale, fine-grained lacustrine (lake) deposits, and many glacial tills; organic material is common in peat bogs and other lowland depressions, and in the active soil zone (solum). The highest CEC values are found in the upper part of the solum (A horizon). Coarse-grained materials (sands and gravels) have very low CEC values. Most geologic materials in northern Illinois have relatively low CECs, and the potential is high for contamination of groundwater within these materials.

Low CEC values are generally less than about 5 milliequivalents (meq)/100g; high values generally exceed 15 meq/100g, and may be as high as 35 meq/100g. Recent research has shown that a layer of material more than 10 feet thick with a CEC of 10 meq/100g can generally attenuate all but the most highly mobile ions.

The attenuation capacity of geologic materials is different for each specific compound and complex. The relative mobility of some individual ions, compounds, and complexes in landfills leachate was measured by Griffin et al. (1976). Research indicates that most toxic metals such as lead, mercury, and chromium are relatively immobile; however, some toxic substances such as arsenic and chromite (Cr$^{6+}$ ion) are mobile under some conditions. Ammonia, iron, and sodium ions, found in most common wastes, are relatively mobile. Chloride ions, also found in most wastes, move almost without any attenuation by earth materials. Recent research on the mobility of organic chemical wastes suggests that some organic solvents may be highly mobile.

**Land burial of wastes: Plate 2**

In rating geologic materials on their capacity to protect aquifers from contamination by buried wastes (plate 2), we assumed that municipal landfills can contain industrial wastes (some toxic) as well as domestic refuse. The ratings of materials depend on their hydrogeologic properties (table 2), capacity for retaining wastes over time, and attenuation characteristics, and on the release rate of nonattenuated ions, compounds, and complexes to the environment. The state of the waste product (solid, semi-solid, or liquid) was not considered because it affects only the time required for a contaminant to mobilize in the trench and the initial rates of contaminant loading.

The following specific mapping conventions were used in preparing plate 2:

- Gravel pits and quarries were mapped as if original materials were present. (However, pits and quarries must be evaluated individually to determine their suitability for land burial of wastes, since in a deeply excavated pit, a potentially contaminable aquifer...
is closer to the surface than it would be in a shallower excavation.)

- Aquifers and potential aquifers within 50 feet of land surface or 30 feet below the base of the landfill trench were mapped because waste burial to a depth of 20 feet was assumed.

- Areas of steep slopes (greater than 5%) were indicated on the map because contaminants can move along subsurface material boundaries and exit on sloping areas, creating a surface contamination problem. (Detailed USDA Soil Conservation Service county soil maps and reports give more precise information on slopes, surface drainage, and erodability.)

Mapped areas on plate 2 are listed (in the legend) in order of their capacity to protect aquifers and surface water from contamination. It is assumed that most wastes are buried below the water table in a trench 20 feet deep, and therefore are in contact with groundwater. In northern Illinois the top of the zone of saturation is frequently shallower than 20 feet below the land surface. In low-permeability materials preferred for disposal sites the water table will rise into the refuse, creating a groundwater mound; therefore, even though disposal initially may have been above the water table, the refuse could eventually come in contact with groundwater. The map units for plate 2 are as follows:

**Map Unit A₁:** highest potential for aquifer contamination—areas where the Galena-Platteville dolomite occurs within 20 feet of land surface. These areas are generally in the uplands of western Winnebago County, in parts of southeastern Winnebago County, and in parts of the southern half of Boone County. Fracture and joint systems in the dolomite permit fairly rapid, nearly unimpeded movement of water (and any contaminants in it) to nearby shallow wells finished in the dolomite. Therefore, landfills developed in dolomite quarries or in sand and gravel or till directly on the dolomite are likely to yield contaminants that will migrate to pumping wells or toward an adjacent river.

**Map Unit A₂:** high potential for aquifer or surface water contamination—areas where sand and gravel deposits (often more than 50 ft thick) occur at land surface. These areas occur principally in the Rock, lower Pecatonica, and Sugar River valleys in Winnebago County, and in the Kishwaukee River and Piscasaw Creek valleys, mostly in Boone County. Contaminants can be transmitted easily from landfills to nearby wells finished in the sand and gravel, or discharged directly into nearby streams.

**Map Unit B:** moderate potential for aquifer or surface water contamination—areas where sand and gravel within 20 feet of land surface is overlain by till or other fine-to medium-textured material. These areas occur primarily east of the Rock River and north of the Kishwaukee River in eastern Winnebago County, and in northern Boone County. Waste buried in a pit or trench about 20 feet deep may be in contact with the sand and gravel deposit; therefore, there is little or no natural protection of an aquifer by overlying finer-grained materials.

### TABLE 2. Estimated hydraulic conductivity of typical geologic materials in Illinois.

<table>
<thead>
<tr>
<th>Geologic material</th>
<th>cm/sec</th>
<th>gpd/ft²</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean sand and gravel</td>
<td>$1 \times 10^{-2}$</td>
<td>$&gt; 20$</td>
<td>May be highly permeable</td>
</tr>
<tr>
<td>Fine sand and silty sand</td>
<td>$1 \times 10^{-3}$ to $1 \times 10^{-2}$</td>
<td>0.2 to 20</td>
<td></td>
</tr>
<tr>
<td>Silt (loess, colluvium, etc.)</td>
<td>$1 \times 10^{-4}$ to $1 \times 10^{-3}$</td>
<td>$1 \times 10^{-1}$ to 2</td>
<td></td>
</tr>
<tr>
<td>Gravelly till, less than 10% clay</td>
<td>$1 \times 10^{-5}$ to $1 \times 10^{-4}$</td>
<td>$2 \times 10^{-3}$ to $2 \times 10^{-1}$</td>
<td>Often contains gravel/sand lenses or zones</td>
</tr>
<tr>
<td>Till, less than 25% clay</td>
<td>$1 \times 10^{-6}$ to $1 \times 10^{-5}$</td>
<td>$2 \times 10^{-4}$ to $2 \times 10^{-3}$</td>
<td>Often contains gravel/sand lenses or zones</td>
</tr>
<tr>
<td>Clayey tills, greater than 25% clay</td>
<td>$1 \times 10^{-7}$ to $1 \times 10^{-6}$</td>
<td>$2 \times 10^{-5}$ to $2 \times 10^{-3}$</td>
<td>Often contains gravel/sand lenses or zones</td>
</tr>
<tr>
<td>Sandstone</td>
<td>$&gt; 1 \times 10^{-4}$</td>
<td>$&gt; 2$</td>
<td></td>
</tr>
<tr>
<td>Cemented fine sandstone</td>
<td>$1 \times 10^{-7}$ to $1 \times 10^{-6}$</td>
<td>$2 \times 10^{-3}$ to 2</td>
<td>Frequently fractured</td>
</tr>
<tr>
<td>Fractured rock</td>
<td>$&gt; 1 \times 10^{-4}$</td>
<td>$&gt; 2$</td>
<td>May have extremely high hydraulic conductivity</td>
</tr>
<tr>
<td>Shale</td>
<td>$1 \times 10^{-1}$ to $1 \times 10^{-7}$</td>
<td>$2 \times 10^{-7}$ to $2 \times 10^{-3}$</td>
<td>Often fractured</td>
</tr>
<tr>
<td>Dense limestone/dolomite (unfractured)</td>
<td>$1 \times 10^{-1}$ to $1 \times 10^{-8}$</td>
<td>$2 \times 10^{-7}$ to $2 \times 10^{-4}$</td>
<td></td>
</tr>
</tbody>
</table>

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Map Units C₁, C₂, and C₃: some potential for aquifer contamination—areas where dolomite (C₁) or sand and gravel (C₂ and C₃) are likely between 20 and 50 feet of land surface. C₁ and C₂ areas are mostly overlain by till or other fine- to medium-textured material; C₃ areas are mostly overlain by waterlain silty clay materials that may be somewhat variable in character. C₁ and C₂ areas are scattered throughout the two counties but are concentrated along the dissected margin of the uplands adjacent to the major river valleys and some of their tributaries. C₃ areas are most extensive in the upper Pecatonica Valley in Winnebago County and are found locally in the lower part of small valleys tributary to the Rock, Kishwaukee, lower Pecatonica and Piscasaw valleys.

Because geological materials in Map Unit C areas are the most variable, and because specific data are often lacking, predictions about the potential for aquifer contamination from waste burial are often unreliable. For this reason, careful site investigations are necessary before waste burial operations are begun in these areas.

Map Units D, E, F, and G: lowest potential for aquifer contamination—Map Unit D areas are directly underlain by more than 50 feet of predominantly sandy till, and nearly half the D areas contain relatively steep slopes (indicated by D*). The largest areas mapped as D are in eastern Winnebego County and northern Boone County. D* areas are concentrated along the uplands east of the Rock River valley and north of the Kishwaukee River and Piscasaw Creek valleys.

Map Unit E areas are similar to D areas, except that the predominant till is silty clay, which has a somewhat lower hydraulic conductivity (table 2). Most of the E* areas are dissected upland areas adjacent to the south side of the Piscasaw and Kishwaukee valleys.

Map Units F and G are underlain by more than 10 feet of the Maquoketa Shale Group; F areas have less than 50 feet of till, G areas more than 50 feet of till, over the Maquoketa. Except for small areas in northern and west-central Boone County, all areas categorized as F and G are located in southeastern Boone County.

Map areas D, E, F, and G are considered to have the lowest potential for contamination of underlying aquifers. Significant portions of these areas may have poor surface drainage conditions or may be subject to seasonally high water table conditions. (These areas—D*, E*, F*, or G* on plate 2—are shown in more detail on plate 3.) Although subsurface conditions may be favorable for developing a landfill, a potential for surface water contamination exists, and landfills may be troublesome to design, engineer, and operate. In all cases, site investigation must be carried out to verify the existing geologic condition.

Waste disposal by septic systems: plate 3
In rating land areas on their suitability for septic system operation, we considered (1) the permeability of the geologic materials and their capacity to protect aquifers and surface water from contamination, and (2) the capacity of the materials to accept waste. (The number of septic systems operating within a specified area must be considered, along with the hydrogeologic factors, in determining contamination potential.) Plate 3 should not be used to evaluate the impact of widely scattered individual septic systems.

Materials having high hydraulic conductivities will readily accept septic waste, but may produce a contamination hazard; conversely, the potential for aquifer contamination is low in materials having low hydraulic conductivities, but the septic systems may not operate properly.

The most widely used type of septic system is the buried tank with a shallow overflow seepage (filter) field, buried at depths less than 3 feet. If the filter field is installed below this depth, the attenuation of the contaminants by the soil is not as effective, particularly if the underlying material has a relatively high hydraulic conductivity. However, even when properly installed, septic systems spaced close together (5 to 25 per sq mi) are likely to produce a concentration of recharge of the septic effluent to the shallow aquifers.

Criteria used for plate 3 are based on the Illinois Department of Public Health’s definition of a public septic system—a system that serves 11 or more residences. (We have assumed that the contamination potential from one septic system serving 11 residences is the same as that from 11 individual systems serving 11 residences.) The U.S. Department of Agriculture has established criteria relating soil characteristics to the operation of septic systems. Their criteria should be consulted along with the regulations of the County Departments of Health and County ordinances.

Map Units A₁, A₂, B₁, B₂, and B₃: highest potential for aquifer contamination from intense use of septic systems—areas where dolomite or extensive sand and gravel aquifers occur directly below land surface (A units) or where sand and gravel or dolomite aquifers occur within 20 feet of land surface (B units). These areas are essentially the same as those mapped on plate 2 as most sensitive for land burial of wastes.

Map Units C₁ and C₂: lowest potential for aquifer contamination from intense use of septic systems—areas where sandy or sandy-loamy till (C₁) or loamy to silty-clay till (C₂) are usually greater than 20 feet thick. Although groundwater contamination hazard is minimal in these areas, acceptance of septic effluent by the geologic materials is a principal problem. In some places, steep slopes (indicated by *) allow septic effluent to move rapidly to land surface and into drainageways before it has been adequately filtered and attenuated. In other places, high water table conditions may prevent septic effluent from entering the ground, which may cause the effluent to move upward to land surface. (These conditions also occur locally in A and B areas.) Perched water can be a problem in some C areas.

In C₂ areas, unusually low hydraulic conductivity of the materials often creates a serious acceptance problem. Septic systems may work well under dry conditions but operate poorly during periods of heavy rainfall, particularly during the spring. This may be especially true for areas having soil drainage problems.

Pollution index. Since contamination of aquifers is most likely to occur where there is a large concentration of
septic systems, guidelines have been established to evaluate contamination hazards. Cartwright and Sherman (1974) consider that permeability, volume of effluent, and the thickness of material between the effluent discharge horizon and the shallowest aquifer are the most significant factors in this evaluation. They used the standard percolation test as a measure of permeability, the housing density as an approximation of volume of effluent, and a specific measure of the thickness of material between the point of effluent discharge and the underlying aquifer to be protected. From these parameters they developed a formula for estimating pollution hazard:

\[ P_i = \frac{200}{\sqrt{T(5)}} \]

where:
- \( P_i \) = pollution index
- \( D \) = housing density (number of residences with septic systems within a distance of 0.28 mi—a circle having an area of ¼ sq mi); in areas of closely spaced residences the number of homes per acre is multiplied by 160.
- \( I \) = time (min) for water to fall 6 inches, as measured in a standard percolation test
- \( T \) = thickness (ft) of material between discharge level and underlying aquifer to be protected; if \( T \) is less than 5, assume \( T(5) = 1 \) (Cartwright has changed the original 0 to 1).

Values of \( I \) for individual soils and their parent materials can be obtained from the Soil Survey report for Boone and Winnebago Counties (Grantham, 1980). \( P_i \) values greater than 10 suggest that some potential for contamination exists and that the site should be carefully studied and monitored. Although the density of septic systems is a critical factor in evaluating contamination potential, the efficiency of the individual systems, the number, the depth and average pumping rate of nearby wells, and the location of housing units with respect to the local groundwater flow system may also affect the potential for contamination. Wehrmann (1983) made a detailed study of potential contamination from septic systems in the Roscoe area.

The many local variations in near-surface geologic conditions and soil characteristics must be carefully considered when subdivisions including individual septic systems are planned. Particular attention must be paid to local soil drainage conditions, shown best on the SCS detailed soils maps and on the map of geologic materials (plate 1).

Surface spreading of wastes and chemicals
Plate 3 differentiates areas where aquifer and surface water contamination may result from spreading of wastes (industrial wastes, sewage sludge, and accidental chemical spills) and agricultural chemicals on land surface or in the active soil zone (solum). Although the solum has attenuating capabilities, it generally develops sufficient hydraulic conductivity to allow some water and potential contami-nants to pass. Application rates for spreading depend on the slope, soil type, soil characteristics, and amount of precipitation; rates should be adjusted carefully to prevent overloading of the soil, and to supply plant needs for only one season (Graffis et al., 1977).

