GEOLOGY FOR PLANNING IN NORTHEASTERN ILLINOIS

I. GEOLOGIC FRAMEWORK, PROJECT GOALS AND PROCEDURES

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BACKGROUND AND SCOPE OF PROJECT

Northeastern Illinois, including the Chicago metropolitan area and remaining portions of Cook, DuPage, Kane, Lake, McHenry, and Will Counties, encompasses a diversity of land-use types. Across the region, one encounters intensive urban commercial and industrial development, high density residential development, suburban residential and commercial development, and rural agricultural areas punctuated by small towns. The expectation of continued development in marginal urban areas and of changing land-use patterns in areas of past development intensifies the need for regional planning. The purpose of this study is to provide the Northeastern Illinois Planning Commission (NIPC) with geologic information vital to the planning process in Northeastern Illinois.

One essential basis for rational land-use planning is a thorough understanding of the physical environment, focusing on the geologic materials themselves. Definition and characterization of geologic materials is a necessary first step. Then, consideration can be given to the interaction of these geologic materials with potential pollutants that may be generated by residental, commercial, and industrial development. In addition, it is important for planners to consider the resource value of geologic materials, the limitations of geologic materials for various land uses, and water movement on and through the various geologic materials. Such technical data provides an essential basis for decisions among conflicting land uses.

This regional study, Geology for Planning in Northeastern Illinois, was initiated by the Northeastern Illinois Planning Commission (NIPC) under provisions of Section 208 of the Federal Water Pollution Control Act Amendments of 1972 (Pl 92-500). Section 208 calls for preparation of regional

plans for coping with water pollution in areas with substantial water quality problems as a result of urbanization or industrialization. For purposes of 208 planning, the entire six county northeastern Illinois region was designated as a water quality problem area with NIPC as the water quality planning agency. Since Section 208 requires that any water quality plan be technically feasible, the Northeastern Illinois Planning Commission asked the Illinois State Geological Survey (ISGS) to provide basic geologic data, natural resource information, and interpretive maps bearing on ground water, land utilization techniques and waste disposal and land treatment practices. This work was supported by 208 funds and coordinated through the NIPC 208 management staff. Work by the Illinois State Geological Survey was administered by Keros Cartwright, Head, Hydrogeology and Geophysics Section, and coordinated by John P. Kempton, principal investigator and Geologist in the Hydrogeology and Geophysics Section. Contract funds for this project were adminstered through the University of Illinois.

Previous work in Norhteastern Illinois by the Illinois State Geological Survey includes a variety of geologic studies, some of which are directly applicable to this project. Bretz (1939, 1955) studied the geology of the Chicago metropolitan area; his work has been recently updated by Willman (1971). County-wide geology for planning studies have already been published for McHenry (Hackett & McComas, 1969), Lake (Larsen, 1973), and DeKalb Counties (Gross et al., 1970); the Lake and McHenry studies will be updated for this current project. Will and Kane County environmental geology studies were in progress when this study was initiated.

This study includes a set of maps detailing the geologic materials

to a depth of 20 feet (6.1 meters) for each of the six counties. In addition, this study includes a series of interpretive maps for each county which were prepared by applying certain criteria to the basic geologic materials map and selected additional maps. The geologic materials mapping was done at the 1:24,000 scale on (7½ minute quadrangle) U. S. Geological Survey topographic maps which were then reduced to the scale of 1:62,500 county bases generated by the ILLIMAP system (Swann et al., 1970). Various types of data were utilized for the basic mapping of geologic materials, including field and laboratory studies, logs and sample descriptions of water wells and engineering borings, test data from engineering borings, previously published and unpublished ISGS reports, interpretations from aerial photos, USDA Soil Conservation Service soil survey investigations, and University of Illinois Agricultural Experiment Station reports. The series of interpretive maps for each county generally includes five maps detailing conditions for various waste disposal and land treatment practices; a map showing generalized terrains; maps indicating ground water, sand and gravel, rock, clay, and peat resources; and maps indicating limitations for various land uses. Certain maps may not be applicable for all counties across the region; these deletions are detailed in discussions of the individual counties.

The purpose of this general section (volume 1) is twofold: (1) to provide background information on the geology, geologic materials, and hydrogeology of Northeastern Illinois; (2) to explain in detail the mapping criteria and procedures employed for the geologic materials maps and the various interpretive maps. In addition to this general section, six individual county reports were prepared which detail the results of the geologic materials mapping and interpretive mapping for each county. A regional

summary follows the county reports and includes selected regional maps prepared at a scale of 1:125,000. A glossary of terms (Appendix A) and a list of pertinent references (Appendix B) follow the regional summary.

GEOLOGIC SETTING OF NORTHEASTERN ILLINOIS AND DESCRIPTION OF GEOLOGIC MATERIALS

In Northeastern Illinois, the layered bedrock is generally mantled by overburden materials that were deposited by glacial ice, wind, and water. Locally, however, where glacial and postglacial materials are thin, the bedrock may be at or near the land surface. Shallow bedrock outcrops commonly occur in stream valleys in Northeastern Illinois where the overlying materials have been dissected and in areas of locally high relief on the buried bedrock surface.

Several types of layered bedrock directly underlie the glacial and postglacial materials in Northeastern Illinois. In the eastern portion of the region, the bedrock surface consists of Silurian age dolomite (S), which may contain small amounts of associated chert and shale. The Silurian dolomite was originally deposited as limestone in a shallow sea and later "dolomitized". Moving west across the area, successively older rocks lie at the bedrock surface. These include the Ordovician-age Maquoketa Shale (Om), which generally includes a middle carbonate unit, and the Galena Dolomite (Og), which may be locally shaly and grade into non-dolomitized limestone. In the southern and southwestern part of the region, the bedrock surface consists of a younger series of shales which are part of the Pennsylvanian-age Kewanee Group (Pk). These locally contain coal, sandstone, and limestone. The Kewanee Group is part of several sedimentary cycles

Table 1

Detailed Description of
Geologic Units Which Are Mapped in
Cook, DuPage, Kane, Lake, McHenry and
Will Counties Within 20 feet of Land Surface
(In Alphabetical Order)

Symbol	Description
ag	Accretion gley; local wash in poorly drained upland depressions of present surface; may include some loess and organic matter.
c	Cahokia Alluvium; flood-plain and channel deposits of present rivers and streams; consists mainly of poorly sorted silty clay and silty sand, locally contains lenses of sand and gravel, may include small areas of organic material.
e	Equality Formation (undifferentiated); medium to fine-textured water-laid silt, sand and clay, deposited in glacial lakes.
ec	Equality Formation, Carmi Member; largely underwater deposits in glacial lakes, mainly bedded silt with some fine sand, frequently laminated and containing beds of clay or silty clay, some massive.
ed	Dolton Member; largely shoreline deposits of glacial lakes, can include deltaic, near-shore-type deposits; mostly medium-grained sand with local lenses of sandy gravel along beaches and bars, some silt and clay where gradational to Carmi Member.
gl	Grayslake Peat; peat, muck and locally marl, dominantly sandy silty or clayey organic-rich material, frequently includes high percentage of recognizable plant remains.
h	Henry Formation (undifferentiated); sand and gravel with local beds of silt, ranges from coarse gravel to fine silty sand; locally poorly sorted and containing much silt and clay, till inclusions and boulders; locally equivalent to interbedded sand and gravel within Wedron Formation.
hb	Henry Formation, Batavia Member; sand and gravel deposited as outwash plains, mainly well sorted, can be stratified, coarse to medium-grained gravel and coarse to fine sand, locally finer textured near outer margins of deposit, gradational to the Mackinaw Member where valley trains open onto plains and occasionally gradational to Wasco Member near ice margins; mainly an upland deposit; can contain discontinuous local ponding deposits of silts and fine sands at the surface and lenses in the subsurface.
hm	Henry Formation, Mackinaw Member; sand and gravel deposited as valley trains, generally similar to Batavia Member in character, well sorted, evenly bedded; confined to valley positions, gradational to Wasco and Batavia Members.

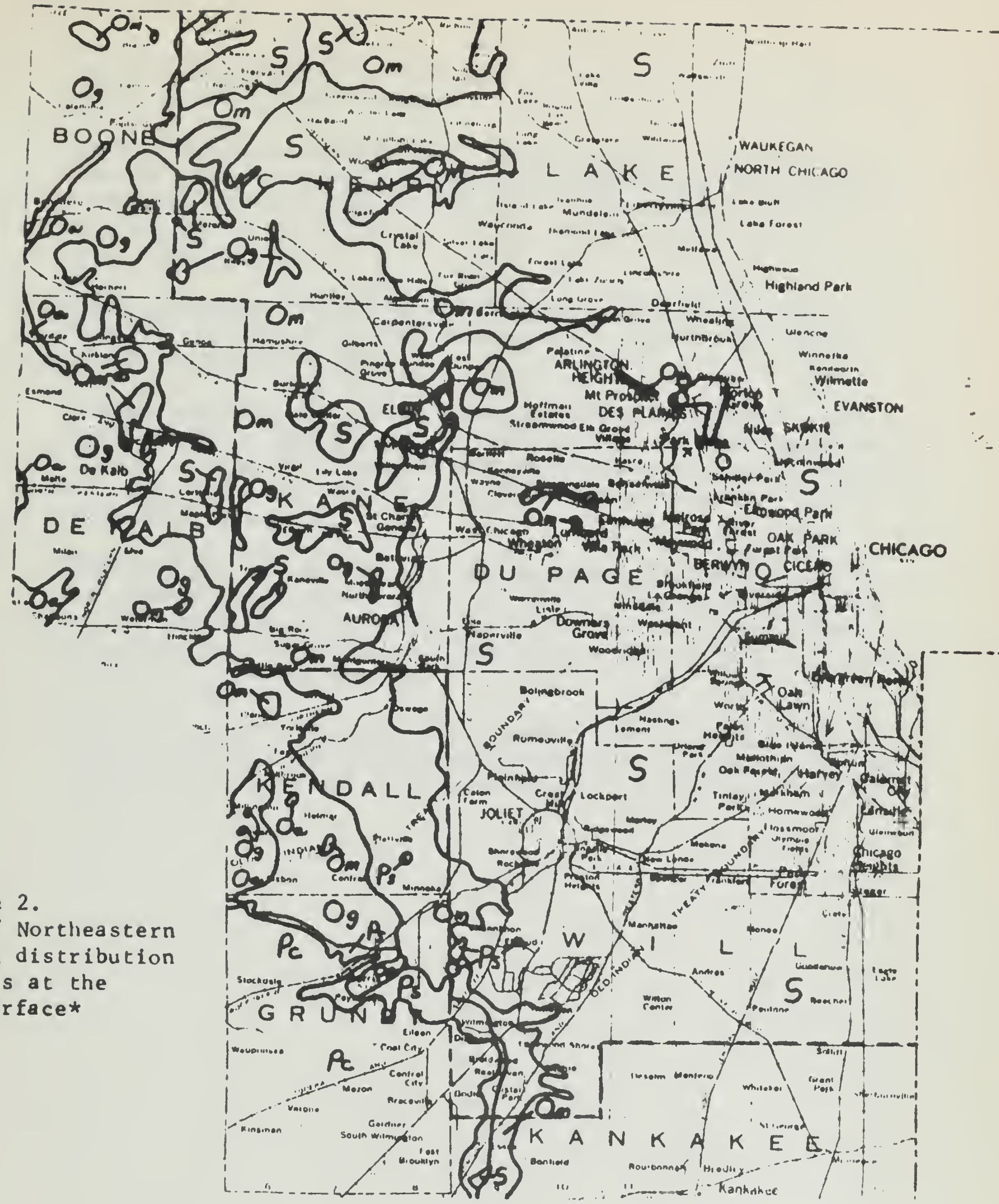


Figure 2.
ologic Map of Northeastern
inois showing distribution
of rock units at the
bedrock surface*

Mapped Units

Unit	Symbol	Age
Kewanee Group Shales	Pc, Ps	Pennsylvanian
Niagaran and Alexandrian Series Dolomite	S	Silurian
Maquoketa Group Shale	Om	Ordovician
Galena Dolomite	Og	Ordovician
Ancell Group Sandstone	Oa	Ordovician

*See Table 1 for descriptions of lithologies

northern margin; occasionally overlies sand and gravel (wm-o) within 20 feet of land surface.

w-o Wedron Formation, outwash undifferentiated; any subsurface continuous sand and gravel deposit, interbedded within the Wedron Formation, usually well sorted, may be locally poorly sorted with lenses of silt, clay and till. Ranges from coarse gravel to fine silty sand.

wy Wedron Formation, Yorkville Till Member; mostly dark gray to brownish gray clayey and silty clay till, calcareous, sparcely pebbly, generally uniform.

wy-a Wedron Formation, Ablation phase, Yorkville Till Member; gray brown to brown, pebbly, loam to clay loam till, frequently underlain or overlain by discontinuous sand and gravel or lacustrine silt and clay, includes flow tills; a discontinuous deposit overlying Yorkville Till.

wt-a Wedron Formation, Ablation phase, Tiskilwa Till Member; brown and pinkish brown pebbly sandy silt till, frequently underlain or overlain by sand and gravel or lacustrine silts and clays, discontinuous surface deposit overlying Tiskilwa Till, can include flows off the moraine.

ww Wedron Formation, Wadsworth Till Member; mostly gray clayey and silty clay till, calcareous, relatively low in pebbles, cobbles and boulders, low sand content in matrix, may contain local thin lenses of silt.

hw Henry Formation, Wasco Member; sand and gravel deposited as ice contact hills and ridges (kames, eskers and kame terraces), poorly sorted, irregularly bedded with variable grain-size; commonly contains lenses and masses of silt, clay and till; may be gradational to Batavia or Mackinaw Members.

lmr Lake Michigan Formation, Ravinia Sand Member; well sorted, largely medium-grained beach sand containing lenses of gravel, principally occurs as modern beaches along Lake Michigan.

m Made-land areas; includes major fills, filled channels, ponds, and reclaimed land areas along the Lake Michigan shoreline; also includes land reclaimed from past extractive operations where fill consists mainly of transported material (example: former clay pits utilized as sanitary landfills).

