SOME ENVIRONMENTAL GEOLOGIC FACTORS AS AIDS TO PLANNING IN CASS COUNTY, INDIANA

Special Report 22

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Department of Natural Resources
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Some Environmental Geologic Factors as Aids to Planning in Cass County, Indiana

By JOHN R. HILL

ENVIRONMENTAL STUDY 16

DEPARTMENT OF NATURAL RESOURCES
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By JOHN R. HILL

Introduction

Named for General Lewis Cass in 1828, Cass County has a rich heritage, having grown from its frontier days when the Miami Indians roamed the forested hills and valleys to its contemporary role as a predominantly agricultural area. The county embraces 265,600 acres, of which 213,216 are croplands; the remaining 52,384 acres are urban, forested, small water, and other kinds of areas (1967 figures).

Most of the county is blanketed by glacial sediments that form the gently rolling upland and that were deposited during the Ice Age and subsequently modified by erosion. The bluffs along the Wabash River afford the greatest topographic relief; their bedrock cores are exposed at many localities along the river's course. Industrial minerals, such as crushed stone and sand and gravel, are derived from the bedrock and the glacial drift. Although mineral production represents only a minor part of the county income, many aspects of daily life in urban and rural communities are influenced by the local geology. Crops are grown in soils that formed on glacial drift. Most of the fresh water is pumped from buried geologic formations. Refuse is isolated in sanitary landfills located in glacial deposits. Construction of nearly every variety involves excavating or boring into earth materials. Consequently, a knowledge of the local geology is desirable for most facets of planning.

This report is intended to provide a background for the character and distribution of geologic materials, both at the surface and in the subsurface, throughout the county. On the basis of this information, limestone resources, sand and gravel resources, sanitary landfills, oil and gas production and storage, and water wells are discussed.

Bedrock Geology

STRATIGRAPHY

Lying beneath the cover of glacial drift and cropping out at various localities along the Wabash River is a layered sequence consisting mostly of limestones and dolomites that range in age from Middle Devonian to Late Silurian. The youngest bedrock in Cass County consists of limestones of the Traverse Formation, which are assigned to the middle part of the Devonian System. Best exposed at the abandoned France Stone Co. quarry, east of Logansport, the Traverse consists of light-medium-gray to tan finely crystalline dolomitic limestone. It is massive to irregularly bedded and contains abundant stromatoporoids and colonial corals. The Devonian rocks have been eroded from the northern two-thirds of the county except for isolated patches illustrated in figure 1.

Underlying the Devonian strata and separated from them by a regional unconformity is the Salina Formation, which in Cass County is assigned to the upper part of the Silurian System. Most of the rocks exposed either in outcrop or in quarry operations belong to two members of the Salina: the Kenneth Limestone Member and the Kokomo Limestone Member. At the Louisville Cement Co. quarry, the Kenneth is dark-gray micritic limestone that has sparry zones and contains much white nodular chert. The subjacent Kokomo is gray to tan micritic limestone that is essentially massive in the upper few feet but for its greater part exhibits fine laminae, especially on weathered surfaces. The Kokomo is dolomitic in places, lacks fossils and chert, and only rarely contains secondary calcite.

The Salina Formation in Cass County both overlies and is in lateral facies relationship with the upper part of the Wabash Formation