Plate 3 identifies areas where aquifer contamination potential is low and areas where contamination potential is high and spreading of wastes should be carefully controlled and monitored. Certain types of potentially hazardous wastes must be individually evaluated.

Geologic conditions that: (1) permit rapid downward movement of contaminants into the shallow aquifers or (2) promote runoff of contaminants into surface water bodies increase the possibility of contamination from surface spreading of wastes and agricultural chemicals. The first condition occurs where extensive areas of dolomite (A_1) or sand and gravel (A_2) lie directly below land surface or within 20 feet of the surface, overlain by fine-grained materials (B_1, B_2, B_3); the second condition occurs in areas of clayey till (C), poor surface drainage, and/or steep slopes. In all cases, overapplication of chemicals is the principal concern. The ISGS is investigating potential contamination from spreading of sludge on agricultural land northwest of Rockton. The State Water Survey is investigating contamination by toxic organic chemicals from near-surface sources northwest of Roscoe.

A buildup of trace elements in sewage sludge (used as fertilizer) can cause local problems. Nitrogen, one of the most mobile elements, is frequently a significant contaminant when overapplied, particularly as liquid ammonia. Local buildup of nitrates is also common around feedlots. Lawn fertilizers can also contribute significantly to local contamination in subdivisions and all established residential areas.

When herbicides and insecticides are properly used, they are usually retained in the active soil zone (solum). A few instances of aquifer and surface water contamination by herbicides and insecticides have been reported. The glacial till materials generally contain sufficient clay to attenuate certain organic compounds; thus, herbicides and insecticides are generally immobile except in soils with very low clay contents.

LIMITATIONS OF WASTE DISPOSAL MAPPING
The interpretive maps showing geologic conditions related to waste disposal and land treatment practices (plates 2, 3) were derived principally from the stack-unit map of the geologic materials (plate 1). Therefore, it is important to discuss the limitations and advantages of stack-unit mapping and to consider the adequacy of the criteria established for the preparation of the interpretive maps.

The accuracy of a stack-unit map depends on the quantity, type, and distribution of basic data; the geological complexity of the areas being mapped; the depth for which data must be obtained; and the scale at which the map is prepared and printed (Kempton, 1981).

Our basic mapping, initially compiled on U.S. Geological Survey 7.5-minute topographic quadrangle maps at a scale of 1:24,000, incorporated not only all the geologic data available (from well and engineering boring logs, descriptions of well and boring samples, and field observations), but also detailed information obtained from soil
survey maps. By integrating geologic and soil data, we were able to map materials and their boundaries in the upper 20 feet with considerable accuracy (mapping in the upper 20 feet is considered to be 75 to 95 percent reliable). Because each of the glacial tills has a fairly uniform composition, the sequence and distribution of these tills was relatively easy to establish.

The accuracy of the boundaries of mapped surface units depends largely on the accuracy of the boundaries of the soil parent materials determined from the soil survey maps (McComas, Hinkley, and Kempton, 1969). Large areas mapped as one geologic material more than 20 feet thick represent the most accurate parts of the map.

Generally, the availability and accuracy of geologic data decreases with depth. Subsurface boundaries are probably the least reliable. Since the margins of geologic deposits frequently thin out or grade into other materials, the mapped position of the boundary between otherwise well-defined units may therefore be the least accurate aspect of the map and the most subject to change as more data become available.

In preparing the two contamination potential maps we considered these factors in addition to the composition, position, and extent of the geological deposits: general slope characteristics, depth to an aquifer, surface drainage, and the nature of the general shallow groundwater flow system (plate 3; figs. 11, 15, 19); however, the groundwater flow system could be determined only in a general way.

Factors not considered in preparing the interpretive maps were: (1) state of waste materials (only mobilization time was considered); (2) burial of low-level radioactive waste that requires some 500 years containment; and (3) site-specific or seasonal factors, such as distance to nearest water well, frost depth, seasonal water table, local slope variations, local variations in geologic materials, and density of disposal sites within a given area.

Some interpretations were based on professional judgment of the probable behavior of a given earth material as potential contaminants move through it. Certain mapping generalizations also had to be made (combining or eliminating small units), and in some instances, specific details of surface drainage were not mapped.

Because the interpretive maps prepared for this project are based on data from both geologic and soil survey maps, they are more useful and reliable than interpretations made directly from either a geologic or soils map alone. On soils maps, detailed information of the material is limited to a maximum depth of 5 feet. Such information, which includes cation exchange capacities, hydraulic conductivity, and character of surficial geologic materials, is necessary for determining application rates of fertilizers, insecticides, and herbicides in treatment of fields. But geologic data on materials below 5 feet are required for making interpretations about infiltration rates and potential for groundwater contamination.

The depth consideration is particularly important for land burial of wastes, since waste is normally buried in trenches about 20 feet deep. Septic systems utilize filter fields that are commonly developed in the lowermost part of the solum (lower B horizon), and they are also greatly affected by the hydraulic conductivity of the parent geologic materials as well as the soils. Because little or no attenuation of contaminants takes place in the upper solum, septic systems are likely to transmit contaminants directly to shallow aquifers.

The interpretive maps are intended as practical regional guides to be used to determine the possibility of contamination of the shallow groundwater system by various waste disposal methods and land treatment practices. The maps also indicate the limitations imposed by the acceptance rates of the various geologic materials, thereby suggesting areas where high density use may cause the contaminants to rise to the land surface. When used in conjunction with the soil interpretations, they should provide a basis for local and county planning aimed at reducing water contamination.

GEOLOGY AND CONSTRUCTION
Specific geologic conditions
The primary concern in mapping geologic conditions related to construction was the suitability of geologic materials for support of light construction (generally involving 1- and 2-story buildings having shallow foundations and relatively low loads transmitted to footings). Ease of excavation for basements or utilities, adequate bearing strengths to support structures, and drainage conditions are the major concerns of builders. In terms of these construction considerations, the physical properties and terrain characteristics of some geologic units are very similar; for this reason, some geologic units shown on the geologic map (plate 1) were combined and shown as one unit on the map of general construction conditions (fig. 18).

Because the type of soil can significantly influence geologic conditions at a specific site, detailed information on soils available from the Soil Survey of Winnebago and Boone Counties (Grantham, 1980) should be used along with data from this report. The measurements and descriptions referred to in this section should not be used for design purposes.

The ideal site for most structures is one that (1) is not susceptible to flooding; (2) has thick, well-drained soil materials having a high bearing capacity; (3) can be excavated with minimum difficulty; and (4) has no known natural hazards. Because few ideal sites exist, remedial work or special design and construction techniques may be necessary. Figure 18 should be used in conjunction with plate 3 for preliminary evaluations prior to site selection for subdivision development.

The following conditions are considered most critical to general construction.

Susceptibility to flooding. Areas susceptible to flooding lie within the 100-year floodplain (designated on the U.S. Geological Survey Flood-Prone Areas Map). The Illinois State Water Survey and Flood Insurance Maps prepared for the Federal Insurance Administration provide detailed information on flood elevations and specific sites.

Thickness of surficial materials. Drift thickness in the two counties ranges from zero to about 450 feet (fig. 11). For this study, surficial material was considered thick if composed of more than 20 feet of drift, moderately thick if
Figure 18. General construction conditions in Boone and Winnebago Counties.
MOST FAVORABLE FOR GENERAL CONSTRUCTION

This category has units with well-drained profiles, moderate and high bearing capacities; can be excavated by light or heavy equipment; bedrock does not generally occur within 20 ft. Unit lies outside the 100-year floodline. Few or no geologic hazards are known. These units normally require less exploration on testing and foundation preparation for most small construction projects.

Unit is above the 100-year flood plain and will provide medium bearing capacity on well-drained, highly permeable materials of low frost susceptibility and low potential volume change. Materials of the unit have moderate erosion potential and are easily excavated, but slopes may be unstable.

Major river valleys and terrace outwash plains of Rock and lower Pecatonica valleys

MODERATELY FAVORABLE FOR GENERAL CONSTRUCTION

This category is characterized by moderate drainage in upper profile, poor drainage in lower profile, and moderate-to-high bearing capacities for outwash and till respectively. These materials typically can be excavated with heavy equipment with some difficulty. Ripping or blasting will probably be required for deep bedrock excavations. Low-lying areas are subject to flooding. Bedrock surface can be uneven adjacent to large streams and buried preglacial valleys. Karst features (such as sinkholes, caves, open joints) can be encountered in bedrock. Foundation exploration and/or testing is recommended; some foundation preparation may be necessary.

Less consolidated (upper) part of unit has medium bearing capacity, high-to-moderate permeability, high frost susceptibility, probably low potential volume change; not susceptible to flooding except near small streams. These materials are moderately susceptible to erosion, and easily excavated to bedrock. Slopes cut into outwash may be unstable. Bedrock has high bearing capacity but will impede downward water drainage; this may cause temporary ponding of water at the bedrock contact.

Lower Kishwaukee Valley and slopes

Legend for figure 18. General construction conditions in Boone and Winnebago Counties.
**LEAST FAVORABLE FOR GENERAL CONSTRUCTION**

Category is characterized by poorly drained profile with variable to low bearing capacity and variable excavation characteristics; subject to periodic flooding, flash flooding, or ponding of rainwater. Other geologic hazards include: compressible organic material, lacustrine silts and clays, and fluctuating groundwater levels potentially creating confined artesian conditions in some areas. Foundation exploration and testing are recommended. Foundation preparation may be extensive.

Thin surficial materials have moderate drainage and bearing capacity and high frost susceptibility. Bedrock has high bearing capacity, but can impede downward water drainage, causing rapid runoff.

Uplands and slopes of the Pecatonica and Sugar River valleys and tributaries

<table>
<thead>
<tr>
<th>Upland Creeks and streams</th>
<th>Poorly drained alluvium has variable bearing capacity and thickness, probably subject to occasional flooding. Till and bedrock have high bearing capacities but may have irregular surfaces.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rock, Kishwaukee, Pecatonica, and Sugar River valleys</td>
<td></td>
</tr>
<tr>
<td>Poorly drained alluvium with extremely variable bearing capacity lies over dense gravel and sand outwash. Area is within the 100-year flood boundaries. Local dune sand can occur over outwash.</td>
<td></td>
</tr>
</tbody>
</table>

Pecatonica River valley and Rock River tributaries

| Moderately drained loess, dune sand, and colluvium or poorly drained peat and muck lie over very poorly drained lacustrine silt and clay. These materials generally have low or variable bearing capacity, variable frost susceptibility, and very low permeability, and are subject to settlement and periodic flooding. |

Isolated occurrence in the bottom of upland streams

| High compressible, frost susceptible, poorly drained organic materials lie over till. Subject to periodic flooding. |

Isolated occurrences in Kishwaukee River valley

| Compressible, frost susceptible, poorly drained peat and muck lie over well-drained, non-compressible sand and gravel. |

Upland plane in southeast Boone County

| Lacustrine deposits of multiple layered, compressible, frost susceptible silts and clays lie over well-drained outwash. Subject to periodic flooding. Potential exists for artesian conditions to develop in confined outwash aquifer. Thorough foundation exploration is recommended. |

GEOLOGY FOR PLANNING IN BOONE AND WINNEBAGO COUNTIES
composed of 5 to 20 feet of drift, and thin if composed of less than 5 feet of drift.

**Internal drainage characteristics.** Surface runoff and infiltration characteristics of surficial materials affect soil drainage. Well-drained soils are considered more desirable for construction than are poorly drained soils. Areas having soils subject to flooding and seasonally high water tables in Boone and Winnebago Counties are shown on plate 3.

**Bearing capacity and excavation ease.** Bearing capacity of earth materials depends on many factors, including loading history, material types, drainage characteristics, and moisture content. Bedrock, till, outwash, and dune sand have the highest bearing capacities; bearing capacities are considerably lower for alluvium, lacustrine deposits, loess, colluvium, peat, and muck. Table 3 shows ranges of values (obtained from some available boring records) for various tests (standard penetration, pocket penetrometer, and uniaxial compression) related to bearing capacity. The table does not show the landscape position of the borings, geologic sequence of a material, consolidation history, and other factors that influence bearing capacity. Data reported in table 3 are based on only a few tests and should be used only in the planning stage of geotechnical investigations.

Although ease of excavation at a particular site depends partly on human factors (operator efficiency and machinery used), and on weather, it is related primarily to the geologic materials being excavated and their position on the landscape. Gravel, sand, and loess are easy to excavate; some tills are moderately to very difficult to excavate.

**Natural hazards.** In the two-county area, natural hazards include compressible peat and muck deposits, poorly drained lacustrine deposits, areas of shallow artesian conditions, unstable slopes, and areas having high susceptibility to frost and poor shrink/swell characteristics.

*Peat and muck* consist mostly of organic matter, plus varying amounts of sand, silt, and clay. Organic matter has large amounts of water stored in its voids and is susceptible to freezing. Its compressibility makes it undesirable for fill or building foundations. The largest peat and muck areas are in northeastern Boone County. *Lacustrine silts and clays* occur throughout the two counties, but primarily in the floodplain of the Pecatonica.

<table>
<thead>
<tr>
<th>Geologic unit</th>
<th>Description</th>
<th>Moisture content (% weight of soil)</th>
<th>Standard penetration* (blows/12 in.)</th>
<th>Bearing capacity** (tons/ft²)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alluvium</td>
<td>Silty clay, sand or gravel</td>
<td>25 to 30</td>
<td>1 to 10</td>
<td>.5 to 2.5P</td>
<td></td>
</tr>
<tr>
<td>Colluvium</td>
<td>Sandy silty clay</td>
<td>11 to 27</td>
<td>6 to 18</td>
<td>.5 to 2.3P</td>
<td></td>
</tr>
<tr>
<td>Dune sand</td>
<td>Clayey sand, silty sand</td>
<td>—</td>
<td>1, 20 to 40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loess</td>
<td>Clayey silt, silty clay</td>
<td>23 to 27</td>
<td>7 to 14</td>
<td>1.4U</td>
<td>Low to moderate plasticity</td>
</tr>
<tr>
<td>Peat</td>
<td>Gray or black silt or silty clay</td>
<td>40 to 90</td>
<td>7 to 8</td>
<td>0.7 to 1.2U</td>
<td></td>
</tr>
<tr>
<td>Lacustrine deposits</td>
<td>Silt</td>
<td>15 to 25</td>
<td>20 to 40</td>
<td>2 to 4P</td>
<td>Blow counts 10-12 on terraces</td>
</tr>
<tr>
<td>Outwash</td>
<td>Sandy gravel, sand and gravel</td>
<td>—</td>
<td>1 to 20</td>
<td></td>
<td>Blow counts variable</td>
</tr>
<tr>
<td>Till</td>
<td>Undifferentiated</td>
<td>10 to 22</td>
<td>—</td>
<td>&lt;1. to 2U</td>
<td>Bulge failure</td>
</tr>
<tr>
<td>Glasford Fm</td>
<td>—</td>
<td>—</td>
<td>3 to 7</td>
<td>3.5 to 4.5P</td>
<td></td>
</tr>
<tr>
<td>Winnebago Fm</td>
<td>Undifferentiated</td>
<td>6 to 10</td>
<td>&gt; 100</td>
<td>&gt; 4.5P</td>
<td>Blow counts in 60s when sand dominant</td>
</tr>
<tr>
<td>Esmond Mbr</td>
<td>Silt, loam, silty clay loam</td>
<td>13 to 19</td>
<td>15 to 25</td>
<td>2.5 to 4.0P</td>
<td>Shear and bulge failures</td>
</tr>
</tbody>
</table>

* Standard penetration is measured by the number of blows needed for a hammer to drive a sampler a certain distance into the soil.