Og Galena Group, Wise Lake (top) and Dunleith Formations; mostly pure, medium- to thick-bedded, yellow-gray to tan dolomite above; thinner bedded, slightly less pure, and locally cherty dolomite below; limestone mottled with dolomite locally.

Om Maquoketa Group (Ordovician), Neda ~~Oolite~~ (top), Brainard Shale, Fort Atkinson Limestone, and Scales ~~Mound~~ Shale; red shale and oolite in local areas at the top; upper part largely greenish gray shale that in places grades laterally to silty argillaceous dolomite and dolomitic siltstone; limestone and dolomite with interbedded shale in middle part; largely gray to dark brownish gray shale in lower part.

Pk Kewanee Group (Pennsylvanian)-Carbondale (top) and Spoon Formation; largely shale and sandstone with thin beds of coal, clay and limestone.

pl Parkland Sand; wind-blown dune deposits; mainly fine-grained sand, may overlie or grade into similar materials (e.g., Equality, Dolton Member).

py Peyton Colluvium; mainly fine-grained slopewash along valley sides; consists of material derived from adjacent uplands by downslope gravity movement; original structure destroyed; gradational to Lacon (slump blocks) and Cahokia (valley alluvium).

S Silurian dolomite - Racine (top), ~~Waukesha~~, Joliet, Kankakee ~~and Edgewood~~ Formations; largely dolomite, slightly to moderately argillaceous with scattered chert nodules; Racine Formation contains large reefs of massive to well bedded pure dolomite, minor beds of shale and shaley dolomite in lower part and locally bordering reefs in upper part; partly limestone in places near Kankakee Valley; fills pre-Silurian valleys as much as 100 feet deep in Maquoketa Shale in some areas.

sm Land disturbed by extractive operations; includes coal strip

mines, quarrier, gravel pits, clay pits and spoil piles; depth of excavation and thickness and composition of spoil and fill variable but frequently similar to material removed for extractive operation.

w Wedron Formation (undifferentiated), mostly glacial till (a matrix of sand, silt and clay with pebbles, cobbles and occasional boulders imbedded), with interbedded layers and lenses of sand and gravel and silt, frequently separating till members but occasionally occurring within individual till members. Stratigraphically lies above Winnebago Formation and thin, discontinuous silt and organic silt of Robein Silt and locally below one or more of the above listed units.

wh Wedron Formation, Haeger Till Member; mostly yellowish brown to gray brown gravelly, silty sand till, calcareous, frequently thin and patchy over sand and gravel (wh-o). Marginal areas (McHenry, Kane) may include some stagnant ice features - thin tills with hills and ridges of sand and gravel and small poorly drained low-lying areas of equality, accretion gley and occasionally Grayslake Peat.

wh-o Wedron Formation, Haeger outwash; sand and gravel deposited as pro-glacial outwash, mainly well-sorted, clean, coarse to medium grained gravel and coarse to fine sand, fairly continuous within the extent of Haeger advance, "cut-off" at its margin and frequently exposed at the surface.

wia Winnebago Formation, Argyle Till Member; pinkish tan or salmon, sandy loam till, calcareous, can include lenses of sand and gravel and silt, found within 20 feet of the surface only in northwestern McHenry County.

wic Winnebago Formation, Capron Till Member; brown to pinkish gray sandy loam till, calcareous, generally uniform texture contains light brown silty phase below sandy plane in subsurface.

wic-a Winnebago Formation, Ablation phase, Capron Till; sandy and gravelly loam till which may have lenses and ridges of sand and gravel or lacustrine silts and clays; a thin, discontinuous surface deposit overlying Capron Till.

wic-o Winnebago Formation, Capron outwash; sand and gravel deposited as pro-glacial outwash, well-sorted, coarse to medium-grained gravel and coarse to fine sand. May be discontinuous beneath the till and is undifferentiated in places from overlying gravels in outwash plains.

w-l Wedron Formation; lacustrine undifferentiated; any subsurface lacustrine deposit within the Wedron Formation of unknown association.

wm Wedron Formation, Malden Till Member; mostly yellowish brown to gray sandy silt till, calcareous, pebbly, locally contains incorporated pinkish gray sandy silt till (Tiskilwa) mainly along

Time Stratig. System	Series	Stage	Rock Stratigraphy Megagroup	Group	Formation	Graphic Column	Thickness (Feet)	Kinds of Rock	
QUAT.	PLEIS				(See fig. 2 w)		0-350	Till, sand, gravel silt, clay peat marl loess	
PENN.	DESM			Kewanee	Carbondale		0-125	Shale, sandstone, thin limestone, coal	
					Spoon		50-75	As above, but below No 2 Coal	
MISS	VAL				Burl-Keokuk		0 700	Limestone	Only in Des Plaines Disturbance
	KIND				Hannibal			Shale, siltstone	
DEV	UP				Grassy Creek		0-5	Shale in solution cavities in Silurian	
SILURIAN	NIAGARAN		Hunton		Racine		0-300	Dolomite, pure in reefs, mostly silty, argillaceous, cherty between reefs	
				Sugar Run	~~Waukesha~~		0-30	Dolomite, even bedded, slightly silty	
					Joliet		40-60	Dolomite, shaly and red at base, white, silty, cherty above, pure at top	
	ALEX			Elwood and Wilhelmi	Kankakee		20-45	Dolomite, thin beds, green shale partings	
					~~Edgewood~~		0-100	Dolomite, cherty, shaly at base where thick	
ORDOVICIAN	CIN.	RICH		Maquoketa	Neda		0-15	Oolite and shale, red	
					Brainard		0-100	Shale, dolomitic, greenish gray	
					Ft. Atkinson		5-50	Dolomite, green shale, coarse limestone	
		MAY. ED.			Scales		90-120	Shale, dolomitic, gray, brown, black	
	CHAMPLAINIAN	TRENT.	Ottawa	Galena	Wise Lake		170-210	Dolomite, buff, pure	
					Dunleith			Dolomite, pure to slightly shaly locally limestone	
					Guttenberg		0-15	Dolomite, red specks and shale partings	
		BLACKRIVERAN		Platteville	Nachusa		0-50	Dolomite and limestone, pure, massive	
					Grand Detour		20-40	Dolomite and limestone, medium beds	
					Mifflin		20-50	Dolomite and limestone, shaly, thin beds	
					Pecatonica		20-50	Dolomite, pure, thick beds	
				Ancell	Glenwood		0-60	Sandstone and dolomite, silty; green shale	
					St. Peter		100-600	Sandstone, medium and fine grained; well rounded grains, chert rubble at base	
	CANADIAN		Knox	Prairie du Chien	Shakopee		0-70	Dolomite, sandy; oolitic chert; algal mounds	
					New Richmond		0-35	Sandstone, fine to coarse	
					Oneota		190-250	Dolomite, pure, coarse grained; oolitic chert	
					Gunter		0-15	Sandstone, dolomitic	
CAMBRIAN	CROIXAN	TREMP			Eminence		50-150	Dolomite, sandy	
					Potosi		90-220	Dolomite; drusy quartz in vugs	
		FRAN			Franconia		50-200	Sandstone, glauconitic; dolomite, shale	
					Ironton		80-130	Sandstone, partly dolomitic, medium grained	
		DRESBACHIAN			Galesville		10-100	Sandstone, fine grained	
					Eau Claire		370-570	Siltstone, dolomite, sandstone and shale, glauconitic	
			Potsdam		Mt. Simon		1200-2900	Sandstone, fine to coarse; quartz pebbles in some beds	
PRE-CAM								Granite	

Figure 1. Columnar section of bedrock units in Northeastern Illinois (~~from~~ after Willman, 1971).

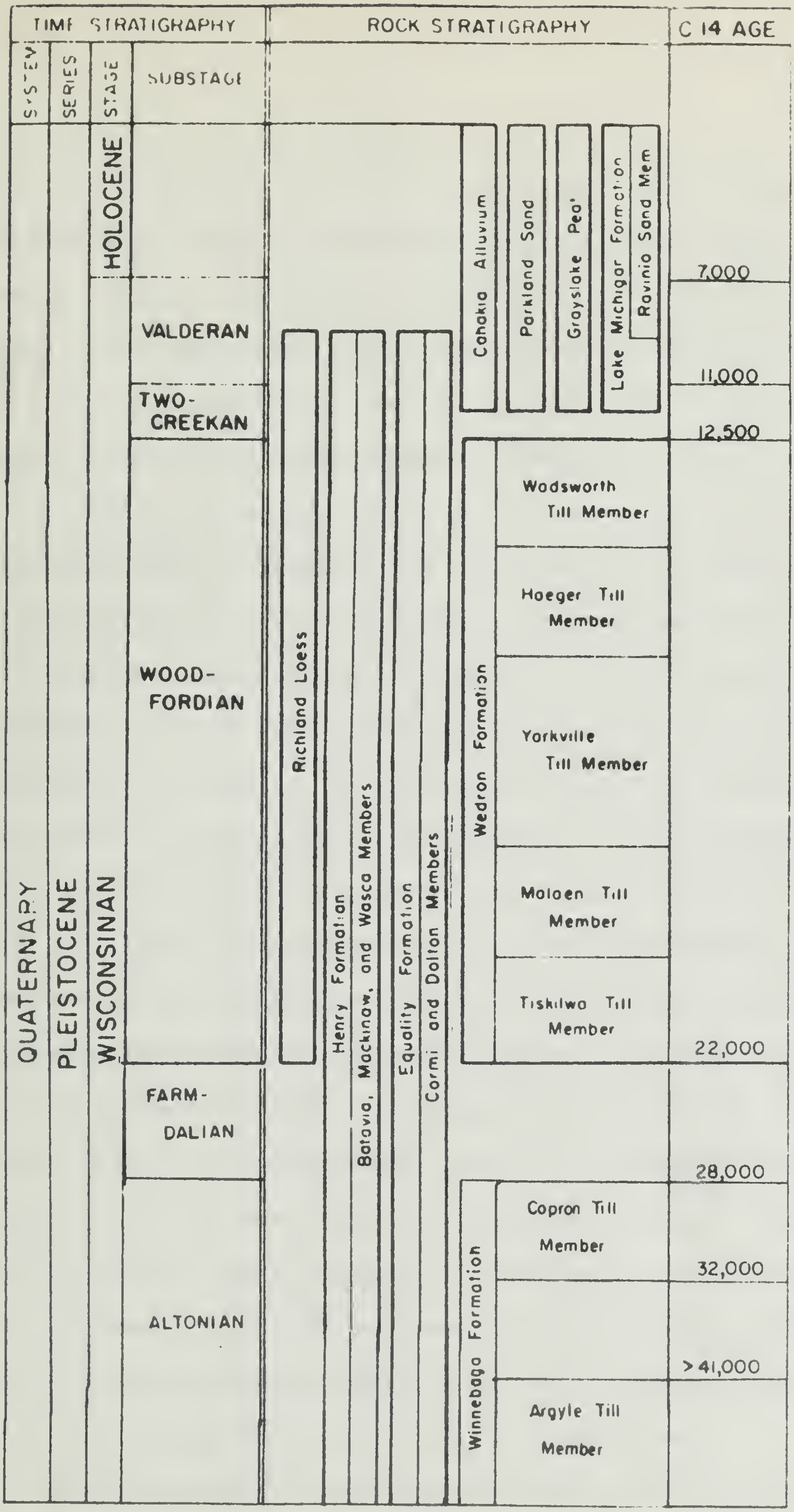


Figure 3. Classification of principal surficial Pleistocene materials of northeastern Illinois (after Willman and Frye, 1970).

associated with fluctuating shorelines in the central United States during the Pennsylvanian. For detailed information on the bedrock geology of Northeastern Illinois, see Figure 1 and Willman, 1971. A more detailed description of the upper bedrock units mapped in Northeastern Illinois is given in Table 1. A generalized geologic map, which shows the distribution of the upper bedrock units in Northeastern Illinois, is given in Figure 2.