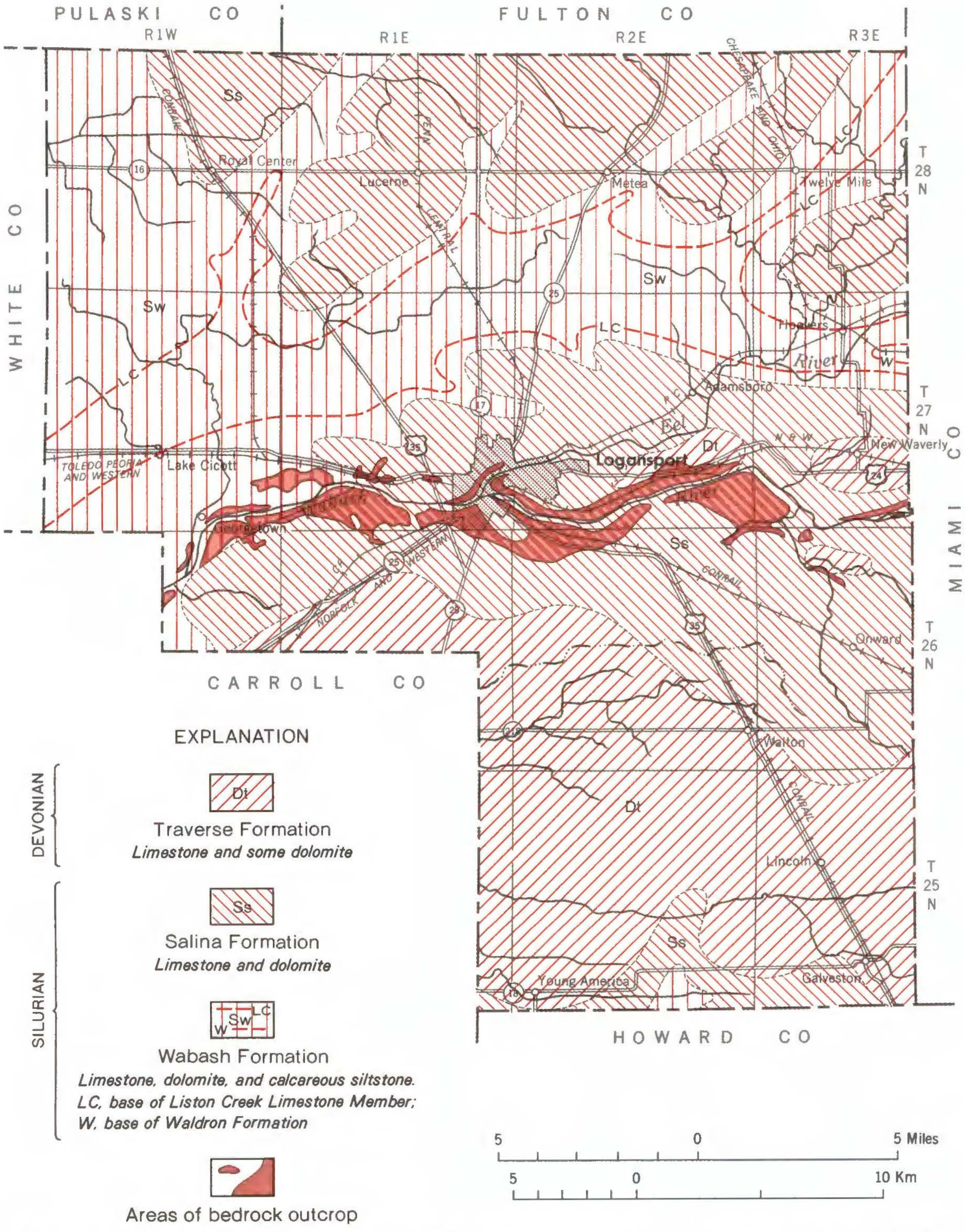


Figure 1. Map showing distribution of bedrock formations on outcrop and beneath glacial drift in Cass County. Modified from Wayne and others, 1966.

SYSTEM	SERIES	GROUP	FORMATION OR MEMBER
DEVONIAN	Erian	Muscatatuck	Traverse Formation
SILURIAN	Cayugan		Wabash Formation Liston Creek Limestone Member Mississinewa Shale Member / Salina Formation Kenneth Limestone Member Kokomo Limestone Member / Huntington Lithofacies
	Niagaran		Louisville Limestone Waldron Formation Limberlost Dolomite Salamonie Dolomite
	Alexandrian		Sexton Creek Limestone
ORDOVICIAN	Cincinnatian	Maquoketa	Brainard Shale Fort Atkinson Limestone Scales Shale
	Champlainian		Trenton Limestone Black River Limestone Joachim Dolomite St. Peter Sandstone
	Canadian		Knox Dolomite
CAMBRIAN	St. Croixan		Franconia Formation Ironton Sandstone Galesville Sandstone Eau Claire Formation Mount Simon Sandstone

Figure 2. Generalized bedrock stratigraphic column for Cass County.

(fig. 2). For example, well logs indicate that the Kenneth and Kokomo Limestone Members in northwestern Cass County are lateral equivalents of the Liston Creek Limestone Member of the Wabash Formation. The Liston Creek, however, does not crop out in the county, and along with all other bedrock formations, it is a subsurface unit because of thickening glacial drift north of the Wabash River.