**P** = calibrated pocket penetrometer value; U = uniaxial (unconfined) compression test.

This table was compiled from test data taken from various sources. Details of test methods are not known. Information in this table should not be used for design purposes, since test values at individual sites may vary.
River. They can cause significant construction problems because variations in soil drainage allow differential settlement to occur in structures founded on these materials. Excavations in lacustrine deposits fill with water because of the poor drainage, low relief, and high water table; therefore, a basement foundation may exhibit buoyancy if groundwater is not drained or pumped to lower the water table. Construction of basements is not desirable in such a setting unless special building techniques are used. Landscape position is very important in siting small structures on lacustrine materials; slightly elevated sites are desirable. The Winnebago and Boone County Soil Survey maps, used in conjunction with figure 18, should be helpful in locating suitable construction sites in lacustrine materials.

*Artesian conditions* are possible where permeable material is bounded above and below by significantly less permeable units. For example, in lowland areas of southern Boone county, outwash occurs between lacustrine material and till. This succession confines the groundwater in sand, causing artesian conditions during wet periods. In such places, foundations laid during the dry season (when artesian conditions are hard to detect) can develop serious, often completely unexpected problems in wet weather. Artesian conditions are of most concern in low-lying areas where recharge of the confined outwash is relatively rapid. Foundation exploration is recommended in such areas.

**Landslides** in Illinois commonly occur along bedding planes of rocks, at soil-rock contacts, and along old soil horizons; they are often triggered by increased rainfall or construction activities. Dune sands and outwash generally will not support steep slopes in excavations unless they are shored or otherwise maintained. When moist, clay-filled joints in bedrock are weak they may provide a glide plane for landsliding. This condition is difficult to predict but may occur along the larger streams where the drift is thin. A related problem exists where runoff is increased because of paving and construction; this can result in increased stream flow, causing slope instability, particularly on the outside of meander bends. Control of runoff and protection of stream banks may be necessary to prevent structural damage to buildings along such streams.

**Frost susceptibility and shrinkage and swelling of soils** frequently cause seasonal damage to building foundations, driveways, and roads. Heaving of the ground surface can result from expansion due to freezing or absorption of water. In the two-county area, soil derived from loess, dune sand, peat, lacustrine deposits, and colluvium is generally the most susceptible to frost heave. Outwash is generally not susceptible to frost heave.

Loess, peat, and lacustrine silts are also susceptible to shrinking and swelling resulting from changes in water content. It is not known whether glacial tills have this characteristic, but it is thought that till is not susceptible to this phenomenon. Dune sand and outwash generally do not shrink and swell.

**Regional construction conditions**

Figure 18 indicates six areas where geologic materials are similar in terms of suitability for general construction.

Most of central and northern Boone County and part of eastern Winnebago County east of the Rock River valley (except for the well-drained Kishwaukee River valley). These areas are composed principally of loess, dune sand, or colluvium over till, having moderately desirable construction conditions. Less desirable conditions occur in the upland stream valleys.

**The lowlands of the Rock and Kishwaukee Rivers.** These areas consist of well-drained outwash on terraces and poorly-drained alluvium on floodplains. The terraces have desirable characteristics for construction; the flood-prone areas are less desirable.

**The Kishwaukee River Valley in southeastern Winnebago County and southern Boone County.** In these areas, layered lacustrine deposits lying over outwash may develop intermittent artesian conditions during wet periods; therefore, they are potentially undesirable for certain types of construction.

**The uplands of southwestern Winnebago County between the Rock and Pecatonica Rivers.** Varying thicknesses of surficial materials having medium to high bearing capacities overlie bedrock that is generally within 20 feet of the surface. These areas are moderately favorable for many types of construction. Less desirable areas are areas of very thin, highly compressible and frost-susceptible surficial materials in the southern part of this region.

**The lowlands of the Pecatonica River and Otter Creek.** This area was dammed during the glacial period and is composed of poorly drained, thinly-bedded sands, silts, and clays deposited in slackwater lakes. Careful investigation prior to foundation construction is necessary in this area.

**The uplands of northwestern Winnebago County.** This region consists mostly of very thin, frost-susceptible surficial materials over bedrock, and is generally not desirable for construction involving excavations. The well-drained outwash on upper terraces adjacent to the Sugar River floodplain is more favorable for construction.

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**NATURAL RESOURCES**

Abundant natural resources in northern Illinois—surface water and groundwater, sand and gravel, peat, and dolomite—have provided considerable impetus to the development of Boone and Winnebago Counties.

**GROUNDWATER RESOURCES**

In northern Illinois, groundwater resources are available from four major aquifers: (1) sand and gravel aquifers in the glacial drift; (2) the shallow dolomite aquifer, consisting of the Galena and Platteville Dolomite Groups; (3) sandstone aquifers consisting of the Glenwood-St. Peter and Ironton-Galesville Sandstones; and (4) the deeper Mt. Simon Aquifer, consisting of the Mt. Simon Sandstone and the basal sandstone (Elmhurst Member) of the Eau Claire Formation.

Additional information on bedrock aquifers in Winnebago County is available in Hackett (1960). Information on current water levels in municipal wells penetrating
bedrock aquifers and projections of future water levels is available from the Illinois State Water Survey, Cham­paign, Illinois.

Bedrock aquifers
Bedrock geology has been discussed previously; the prin­cipal elements of the bedrock are shown in figures 6 and 9. Since little new work was necessary for adequately defining the bedrock aquifers, much of the following information is summarized from Hackett (1960). Bedrock aquifer resources for the entire northern Illinois region are being studied by the Illinois State Geological Survey, the Illinois State Water Survey, and the U.S. Geological Survey.

Groundwater is available throughout all of Boone and Winnebago Counties from one or more of the bedrock aquifers. Although the Galena-Platteville dolomite is probably the most widely used bedrock aquifer for domestic supplies, the deeper sandstones are the most dependable and predictable sources for larger quantities of groundwater. Smith and Larson (1948) recognized few, if any, differences in water levels among the various bedrock aquifers; the aquifers differ primarily in their water-yielding character­istics and depths.

Although Silurian (Alexandrian) dolomite is locally present at the bedrock surface in southeastern Boone County (figs. 6, 7), it covers too small an area and is too thin to be considered an aquifer. The Ordovician Maquoketa Shale Group (figs. 6, 7) covers a relatively sizable area of the bedrock surface of southeastern Boone County. Although not normally considered an aquifer, it is locally fractured and jointed, or contains thin beds of dolomite; where fractures and joints occur (usually just below the bedrock surface), it may yield small supplies for domestic use.

Galena-Platteville Dolomite. The Galena and Platteville Groups constitute the uppermost bedrock throughout most of Boone and Winnebago Counties (fig. 7). Because of their widespread distribution, consistent water-yielding zones, and shallow position, these rocks provide water to more wells than does any other aquifer system in the counties.

In some areas, the top of the zone of saturation within the joints and fractures of the dolomite is close to land surface; groundwater can frequently be found under the uplands where there is less than 20 feet of drift. In places where the dolomite is considerably below the top of the zone of saturation, artesian (confined) conditions are likely to exist.

Hackett (1960) reported that 84 percent of the wells drilled into the dolomite in Winnebago County penetrated up to 100 feet of dolomite. Only 10 percent penetrated less than 20 feet into the dolomite. Hackett also found that the average depth of the dolomite well was 104 feet, and the average depth of penetration into the dolomite for water supplies was 71 feet, indicating that the thickness of drift cover over the dolomite in Winnebago County averaged about 33 feet.

During this study we recorded and graphed (by town­ship) all wells in both counties finished in the Galena-Platte­ville and recorded yields of each well as reported by the drilling contractor. In general, the depth of penetration reported by Hackett for Winnebago County holds for both counties; however, the average thickness of drift cover is much greater in northeastern Boone County. Reported well yields range from 5 to 40 gallons per minute (an average yield of about 20 gallons per minute). There appears to be no significant difference in depth of penetration or yields of wells finished in the Galena-Platteville regardless of whether the Galena-Platteville is at the bedrock surface or overlain by the Maquoketa. It seems likely, therefore, that in the areas underlain by the Galena and Platteville Dolo­mite Groups (fig. 7), most wells drilled for domestic, stock, or other small water supplies should penetrate 20 to 100 feet into the dolomite to obtain a satisfactory yield.

These dolomite aquifers are very sensitive to contam­ination (plates 2, 3) because water moves quickly through the joints and fractures and there is little opportunity for the filtering action that occurs when water moves slowly through granular materials. Therefore, where the drift cover is relatively thin or consists entirely of permeable materials, the potential for contamination is high.

Sandstone aquifers. The St. Peter Sandstone (Ancell Group), the Ironton-Galesville Sandstone, and the Elmhurst-Mt. Simon Sandstone (figs. 6, 8, 9) are found throughout the two counties and furnish large quantities of water to the cities, villages, and industries within the counties. Only the shallowest aquifer (the St. Peter Sandstone) is used for domestic groundwater supplies. The deeper aquifers are used only for larger municipal and industrial water supplies, because construction and maintenance costs are high. Although relatively few wells are drilled to the Ironton-Galesville and Elmhurst-Mt. Simon aquifers, these wells probably supply as much water as all the wells finished in the other bedrock aquifers. Only the thick sand and gravel aquifers of the glacial drift can produce comparable large water supplies.

The St. Peter Sandstone is present at a depth of about 500 feet in eastern Boone County, and is the upper bedrock unit in the deeper parts of the Troy Bedrock Valley in Boone County and in the Rock and Pecatonica Bedrock Valleys in Winnebago County. In northwestern Winnebago County it is locally exposed at land surface, and it is within 300 feet of land surface throughout much of western Winnebago County (figs. 7, 8). Where the bedrock valleys have been cut into the St. Peter, sand and gravel aquifers within these valleys may be in direct contact with the St. Peter (fig. 13).

Glacial drift aquifers
The drift aquifer map (fig. 19) differentiates the two-county region into seven units according to the probability that one or more sand and gravel aquifers are present. Outwash sand and gravel deposits are quite variable in sorting, grain size, and thickness; however, any single outwash deposit is generally characterized by well-sorted, coarse sands and gravels that may yield large quantities of water. The principal glacial drift aquifers are generally limited to the major bedrock valleys where the sand and gravel deposits are thickest (fig. 13a-f). Figure 19 was compiled using samples and logs from both water wells and test hole borings. Surficial sand and gravel distribution was based on plate 1.
Map unit 1. This unit (fig. 19) represents laterally extensive, surficial sand and gravel deposits more than 50 feet thick (figs. 13b-f). This unit is found only in the Rock River valley and the downstream portions of the Pecatonica River valley and the Raccoon Creek valley in Winnebago County (downstream deposits in these valleys are somewhat finer grained than are the upstream deposits). These coarse-grained valley train deposits, locally more than 100 feet thick, are continuous along the Rock Bedrock Valley. **Because of their thickness and high permeability, they can supply water for municipal and industrial needs.**

Map unit 2. This unit represents thick (greater than 50 ft), laterally extensive surficial sand and gravel that may have finer-grained material either in the upper 40 feet or interbedded within the deposit at greater depth (figs. 13d-f). This map unit occurs: (1) along the tributaries and margins of the Rock River valley, the tributaries and margins of the downstream portions of the Pecatonica River valley, and the tributary valleys along the eastern side of the Raccoon Creek valley in Winnebago County; (2) in the lower two miles of the Rock River valley southwest of the Rock and Kishwaukee River junction in Winnebago County; (3) in the valley fill of the middle and lower portions of the Troy Bedrock Valley in Boone County and the southeastern corner of Winnebago County; and (4) in the valleys of the Kishwaukee River, and Piscasaw and Coon Creeks in Boone County.

These sand and gravel deposits are generally coarse grained and permeable. The surficial outwash deposits of the Kishwaukee and Piscasaw Valleys directly overlie older valley-fill outwash or are separated from them by glacial till deposits in the Troy Bedrock Valley of central and northeastern Boone County. The glacial till within this succession varies in thickness, becoming thicker where the older valley-fill outwash thins out. **The surficial and older valley-fill outwash both are aquifers suitable for the development of medium- to large capacity wells.**

Map unit 3. This unit represents small scattered areas usually found along the principal valleys or, on rare occasions, on bedrock or till highs. The deposits are surficial sands and gravels less than 50 feet thick that locally become very thin. **Although the deposits are limited in extent and are quite variable in thickness because of interbedding with glacial tills or fine-textured waterlain materials, they may locally be a source of water for small-to-medium capacity wells.**

Map unit 4. This unit includes areas east of the Rock River valley in Winnebago County and north of the Kishwaukee River valley in Boone County. One or more significant (greater than 10 ft thick) sand and gravel aquifers are present, interbedded with or below glacial till or other fine-grained material. A more accurate mapping of the sand and gravel bodies may be developed as more data become available. Figures 13b and c indicate the general position of these aquifers in northern Boone County. **The deposits vary in thickness and lateral extent, and it is impossible to predict the precise depth, thickness, or water-yielding properties without additional data. However, in these areas the aquifers appear to be suitable for supplying water for domestic use.**

Map Unit 5. This unit is mapped where the depth to bedrock is greater than 50 feet and the sand and gravel aquifers are present locally at the surface and/or below or within glacial till or fine-grained sediment. This unit is mapped (1) on some of the uplands in Boone County; (2) along the margins of most of the major valleys and in several of the minor valleys in Boone and Winnebago Counties; (3) in the Sugar River valley; (4) in the upstream and middle portions of the Pecatonica River valley; and (5) in the Kent Creek valley.