Overlying the bedrock are the glacial and postglacial materials. These materials range in thickness from a few feet in the southern DesPlaines River Valley to over 470 feet (143 meters) in the northwest corner of McHenry County. The glacial materials were deposited during the Pleistocene Epoch, which extended from about a million years ago to about ten thousand years ago in Northeastern Illinois. During this period, most of the northern hemisphere above the 50th parallel was repeatedly covered by glacial ice. Ice sheets formed in sub-arctic regions four different times and spread outward until they covered the northern parts of Europe and North America. In North America the four glaciations, in order of occurrence from the oldest to the youngest, are called the Nebraskan, Kansan, Illinoian, and Wisconsinan Stages of the Pleistocene Epoch. In Northeastern Illinois all of the glacial deposits are thought to be Wisconsinan in age. The postglacial deposits are assigned to the Holocene Stage of the Pleistocene Epoch. Figure 3 illustrates Pleistocene time-stratigraphic relationships for Northeastern Illinois. Northeastern Illinois was invaded by glaciers from several directions, but the remaining glacial deposits are mainly the result of ice moving out of the Lake Michigan Basin during the late Pleistocene.

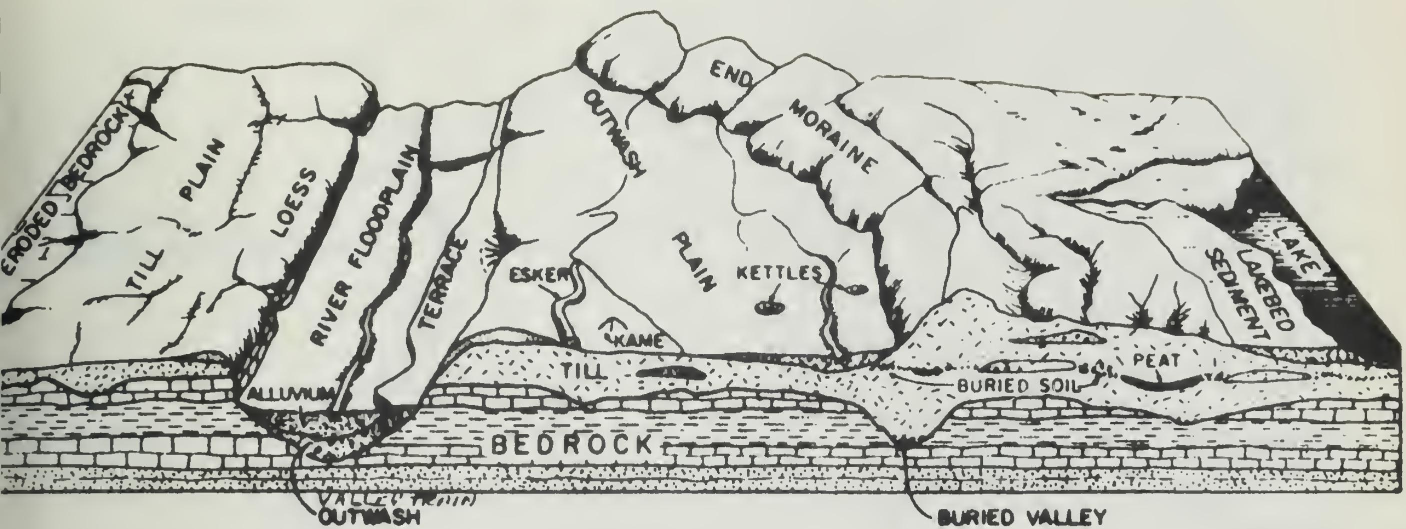
Pleistocene glaciers and their associated meltwaters changed the topography and drainage of the Northeastern Illinois landscape. The first

glaciers scraped and smeared the landforms of the bedrock surface. Later glaciers overrode the earlier glacial deposits and remaining areas of bedrock outcrop, leveling and filling many areas to create the flatter landforms of the Illinois prairie. The moving ice was able to transport large amounts of rock and earth, often for hundreds of miles.

The continual floods released by melting ice were able to entrench new drainageways and deepen existing drainageways; often, channels were subsequently refilled with sediments as great quantities of rock and earth were carried beyond the glacier fronts. The melting of a continental ice sheet provided a tremendous volume of water that eroded and transported sediments. In some areas, melting water was trapped by an ice dam or topographic barriers; in such cases, quiet water lakes were formed in which sediments also accumulated.

The deposits of earth and rock materials moved by a glacier and deposited in the area once covered by the glacier are collectively called drift. Drift that is ice-laid is called till. Water-laid drift includes fluvial (river) deposits, which are called outwash, and lacustrine (lake) deposits. The relationship of glacial drift to the glacial landforms discussed in this section is indicated in Figure 4. Figure 5 indicates the distribution of glacial deposits for the entire state.

Till, which is unsorted debris deposited directly by glacial ice, is the most abundant glacial deposit in Northeastern Illinois. It consists of pebbles, cobbles, and large boulders imbedded in a matrix of clay, silt, and sand. Tills deposited by each of the numerous glaciers which advanced across the area have physical properties that make them unique, enabling



Piskin, 1975

gure 4. Block diagram showing relation of glacial and alluvial deposits to landforms and bedrock surface.

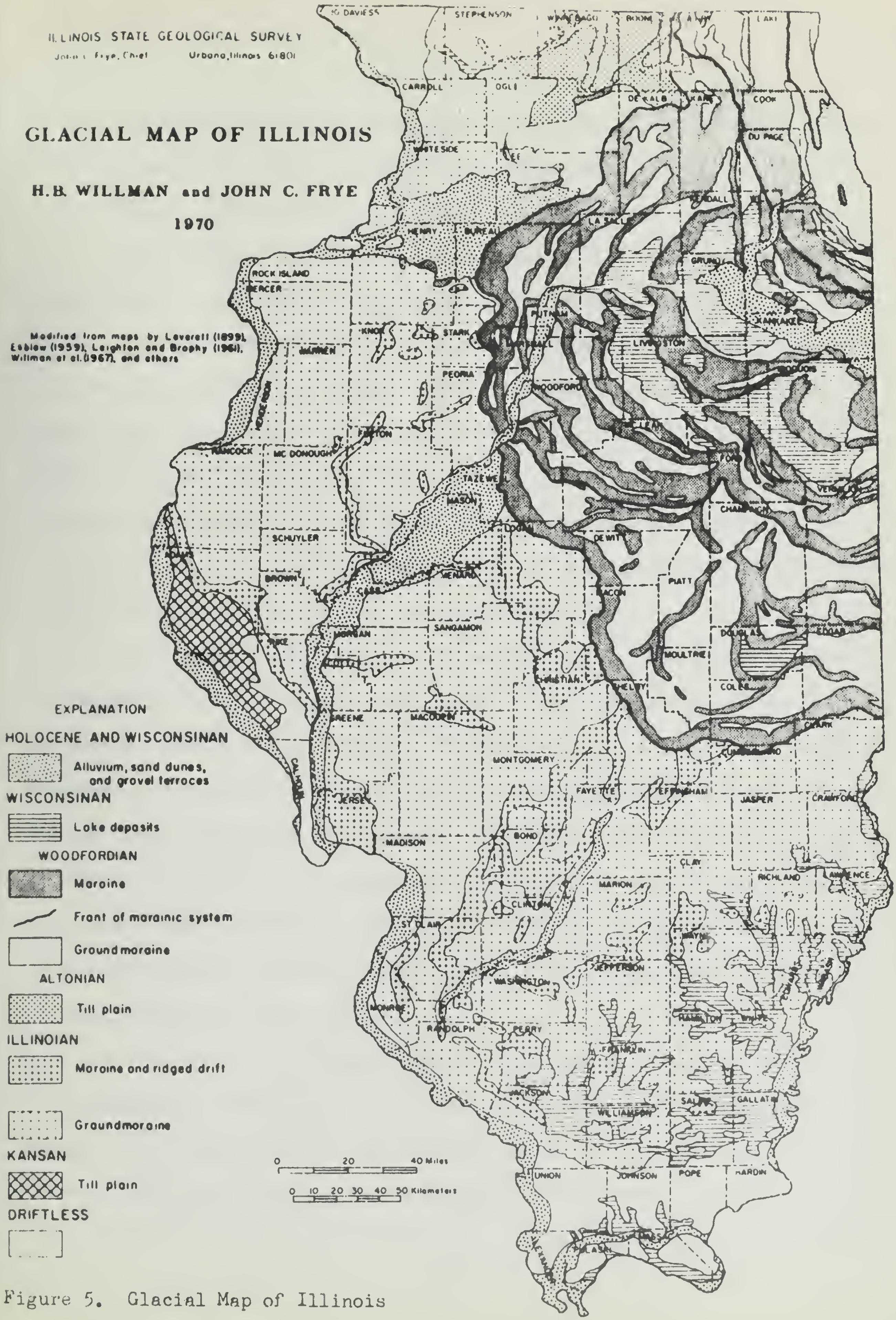


Figure 5. Glacial Map of Illinois

them to be distinguished from each other. Matrices of tills in Northeastern Illinois range in texture from silty clay (Wadsworth) to gravelly, silty sand (Haeger). Most of the tills mapped in Northeastern Illinois are members of the Wedron Formation, the youngest tills in Illinois; older Winnebago Formation tills (Argyle Member and Capron Member) occur only in northwestern Kane and western McHenry Counties. In order of decreasing age, the till units mapped in Northeastern Illinois include the Argyle (wia), the Capron (wic), the Tiskilwa (wt), the Malden (wm), the Yorkville (wy), the Haeger (wh), and the Wadsworth (ww). Figure 3, which indicated time stratigraphic relationships for the Pleistocene of Northeastern Illinois, also summarizes rock-stratigraphic nomenclature for the mapped till units. Table 1 gives detailed descriptions of the individual tills.

Tills may be deposited as recessional or end moraines, which are arc-shaped ridges deposited along a glacial margin where the flowing ice is melting as fast as it moves forward; they may also be deposited as ground moraines or till plains, which are gently undulating sheets deposited when the ice front melts back, or retreats. Deposits of till identify areas once covered by glacial ice. Northeastern Illinois has many alternating ridges and plains, which are the succession of recessional or end moraines and till plains deposited by the Wisconsinan glacier. See Figure 4 for an illustration of moraines and till plains.

Sorted and stratified sediment deposited by water melting from the glacier is called outwash. In Northeastern Illinois, outwash deposited during final deglaciation is collectively mapped as the Henry Formation (h). Outwash deposited between tills is indicated by the suffix -o added to its associated till name. Outwash is bedded, or layered, because it was deposited

by flowing water that varied in gradient, volume, velocity, and direction. As a meltwater stream transports sediments, it sorts them by size - the finer sands, silts, and clays are carried farther downstream than the coarser gravels and cobbles. Typical outwash in Illinois is in multilayered beds of clays, silts, sands, and gravels that can look much like modern stream deposits. For mapping purposes, a distinction is made between outwash deposited in river valleys as valley trains, which is mapped as the Mackinaw Member of the Henry Formation (hm), and outwash deposited as broad outwash plains, which is mapped as the Batavia Member of the Henry Formation (hb). A detailed description of both members is given in Table 1.

In addition to flowing away from the front of a glacier, meltwater streams also flowed under the ice, on the ice, and in crevices within the ice. In some places, the coarse sediment load of a meltwater channel through the ice is preserved, after deglaciation, as a sinuous ridge called an esker. Cone-shaped mounds of coarse outwash, called kames, were formed where meltwater plunged through crevasses in the ice or into ponds along the edge of the glacier. Kames and eskers are collectively mapped as the Wasco Member (hw) of the Henry Formation (Table 1). See Figure 4 for an illustration of kames, eskers, outwash plains, and other landforms composed of glacial outwash.

Some deposits that are formed during the melting or wasting of a glacier are not completely sorted by water and carried away as outwash. They do, however, undergo some movement and sorting and are called ablation drift. As the ice melts downward, rock debris that was frozen in the ice is left as a veneer on the ice surface; meltwater may cause this material to slump or slide down the surface of the ice. Thus, at the surface of a

till deposit, there is often a mantle of till-like materials that are less clayey and less dense than the underlying till; these materials may also contain poorly-sorted sand and gravel, waterlaid silt, and lacustrine or alluvial silt and sand. Both Kane and McHenry Counties contain extensive deposits of ablation drift. Ablation drifts are mapped by adding the suffix -a to their associated till. See Table 1 for descriptions of ablation drifts mapped in Northeastern Illinois.

Fine-textured lacustrine sediments, mainly clay and silt, were deposited in ponds and lakes that were located in glacier-dammed stream valleys, sags on till plains, and some low, moraine-diked till plains. In some areas, preserved ice blocks that were surrounded by outwash sediments eventually melted, leaving a "kettle" lake in which sediments could also accumulate. Meltwater streams that entered a lake quickly lost speed and almost immediately dropped the sands and gravels they carried, forming deltas at the edge of the lake. Very fine sand and silts were moved across the lake bottom by wind-generated currents; the clays, which stayed in suspension longest, settled out last. The deposits of postglacial lakes are collectively mapped as the Equality Formation (e). A distinction is generally made between the fine-textured lake bottom deposits, the Carmi Member (ec), and the coarser-textured shoreline and delta deposits, the Dolton Member (ec). Older lacustrine deposits are mapped with their associated till and indicated by the suffix -l. See Table 1 for descriptions of lacustrine deposits mapped in Northeastern Illinois.