It is impossible to predict the lateral extent and the thickness of these localized sand and gravel aquifers because of insufficient data. The valley fill of the Pecatonica and Sugar River valleys and their tributaries is characterized by thick, extensive fine-grained (silty sand to fine sand) lake deposits. Only locally do these backwater deposits contain coarse-grained outwash of limited lateral extent. **The fine-grained backwater sediments and the glacial tills, typical deposits in areas designated unit 5, are not suitable for well development. Although the localized sand and gravel aquifers cannot be predicted they may represent a valuable source of water for small-capacity residential or irrigation wells.**

---

1. Surficial sand and gravel at least 50 ft thick and locally up to 100 ft thick; part of a relatively widespread sand and gravel deposit; high probability of sand and gravel aquifers.
2. Surficial sand and gravel similar to above but finer-textured material possible in upper 40 ft; includes areas of older valley fill containing interbedded fine-textured materials; high probability of sand and gravel aquifers.
3. Surficial sand and gravel less than 50 ft thick over bedrock or till "highs" or near valley walls; locally very thin; good probability of sand and gravel aquifers.
4. Good probability of relatively thick subsurface sand and gravel aquifers below or interbedded within glacial till or other fine-grained sediments.
5. Glacial drift greater than 50 ft thick; sand and gravel aquifers locally reported below or within glacial till or other fine-grained sediments; data insufficient to predict extent or thickness of sand and gravel.
6. Glacial drift greater than 50 ft thick; low probability of sand and gravel aquifers.
7. Glacial drift less than 50 ft thick; low probability of sand and gravel aquifers.

Legend for figure 19. Distribution of sand and gravel aquifers in Boone and Winnebago Counties.
Figure 19. Distribution of sand and gravel aquifers in Boone and Winnebago Counties.

John P. Kempton
Amy N. Stecyk
Map unit 6. This unit represents areas where the glacial drift is greater than 50 feet thick. Unit 6 areas are limited to the uplands in Boone County with more than 50 feet of drift, and to the uplands east of the Rock River valley in Winnebago County where the drift is more than 50 feet thick.

Glacial till, the most common deposit in the areas designated unit 6, has low permeability and is a poor source of water. The sand and gravel in unit 6 areas is probably limited in lateral extent and quite variable in thickness, sorting, grain size, and permeability. The probability of locating a sand and gravel aquifer capable of supplying significant amounts of water is low.

Map unit 7. This unit is mapped in areas where the drift overlying the bedrock is less than 50 feet thick. Most areas designated as unit 7 occur in the uplands of southern Boone County, the western edge of Boone County extending westward to the Rock River valley in Winnebago County, and in extensive areas west of the Rock River valley in Winnebago County. As in unit 6, the sand and gravel aquifers are localized, limited in extent, and variable in thickness and permeability. The probability of locating a significant sand and gravel aquifer is low.

MINERAL RESOURCES

The mineral deposits of Boone and Winnebago Counties have played an essential role in the economic growth of the two counties, providing large quantities of aggregate necessary for highway development and industrial and residential construction. Extensive deposits of sand and gravel occur in the valleys of the Rock and Kishwaukee Rivers and Piscasaw Creek. Dolomite underlies most of the two-county area, but is produced within 20 feet of the surface. Many surficial peat deposits occur in the two counties, but no deposits are being commercially excavated at present. Some of the thicker, more extensive deposits are potential sources of soil conditioner for horticultural and agricultural purposes.

Figure 20 shows the distribution of sand, gravel, and peat deposits. This map is based on the rock stratigraphic units formalized by Willman and Frye (1970) and on plate 1 of this report. Figure 21 shows dolomite resources within 20 feet of the surface.

Long-range planning is necessary to provide for the continued availability of aggregate in regions undergoing rapid urbanization. Crushed stone and sand and gravel have low initial value and cannot be economically mined in urban areas where land costs tens of thousands of dollars per acre; yet the cost of transporting aggregates is very high. Known resources of aggregate located in the path of urbanization should be protected: resources underlying subdivisions, factories, or shopping malls are inaccessible because of economic, social, and legal considerations. Careful planning for sequential land use can permit extraction of mineral resources before the land is reclaimed for other purposes.

**Sand, gravel, and peat resources**

Unconsolidated sand and gravel deposits. Most sand and gravel deposits in Boone and Winnebago Counties formed roughly between 200,000 and 20,000 years ago, when several lobes of continental glaciers moved across southern Wisconsin and northern Illinois, carrying enormous amounts of rock debris (Anderson, 1967; Hunter and Kempton, 1967). Large volumes of sand and gravel were deposited in major meltwater channels; these deposits are called valley trains. Where these materials blocked and ponded pre-existing drainageways, fine sand, silt, and clay were deposited in slackwater lakes. When outwash deposits were exposed to strong winds, the winds picked up the clay, silt, and finer sand-size materials and redeposited them on the uplands. Many less extensive sand and gravel deposits formed in direct contact with the glacial ice.

The potential value of a sand and gravel deposit as an

<table>
<thead>
<tr>
<th>Material</th>
<th>Maximum size*</th>
<th>Minimum size**</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>(in.)</td>
<td>(cm)</td>
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<tr>
<td>Gravel</td>
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<td>no limit</td>
</tr>
<tr>
<td>Boulders</td>
<td>10.0</td>
<td>25.6</td>
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<tr>
<td>Cobbles</td>
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<td>0.187†</td>
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<tr>
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<tr>
<td>Sand</td>
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<td>0.100</td>
</tr>
<tr>
<td>(includes granules)</td>
<td>0.0197</td>
<td>0.050</td>
</tr>
<tr>
<td>Coarse</td>
<td>0.0098</td>
<td>0.025</td>
</tr>
<tr>
<td>Medium</td>
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<td>0.0125</td>
</tr>
<tr>
<td>Fine</td>
<td>0.0029‡</td>
<td>0.0074</td>
</tr>
<tr>
<td>Very fine</td>
<td>0.00016</td>
<td>0.0004</td>
</tr>
<tr>
<td>Mud</td>
<td>Silt</td>
<td>0.0029‡</td>
</tr>
<tr>
<td></td>
<td>Clay</td>
<td>0.00016</td>
</tr>
</tbody>
</table>

*Particles pass through a sieve with square openings with these size measurements.

**Particles are retained on a sieve with square openings with the following size measurements.

†Number 4 mesh size.

‡Number 200 mesh size.
aggregate resource depends upon the (1) thickness and extent of the deposit; (2) thickness and variability of overburden; (3) particle-size distribution and rock types (quality) present in the deposit; (4) accessibility of the deposit to heavy-duty roads and railroads; and (5) distance of the deposit from the point of use. Rigid specifications have been set in terms of proper size gradations and the maximum allowable amount of deleterious material for sand and gravel to be used in concrete and asphalt aggregates. (Illinois Department of Public Works and Buildings, Division of Highways, 1971).

In this report sand and gravel have been designated according to their potential as possible sources of large amounts of high quality sand and gravel (table 4). Deposit types are further classified into subtypes on the basis of variations in physical properties (such as thickness of sand and gravel and character and thickness of overburden) that affect the resource potential of a deposit. The distribution of each type and subtype is shown in figure 20.

The largest accumulations of sand and gravel are in the Rock River (type 1), and in the Kishwaukee River and Piscasaw Creek (type 2). Type 1 and 2 deposits are more important economically (table 5) than any of the other deposit types in Boone and Winnebago Counties. The relative economic importance of less extensive deposits of sand and gravel (types 4 through 7) is not always clear; however, as more data become available or uses for aggregate increase, these deposits could become important sources of products such as blend, mortar, and fill sand.

Type 1—Rock River valley train. The broad plain of the Rock River valley, extending almost north-south from South Beloit through Rockford, has for many years been the greatest, most available source of sand and gravel for the construction industry in Boone and Winnebago Counties (table 5). This valley also contains the area of greatest population and industrial development. The valley train is a terraced, elongate, generally uniform deposit consisting of medium- to very coarse-grained sand and lesser amounts of pebbles and cobbles (table 4). Cobbles more than 5 inches (13 cm) in size and boulders are rare.

The valley train is divided into three subtypes: subtype 1-1, a high terrace complex; subtype 1-2, a low terrace complex; and subtype 1-3, buried by floodplain alluvium. All three subtypes are more than 50 feet (15 m) thick throughout the valley, except where they (1) are adjacent to the valley walls, (2) overlie a bedrock high at Loves Park (fig. 19, sections 1, 12, and 13, T. 44 N., R. 1 E.), or (3) overlie another bedrock high in the high terrace area west of South Beloit and north of Rockton. Subtype 1-1 deposits reach a maximum thickness of 200 feet (61 m) in the deepest portions of the bedrock valley; however, because the valley train represents several periods of sand and gravel deposition (Hackett, 1960), the sand and gravel may be interrupted in some places by layers composed of silt and clay (figs. 13d-f and 19). Areas where subtype 1-1 deposits are less than 20 feet (6 m) thick are designated subtype 1-1a.

Subtypes 1-1 and 1-2 are covered by less than 10 feet (3 m) of overburden, consisting mostly of windblown sand. Anderson (1967) indicates that in general, the high terrace (subtype 1-1) is a little more gravelly than the low terrace (subtype 1-2).

Subtype 1-1 occurs at elevations from slightly above 780 feet (238 m) (near South Beloit) to elevations of about 730 feet (223 m) at the Greater Rockford Airport. Subtype 1-2 occurs at elevations from about 750 feet (229 m) near Rockton to elevations of about 700 feet (213 m) west of the Greater Rockford Airport. Therefore, subtype 1-2 areas contain about 30 feet (9 m) less sand and gravel than do subtype 1-1 areas. Subtype 1-3 occurs at elevations ranging from about 730 feet (223 m) near South Beloit to about 690 feet (210 m) west of the Greater Rockford Airport. Subtype 1-3 areas generally contain 20 to 40 feet (6 to 12 m) less sand and gravel than do subtype 1-2 areas, because of the elevation differences and the thicker overburden (up to 20 feet of silty, clayey alluvium). Subtype 1-3 deposits are subject to flooding by the Rock River.

Type 2—Kishwaukee River and Piscasaw Creek valley trains. The nearly flat valley bottoms of the Kishwaukee River and Piscasaw Creek contain elongate, generally uniform deposits of sand and gravel. The bedrock valley floors of these rivers are shallower than those of the Rock River, and therefore the deposits are not as thick—probably a maximum of 120 feet (37 m). Terraces in the Kishwaukee River and Piscasaw Creek valleys lie at levels different from those along the Rock River (Hunter and Kempton, 1967). They are composed of medium to very coarse sand, and generally contain less gravel than is found in the Rock River valley.

Type 2 deposits have been excavated and utilized primarily in the vicinity of Belvidere (table 5) and are the second most important areas of potential sand and gravel resources in Boone and Winnebago Counties. These deposits are downstream extensions of sand and gravel deposits mapped in McHenry County (Anderson and Block, 1962; Kempton et al., 1977; and Masters, 1978).

These valley train deposits are divided into three subtypes similar to those in the Rock River valley (fig. 20) except that the upper surfaces of all three subtypes lie much closer to floodplain levels of the Kishwaukee River and Piscasaw Creek.

Subtype 2-1 is a high terrace complex that extends down the Piscasaw Creek and lower Kishwaukee River valleys (fig. 20); it seems to become more gravelly upstream (northeastward), and also more gravelly at depth. The water table is relatively shallow. Subtype 2-1 deposits are generally 50 to 120 feet (15 to 37 m) thick, except in the vicinity of Belvidere, where they are less than 50 feet (15 m) thick (fig. 19). Areas adjacent to valley walls, where deposits are less than 20 feet (6 m) thick—such as the extensive area southwest of Belvidere—are designated subtype 2-1a (fig. 20). Overburden of type 2-1 deposits generally consists of less than 10 feet (3 m) of windblown silt.

Subtype 2-2 is a low terrace complex that occurs along the Kishwaukee River, Coon Creek, and the South Branch Kishwaukee River (fig. 20). These areas are only about 5 feet (1.5 m) above adjacent floodplain levels, and 5 to 15 feet (1.5 to 4.5 m) below adjacent subtype 2-1 areas. Subtype 2-2 deposits are generally overlain by less than 10 feet (3 m) of windblown sand.
Figure 20. Sand, gravel, and peat resources of Boone and Winnebago Counties.
GEOLGY FOR PLANNING IN BOONE AND WINNEBAGO COUNTIES
### UNCONSOLIDATED SAND AND GRAVEL DEPOSITS

#### TYPE 1: ROCK RIVER VALLEY TRAIN DEPOSITS

**Subtype 1-1: High terraces**
- Areas of little relief known or believed to be underlain by uniform, elongate deposits 50 to 200 ft (15.3 to 61 m) thick containing coarse sand and fine gravel, with less than 10 ft (3.3 m) of sand overburden.

**Subtype 1-1a**
- Areas like subtype 1-1 but much thinner—less than 20 ft (6.1 m)—are designated subtype 1-1a. Generally located between subtype 1-1 and the uplands.

**Subtype 1-2: Low terraces**
- Areas very similar to subtype 1-1, but slightly finer grained and about 30 ft (9.2 m) lower in elevation.

**Subtype 1-3: Flood plain areas**
- Areas like subtype 1-1 (may be slightly finer grained) but about 50 ft (15.3 m) lower in elevation. Areas subject to flooding. Overburden generally silty, clays, alluvium 5 to 20 ft (1.5 to 6.1 m) thick.

#### TYPE 2: KISHWAUKEE RIVER AND PISCASAW CREEK VALLEY TRAIN DEPOSITS

**Subtype 2-1: High terraces**
- Areas of little relief known or believed to be underlain by uniform, elongate deposits containing coarse sand and fine gravel (generally somewhat less gravel than in the Rock valley), with less than 10 ft (3.1 m) of silty overburden.

**Subtype 2-1a**
- Areas like subtype 2-1 but generally less than 20 ft (6.1 m) thick. Generally located between subtype 2-1 and the uplands.

**Subtype 2-2: Low terraces**
- Areas like subtype 2-1, but generally with less gravel, especially in the Kishwaukee River valley, and 5 to 15 ft (1.5 to 4.6 m) lower in elevation. The overburden is generally sand, less than 10 ft (3.1 m) thick.

**Subtype 2-3: Floodplain areas**
- Areas like adjacent subtype 2-1 and 2-2 areas, about 5 ft (1.5 m) lower in elevation than subtype 2-2 areas. The overburden is generally silty, clays, alluvium less than 10 ft (3.1 m) thick. Areas subject to flooding.

#### TYPE 3: KAMES, ESKERS, KAME TERRACES

**Subtype 3-1: Thick, continuous deposits**
- Areas of rolling hills and ridges (kames and eskers) known or believed to be underlain wholly or in part by thick, irregular deposits of sand and gravel 20 to possibly 80 ft (6.1 to 24.4 m) thick. Deposits may vary from sandy to gravelly and poorly to well sorted. Overburden may be silt and clay, or sand, up to 10 ft (3.1 m) thick. Deposition occurred as ice contact deposits.

**Subtype 3-2: Thin and discontinuous deposits**
- Areas like type 3-1, but generally less than 20 ft (6.1 m) thick are designated subtype 3-2. They may be discontinuous (patchy).

#### TYPE 4: BURIED OUTWASH

**Subtype 4-1: Outwash usually covered by glacial till**
- Areas known or believed to be underlain locally, wholly or in part, by up to 20 ft (6.1 m) or more of sand and gravel, usually cropping out beneath glacial till. Outwash varies from sand to cobbly gravel within short distances and depths. Overburden is primarily glacial till varying from 0 to 20 ft (6.1 m) and thickening away from valley sides. Deposition occurred at least partly as ice contact deposits.

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Legend for figure 20. Sand, gravel, and peat resources of Boone and Winnebago Counties.
Subtype 4-2: Outwash with a clayey silt overburden

Additional areas known or believed to be underlain by outwash that may be 20 ft (6.1 m) or thicker in places, but usually less than 10 ft (3.1 m) thick. Overburden generally less than 10 ft (3.1 m) thick.

TYPE 5: SUGAR CREEK VALLEY TRAIN

Subtype 5-1: Low terrace deposits

Areas of little relief known or believed to be underlain by deposits 20 to 50 ft (6.1 to 15.3 m) or more thick except along valley sides. The uniform, elongate deposits contain coarse sand. Overburden is finer sand, less than 10 ft (3.1 m) thick.

Subtype 5-2: Floodplain areas

Areas like type 5-1 areas, but lower in elevation—less than 10 ft (3.1 m). Overburden is clayey, silty alluvium. Areas subject to flooding.

TYPE 6: WIND-BLOWN SAND DEPOSITS

Subtype 6-1: Continuous sand deposits

Areas known or believed to be underlain by medium-grained sand 2 to 5 ft (0.6 to 1.5 m) thick and in some places up to 20 to 30 ft (6.1 to 9.2 m). Areas occur in dunes and as sheet deposits that mantle many valley train terrace and some other sand and gravel deposits.

Subtype 6-2: Discontinuous sand deposits

Areas like type 6-1 areas, but generally discontinuous and thinner.

TYPE 7: FINE-GRAINED SLACKWATER DEPOSITS

Areas of little relief known or believed to be underlain by widespread deposits of uniform, horizontally bedded clays, silts, and very fine sands. Deposits are about 50 ft (15.3 m) thick in the Pecatonica River Valley except near the valley sides. Overburden generally less than 10 ft (3.1 m) of clays, silts, and sometimes sand. Deposition occurred in quiet water lakes.

ST. PETER SANDSTONE DEPOSITS

TYPE SS: ST. PETER SANDSTONE

Areas known or believed to be underlain by fine- to coarse-grained, loosely cemented, white sandstone up to 200 ft (61 m) thick. Overburden may consist of 0 to 20 ft (6.1 m) of dolomitic bedrock or glacial to recent sands, silts, and clays. Deposition occurred in a relatively shallow continental sea during the Ordovician Period (about 450,000,000 years ago).

PEAT DEPOSITS

TYPE P: PEAT DEPOSITS

Areas known or believed to be underlain by 1 to 4 ft (0.3 to 1.2 m) or more thickness of peat and muck, often interbedded with silt and clay. Generally no overburden. Deposition usually occurs in poorly drained areas of groundwater discharge.

Areas known or believed to be devoid of large sand, gravel, or peat deposits. Locally small accumulations may be present.

Areas surface mined for sand and gravel.

Active or intermittently active sand and gravel pits, with the county pit number (table 8).

Abandoned sand and gravel pit (table 8).
Subtype 2-3 deposits have been covered by about 10 feet (3 m) of fine-grained floodplain deposits (fig. 20). The underlying sand and gravel is similar to that underlying the adjacent subtype 2-1 and 2-2 deposits, except that subtype 2-3 sands and gravels are entirely below the water table and are subject to flooding by the Kishwaukee River and Piscasaw Creek.

**Type 3—Kames, eskers, and kame terraces.** Ice-contact deposits of sand and gravel in the form of rolling hills and ridges are fairly common in the upland areas of the southern quarter of Boone and Winnebago Counties, and in the eastern half of Boone County (fig. 20). Scattered ice-contact deposits are present in other areas, such as those in the northwestern portion of T. 45 N., R. 1 E. Type 3 and other ice-contact deposits generally predate the valley train deposits. The particle-size characteristics of these sand and gravel deposits often vary considerably over relatively short distances and depths. The deposits may contain masses of till, silt, and clay along with bodies consisting mostly of sand or coarse gravel.

### TABLE 5. Locations and types of deposits of sand and gravel pits in Boone and Winnebago Counties, Illinois.*

<table>
<thead>
<tr>
<th>IDOT plant no.</th>
<th>Company name</th>
<th>Location</th>
<th>Pit name</th>
<th>Distance and direction from nearby town</th>
<th>Rated capacity** (tons/day)</th>
<th>Type of deposit†</th>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Kishwaukee S &amp; G</td>
<td>SW 22, 44N-3E</td>
<td>Davis</td>
<td>Belvidere 1W</td>
<td>3500</td>
<td>2-1,2-2</td>
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<tr>
<td></td>
<td></td>
<td>SW NE 27, 44N-3E</td>
<td>Part of Spencer Park</td>
<td>Belvidere 1W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>New owner</td>
<td>NW SE 29, 44N-4E</td>
<td>Meyer</td>
<td>Belvidere 2.5E</td>
<td>2500</td>
<td>4-1</td>
</tr>
<tr>
<td>4</td>
<td>Codoray Brothers</td>
<td>SE SW 28, 44N-4E</td>
<td>Spots</td>
<td>Belvidere 3.5E</td>
<td>1000</td>
<td>4-1</td>
</tr>
<tr>
<td>5</td>
<td>Lee, Charles &amp; Son</td>
<td>NW NE 32, 43N-3E</td>
<td>Vowles</td>
<td>Irene 1S</td>
<td>500</td>
<td>3/rock quarry 202†</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NE NE 24, 46N-4E</td>
<td>—</td>
<td>Capron 5NE</td>
<td>—</td>
<td>3</td>
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<tr>
<td>10</td>
<td>Belvidere Sand &amp; Stone</td>
<td>SE NW 18, 44N-4E</td>
<td>—</td>
<td>Belvidere 2NE</td>
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<td></td>
<td></td>
<td>NW NW 14, 44N-3E</td>
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<td>Belvidere 2N</td>
<td>—</td>
<td>6(7)</td>
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<td></td>
<td>Zaugg, D. J.</td>
<td>SW NW 19, 44N-3E</td>
<td>—</td>
<td>Belvidere 5W</td>
<td>intermittent 4-1/rock quarry 215†</td>
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<tr>
<td></td>
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<td>—</td>
<td>4-1</td>
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<td></td>
<td></td>
<td>S½ SE 30, 44N-4E</td>
<td>—</td>
<td>Belvidere 1.5E</td>
<td>intermittent 4-1</td>
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<tr>
<td><strong>WINNEBAGO COUNTY</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>SW SW 19, 46N-2E</td>
<td>—</td>
<td>Rockton .5SE</td>
<td>—</td>
<td>1-2,1-3(?)</td>
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<td>5</td>
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<td>—</td>
<td>Rockford SW</td>
<td>2000e</td>
<td>1-1,1-2</td>
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<td>Airpot</td>
<td>Rockford SW</td>
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<td>1-1,1-3</td>
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<td>9</td>
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<td>Nolan</td>
<td>Perryville 2S</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>NW SE 34, 27N-10E</td>
<td>—</td>
<td>Wm. Howard</td>
<td>Pecatonica 1SE</td>
<td>6(7)</td>
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<tr>
<td></td>
<td></td>
<td>SE 28, 45N-2E</td>
<td>Part of Rock Cut State Park</td>
<td>—</td>
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<td>intermittent 6/4-1</td>
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<tr>
<td>14</td>
<td>Rockford S &amp; G</td>
<td>SE NE 8, 45N-2E</td>
<td>—</td>
<td>North Shores</td>
<td>Roscoe 2S</td>
<td>2800</td>
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<tr>
<td>16</td>
<td>Rockford S &amp; G</td>
<td>SW SE 4, 43N-1E</td>
<td>Hoogie</td>
<td>Rockford SW</td>
<td>1500e</td>
<td>3</td>
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<td>20</td>
<td>Material Service</td>
<td>SE NW 17, 46N-2E</td>
<td>Durgon</td>
<td>S. Beloi 2S</td>
<td>800</td>
<td>1-1</td>
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<tr>
<td></td>
<td></td>
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<td>Rockford S &amp; G</td>
<td>SE 3, 43N-1E</td>
<td>South Main</td>
<td>Rockford 2S</td>
<td></td>
<td>1-2</td>
</tr>
<tr>
<td>29</td>
<td>Elmhurst Chicago</td>
<td>NW 8, 46N-2E</td>
<td>Ill.-Wisc.</td>
<td>S. Beloi S</td>
<td></td>
<td>1000</td>
</tr>
<tr>
<td>30</td>
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<td>—</td>
<td>Rockford 5S (new)</td>
<td>3-1/rock quarry 245†</td>
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<td>Cherry Valley S &amp; G</td>
<td>SW 1, 43N-2E</td>
<td>—</td>
<td>Cherry Valley</td>
<td>(new)</td>
<td>2-2</td>
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<tr>
<td>88</td>
<td>Speedway S &amp; G</td>
<td>SE NE 20, 45N-2E</td>
<td>—</td>
<td>Harlem 1.5N</td>
<td>500</td>
<td>1-1</td>
</tr>
<tr>
<td>90</td>
<td>Kelly &amp; Sons</td>
<td>NE NE 29, 46N-2E</td>
<td>Kelly</td>
<td>Roscoe 1N</td>
<td></td>
<td>500</td>
</tr>
<tr>
<td>91</td>
<td>Rein, Schultz &amp; Dahl</td>
<td>NW NW 31, 43N-2E</td>
<td>—</td>
<td>Morristown 1.5SE</td>
<td>2500</td>
<td>6/3-1</td>
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<tr>
<td></td>
<td></td>
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<td>—</td>
<td>Harlem E</td>
<td>—</td>
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<tr>
<td></td>
<td></td>
<td>NE 8, 46N-2E</td>
<td>Pearl Lake</td>
<td>S. Beloi S</td>
<td></td>
<td>1-1</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>—</td>
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<td></td>
<td>1-1</td>
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<td></td>
<td>NE 9, 28N-11E</td>
<td>Campground</td>
<td>Shirland 2W</td>
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<td>6/5 يبدو</td>
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</tbody>
</table>

* Data in this table were compiled from Illinois Department of Transportation (1977), ISGS files and limited field checking of pits in 1981. Recently abandoned pits are located without I.D.O.T. plant numbers, company names, or capacity data.


† Numbers explained in legend on plate 10 and in text.

†† Pits with quarries developed in underlying bedrock (see table 7).
Subtype 3-1 deposits commonly are more than 20 feet (6 m) thick, but are not known to exceed 80 feet (24 m). Overburden, which may be up to 10 feet (3 m) thick, usually consists of silt and clay, but may be sand in some areas (plate 1). Although subtype 3-1 deposits are worked at only a few pits (table 5 and fig. 20), for many years they have been important local sources of sand and gravel in nearby rural areas. Much of the market has switched over to the larger, more economically productive pits in type 1 and 2 areas; however, rising transportation costs could lead to the activation of more pits in type 3 areas for local uses such as fill or gravel surfacing for township and farm roads. Type 3 deposits are ranked third in importance as a potential source of sand and gravel resources. Because of their limited areal extent and variability they have much less potential to serve long-term aggregate needs than do the type 1 and 2 deposits.

Subtype 3-2 deposits are similar to subtype 3-1 deposits, but are generally less than 20 feet (6 m) thick and more often discontinuous. Some subtype 3-1 and 3-2 deposits, such as many of those in T. 43 N., R. 2 E. (plate 1), may directly overlie dolomite bedrock of relatively shallow depths.

Type 4—Buried outwash. This outwash often consists of ice-contact sand and gravel deposits that vary horizontally and vertically over relatively short distances and depths. Their overburden is often glacial till, and a distinct topographic expression is lacking. Type 4 deposits are most common in the Beaver Creek drainage basin where they have been naturally exposed. Subtype 4-1 deposits (fig. 20) are generally 20 feet (6 m) or more thick. Overburden ranges from 0 to 20 feet (6 m) thick and usually consists of glacial till or sometimes clayey silt or sand. Occasionally the deposits lie at the ground surface on valley sides where the overburden has been removed by erosion. Small, abandoned pits are often formed in such locations. Subtype 4-1 deposits commonly extend under the adjacent uplands beyond their mapped areas, where the till is more than 20 feet (6 m) thick. However, the continuity of such deeply buried deposits is difficult to determine. Removal of thick till overburden is too costly for economical mining of the underlying sand and gravel.

Subtype 4-2 deposits are similar to subtype 4-1 deposits, except that the sand and gravel is thinner and the overburden generally consists of clayey silt or sand. They usually contain less than 10 feet (3 m) of sand and gravel, but are about 20 feet (6 m) thick in some places. Their overburden commonly consists of less than 10 feet (3 m) of clayey silt or sand. The absence of till overburden indicates that subtype 4-2 sand and gravel was deposited in a different glacial ice event or depositional environment than were subtype 4-1 deposits.

Very few pits are now operating in type 4 deposits (table 5, fig. 20); however, numerous small, abandoned pits indicate that type 4 deposits once were important local sources of sand and gravel, especially in rural areas. One pit located downstream in Beaver Creek drainage basin is worked in conjunction with a bedrock quarry operation (Sec. 19, T. 44 N., R. 3 E.).

Type 5—Sugar Creek valley train. This elongate, generally uniform deposit of coarse sand, found in the wide valley of Sugar Creek in north-central Winnebago County, was deposited as a valley train, similar to the Rock River valley train, except that gravel is virtually absent. Very little sand has been excavated from type 5 deposits; however, they could become important sources of sand in the future. One small, abandoned sand pit is shown on table 5 and figure 20.