Some of the silty and sandy sediments deposited during glacial or postglacial times were carried not by ice or water but by wind. Wide-

spread deposits of windblown silt (with minor amounts of clay), which were blown from the floodplains of major outwash streams, are called loess. Loess is generally thin across most of Northeastern Illinois, but the surficial Richland Loess (ri) is mapped in Kane County where it attains thicknesses greater than five feet (1.5 meters). See Table 1 for a description of the Richland Loess. Windblown sand is also locally present in Northeastern Illinois. It occurs near the present shoreline of Lake Michigan; former shorelines of Lake Michigan's ancestor, Lake Chicago; and in southwestern Will County. Windblown sand is collectively mapped as the Parkland Sand (pl). Table 1 gives additional descriptions of the windblown sediments.

Other types of postglacial materials, some of which may contain significant amounts of organic material, are also present in Northeastern Illinois and are described in Table 1. The deposits of modern rivers and streams are collectively mapped as the Cahokia Alluvium (c), which includes sediments deposited both in the valleys and on the floodplains. The alluvial (river) deposits include both fine and coarse-textured sediments but may locally contain some organic material. Deposits that consists mainly of organic peat and muck are mapped as the Grayslake Peat (gl). Sediments found in shallow, poorly drained depressions are mapped as accretion gley (ag), while sediments along stream valleys which accumulated as a result of slopewash and other downslope gravity movements are mapped as Peyton Colluvium (py). Both accretion gley and colluvium may contain a significant percentage of organic matter. Organic-rich alluvium, muck, peat, accretion gley, and colluvium may all locally grade into each other.

Modern lacustrine (lake) sediments are also present in Northeastern Illinois. The deposits associated with large modern lakes are collectively mapped as the Lake Michigan Formation (lm). Individual members of the Lake Michigan Formation may also be distinguished; an example is the Ravinia Sand Member (lmr), which includes modern beach sands.

Finally, man's contributions to geologic materials in Northeastern Illinois must be considered. In this report, major fills and made-land areas (m) are distinguished from areas disturbed by extractive operations (sm) such as quarries, gravel pits, clay pits, and coal strip mines. See Table 1 for more detailed descriptions.

To summarize, the geologic setting of Northeastern Illinois reflects the diverse physical environments of the area over many millions of years. Over the vast majority of the area, the deposits of the last 20,000 years are the most abundant; these include most of the glacial and postglacial materials mapped in Northeastern Illinois. The next section will discuss the significant physical and mineralogical properties of these geologic materials.

PHYSICAL AND MINERALOGIC PROPERTIES OF GEOLOGICAL MATERIALS

Tables included with each individual county report summarize the range (R), number of samples (n), and average values ($\overline{X}$) of physical and mineralogic data for all of the mapped geologic materials except the bedrock units. The textural and mineralogic data were obtained from samples tested and analyzed by the Illinois Geological Survey Staff. The strength and index properties related to engineering performance were obtained from field and laboratory test results included with borings on file at the ISGS;

these borings are from a variety of engineering projects in the study area.

Textural (grain-size) data are given in terms of relative percentages of gravel (> 2mm), sand (.0625-2mm), silt (.0625-.0039mm), and clay (< .0039mm). The percent gravel is based on the entire sample as 100 percent; however, the relative percentages of sand, silt, and clay are based on the < 2mm fraction as 100 percent after the gravel has been removed. A combined sieve-hydrometer technique was used.

The mineralogic data consist of the results of X-ray diffraction work on the clay fraction of units which contain a significant percentage of clay. A semiquantitative determination of the relative amounts of various types of clay minerals can be made by ratioing their respective peak heights multiplied by appropriate absorption coefficients (Glass, personal communication). A total sample (100%) is subdivided into the percent montmorillonite and other expandables (clays that expand to 17Å upon treatment with ethylene glycol), the percent illite (10Å), and the percent kaolinite plus chlorite (7Å). In addition, the relative amounts of dolomite and calcite in the clay fraction can be estimated by their relative peak heights; these are included simply as ratios of D (dolomite) to C (calcite). Most of the glacial tills and related water-laid materials in Northeastern Illinois have clay fractions which contain a high percent of illite; they also contain more carbonate as dolomite than as calcite.

Tables included with each county report also indicate the mean ($\overline{X}$) and range (R) of selected strength and index properties for the mapped geologic materials; these tests are valuable to the civil engineer, who is

concerned with the behavior of earth materials under certain natural or imposed conditions. Tests to determine index properties generally enable the engineer to easily classify geologic materials by indicating the consistancy of the soils. Included in these properties are strength tests which indicate the relative strengths of geologic materials. Strength tests may be performed under the approximate conditions anticipated for a particular project. Samples of geologic materials are commonly subjected to a series of standardized strength and index tests to classify materials and to provide input for engineering design calculations. In this report, available data on the dry weight percent water content (w), standard penetration test (N), and unconfined compressive strength (qu) are summarized for geologic materials mapped in each county.

The standard penetration test (N) is a field sampling procedure; the unconfined compressive strength test (qu) is a laboratory procedure. The standard penetration test (N) is the most common sampling procedure for hard or granular materials; although it may also be obtained for soft cohesive materials. Qu's are commonly obtained for softer materials with a high degree of cohesion. The N value is the number of blows required by a 140 pound (63.6 kg) weight dropping 30 inches (.76 meter) to drive a standard split barrel sampler (2 inches or 5cm outside diameter) a distance of one foot (.3 meter). The unconfined compressive strength of undisturbed samples is determined by loading a relatively undisturbed thin-wall tube sample at a constant rate to 20 percent strain or failure, whichever occurs first; qu values in this report are expressed in tons per square foot (TSF). Approximate qu values can be obtained with a pocket penetrometer or a RIMAC spring tester. For purposes of this study, both laboratory test results

and approximated test results (penetrometer or RIMAC) were averaged together because there was a paucity of any one type of data. Such a technique tends to give a wide range of qu values. For units which were sampled with both thinwall tubes and split barrel samplers, both qu and N values are given. The American Society of Testing and Materials (ASTM) prescribes standardized sampling and testing procedures for obtaining N and qu values; for reference, the latest revision of the following ASTM designations should be consulted:

1. Split barrel sampling and standard penetration test: ASTM D-1586
2. Thinwall tube sampling: ASTM D-1587
3. Unconfined compression test: ASTM D-2166

The water content (w) of a particular sample is the weight of water divided by the total weight of solids. For information on the correct procedure for determining water contents, refer to the latest revision of ASTM D-2216.

HYDROGEOLOGIC FRAMEWORK OF NORTHEASTERN ILLINOIS, INCLUDING WELL CHARACTERISTICS

In order to evaluate the criteria and maps pertaining to waste disposal practices and recharge-discharge characteristics, it is necessary to have a working knowledge of some basic hydrogeologic principles and how they apply to Northeastern Illinois. General references for this section are Suter _et al._, 1959, and Hughes, Landon, Farvolden, 1971. In Northeastern Illinois, ground water is derived from precipitation that falls mainly as rainfall and seeps into the ground. The water infiltrates through loose particles of the soil and percolates downward. This process is illustrated

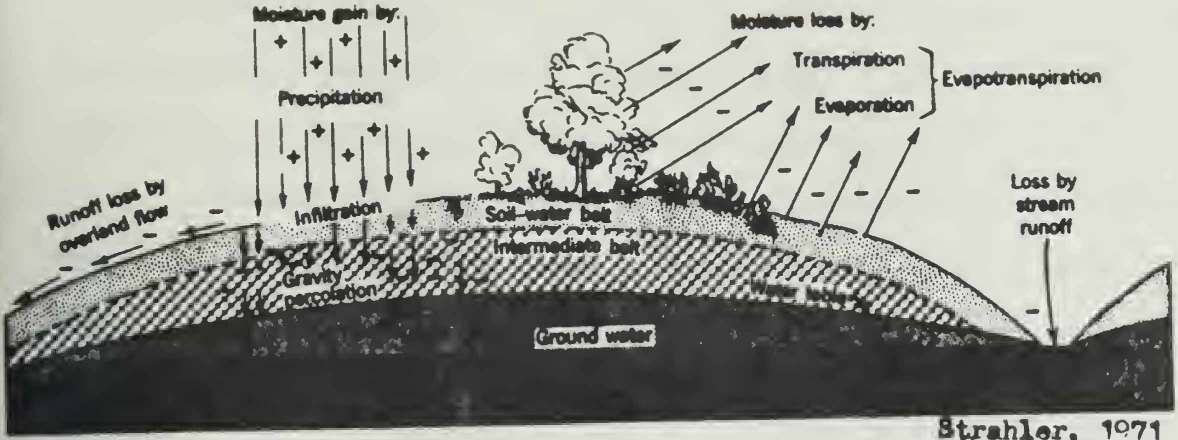
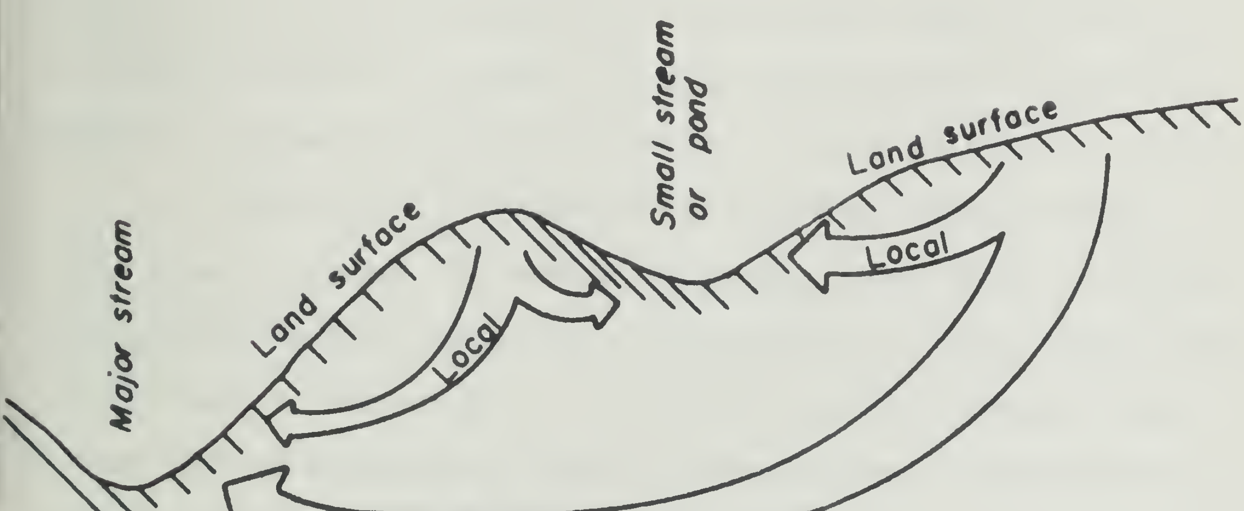


Figure 6a. Hydrologic cycle in Northeastern Illinois



Cartwright & Sherman, 1969

Figure 6b. Concept of superimposed local and regional flow systems in Northeastern Illinois

in Figure 6a. Below a certain depth, which is called the "top of the zone of saturation" or "water table", almost all openings (pores) in the earth materials are filled with water. A few pore spaces are filled with gases. Ground water is defined as water in the zone of saturation.

Openings in which ground water is stored in the zone of saturation range 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 refers to its pore space and is expressed quantitatively as the percentage of total volume. Earth materials that have interconnected openings large enough to store and transmit water readily into a well or spring are called aquifers. The relative ease with which an earth material transmits water under pressure is called its hydraulic conductivity or permeability. Permeability refers to the ability of an earth material to transmit any fluid, while hydraulic conductivity refers to a property of both the material and the fluid (Domenico, 1972).