Subtype 5-1 areas contain low terrace deposits of sand covered by less than 10 feet (3 m) of overburden consisting mainly of windblown sand finer in texture than the underlying valley train deposits. These deposits are believed to be greater than 20 feet (6 m) thick, except along the valley sides. Down the middle of the valley, the sand is probably more than 50 feet (15 m) thick.

Subtype 5-2 deposits underlie floodplain areas; they are essentially the same as subtype 5-1 deposits, except that they are 10 feet (3 m) lower in elevation. Their overburden consists of less than 10 feet (3 m) of alluvial clays and silts. They are subject to flooding by Sugar Creek.

Type 6—Windblown sand deposits. Dune and sheetlike deposits of windblown coarse-to-fine sand were derived from proglacial valley train deposits and perhaps from upland ice-contact kames, eskers, kame terraces, and other outwash deposits or fine-grained slackwater deposits.

Subtype 6-1 deposits are windblown sand that mantles most valley train terrace complexes, some nearby upland ice-contact sand and gravel areas, and some slackwater deposits. These continuous, sheetlike deposits are generally 2 to 5 feet (0.6 to 1.5 m) thick. In places the sand may be up to 20 to 30 feet (6 to 9 m) thick, especially where it has piled up into dune fields, as in part of sections 1, 2, 11, and 12, T. 46 N., R. 1 E., west of South Beloit (Flint, 1930). Type 6 sand deposits have been excavated along with valley train sand and gravel in many places on the major terraces in Boone and Winnebago Counties. Overburden is generally limited to a loamy soil.

Subtype 6-2 deposits are similar to subtype 6-1 deposits except that they are generally discontinuous and commonly are much less than 5 feet (1.5 m) thick. Subtype 6-2 deposits generally are found in the uplands near subtype 6-1 deposits, but occasionally are found on terraces, such as those north of the Kishwaukee River on the east side of Boone County (fig. 20).

Little, if any, sand, has been produced from exclusively type 6 deposits, except perhaps for local fill use. A more detailed study of type 6 deposits may reveal areas where it could be mined directly as blend sand for use in asphalt concrete (Hester and Labotka, 1970), and type 6 deposits could become an important source of fine-to-medium sand in the future.

Type 7—Fine-grained slackwater deposits. The wide, nearly flat, valley bottom of the Pecatonica River in central Winnebago County contains the most extensive slackwater deposits in the two-county area. Here they are generally about 50 feet (15 m) thick; they become thinner toward the valley sides and in tributaries.

Many other slackwater deposits are found in smaller valleys tributary to the major valleys that contain the type
1 and 2 deposits. Type 7 deposits are generally 5 to 20 feet (1.5 to 6 m) thick. Almost all type 7 areas represent deposition of fine-grained material in quiet-water lakes. One exception is the area in southwestern Winnebago County (T. 26 N., R. 10 E.) where well-bedded clays, silts, and very fine sands were deposited in a proglacial lake (fig. 20). Another exception is the group of deposits in southeastern Boone County (T. 43 N., R. 4 E.) where thin-bedded medium- to coarse-grained sand probably was deposited in shallow glacial lakes (Hunter and Kempton, 1967). Just north of this area in T. 44 N., R. 4 E., type 7 deposits commonly overlie sand and gravel. This relationship is also found in the large type 7 deposit in T. 44 N., R. 1 E., Winnebago County. In other areas, type 7 deposits are overlain by about 10 feet (3 m) or less of other clayed silts, mainly recent alluvium adjacent to streams.

Type 7 deposits are not known to have been excavated commercially anywhere in the two-county area. They do not contain significant amounts of gravel. However, type 7 deposits do contain abundant coarse silt, very fine sand, and fine sand that could be used as blend sand in asphalt concrete if deposits of such material can be located in sufficient volumes and in favorable mining locations. The lower Pecatonica River valley may be the most favorable area for such deposits, especially where this sand occurs within 5 feet (1.5 m) of the surface.

St. Peter Sandstone deposits. The St. Peter Sandstone is a bedrock unit consisting of high purity white quartz sandstone that is clean, well-sorted, fine to coarse grained, very well-rounded, and loosely cemented (Willman et al., 1975). It occurs near the surface and in small outcrops in northwestern Winnebago County (type SS on figure 20). From there it dips southeastward, occurring progressively deeper in the subsurface toward southeastern Boone County (fig. 9). It lies below, and is older than, the dolomite bedrock units that are quarried for crushed stone.

Although it has not been mined in the two-county area, the St. Peter could become an important resource on the northwest side of the Sugar Creek valley, where it often lies within 20 feet (6 m) of the surface. The St. Peter Sandstone may also be present at depths shallow enough to mine in the intermittent tributaries north of Otter Creek. In both these regions the prospects for finding reserves of an economically mineable sand are limited by excessive thickness of overburden materials.

The sand in the St. Peter Sandstone could be used as a fine aggregate such as mortar sand, blend sand, or fill sand. It could also be used as a multi-purpose industrial sand (Lamar, 1927), as is done in both La Salle and Ogle Counties (Malhotra and Smith, 1976), where it is extensively mined for use in glass manufacturing, molding sand, and abrasive media; filler in enamels, paints, pottery, and tile; an ingredient in many chemicals; and a multitude of other uses.

Peat deposits. Peat deposits designated type P on figure 20, commonly occur in poorly drained areas of groundwater discharge, such as bogs and lakes, in various parts of Boone and Winnebago Counties. They are underlain by glacial deposits. Peat began to accumulate in these areas imme-

DIOLIS STATE GEOLOGICAL SURVEY CIRCULAR 531
TABLE 6. Chemical analyses of dolomite samples from quarries in the Galena Group in Boone and Winnebago Counties.

<table>
<thead>
<tr>
<th>Sample no.</th>
<th>Thickness of sampled interval (ft)</th>
<th>Location</th>
<th>SiO₂</th>
<th>TiO₂</th>
<th>Al₂O₃</th>
<th>Fe₂O₃</th>
<th>R₂O₃</th>
<th>CaO</th>
<th>MgO</th>
<th>Na₂O</th>
<th>K₂O</th>
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<td>BOONE COUNTY</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
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<td>20.80</td>
<td>-</td>
<td>-</td>
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<td>45.87</td>
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* Bradbury, 1965
** Lamar, 1957
† Lamar et al., 1934
tt U.S. Geological Survey, 1912
this chemical composition: CaO, 30.41 weight percent; MgO, 21.86 weight percent; and CO₂, 47.73 weight percent. Table 6 indicates that parts of the Galena Group may contain high-purity dolomite suitable for chemical and industrial uses. Because the Wise Lake Formation of the Galena Group commonly contains little or no chert or other impurities, development of an industry based on high-purity dolomite resources in Boone and Winnebago Counties may be possible in the future.

**Economic geology. The Ancell Group**, exposed in northwestern Winnebago County, consists mostly of sandstone; however, the Glenwood Formation consists of buff to green, very argillaceous (clayey) dolomite near the top and fine- to medium-grained sandstone lower in the section. The Glenwood Formation is underlain by the St. Peter Sandstone, which is too loosely cemented to be suitable for ‘coarse’ construction aggregate.

The **Platteville Group** consists mostly of silty or clayey (argillaceous) limestone and dolomite. The lower part of the Pecatonica Formation at the base of the Platteville Group is often contaminated with sand grains probably derived from erosion of the underlying sandstones. The formations of the Platteville are generally more dolomitic in Boone and Winnebago Counties than in areas to the south of the two-county region. Formations in the upper part of the Platteville commonly are somewhat cherty. Although they are generally finer-grained and grayer in color than the rocks of the overlying Galena Group, the Nachusa Formation of the Platteville can be mistaken for some parts of the Galena. The Platteville Group increases in thickness from west to east across the two-county region. In the Rockford area the group is about 115 feet thick.

**Rocks of the Galena Group** make up the bedrock surface in most of the two-county region (fig. 7). Because it is the thickest unit in the Galena Group, the Dunleith Formation is generally the uppermost unit exposed at the bedrock surface. In eastern Winnebago and western Boone counties, the Wise Lake and Dubuque Formations that overlie the Dunleith in the Galena Group form the bedrock surface. Still farther east in Boone County the uppermost bedrock unit consists of shales of the Maquoketa Group that overlie the Galena Group.

The Dunleith Formation of the Galena Group consists mostly of buff, vuggy, slightly cherty dolomite in beds commonly less than 1 foot thick. The Dunleith commonly is 125 feet thick where the top has not been eroded. The Wise Lake Formation overlies the Dunleith Formation in the eastern part of the two-county region. The Wise Lake consists mostly of buff, vuggy, rough-weathered, pure dolomite in beds commonly more than 1 foot thick. Where the top surface has not been eroded, the Wise Lake Formation is commonly about 70 to 75 feet thick.

The Dubuque Formation overlies the Wise Lake Formation in the eastern part of the two-county region. The unit consists of fine- to medium-grained, dark buff to gray argillaceous dolomite in beds less than 1 foot thick. Thin shaly partings exist throughout the formation; these partings are more common and thicker toward the top of the unit. Where the top has not been eroded, the Dubuque Formation is up to 40 feet thick.

Figure 21 shows the distribution of bedrock buried at depths less than 20 feet and the locations of active and recently deactivated quarries. Table 7 gives information about the ownership, location, and materials excavated at the quarry sites shown in figure 21. Figure 21 and table 7 show that quarries located in western Winnebago County are developed in either the Platteville or Galena Groups. Eastward across the two-county region, in the direction of regional dip, quarries in the Platteville Group are progressively less common. Ten of the 18 quarries in T. 26, 27, 28, and 29 N., R. 10 and 11 E., mine from the Platteville Group. Only one of the 26 quarries in T. 43, 44, 45, and 46 N., R. 1, 2, and 3 E., mines from the Platteville.

Figure 21 can be used in conjunction with the bedrock geologic map (fig. 7) and the drift thickness map (fig. 11), to select areas where exploration for new quarry sites is likely to be most successful. Since the Galena and Platteville Groups commonly are more than 100 feet thick, it is economically feasible to remove the loose overburden up to 40 or 50 feet thick to extract proven thick reserves of stone. Thus, exploration for new sites need not be restricted to outcrop and subcrop areas shown on figure 21.

Quarry operators have reported that the Wise Lake Formation of the Galena Group commonly produces the best aggregate. Exploration for the Wise Lake Formation is most likely to be successful in eastern Winnebago and western Boone Counties in a strip paralleling the east side of the Rock Bedrock Valley. Farther to the east, the Dubuque Formation overlies the Wise Lake, but deep quarrying and selective mining techniques would permit production of high-grade aggregate from the Wise Lake and lower quality aggregate from the Dubuque. The Dubuque is always less than 40 feet thick.

In western Winnebago County, the Wise Lake Formation generally is absent, but abundant dolomite resources for aggregate are available from other parts of the Galena and Platteville Groups. Table 10 shows that at least one quarry extracting stone from the Platteville Group is able to produce grade B aggregate suitable for bituminous concrete (asphalt) paving surface courses.

The Wise Lake Formation of the Galena Group, and perhaps other parts of both the Galena and Platteville Groups, may contain significant resources of high-purity dolomite suitable for chemical and industrial use. The possibility exists for development of significant heavy industry utilizing these resources. However, future development of the high-purity dolomite resources of the two-county region is unlikely because of the competitive advantage of quarries located closer to the major markets for dead-burned dolomite.

**Shales of the Maquoketa Group** overlie the dolomitic rocks of the Galena Group. The Maquoketa shales are not suitable for use as construction aggregate.

**Effects of blasting in mining operations.** Extraction of dolomite in surface or underground mines requires blasting to loosen the stone from the bedrock. Daily blasts at a large
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<th>Status A/I*</th>
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† Data compiled from Illinois Department of Transportation, Bulletin 23 (1977); telephone reports of operators of record of active quarries; published reports of the Illinois Geological Survey; interpretations of data gathered specifically for this report. Site numbers refer to figure of this report.

* G = Galena Group; P = Platteville Group; A = Active quarry; I = Inactive or recently deactivated quarry; a = Class A aggregate suitable for Portland cement concrete pavement; b = Class B aggregate suitable for bituminous concrete (asphalt) pavement top course; c = Class C bituminous aggregate for lower grades of asphalt pavement; d = base and surface aggregates for base courses and water-bound macadam surfacing. Classes from Illinois Department of Transportation specifications.
Figure 21. Dolomite resources of Boone and Winnebago Counties.
Maquoketa Shale
Galena Group buried at depths less than 20 ft
Galena Group exposed at surface
Platteville Group buried at depths less than 20 ft
Platteville Group exposed at surface
Aancell Group buried at depths less than 20 ft
Aancell Group exposed at surface
Bedrock buried at depths greater than 20 ft
Active quarry site
Inactive quarry site
quarry may be a significant nuisance to nearby property owners, but with reasonable care, damaging vibrations can be avoided.

Several criteria are generally used to measure safe vibration levels during blasting. The parameters most often considered are particle displacement, particle velocity, particle acceleration, and frequency. The distance to which damaging vibrations will extend depends both on the amount of blasting agent exploded in a single shot and the geology of the area in which the blasting occurs. Some dolomite quarries in the Chicago area conduct blasting within 300 feet of houses.

Most quarries are located in rural areas where the effects of blasting may be inconsequential because of low population densities. However, it may be necessary to develop an unpopulated buffer zone around a quarry in an area undergoing rapid urbanization. Some protection can be provided by the area of stone reserves around the active quarry operation, but encroachment of housing too close to the reserve area may prevent full extraction of the available reserves.

Clay resources
Clay product businesses are often hampered by the price and availability of fuel and local labor costs. Clay plants are capital intensive and must use up-to-date technology to remain competitive. High transportation costs and legislated preference (in government building projects) to local suppliers favor local producers. Chicago-style brick is an excellent example of a unique product that remains in demand in the Chicago area because it is locally produced.

Tills similar to the Esmond and Belvidere (plate 1) are used in northeastern Illinois to produce brick, wall tile, and drain pipe. Pebbles found in clay deposits might have to be removed for use in some products. Only the upper, oxidized part of the tills can be used for some products. Tests made of the Esmond and Belvidere Tills indicated that they could probably be used for drain tile, flower pots, low cost fillers, Chicago-style brick, and some structural clay products. Although the Esmond contained more clay, both tills had relatively low clay contents. Although test results suggest the potential for usable deposits, the low clay content causes fair to poor plasticity, which might reduce the strength and durability of finished products.

Oxidized loess (plate 1) was used for several years to produce drain tile near Capron. The general availability of loess in the area could make it a potential resource, but records at the Survey indicate drying difficulties and a product with low durability.

A few samples of lacustrine material were taken from boring ISGS 12 (fig. 4). Although these materials are frequently suitable for capping or lining waste repositories, the clay content at this location was too low for this purpose. Other areas where this ancient lake deposit occurs (fig. 20) might be richer in clay and therefore be usable. Tills from the Esmond and Belvidere probably would provide the best local materials for liners.

If the St. Peter Sandstone (fig. 7) were mined the fine clay in the sandstone could be a usable by-product. Although shale from the Maquoketa Group contains excessive dolomite in most of the region, it might be used for red-firing products if prospected more thoroughly.

--- SUMMARY ---

This report has provided comprehensive information on the geology, hydrogeology, and mineral resources of Boone and Winnebago Counties for use in resource-based land-use planning and development. Data on the composition, thickness, and regional distribution of glacial drift and bedrock materials were used to construct maps of: geologic materials to a depth of 20 feet; bedrock topography; drift thickness; major terranes; and glacial drift aquifers. On the basis of these maps, interpretive maps were then prepared that:

- rate geological sequences on their capacity to protect aquifers and surface water from contamination by land burial of municipal wastes, waste disposal by septic systems, and surface spreading of wastes and agricultural chemicals;
- rate geological sequences on their suitability for general construction;
- delineate resources of sand, gravel, peat, and dolomite.

THE GEOLOGIC FRAMEWORK

Bedrock. Bedrock directly below the glacial drift consists of dolomite, shale, and sandstone. The Galena and Platteville Dolomite Groups are the uppermost bedrock units over most of the area. The St. Peter Sandstone is at bedrock surface in the bottom of the Rock, Sugar, Pecatonica, and much of the Troy Bedrock Valleys, and is exposed at land surface on the uplands in northwestern Winnebago County. The Maquoketa Shale Group is present only in southeastern Boone County.

Glacial drift. The surficial drift consists largely of sandy tills. Loam or fine-textured tills cover southern Boone County and extreme southeastern Winnebago County. Extensive sand and gravel outwash deposits are found in the major river valleys. Sand and gravel also occurs in linear ridges (eskers) and hills (kames), primarily in southern Boone County. Lacustrine (waterlaid) silts and clays are confined mostly to the Pecatonica River valley and to the small tributary valleys of the Rock and Kishwaukee Rivers and Piscasaw Creek. They are also found in the subsurface in the Rock and Troy Bedrock Valleys.

Bedrock topography/drift thickness. Major surface valleys generally correspond with bedrock valleys, except in eastern Boone County where the Troy Bedrock Valley is completely buried. Extensive, deep bedrock valleys contain thick glacial drift: up to 300 feet thick in the Pecatonica-Sugar-Rock Bedrock Valley system in Winnebago County and more than 450 feet thick in the Troy Bedrock Valley in Boone County. The uplands between the bedrock valleys can be grouped into four areas on the basis of drift thickness: (1) west of the Rock Bedrock Valley and south of the Pecatonica Bedrock Valley, where drift is generally less than 20 feet thick; (2) west of the Rock Bedrock Valley...
and north of the Pecatonica Bedrock Valley, where drift is commonly less than 5 feet thick; (3) east of the Rock Bedrock Valley and northwest of the Troy Bedrock Valley, where drift is more than 50 feet and frequently more than 100 feet thick; and (4) east of the Rock Bedrock Valley and south and east of the Troy Bedrock Valley, where drift is usually between 50 and 100 feet thick. In general, the modern topography reflects the topography of the bedrock in areas where the drift is less than 50 feet thick.

Terranes. The uplands and lowlands of the two counties have been categorized into terranes (a terrane is a mapping unit consisting of a topographic feature and the related sequence of materials of which it is composed). Broad, relatively flat uplands underlain by dolomite are present in central Winnebago County. Throughout eastern Winnebago County, in most of northern Boone County, and in part of southern Boone County, uplands and slopes are underlain principally by till. In these uplands, sandy till areas can be distinguished from loamy to silty clay till areas. In eastern Winnebago County and central Boone County, sloping topography adjacent to the Rock and Kishwaukee Rivers and Piscasaw Creek is underlain by till; in much of western Winnebago County, sloping topography is underlain by dolomite. Lowlands are broadly categorized as those underlain principally by sand and gravel (in the Rock, Sugar, and Kishwaukee River valleys and Piscasaw Creek valley), and those directly underlain by lacustrine and alluvial silt and clay (primarily in the Pecatonica River valley).

NATURAL RESOURCES

Water resources

Bedrock aquifers. Abundant water resources are available in the counties from deep and shallow sandstone and from relatively shallow, fractured dolomite.

Sand and gravel aquifers. Moderate-to-large groundwater supplies are provided by sand and gravel aquifers at relatively shallow depths in the Rock, Kishwaukee, and Piscasaw valleys and within thick glacial drift below the uplands of northeastern Boone County.

Mineral resources

Sand and gravel. Extensive outwash deposits in the valleys of the Rock and Kishwaukee Rivers and Piscasaw Creek supply sand and gravel for road material and concrete aggregate. Some sand and gravel is exposed along the valley walls on the east side of the Rock River valley in Winnebago County and on the north side of Beaver Creek in western Boone County; other small deposits are found in widely scattered areas.

Dolomite. Although dolomite deposits underlie all the uplands of Winnebago County and most of Boone County, extraction costs are prohibitive in areas where overburden is thick. High-grade dolomite having relatively thin overburden is found in eastern Winnebago County and southwestern Boone County.

Peat. Peat deposits are found in bogs in various parts of both counties; however, no peat is being commercially excavated at present. Some of the more extensive deposits are potential sources of materials for use as soil conditioner.

LAND-USE EVALUATIONS

Land burial of municipal wastes

Sequences of geologic materials were rated on their capacity to protect aquifers from contamination resulting from land burial of wastes (it was assumed that most wastes are buried below the water table in a trench 20 feet deep, and therefore in contact with groundwater).

- **Highest potential for aquifer contamination resulting from land burial of wastes:** almost all of western Winnebago County and the Rock and Kishwaukee River valleys and their tributary valleys where dolomite bedrock or thick deposits of sand and gravel are within 20 feet of land surface.
- **Lowest potential for aquifer contamination resulting from land burial of wastes:** uplands of southern Boone County and southeastern Winnebago County where relatively flat land is covered with loamy to silty clay till thicker than 50 feet. Some of the thicker sandy till areas may have favorable spots for landfill sites; however, since subsurface data are inadequate in many of these areas, extensive onsite investigation is necessary prior to site selection.

Waste disposal by septic system

Areas in which septic systems work best (where the earth materials readily accept the waste) are generally those in which aquifer contamination from effluent is most likely to occur. Soil drainage conditions, topography, and density of septic tank units must be considered, along with the nature of the geologic materials, in rating geological sequences on their capacity to protect aquifers and surface water from contamination by septic tank effluent.

- **Highest potential for aquifer contamination resulting from intense use of septic systems:** much of northwestern Winnebago County and major river valleys where bedrock or sand and gravel are within 5 feet of land surface.
- **Lowest potential for aquifer contamination resulting from intense use of septic systems:** southern Boone County and the Pecatonica Valley in Winnebago County in fine-grained till and lacustrine areas.
- **Low potential for aquifer contamination and minimum acceptance problems resulting from intense use of septic systems:** northern Boone County and parts of western Winnebago County where drift is thick.

Surface application of wastes and agricultural chemicals

Overapplication of industrial wastes, sewage sludge, and agricultural chemicals to the land surface or active soil zones can result in contamination of aquifers and surface water, as can accidental chemical spills. However, the soil generally has some capacity to attenuate such contaminants.

- **Least favorable for surface application of wastes:** much of western Winnebago County, along the slopes of the Rock and Kishwaukee Rivers and Piscasaw Creek valley
walls, and in places where thin soil covers sand and gravel of major river valleys.

- **Most favorable for surface application of wastes:** relatively flat areas on uplands where there are no acceptance problems (such as in portions of northern Boone County) and no shallow aquifers.

**General construction**
The major factors considered in rating geological sequences on their suitability for general (light) construction were: bearing capacity and excavation ease, susceptibility to flooding, thickness of surficial material (depth to bedrock), internal drainage characteristics, and natural hazards.

- **Least favorable for general construction:** scattered locations throughout both counties on poorly drained land having low bearing capacities, and uplands and slopes in northwestern Winnebago County where the drift is thin over the bedrock.

- **Most favorable for general construction:** well-drained locations in major river valleys and terrace outwash plains; also in some upland areas.

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**REFERENCES**


Belvedere-Boone County Planning Commission, 1980, Boone County land-use plan.


ADDITIONAL REFERENCES


APPENDIX I. Detailed description of drift and surficial bedrock units mapped or encountered in Boone and Winnebago Counties. (Asterisks identify units named or redefined during this study; formal rock-stratigraphic nomenclature is now being established.)

sm: Surface mines
Includes rock quarries and sand and gravel pits where a mixed fill of bedrock and/or Quaternary deposits was replaced or disturbed.

c: Cahokia Alluvium
Mostly poorly sorted sand, silt, and clay (organics locally); deposited by modern rivers and streams on floodplains, in channels, and in places on terraces along the Rock, Pecatonica, and Kishwaukee Rivers and Piscasaw Creek during peak floods; Cahokia Alluvium is always a surficial material.

   c-sl/c-s: Cahokia Alluvium, silty and sandy
Stratified silty alluvium over sandy alluvium on terracelike features above the modern floodplain along Beaver Creek.

py: Peyton Colluvium
Deposits of unsorted sand, silt, and clay—primarily silt that accumulated in toe slope positions; resulted from creep or slope wash from loamy and clayey till and loess upland areas throughout both counties; colluvium is always a surficial material; may locally include slumped bedrock or rock fall debris.

   py-s: Colluvium, sandy
Primarily sandy colluvium adjacent to bedrock, sandy till, and dune areas; occurs mostly in western Winnebago County.

   ppr: Peyton Colluvium, Peoria Loess, and Roxana Silt
A complex deposit of 3 to 5 feet (often more than 5 feet) of colluviated, windblown silt in broad depressional areas between upland highs; occurs mostly in northern and central-western Boone County.

pl: Parkland Sand
Two to five feet of well-sorted, medium-grained windblown sand; upper part of deposit may have a loamy texture; found in dunes and as sheet deposits between dunes; occurs extensively (1) on terraces of the Rock and Kishwaukee Rivers and Piscasaw Creek, (2) in restricted areas on uplands (sometimes over loess), and (3) on the uplands as a discontinuous and thin unit over sandy till and bedrock adjacent to the eastern side of the Rock River; it may stratigraphically overlie any deposit.

gl: Grayslake Peat
Organic deposits of peat and muck often interbedded with silt and clay; sometimes included with Cahokia Alluvium; formed by the accumulation of organic materials in depressional areas on floodplains of major streams and near stream headwaters; occurs only as a surficial material.

ec: Carmi Member, Equality Formation
Well-bedded silt and clay deposits, usually gray or gray-brown; primarily a quiet-water lake sediment, it occurs (1) mostly as a slackwater deposit in the Pecatonica River valley upriver of its junction with the Sugar River, (2) in Otter Creek, a tributary to the Sugar River, (3) in small tributaries to the Rock and Kishwaukee Rivers and Piscasaw Creek, and (4) in southwestern Winnebago County as a proglacial lake deposit; usually overlain by Cahokia Alluvium, loess, or Parkland Sand; fine-grained equivalent of Dolton Member of Equality.

ed: Dolton Member, Equality Formation
Generally thin-bedded, medium- to coarse-grained sand deposited in former shallow-water lakes and deltas; most extensive deposits in southeastern Boone County; usually overlain by Cahokia Alluvium, loess, or Parkland Sand; coarse-grained equivalent of Carmi Member of Equality.

hm: Mackinaw Member, Henry Formation
Generally well-sorted and well-bedded mixture of sand and gravel, more than 50 feet thick; extensive outwash deposits from melting Wisconsinan glaciers in valleys of the Rock and Kishwaukee River and Piscasaw Creek; primarily overlain by (1) Cahokia Alluvium adjacent to major rivers or streams, (2) Parkland Sand, Peoria Loess, and Roxana Silt or Richland Loess on terraces, and (3) Carmi Member of the Equality silts in areas adjacent to quiet-water inlets; overlies a repeatable sequence of sand and gravel, lacustrine materials, and till deposits of an earlier age in major bedrock valleys.

   hm-f: Mackinaw, fine
Primarily well-sorted fine-to-medium sand with local inclusions of silt and clay transitional to Equality Carmi; glacial outwash in the Sugar River and lower portion of the Pecatonica River; overlain mainly by Parkland Sand or Cahokia Alluvium.

hw: Wasco Member, Henry Formation
Unevenly sorted deposits of sand and gravel that leave irregular bedded lenses of silt and till; glacial ice-contact deposits in hills and ridges (kames, kame terraces, and eskers); occurs in southern Boone County and in southeastern Winnebago County as linear ridges trending primarily northwest and along the west side of the Rock River valley; may be overlain by loess or Parkland Sand.
hb: Batavia Member, Henry Formation
Well-sorted deposits of sand and gravel; glacial outwash materials on uplands; restricted occurrence in northeastern Boone County; overlain by Peoria Loess or Peyton Colluvium.

pr: Peoria Loess and Roxana Silt
Windblown silt 2 to 5 feet thick, generally yellowish brown; occurs on uplands throughout the counties; locally overlain by a thin Parkland Sand deposit east of the Rock River; overlies glacial materials of Illinoian and early Altonian age.

pr5: Peoria Loess and Roxana Silt
Windblown silt more than 5 feet thick; occurs on uplands, with thickest deposits in southwestern Winnebago County, adjacent to the western edge of the Rock River valley, and east of the Rock River valley in east-central Winnebago County.

p: Peoria Loess
Windblown silt 2 to 5 feet thick; occurs on uplands on the late Altonian Capron Till surface and on terraces of the Kishwaukee River and Piscasaw Creek.

pc: Peoria Loess and Cahokia Alluvium
Windblown silt 2 to 5 feet thick mixed with silty alluvial material on low terraces along the Pecatonica River and Otter Creek; overlies Carmi Member and Henry Formation deposits.

pc5: Peoria Loess and Cahokia Alluvium
Windblown silt more than 5 feet thick mixed with silty alluvial material on low terraces along the Pecatonia River and Otter Creek.

*wip: Plano Silt Member, Winnebago Formation
Organics, organic silt, and silt; occurs in a former bog in a depressional area south of Rock Cut State Park in east-central Winnebago County; radiocarbon dated between 33,220 ± 710 and 47,400 ± 2400 years ago B.P., the deposit overlies Argyle Till; may be present locally throughout both counties.