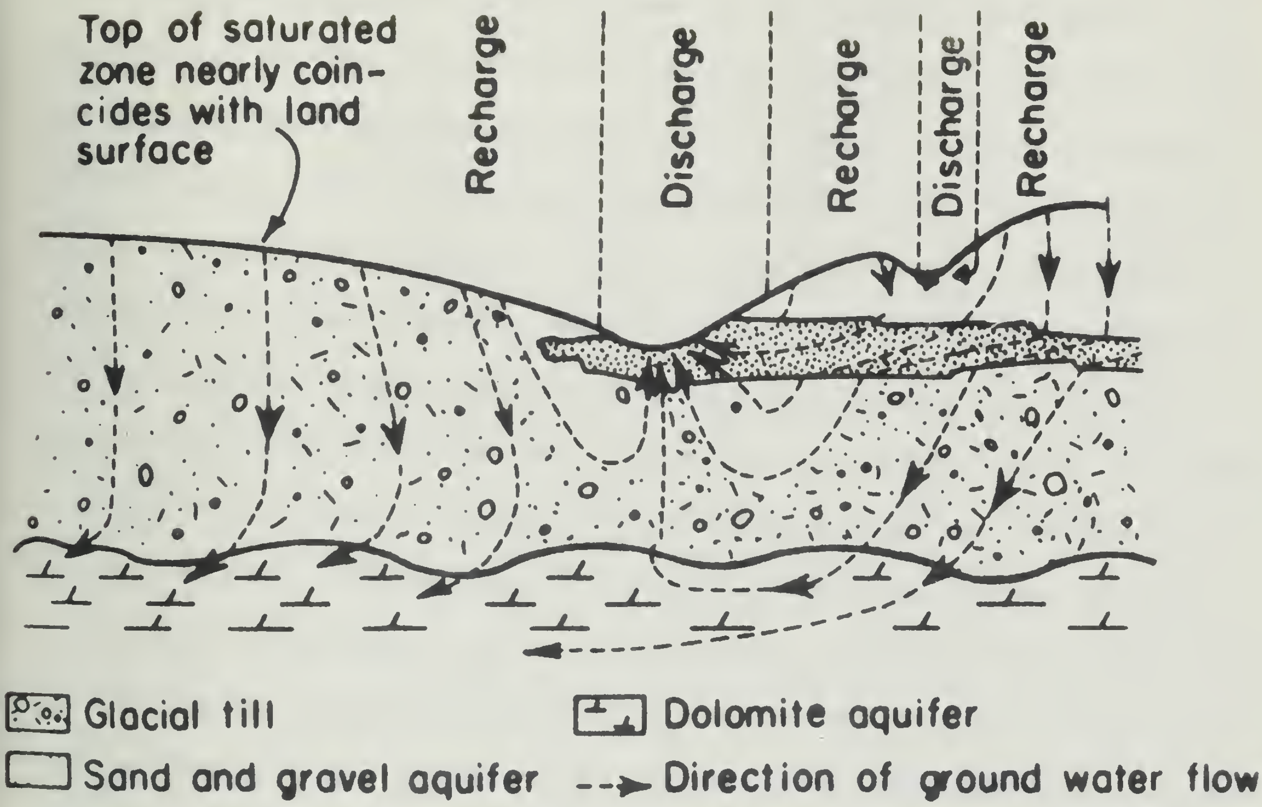
Under natural conditions in Northeastern Illinois, the water table roughly parallels the surface topography, rising under the uplands and intersecting the ground surface along perennial streams, lakes, swamps, and springs. At these points of intersection, called discharge areas, ground water is discharged by gravity flow from adjacent areas where the water table is higher. This is also illustrated in Figure 6a. The position of the water table and the discharge of ground water to streams fluctuate from season to season and year to year.

The process of addition of water to the ground-water reservoir is called recharge. A ground-water "flow system" describes the progres-

sive movement of water through the earth from recharge areas to discharge areas. While the driving force for ground-water movement is gravity, the direction of ground-water movement is a function of potential (or energy). The path that ground water follows through the earth from the recharge to the discharge area may be thought of as imaginary lines of flow (Fig. 6b, 7). This path may have both vertical and horizontal components at any given point in the system. 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 acting as a discharge area for the uplands immediately adjacent to it, which would be 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 DesPlaines River or the Fox River. Figure 6b illustrates the concept of local and regional flow systems. Figure 7 gives an example of a hypothetical flow system in Northeastern Illinois.

To supply a well, ground water must move through an aquifer toward the well. Under water-table conditions, pumping lowers the water table in the vicinity of the well and induces the flow of ground water toward the well from adjacent areas. The lowering of the water table that results from pumping is in the form of an inverted cone (with the well at the center) and is called the "cone of depression" (see Figure 8, Well 1 Example). In this example, a saturated surficial sand and gravel deposit forms a water-table (unconfined) aquifer; there are several areas in Northeastern Illinois where these conditions exist.

If a permeable water-bearing formation, or aquifer, is confined



ure 7. **A hypothetical flow system that could exist in northeastern Illinois.**

Hughes, Landon, Farvolden, 1971

between nonpermeable beds and water is supplied to it from a higher elevation, the water is confined under hydraulic pressure. When such an aquifer is penetrated by a well, water will rise above the aquifer in the well to a height equal to the hydraulic head of the aquifer; this height is a hypothetical surface called the "piezometric surface". Ground water that is confined under pressure in this manner is said to be under "artesian conditions". Wells penetrating such aquifers are called "artesian wells" (see Figure 8, Well 2 example). This example is directly applicable to the Silurian dolomite (shallow bedrock aquifer) in Northeastern Illinois. If the hydraulic head is above land surface at the well, the well will flow. Under artesian conditions, pumping in the vicinity of the well causes a reduction of hydrostatic pressure that induces the flow of ground water toward the well. The aquifer under artesian conditions is not dewatered but remains full because the discharged water is derived by the compaction of the aquifer and associated beds, by the expansion of the confined water, and by flow from the recharge area. It should be noted that major recharge areas may be many miles from the area where the aquifer is being pumped. The reduction of artesian pressure, i.e., the depression of the piezometric surface, in the vicinity of the well that results from pumping an artesian aquifer is also called the cone of depression. In Northeastern Illinois, the shallow and deep bedrock aquifer system and some sands and gravels confined between glacial tills exhibit artesian conditions.

Measurement of the elevation of the zone of saturation (unconfined conditions) or of the piezometric surface (artesian conditions) is made by determining the water levels in wells. Two types of water levels

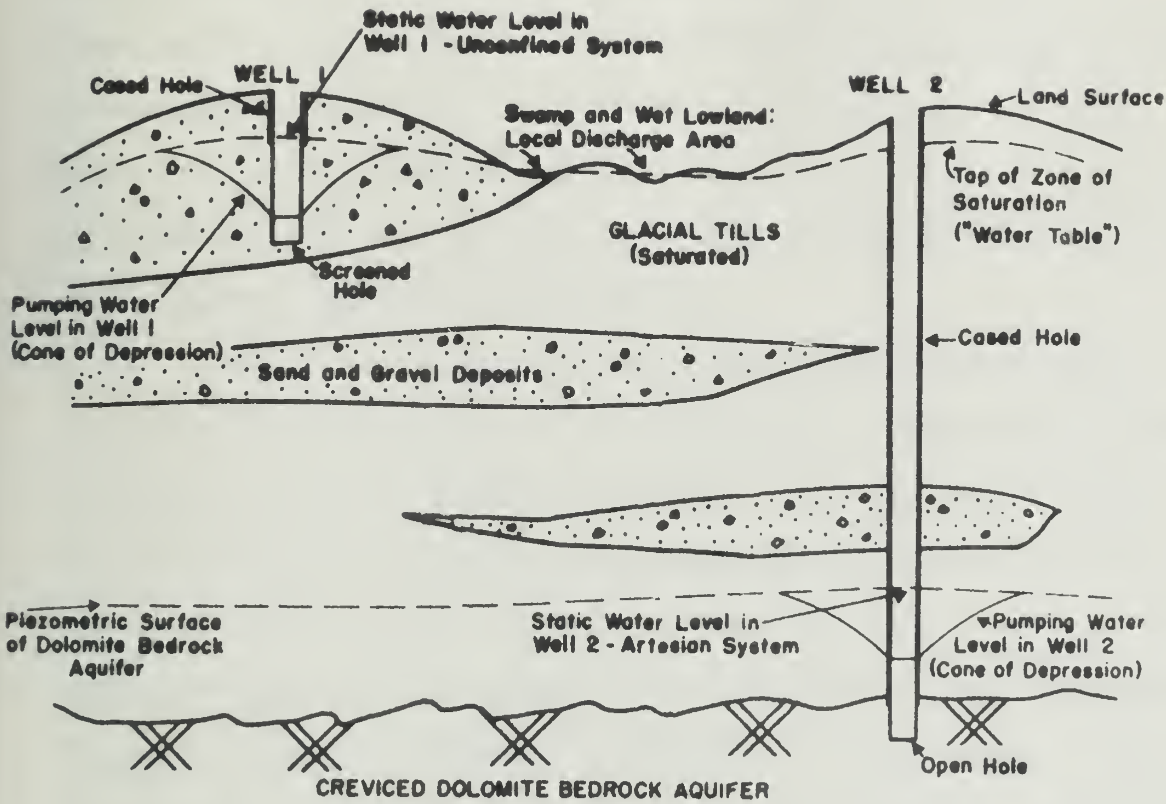


Figure 8. Wells penetrating unconfined (Well 1) and artesian (Well 2) aquifers in Northeastern Illinois

are recognized: nonpumping (static) levels and pumping levels. The "nonpumping (static) level" is the level at which the water stands in a well not influenced by pumping in the immediate vicinity of the well. The static level may change over long periods of time, and it may also be affected by regional pumpage and changes in barometric pressure. It is of great importance in evaluating the water resources of a region. The "pumping level" is the level to which the water surface lowers in wells during pumping; that is, it is the level of the cone of depression. This level reflects the change in pressure required to move water to the well, and depends on the rate and duration of pumping, permeability and thickness of the aquifer, and well characteristics.

The difference between the nonpumping level and the pumping level in a well is called "drawdown". The drawdown is a temporary lowering of the water level due to pumpage in the well. When the pump is stopped the water level rises. This rise in the water level is called "recovery". A continued lowering of the nonpumping level of a region is called a water level "decline". Declining water levels are usually caused by excessive pumpage, diversion of recharge, or drought. In Northeastern Illinois, water levels are generally declining due to heavy pumpage. Details are given in Suter _et al._, 1959; Zeizel _et al._, 1962; and Sasman _et al._, 1973.

MAPPING METHODS AND PROCEDURES

Geologic Materials in Northeastern Illinois to a Depth of 20 Feet (6.1m)

The purpose for which a geologic map is to be used dictates the types of data used, the method of classification of the geologic materials,

and the scale and method of mapping. For this study, the most important information on each recognizable and identifiable geologic material includes its physical and mineralogical properties, its thickness and area distribution, and its relationship to other geologic materials. Since geologic materials were deposited with the oldest materials at the bottom and the youngest materials on top, and each unit has certain recognizable characteristics based on the process by which it was deposited (ice, water, wind), it is possible to extrapolate or predict from relatively scattered data the occurrence of each material and show its occurrence on a map. Since some geologic materials are more uniformly distributed, more extensive and/or more easily identified than others, such units provide the framework within which the remainder can be placed.

For this study certain basic guidelines for the preparation of the geologic materials map have been established. These include:

1. All recognizable geologic units (Table 1) which occur within 20 feet (6.1m) of the land surface are mapped. In general, surface units less than five feet (1.5m) thick or subsurface units less than three feet thick (.9m) are not mapped. In addition, the upper three feet (.9m) is not directly considered where it contains the modern agricultural soil (solum).

2. Each geologic unit known or thought to be present within the upper 20 feet (6.1m) is shown by its symbol (Table 1) alone or in proper sequence with other units.

3. The boundaries established for each surface or subsurface unit are based on available data from outcrops, boreholes, man-

made excavations, and USDA Soil Conservation Service soils maps. The USDA maps provide information on the distribution of the soil parent materials to a depth of approximately 5 feet (1.5m). In some instances, surface features shown on the USGS 7½ minute quadrangle topographic maps or aerial photographs indicate rather accurately the boundaries of certain materials.

4. A geologic unit is mapped in parentheses, e.g., (wm) if: (1) it is thin and irregularly distributed; or (2) data are sparce, and the boundaries of small areas of that unit cannot be accurately drawn. The parentheses indicate that the underlying unit should be considered the principal map unit since it is the most predictable in occurrence. In some cases, the lowermost unit for a given area is in parentheses; this signifies that the unit may or may not be present within 20 feet (6.1m) of the surface, but it is generally thought to be present at depths below 20 feet (6.1m).

5. As a general rule, not all geologic units mapped in a given area may actually be present. The geologic materials map is actually a probability map. In general, there is about a 75 percent or greater chance that a given unit may be present when mapped. When a unit is shown in parenthesis, there is probably only about a 25 percent chance that it will be present at a given location. There is probably less than a 25 percent chance that units <u>not</u> mapped are present at any given location. Although there was generally sufficient data for compiling the

geologic materials maps, several factors contributed to the probabilities of given units being present or absent at a given location: the areal distribution of the data, the regional consistency of individual units, and the general landscape position of particular units. Areas which contain a wide range of materials or areas near or at mapped boundaries are especially subject to differing interpretations as new data become available.

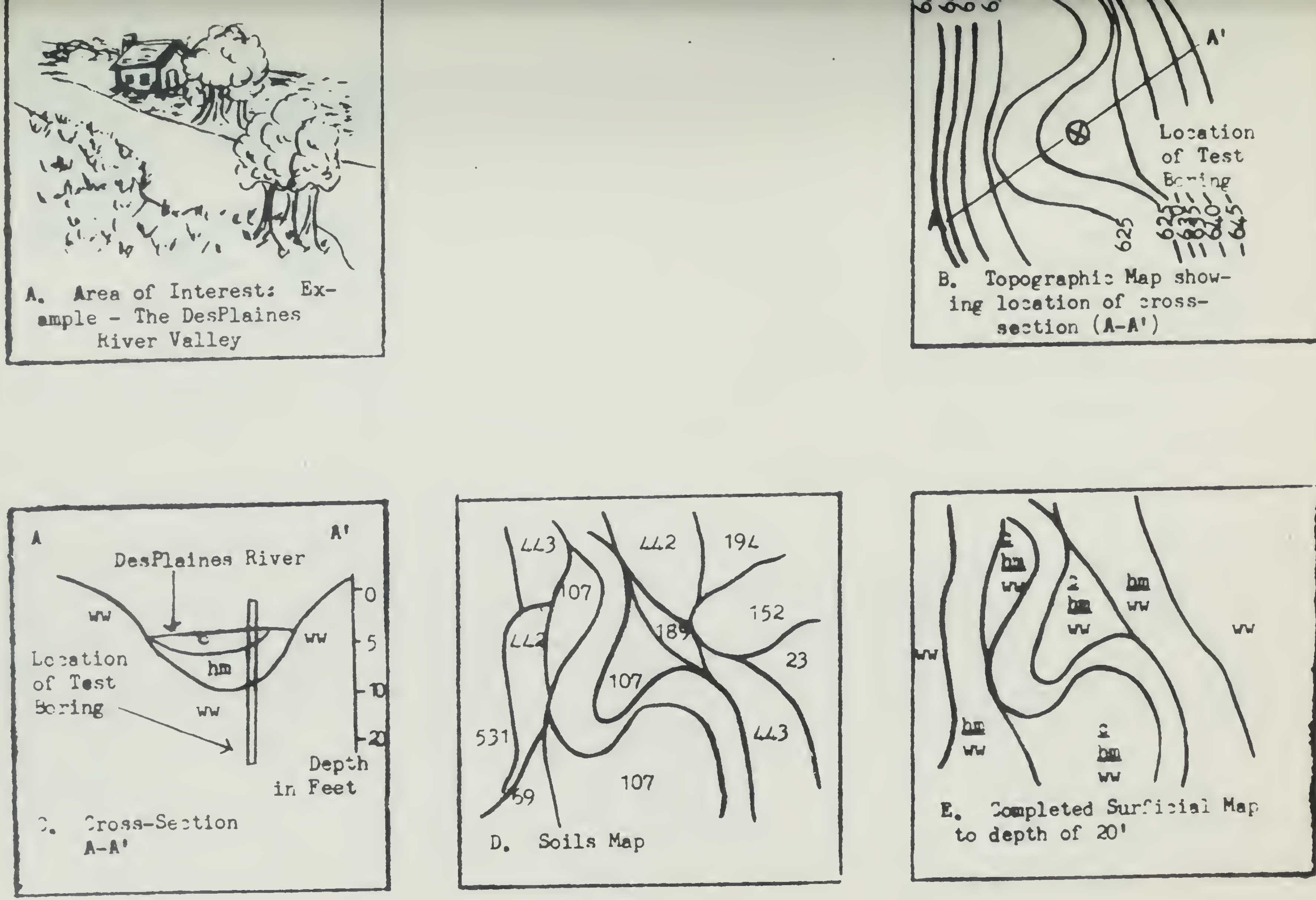
The general procedure for preparing the geologic materials map is shown in Figures 9a and 9b. Figure 9a is a hypothetical section of the northern Des Plaines River Valley, which contains both valley train outwash (hm) and modern alluvium (c) in a till (ww) valley; Figure 9b is a hypothetical upland area in North Central Kane County where the glacial deposits consist of a complex of till (wt), ablation drift (wt-a) valley train (hb) and kamic (hw) outwash, and peat (gl). See Table 1 for unit descriptions. In both figures, the general sequence of steps in preparing the geologic materials map is shown in five steps:

(A) Collect all field data and previous mapping in area. Sketch (A) illustrates the local terrain.

(B) Collect the most recent USGS 7½-minute quadrangle topographic maps for the area and plot existing data, both surface and subsurface.

(C) Sketch or visualize cross-sections through the area of interest, utilizing existing surface and subsurface information.

(D) Collect soil survey maps from USDA Soil Conservation Service and compile the mapped soil series into parent material groups.



A. Area of Interest: Example - The DesPlaines River Valley

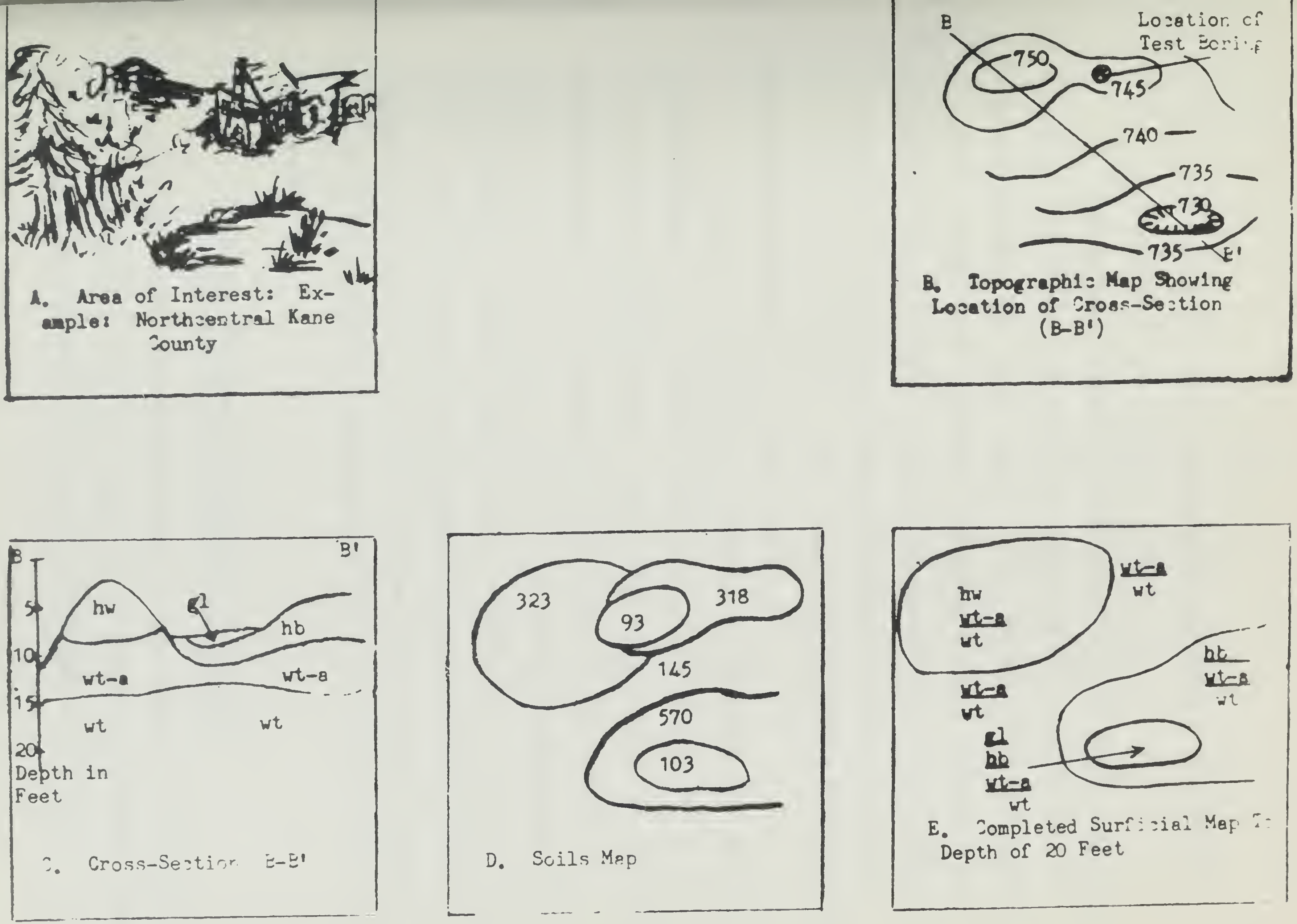
B. Topographic Map showing location of cross-section (A-A')

C. Cross-Section A-A'

D. Soils Map

E. Completed Surficial Map to depth of 20'

Figure 9. Surficial Mapping to Depth of 20 Feet. Example a.



A. Area of Interest: Example: Northcentral Kane County

B. Topographic Map Showing Location of Cross-Section (B-B')

C. Cross-Section B-B'

D. Soils Map

E. Completed Surficial Map To Depth of 20 Feet

Figure 9b. Surficial Mapping to Depth of 20 Feet. Example E.

(E) After all data is plotted and evaluated, draw the final boundaries on the geologic materials map.

When all USGS 7½-minute quadrangle sheets covering a particular county were completed, each sheet was reduced to the 1:62,500 scale of the ILLIMAP county base (Swann et al., 1970), and all boundaries and map units were transferred onto the base. Because of scale limitations, all data points and the location of smaller mines, quarries, and pits were recorded only on the 7½-minute quadrangles and not transferred to the 1:62,500 scale county bases. Larger areas of made land and pits or quarries are, however, outlined on the county bases.

Finally, it should be stressed that the geologic materials maps are not intended to be used at a scale larger than the 1:24,000 scale of the 7½-minute quadrangle sheets. Even though these maps can be considered excellent guides to the materials and conditions that are present in a given area, they are subject to all of the limitations described above and do not presume to replace individual site investigations for specific projects. Generally speaking, the geologic materials maps should indicate all of the regional and some of the localized units that are encountered in a given area; accuracies decrease when regional units tend to be discontinuous.

Principal Terrains in Northeastern Illinois and Generalized Recharge-Discharge Characteristics

The nature of ground-water flow is significant to regional planning. Information on local and regional flow systems is pertinent to the evaluation of ground-water resources, the transmission of potential con-

taminants into the ground-water reservoir, the preservation of belts of natural recharge, and the designation of areas for artificial recharge. For this report, only very generalized maps, which show idealized shallow flow systems, have been made; these were based on regional terrain analysis. Stated very simply, terrain analysis relates geologic materials and topography to an idealized regional concept of shallow flow systems. There were basically two reasons for this approach: (1) long-term water level records for wells penetrating the glacial drift and shallow bedrock aquifers were not available; and (2) the complexities of local and regional flow systems in the shallow aquifers did not lend themselves to attempts at three dimensional mapping. Later sections of this report will specifically consider the application of the terrain maps to problems of waste disposal and the identification of ground-water resources in the various counties.

Terrain analysis consists of, first, outlining major uplands, intermediate areas, and lowlands; and secondly, integrating the relative hydraulic conductivities (permeabilities) of geologic materials with their terrain position. Uplands are generally characterized by relatively steep slopes (greater than 4%) underlain by glacial till or sand and gravel; intermediate areas are generally flat to rolling plains underlain by a wide range of materials; and lowlands generally include valleys or poorly drained areas often underlain by medium to coarse textured materials. As discussed previously, shallow unconfined flow systems in Northeastern Illinois are generally recharged by rainfall infiltrating into upland and intermediate area surfaces; this is especially effective when these surfaces

are underlain by relatively permeable materials. Shallow flow systems generally discharge into local or regional surface water bodies, which are located in lowland terrain areas.

The generalized terrain for each county is shown on a map included with each county report. Each map delineates upland, intermediate, and lowland areas, as well as areas underlain by sand and gravel. The terrain maps for each county are conceived as intermediate steps in producing a regional map that will provide the bases for evaluating the regional shallow ground-water systems. In the past, designation of prime natural recharge areas has often concentrated only on the nature of the surficial materials, without taking into consideration their relative hydrogeologic position. It is therefore our intent to assemble all county terrain maps when completed and evaluate both the surficial materials and regional terrain characteristics to establish if the uplands and portions of the intermediate areas (plains) can be identified as regional recharge areas. In addition we will attempt to indicate areas which may be suitable for artificial recharge to shallow aquifers. However, such mapping implies additional considerations beyond those necessary for determining regional recharge areas. These include: (1) a potential source of water for recharge, (2) reservoir and aquifer storage capacity, and (3) the need to concentrate artificial recharge operations in areas where water levels have been lowered by heavy pumpage. To the extent these factors can be evaluated, areas suitable for artificial recharge will be delineated.

Poorly Drained Soils in Northeastern Illinois

From the standpoint of land use, soil drainage conditions are

one of the most important considerations for planning decisions in Northeastern Illinois. There are many factors which influence soil drainage in Northeastern Illinois; some of these factors are 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 position with respect to local and regional ground-water flow systems and surface water drainageways. In addition, man may influence soil drainage characteristics by the disruption of natural drainageways to cause localized ponding or the placement of agricultural tile to promote drainage. In some cases, the disruption of agricultural tile systems by construction operations may cause an area to revert back to its natural poorly-drained condition.