*wic: Capron Till Member, Winnebago Formation
Pinkish-brown, friable, silty till generally up to 30 feet thick; average sand-silt-clay percentage of 31-37-32; illite is the primary clay mineral averaging 55 percent; occurs north of Piscasaw Creek to about 3 miles south of the state line; occurs as uppermost unit of the Winnebago Formation tills, and is underlain by Clinton Till and overlain by 0 to 2 feet of Peoria Loess; surface of the silty till appears eroded.

*wic-s: Capron Till Member, Winnebago Formation-sandy
Pinkish-brown, friable, sandy till, generally up to 30 feet thick; average sand-silt-clay percentage of 42-35-23; illite averages 55 percent; occurs in the extreme northeastern corner of Boone County; stratigraphic relationship to the silty Capron is not understood; ice-contact deposits appear to separate the units in northeastern Boone County, possibly suggesting two distinct tills; overlies the Clinton Till and is overlain by 0 to 2 feet of Peoria Loess.

*wicl: Clinton Till Member, Winnebago Formation
Yellowish-tan, very friable, very sandy till about 20 feet thick; average sand-silt-clay percentage of 59-27-14; illite averages 60 percent; characteristically very high in carbonates; occurs (1) as a surficial unit in extreme north-central Boone County, (2) between the Pecatonica River and the northern part of the Rock River in north-central Winnebago County, and (3) locally capping the uplands south of the area mapped in Boone County; stratigraphically underlies the Capron Till and overlies the Argyle Till; has loess cover of from 2 to more than 5 feet; a strong paleosol has formed into much of the till.

*wia: Argyle Till Member, Winnebago Formation
Pinkish or buff-tan, somewhat compact sandy till up to 30 feet thick; average sand-silt-clay percentage of 53-29-18; illite averages 58 percent; occurs as a surficial unit on much of the upland between the Rock and the Kishwaukee-Piscasaw River systems, and generally thin to less than 10 feet on lower slopes; also occurs west of the Rock River in south-central Winnebago County; stratigraphically underlies the Clinton Till and overlies Nimtz Till; ridge tops of Argyle commonly have a strong paleosol overlain by 2 to 5 feet of Peoria Loess and Roxana Silt while sideslopes and toeslopes are often eroded and do not have a paleosol; Argyle Till covers more of the surface area than any other till in the Winnebago and Boone County area.

*win: Nimtz Till Member, Winnebago Formation
Gray-brown or buff, often compact and hard sandy till usually greater than 25 feet thick; may have platy structure; two textural phases are recognized—one has an average sand-silt-clay percentage of 55-31-14, the other a percentage of 49-31-20; where both phases are present the former overlies the latter; illite averages 70 percent; the till occurs (1) as a surficial unit cropping out beneath Argyle Till along the east valley wall of the Rock River, (2) along the north valley wall of the Kishwaukee River, (3) along Beaver Creek, and (4) north and east of the confluence of...
the Rock River with the Kishwaukee River; because it occurs downslope in eroded positions, it commonly lacks a significant loess cover; a paleosol has formed in it; stratigraphically it underlies the Argyle Till and overlies, in numerous places, a sand and gravel unit that in turn overlies tills of the Glasford Formation.

*g-o: Glasford Formation Outwash
Generally poorly sorted mixture of sand and gravel between 5 and 15 feet thick; material may have been deposited by the advancing ice that deposited the Esmond or Belvidere Tills immediately to the south; occurs as a surficial unit; most extensive deposits are adjacent to Beaver Creek; stratigraphically it is overlain by the Nimtz Till and underlain by the Belvidere Till of the Glasford Formation; however, the material may be underlain by either bedrock or the Oregon Till.

*gbl: Belvidere Till Member, Glasford Formation
Pinkish-brown or pale brown, fairly compact silty till; locally it may be more than 40 feet thick, but it usually is less than 20 feet thick; has two silty textural phases—one with an average sand-silt-clay percentage of 16-51-33, the other with a percentage of 29-41-30. The first occurs surficially in the southeastern corner of Boone County; the second in a three-mile wide band from the city of Belvidere northeastward along Piscasaw Creek to the McHenry County line; illite averages 70 percent; the till stratigraphically underlies the Winnebago Formation tills, and overlies the Esmond Till; the surface of the Belvidere is eroded.

*ge: Esmond Till Member, Glasford Formation
Grayish-brown, fairly compact silty clay till generally more than 15 feet thick (in some places its thickness is variable); average sand-silt-clay percentage of 18-42-40; illite averages 78 percent; occurs as a surficial unit in extreme southeastern Winnebago County and southwestern Boone County; stratigraphically underlies the Belvidere Till and overlies the Oregon Till; generally overlain by less than 2 feet of Peoria Loess and Roxana Silt; a loamy zone may separate the loess from the till with no paleosol present.

*gor: Oregon Till Member, Glasford Formation
Pinkish-brown or buff-tan, fairly compact sandy till up to 15 feet thick; the average sand-silt-clay percentage is 50-31-19. It occurs mostly as a surficial unit in southwestern Boone County and southeastern Winnebago County in extreme downslope positions along the lower portions of the Kishwaukee River; it is also the surficial deposit in south-central and southwestern Winnebago County; illite averages 50 percent; stratigraphically underlies the Esmond Till and overlies the Creston Till; east of the Rock River the till generally lacks a loess cover and a paleosol, while west of the Rock River a strong paleosol with more than 5 feet of loess cover is common; till is essentially identical in appearance and analytical characteristics to the Argyle.

*gc: Creston Till Member, Glasford Formation
Pinkish-brown, somewhat compact loamy till up to 20 feet thick; average sand-silt-clay percentage of 30-35-35; illite averages 62 percent; occurs fairly extensively in the subsurface within 20 feet of the surface beneath Oregon and Belvidere Tills in southeastern Boone County; a small area of surficial exposure possibly exists in south-central Boone County; it stratigraphically underlies the Oregon Till and possibly is genetically related to it, and overlies the Fairdale Till; there is no weathering or paleosol separating the Creston from material above.

*gf: Fairdale Till Member, Glasford Formation
Pinkish or yellowish, often very friable, loamy, and sandy till up to 30 feet thick; three textural phases are recognized—the first with an average sand-silt-clay percentage of 36-38-26, the second with a percentage of 46-38-16, and the third with a percentage of 55-29-16, illite averages 68 percent; it is not expressed surficially in either county unless a relationship can be made to the sandy Ogle Till in western Winnebago County; it appears within 20 feet of the surface in extreme south-central Boone County; however, where the drift thickness exceeds 30 feet in southern Boone County and southeastern Winnebago County, the Fairdale Till may be present; stratigraphically underlies the Creston Till and overlies the Herbert Till.

*gh: Herbert Till Member, Glasford Formation
Gray-brown, unoxidized, very compact, sandy till that can be more than 25 feet thick; average sand-silt-clay percentage of 48-38-14 but often the sand content is more than 60 percent; illite averages 76 percent; occurs about 40 to 50 feet beneath the surface throughout southern Boone County; stratigraphically underlies the Fairdale Till and possibly overlies the Ogle Till.

go: Ogle Till Member, Glasford Formation
Yellow-brown or buff, somewhat friable, sandy loam till; average sand-silt-clay percentage of 43-39-18; illite averages 59 percent; occurs as a surficial material in western Winnebago County primarily north of the Pecatonica River; average thickness is generally less than 20 feet because of the shallow bedrock and extreme erosion throughout its mapped area; stratigraphic relationship to overlying units is not understood; however, it underlies the...
Argyle and Clinton Tills; its illite percentage and textural data suggest a close relationship of this unit to the Fox-
hollow Till, but there is no firm basis for correlation; where uneroded the Ogle may contain a strong paleosol
with up to 5 feet of loess.

go-1: Ogle Till Member, Glasford Formation, loamy or silty
Buff or brown loamy or silty till; average sand-silt-clay percentage of 27-47-26; illite averages 48 percent; occurs
in spotty locations in a band from south of the Pecatonica River at the Stephenson County line northeastward
through Shirland to the Wisconsin state line; stratigraphic relationships are not known; however, the low illite
content in these tills would suggest a possible relationship to the Kellerville Till.

gk: Kellerville Till Member, Glasford Formation
Compact, silty till often overlain by organics and/or wood fragments; average sand-silt-clay percentage of 32-42-26;
illite averages 42 percent; occurs only in the deep subsurface in northern Boone County but is exposed in a quarry
northeast of Rockford; stratigraphically the basal Glasford Formation till member, possibly related to silty tills
in western Winnebago County.

gfo: Foxhollow Till Member, Glasford Formation
Buff or brown, fairly compact, sandy loam till; average sand-silt-clay percentage of 43-35-22; illite averages 53
percent; occurs only in the subsurface in extreme northern Boone County and northeastern Winnebago County,
and is exposed in a quarry northeast of Rockford; lies stratigraphically beneath the Argyle and Nimtz Tills, and
above the Kellerville Till; however, its relationship to other Glasford units is not known.

g-ow: Glasford Outwash undifferentiated
Mixture of sand and gravel in a restricted location southeast of the city of Belvidere near the junction of Mosquito
and Coon Creeks; appears to underlie Oregon and Creston Tills.

S: Silurian dolomite, Alexandrian Series
Yellowish gray to light olive gray, argillaceous dolomite; occurs only as a small cap on Maquoketa rocks about two
miles south of the city of Belvidere.

Om: Ordovician shale and dolomite, Maquoketa Shale Group
Greenish gray shale with light yellowish-brown, fine-grained, very fossiliferous dolomite stringers; common fossils
are brachiopods, bryozoas, trilobites, cephalopods, gastropods, bivalves, and ostracods; found within 20 feet of the
surface southwest of the city of Belvidere and east of Belvidere on the McHenry County line; Maquoketa rocks are
the surficial bedrock unit underlying drift over most of southeastern and extreme eastern Boone County; stratigraphi-
cally below Silurian rocks and above Ordovician rocks of the Galena and Platteville Groups.

Og: Ordovician dolomite, Galena and Platteville Groups
Light brown or brownish gray dolomite classified into several formations and members on basis of varying lith-
oologies and faunas; in general, Platteville formations are finer grained and thinner bedded than the Galena forma-
tions; these rocks occur (1) within 20 feet of the surface over most of the uplands in Winnebago County west of
the Rock River, (2) in southeastern Winnebago County, and (3) along the northern portion of the Winnebago-
Boone County boundary; numerous surface exposures exist; stratigraphically below the Maquoketa shales and
above the St. Peter Sandstone.

Oa: Ordovician sandstone, Ancell Group, St. Peter Sandstone Formation
White, well-sorted sandstone; only surficial exposure is in extreme northwestern Winnebago County; in southern
Boone County, the top of the unit is about 450 feet below the surface; this sandstone is the surficial bedrock unit
along the axes of the Rock, Pecatonica, Sugar, and portions of the Troy Bedrock Valleys; stratigraphically below
rocks of the Galena and Platteville Groups and above either older Ordovician rocks or Cambrian rocks.

zs: Sangamon Soil, oxidized
A strongly weathered, yellow-brown or red, clay loam soil with weak to moderate blocky structure in the B-horizon
and massive structure in the A-horizon; joints, clay skins, concretions, and stains are common features; generally
frangible to hard consistency, low to moderate porosity; depth of leaching about 5 to 15 feet; it is an ancient soil
(paleosol) formed in pre-Wisconsinan sediments during the last interglacial stage; it has soil horizons similar to the
modern soil, but is more weathered and has been leached to greater depths; upland profiles are commonly truncated
into the Sangamon subsoil, and where not eroded are light colored forest soils with clay-enriched B-horizons;
occurs on uneroded Glasford Formation surfaces in southeastern Winnebago County, but occurs mostly in south-
western and western Winnebago County; rarely occurs on eroded Esmond, Oregon, or Belvidere Till surfaces;
paleosol often underlies 2 to 5 feet of loess, but where loess is thicker than 5 feet, the paleosol is less likely to
be present.
zu: Undifferentiated paleosol, oxidized
Weathered, reddish-brown paleosol formed primarily in till having characteristics of the Sangamon Soil; occurs on surfaces mapped as Winnebago Formation in central and eastern Winnebago County, and in northern Boone County; usually overlain by 2 to 5 feet of loess; its similarity to the Sangamon Soil suggests that it may also be Sangamon Soil, but because correlation is uncertain, the soil is mapped as undifferentiated.

zs-ag: Sangamon Soil, accretion gley
Brownish-gray to gray, often mottled, silty-clay paleosol with massive to weak blocky structure; joints, clay skins, concretions, and stains are common diagnostic features; usually plastic to hard consistency; porosity is low and the depth of leaching is about 4 to 7 feet; formed in depressional or flat areas that were poorly drained; accretion-gley is less weathered than the better drained Sangamon Soil but has a higher percentage of expandable clays; all Sangamon soils with intact B-horizons are relatively impermeable and severely limit water movement; occurs as patchy erosional remnants in small stream drainageways on pre-Wisconsinan surfaces mostly in western Winnebago County; where preserved it is overlain by 2 to 5 feet of Peoria Loess and Roxana Silt.

zu-ag: Undifferentiated accretion gley soil
Weathered grayish silty paleosol with characteristics of the Sangamon Soil (accretion paleosol); occurs on Winnebago Formation surfaces in patchy erosional remnants; mostly overlain by 2 to 5 feet of loess.
Geologic materials to a depth of 20 feet in Boone and Winnebago Counties

Richard C. Berg

Draftsman: Craig Ronto

This map is only a guide to land use and does not replace the need for detailed investigations for specific uses or sites.
Classification of geologic materials for land burial of wastes in Boone and Winnebago Counties

Richard C. Berg and Keros Cartwright

Draftsman: Craig Rembo

This map is only a guide to land use and should not be used for detailed investigations for specific use or sites.
Classification of geologic materials for waste disposal by septic tank soil absorption systems in Boone and Winnebago Counties

Richard C. Berg and Keros Cartwright

Draftsman: Craig Ronto

This map is only a guide to short use and does not replace the need for detailed investigation for specific uses or sites.
GEOLOGY FOR PLANNING IN BOONE AND WINNEBAGO COUNTIES

PLATES

1. GEOLOGIC MATERIALS TO A DEPTH OF 20 FT IN BOONE AND WINNEBAGO COUNTIES

2. CLASSIFICATION OF GEOLOGIC MATERIALS FOR LAND BURIAL OF WASTES IN BOONE AND WINNEBAGO COUNTIES

3. CLASSIFICATION OF GEOLOGIC MATERIALS FOR WASTE DISPOSAL BY SEPTIC TANK SOIL ABSORPTION SYSTEMS IN BOONE AND WINNEBAGO COUNTIES