A map is included with each county report which shows one aspect of the surface drainage conditions in Northeastern Illinois; namely, the areas of poorly drained soils as interpreted from the latest USDA Soil Conservation Service soil survey maps. Soil development reflects drainage conditions through time and therefore the areas that are naturally poorly drained have developed specific mappable characteristics. Areas which are mapped as poorly drained include: (1) areas where the soil parent materials are peat or organic sediments formed in or adjacent to lakes; (2) areas where the parent materials are largely inorganic sediments formed in small shallow depressions; and (3) areas of relatively impermeable sediments where soils have developed on nearly flat surfaces with limited surface drainage. In the latter areas, shallow water table conditions during wet years supplemented by periods of intense rainfall may result in standing water in the low areas. During the dryer years, these areas may give no

surface indication of poor drainage and therefore may be highly misleading to developers.

The areas of poorly drained soils also include many small or large drainageways, most of which are local or regional discharge areas and are also subject to periodic flooding. Such areas are shown on the USGS Flood Hazard Maps (Hydrologic Atlas Series).

Water Pollution Potential from Waste Disposal and Land Treatment Practices

A major objective of this project is to indicate geologic conditions where waste products and land treatment practices may potentially pollute water resources. To accomplish this goal, a series of five waste disposal maps was prepared for each individual county. Intended to be used as a guide for regional planning, they designate areas in Northeastern Illinois where particular combinations of earth materials, topography, and ground-water flow systems indicate conditions pertinent to various waste disposal and land treatment practices.

By necessity, the boundaries of the areas designating particular conditions are somewhat generalized. These maps indicate the probability of finding suitable or unsuitable sites within a given area, but they cannot be considered a replacement for individual site evaluations. Individualized investigation of any proposed waste disposal site is necessary because of the variability of natural earth materials, limitations of mapping scale, and the erratic distribution of available data. In addition, certain considerations (such as distance to nearest well, frost depth, depth to seasonal water table, minor slope variations, areas with potentially

variable conditions, areas near or at mapped materials boundaries and the density of disposal sites in a given area) cannot be evaluated regionally but should always be included as part of individual site evaluations.

A prime consideration in regard to waste disposal in geologic materials is their cation exchange capacity. Naturally-occurring clays (particle sizes $<.002$ or $<.004$mm) are composed mainly of clay minerals such as illite, chlorite, vermiculite, or montmorillonite with small amounts of associated non-clay 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 accessory ions which satisfy requirements of space and charge within, between, and around layers are variable. Places where accessory ions (most often cations) may fit into the clay mineral structure are called exchange sites; the number of available cation exchange sites in a sample of a particular type of clay mineral determines its cation exchange capacity (CEC). Some clay minerals hold their accessory ions more loosely than others and have a "high cation exchange capacity". Many stable clay minerals are characterized by an increasing CEC as they weather to less stable forms. Organic materials also have a high cation exchange capacity and will cause deposits which contain a significant percentage of organics to have a high CEC. The cation exchange capacity of individual geologic deposits has bearing on their function to release cations to and to adsorb cations from the ground water moving through them. If the ground water contains objectionable cations derived from industrial, domestic, or agricultural waste products, the CEC has a direct bearing on problems of waste

disposal. In such instances, the CEC is a reasonably direct measure of the attenuation capacity of the geologic materials.

As suggested above, the range in CEC values is generally related to both the clay and organic content of the earth materials; as a rule, materials having a higher percentage of clay and organic matter have higher CEC values. Clays are prominent in bedrock shale deposits, in many fine-grained lacustrine (lake) deposits, and in many glacial tills; organic material is common in peat bogs, in certain other lowland depressions, and in the active soil zone (solum). The upper part of the solum (A horizon) generally exhibits the highest CEC values. Coarse-grained materials (sands and gravels) have a very low cation exchange capacity. It should be noted that all Northeastern Illinois materials have a very low exchange capacity.

In the following discussion and individual map legends, reference is made to geologic materials having low to high hydraulic conductivities (permeabilities) and cation exchange capacities. In general, materials having low hydraulic conductivities have values of about 10^{-5} cm/sec or less while materials having high hydraulic conductivities have values about 10^{-2} cm/sec or greater. Low values for cation exchange capacity in Northeastern Illinois are generally less than about 5 milliequivalents (meq)/100g while high values generally exceed 15 meq/100g, ranging up to 35 meq/100g. Recent research has shown that a material with a CEC of 10 meq/100g is generally sufficient, given a reasonable thickness, to attenuate all but the most highly mobile ions.

The attenuation capacity of geologic materials for specific ions, compounds, and complexes is also related to the mobility of the individual

ions, compounds, and complexes. Recent research has shown that most toxic metals such as lead, mercury, and chromium, are relatively immobile, even when in competition for cation exchange sites with organic-rich garbage leachate. Some toxic substances, such as arsenic and chromite (Cr^{6+} ion) are somewhat more mobile under some conditions. Ammonia and chloride ions, found in most common wastes, are the most mobile of all. Some substances, such as low level radioactive materials, are considered mobile in some forms and generally require a minimum of 500 years of containment.

Slope is also an important mapping consideration for waste disposal and land treatment practices. Slope was not directly considered in maps indicating conditions for land burial of wastes because slope would have to be taken into account in site selection and trench design. In general, reference to steep slopes in the following sections refers to slopes greater than four percent. It is difficult to show the many areas of slopes greater than four percent and in particular, slopes greater than seven percent. The terrain map should be consulted as to where these slope conditions are most likely to occur while the detailed USDA Soil Conservation Service county soil maps give more precise information on slopes, surface drainage and erodability.

The maps presented in this report evaluate conditions relative to:

(1) land burial of wastes (including sanitary landfills)

(2) surface spreading of wastes

(3) waste disposal by septic systems

(4) application of fertilizers and soil additives

(5) application of herbicides and insecticides

Designated areas in the five map series are presented generally in order of decreasing restraints. In general, where more than one statement applies for a given area on each map, the category judged to be the most severe limitation is the one applied to the area.

In some cases, where materials are generally considered unsuitable, the hydrogeologic system may be a mitigating factor in regard to waste disposal site selection. For example, sites along major rivers would normally be considered unsuitable where the underlying materials are coarse-grained and have moderately high hydraulic conductivities and low CEC's. However, flow paths in such areas are predictable and a leachate-producing waste disposal operation would result in a limited zone of pollution between the waste disposal site and the major river, a regional discharge area. Important considerations with regard to such sites are: (1) if this zone of pollution, 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) if there are, or may be in the future, pumping wells in the area which may cause leachate to migrate outside of the predictable "zone". Research (Hughes, Landon, Farvolden, 1971) has suggested that, when properly located, spaced, constructed, and monitored, such sites may not degrade the quality of the surface water body. Because such sites must be evaluated individually and carefully monitored during and after waste disposal operations, regional mapping of areas with predictable hydrogeologic systems was purposely excluded from this study.

Land Burial of Wastes (including sanitary landfills)

A map included with each county report differentiates areas for

the burial of all types of waste products in the ground. We have not distinguished the state of the waste product, that is, whether it is solid, semisolid, or liquid. The state of the material governs only the time it may take to mobilize a pollutant in the trench and the initial rates of loading. The attenuation capacity of the earth materials for individual ions, compounds, and complexes, and the release rates of non-attenuated ions, compounds, and complexes determine the pollution potential of buried wastes.

The criteria for land burial of wastes include considerations of the burial of both domestic refuse and industrial chemical waste, some of which may be toxic. Land areas are differentiated according to their capacity for long retention time, attenuation characteristics (mainly cation exchange capacity), and release rates to the environment. Map areas are generally listed in ascending order of their capacity to provide protection from pollution of both ground water and surface waters. The basic assumptions are: (1) burial in a trench 20 feet (6.1m) deep, and (2) contact with ground water. The latter assumption recognizes the fact that, in Northeastern Illinois, the top of the zone of saturation is very often less than 20 feet (6.1m) below the land surface.

On the maps which show conditions for land burial of wastes gravel pit areas are mapped as if original materials are present. Each pit (shown on geologic materials maps) should be treated as a special case to determine suitability for land burial of wastes. In most areas only household refuse should be considered as fill and then only if the site can be engineered to assure protection of ground water.

Surface Spreading of Wastes

Maps included with this report differentiate areas in the individual counties where there may be pollution problems resulting from the spreading of wastes on the land surface or in the active soil zone (solum). The primary concern of this mapping is with the placement of industrial and sewage wastes, by any method, on the land surface. The solum generally develops sufficient hydraulic conductivity to allow certain amounts of water to pass. In placing wastes on the land surface, the proper application rates must be maintained to prevent overloading of the soil. Proper application rates are dependent on the slope, soil types, and soil characteristics. See Graffis et al., 1976, for discussion of application rates. It is assumed that the proper application (loading) rate will be determined. The maps differentiate areas where the practice may fail, areas where extra precautions should be taken, and areas where spreading should be discouraged. Certain types of potentially hazardous wastes must be evaluated separately.

Waste Disposal by Septic Systems

The criteria used for these maps are based on the Illinois Department of Public Health's definition of a public system - one serving eleven or more residences. We have considered that the pollution potential is the same for one septic system serving eleven residences as for eleven systems serving eleven residences. Criteria have been established by the U. S. Department of Agriculture relating soil characteristics to operation of septic systems. These criteria should be consulted along with the regulations (based in part on the USDA criteria) of the Illinois Depart-

ment of Health. The septic system maps will not be applicable, from a pollution standpoint, to evaluating the very minimal impact of widely scattered individual systems.

Application of Fertilizer and Soil Additives

The proper application rates of fertilizer and soil additives should result in their being held in the soil for plant use. Application rates should be adequate to supply seasonal plant needs; this depends upon the character and fertility of the solum. See Graffis et al., 1976, for discussion of application rates. These maps differentiate areas where special care must be taken to avoid excessive application of fertilizers and soil additives.

Application of Herbicides and Insecticides

The proper use of herbicides and insecticides should result in their being retained in the active soil zone (solum). There are few reported instances of ground-water pollution by herbicides and insecticides; there are some reports of surface-water pollution. The glacial till materials generally contain sufficient clay to have a strong attenuating capacity for organic compounds; thus, herbicides and insecticides are generally immobile, except in soils with very low clay contents. These maps differentiate areas where special care must be used in application. See Graffis et al., 1976, for discussion of application rates.

The criteria on which these waste disposal and land treatment maps were based were reviewed by the state office of the USDA Soil Conservation Service staff members of the University of Illinois Department of Agronomy, the Divisions of Water Pollution Control and Land/Noise Pollution

Control of the Illinois State Environmental Protection Agency, planning commissions and health departments of the six counties, and the technical staff of the Northeastern Illinois Planning Commission. The cooperation of all is gratefully acknowledged.

Land Utilization Considerations

In Northeastern Illinois, significant geologic hazards affecting the suitability of land for particular uses are generally lacking. Earthquakes with epicenters in northern Illinois have been neither "frequent nor severe"; the same can generally be said regarding ground movements resulting from earthquakes with epicenters outside of northern Illinois but which were felt in this area (see Heigold, 1972, for additional discussion). Probably the most significant geologic hazards associated with land use in Northeastern Illinois include areas which flood or are poorly drained. Of local significance in southwestern Will County are areas of coal strip mine spoil piles, which may be difficult to stabilize, and areas overlying former underground coal mine operations, which may exhibit ground subsidence.

Although significant geologic hazards are generally lacking in Northeastern Illinois, geologic conditions affect the suitability of land areas for particular uses. Both material properties such as texture and bearing capacity and terrain characteristics such as drainage and depth to zone of saturation affect land-use suitability. Three maps were prepared for each of the six counties to evaluate both terrain and material characteristics for three specific types of land use - namely, community development, roadway construction, and open-space planning. All three

types of maps should be used in conjunction with the USGS Flood Hazard Maps and the poorly drained soils maps. Basic strength and index properties of mapped geologic materials in Northeastern Illinois are detailed in the individual county reports. These properties should also be consulted as a guide to the engineering behavior of materials.

Conditions for Community Development and Roadway Construction

In general, the community development and roadway maps indicate conditions in order of decreasing restraints. The community development maps are specifically geared to subdivision-type construction. Major problems for community development include poor surface drainage, flooding along major drainageways and the presence of low-bearing capacity materials. In many parts of Northeastern Illinois, community developers are also concerned about water well placement and septic field construction; the groundwater resource maps and septic system maps discussed in other sections of this report address themselves specifically to these concerns. Roadway planners, on the other hand, are concerned with determining areas susceptible to flooding or characterized by poor drainage, locating areas of frost-susceptible and low-bearing capacity materials, determining the potential stability of proposed slopes, determining the amount of material to be excavated or replaced in outs and fills, and locating potential sources of borrow or select backfill that are close to the proposed construction. It should be noted that roadway projects may have sufficient resources for remedial measures to cope with undesirable materials which are beyond the scope of much subdivision construction. Such remedial measures may include excavation and replacement of undesirable materials,

loading low-bearing capacity materials to promote consolidation prior to construction, installing elaborate drainage systems, penetrating undesirable materials with deep foundations extended to higher bearing capacity materials, and altering roadway grades or specifications for shoulder and median slopes.

Geologic Considerations for Open-Space Planning

Recognizing the improtance of open-space planning to an urbanizing area, maps indicating geologic considerations for open-space planning were also included with this study. According to the NIPC Regional Open-Space Plan (1971), the following areas should be given prime consideration for preservation as open-space:

1. Areas where soils and geologic conditions make them unsuitable for development.
2. Flood plain areas
3. Areas with potential for reservoir sites
4. Prime ground-water recharge areas
5. Areas with potential for sequential use planning - i.e., areas with potential dolomite or sand and gravel resources; areas with potential for solid or liquid waste disposal
6. Areas of historic, ecologic, or geologic interest.

These criteria lend themselves to a format for the open-space maps that is somewhat different than those of the roadway and community development maps; that is, areas which best exhibit the above characteristics were selected and mapped. Since planning decisions regarding open space are bases on many non-geologic factors, the open space maps do not

attempt to outline areas suitable for specific types of open-space use; rather, they give the necessary geologic input to guide open-space planning decisions. Generally, map areas for resource or waste disposal purposes were rigorously selected from other maps in this series to indicate regions where the probability is greatest that the desired conditions will be present. The full range of conditions for resource or waste disposal purposes can be better assessed by consulting the appropriate maps for each county. Generally, the last category on each open-space map includes regions where some of the conditions indicated in the above criteria are present but where they are less likely to be of major importance. It was beyond the scope of this study to inventory areas currently being utilized as open space or to indicate areas of historic and ecologic interest. Additional information regarding reservoir siting is available from Illinois State Water Survey and Illinois State Geological Survey publications (especially Smith, 1969).

Natural Resources

The abundant natural resources in Northeastern Illinois have assisted the development of the Chicago metropolitan area. Natural resources in the area include surface water, ground water, rock, sand and gravel, clay, coal, and peat. This report includes natural resource maps for Northeastern Illinois detailing sand and gravel aquifers and dolomite, sand and gravel, clay, coal, and peat resources. Information on surface water resources, mainly Lake Michigan, can be obtained from the Illinois State Water Survey and the Division of Water Resources, Illinois Department of Transportation. In the various county reports, some resource maps

have been combined, where practical, and some maps have been deleted, where the resource is absent or insignificant. Some natural resources will be discussed in text form only, generally where they are either minimal or ubiquitous in a particular county.

One additional resource, namely, the fertile soils developed on Wisconsinan glacial drift, should also be considered in Northeastern Illinois. As one of the richest agricultural areas in the world, development on the fringes of a large metropolitan area removes many acres of land from agricultural production. The USDA Soil Conservation Service should be consulted regarding the agricultural productivity of soils in Northeastern Illinois.

Ground Water

In Northeastern Illinois, ground-water resources are grouped into four major aquifers: (1) sand and gravel aquifers in the glacial drift; (2) the shallow dolomite aquifer, including the Silurian Dolomite and the Galena-Platteville Dolomite; (3) the Cambrian-Ordovician Aquifer, in which the Ironton-Galesville and Glenwood-St. Peter Sandstones are the most productive units; and (4) the Mt. Simon Aquifer, which consists of the Mt. Simon Sandstone and the basal sandstone of the Eau Claire Formation (Suter et al., 1959). For this report, only the sand and gravel aquifers in the glacial drift were directly mapped. Shallow bedrock aquifers were locally considered, especially where they lie at or near the land surface or where they form a continuous hydrogeologic unit with basal sands and gravels in the glacial drift. In general, a map is included with each county report which delineates the thickness and areal extent of significant sand and gravel aquifers; for most counties, a series of cross-sections are also

included which indicate the geometry of individual sand and gravel bodies.

Detailed information on bedrock aquifers in Northeastern Illinois can be obtained from Hughes, Kraatz, and Landon, 1966. Information regarding current water levels in municipal wells penetrating bedrock aquifers and projections of future water levels can be obtained from the Illinois State Water Survey. It should be noted that there are both widespread declines in the piezometric surfaces of the deep sandstone aquifers, which are most severe around major pumping centers, and localized cones of depression in the shallow dolomite aquifer. Specific details can be obtained in Csallany and Walton, 1963; Sasman, 1965; Sasman *et al.*, 1973; and other Illinois State Water Survey publications.

Sand and Gravel

Sand and gravel deposits also have significant resource potential when they occur at or near the land surface. Even though sand and gravel deposits vary enormously in size and suitability as a resource (Block, 1960), most commercial sand and gravel deposits in Northeastern Illinois are developed in some type of glacial outwash deposit. The importance of these deposits as a mineral resource depends upon their thickness, areal extent, texture (grain-size distribution), mineralogy, accessibility, and the thickness of overlying materials. Common sand and gravel is used as fine- and coarse-grained aggregate for concrete and asphalt paving mixtures, base courses of highways, material for gravel roads, and for ballast and fill. Specifications for sand and gravel to be used in concrete and asphalt aggregates (Illinois Department of Public Works and Buildings, Division of Highways, 1971) are more rigorous in terms of proper

size gradations and the maximum allowable amount of deleterious material than specifications for the other uses listed above. Maps included with the various county reports generally indicate sand and gravel deposits in order of their importance as a resource. In addition, operating sand and gravel pits are indicated on the maps by appropriate symbols and include all pits known to be operating or intermittently operating during 1974 (Masters, 1976). Each active pit should be found within the quarter section where the symbol is located. It should be noted that, in some areas, development has removed potential sand and gravel resource areas from further consideration or may do so in the future. The Illinois State Geological Survey gratefully acknowledges the Illinois Department of Transportation, the Illinois Toll Highway Authority, and Commonwealth Edison for supplying subsurface information regarding sand and gravel resources.

Peat

Peat is used primarily as a soil conditioner in order to increase organic content, make clayey soil more friable, and increase moisture retention. In 1973, Illinois ranked second of all the states in peat production, producing 71,552 tons (65,047 metric tons) of peat from Cook, Kane, Lake and Whiteside Counties (Malhotra, 1975). Areas mapped as Grayslake Peat (gl) on the geologic materials map for each county may or may not contain commercial peat deposits. Most of the areas mapped as gl were taken from USDA Soil Conservation Service soil survey mapping where several soil series containing significant amounts of organic material were collectively mapped as Grayslake Peat. Where deposits cover less than 40 acres (16 hectares) and are generally less than two feet (.6 meter) thick,

they probably do not constitute a significant resource. In addition, peat in areas drained for agriculture, or similar uses, begins to oxidize relatively rapidly, and becomes a silty organic soil. Therefore, many areas mapped as gl in drained areas can be eliminated from consideration as a potential resource. The few remaining areas of gl are outlined on county maps as possible peat resources. Site investigations are necessary to confirm their resource potential.

Clay

In most of Northeastern Illinois, clay resources are ubiquitous and will not be mapped for the individual counties. Clay mineral and grain-size data suggest that where the Wadsworth, Yorkville, Malden, and Tiskilwa Till Members, the ablation phase of the Tiskilwa and Yorkville Till Members, and the clayey parts of the Carmi Member of the Equality Formation are over 20 feet (6.1 meters) thick, they can be used in the manufacture of Chicago common brick and structural or building tile. If the stones and sand are removed from these deposits, they could also be utilized by art potters or for the manufacture of sand-size bloated lightweight glass balls used in insulation products.

Dolomite

Dolomite resources in Northeastern Illinois are generally limited to areas where the Silurian dolomite or the Ordovician Ft. Atkinson or Galena-Platteville Dolomite are known to outcrop or lie within 50 feet (15 meters) of the land surface. Such areas were mapped for each county in Northeastern Illinois as areas of "potentially quarrable stone". In

the future, dolomite resources deeper than 50 feet may be economically recoverable. Major areas of dolomite resources in Northeastern Illinois include (1) outcrop belts along portions of the Fox and DesPlaines Rivers and the Calumet-Sag Channel; and (2) areas of erosion-resistent organic reef structures on the Silurian dolomite.

The thickness and quality of potentially quarryable rock at individual sites should be carefully evaluated. Major types of deleterious material in quarry operations include shale, clay, and silica (chert). Most quarried dolomite is utilized either as crushed stone for concrete aggregate or highway based courses or as agricultural limestone. Many quarries in Northeastern Illinois are capable of producing Class A aggregate (Illinois Department of Transportation), the highest quality of major aggregate classes and acceptable for use in portland cement concrete.

Coal

Coal resources in Northeastern Illinois are present only in the extreme southwestern part of Will County. There, coal seams are interbedded with the shales of the Pennsylvanian-age Kewanee Group (Pk). Although coal was actively stripped and mined in underground facilities in years past, many operations are no longer active. The discussion of natural resources for Will County includes more detailed information on coal production as well as a map of coal reserves in Will County.

GLOSSARY

accretion gley - fine grained and organic materials which slowly accumulate in poorly drained depressions with intermittent water saturation.

agronomy - the branch of agriculture dealing with the theory and practice of field crop production and soil management.

alluvium - the general term for all sediments deposited in land environments by streams.

artesian conditions - where an aquifer is confined between impermeable layers and the water in the pores of the aquifer is not open to atmospheric pressure, but occurs at greater pressures.

artesian well - one in which the water level rises above the top of the aquifer, whether or not the water flows at the land surface.

attenuation capacity - the ability of a material to adsorb and return certain anions and cations in an exchangeable state.

cation exchange capacity - the capacity of a soil to sorb or hold cations and to exchange species of these ions in reversible chemical reactions. Important for both soil fertility - nutrition studies and for soil genesis.

colluvium - a body of sediment that has been deposited by any process of mass-wasting or by overland flow.

cross-section - a diagram or drawing that shows geologic features transected by a given plane.

detritus - a collective term referring to broken pieces of older rocks, of minerals or of skeletal remains of organisms.

end moraine - a ridge-like accumulation of drift, deposited by a glacier along its front margin.

esker - a body of ice-contact stratified drift shaped into a long narrow ridge, commonly sinuous.

flood plain - that part of any stream valley which is inundated during floods.

fluctuations of the water table - vertical movement of the water table (where atmospheric pressure equals pore water pressure) due to addition by percolation or removal by drought or dewatering of water in the zone of saturation.

formation - the primary rock unit in lithostratigraphy that possesses distinct lithologic features, reflecting a genetic relationship

of deposition under uniform or uniformly alternating conditions throughout its extent. These are mappable units.

geology - the study of the composition and configuration of the Earth's physical features and rock masses, their relationships to one another, and the surficial and subsurface processes that operate on and in the Earth.

kame - a body of ice-contact stratified drift shaped as a short, steep-sided knoll or hummock.

kame moraine - a terminal moraine that contains numerous kames.

kettle - a closed depression in drift, created by the melting out of a mass of underlying ice.

loess - wind-deposited silt, usually containing some clay and some fine sand.

member - a unit that subdivides a formation, generally of distinct lithologic character or of local extent.

muck - a dark-colored soil, commonly in wet places, which has a high percentage of decomposed or finely comminuted organic matter.

nonattenuated ions - ions which are not adsorbed onto materials which they pass through due to their chemical composition and concentration.

outwash plain - sheet-like deposits of sand and gravel transported away from the ice by melt-water streams along the front of the glaciers.

peat - a brownish, light weight mixture of partly decomposed plant tissues in which the parts of plants are easily recognized.

permeability - capacity of a material to transmit a fluid. Degree of permeability depends upon the size and shape of the interconnected voids. It is measured by the rate at which a fluid of standard viscosity can move a given distance through a given interval of time.

release rate - rate at which attenuated ions are released into the ground water.

soil - the unconsolidated mineral matter on the surface of the earth that has been subjected to and influenced by genetic and environmental factors of parent material, climate, organisms and topography all acting over a period of time.

soil materials - the unit of study in soil science in which the characteristics being studied are relatively constant and whose size will vary with the kind and extent of development of those characteristics.

soil series - the basic unit in soil classification. A group of soils having genetic horizons of similar characteristics and arrangement in the soil profile, except for texture of surface soil, and developed from a particular type of parent material.

soil survey - a general term for the systematic examination of soils in the field and in the laboratories, their description and classification, the mapping of kinds of soil, and the interpretations of soils for many uses, including their suitabilities or limitations for growing various crops, grasses or trees, or for various engineering uses, and predicting their behavior under different management systems.

solum - the upper part of a soil profile in which soil-forming processes occur. In a mature soil the A and B horizons constitute the solum.

stratigraphy - that branch of geology which treats of the formation, composition, sequence and correlation of the rock units as part of the earth's crust.

till - a nonstratified glacial deposit containing a wide range of grain sizes.

till plain - an extensive area, with a flat to undulating surface underlain by till, which is commonly covered by ground moraine and subordinate end moraines.

topographic map - map showing the topographic features of a land surface generally by means of contour lines.

transmissibility - rate of flow (gal/day) through a vertical section of an aquifer with a defined width and hydraulic gradient.

valley train - a long narrow body of outwash confined within a valley.

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