In northern Indiana, the Huntington Lithofacies, which crops out along the Wabash River west of Logansport (sec. 36, T. 27 N., R. 1 W., and N½ sec. 32), consists of reef rocks that in places occupy much of the Niagaran and all the Cayugan stratigraphic

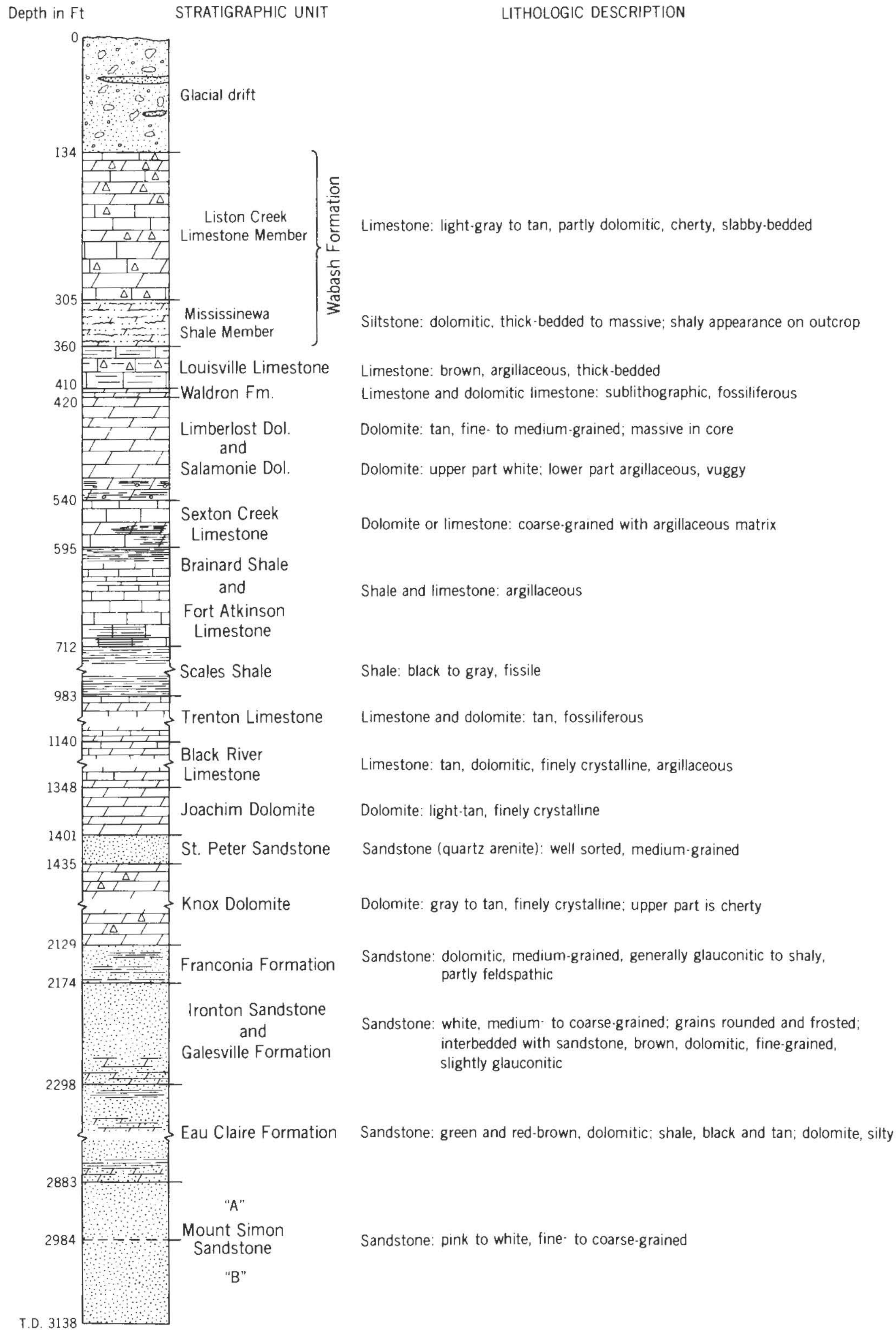


Figure 3. Well log of bedrock units from the Wabash Formation down to the Mount Simon Sandstone. Location: NE¼NE¼SE¼ sec. 6, T. 28 N., R. 1 E.

intervals from the uppermost part of the Salamonie Dolomite to the top of the Salina Formation (fig. 2). (Borings and outcrop exposures of the Huntington Lithofacies indicate that the reef environment was maintained at some geographic localities for much of Silurian time, which resulted in a continuous stacking of stromatoporoid, coral, and other biofragmental debris.) The Georgetown reef, near Georgetown on the Wabash River (sec. 26, T. 27 N., R. 1 W.), belongs to the Huntington Lithofacies and is composed primarily of skeletal-biofragmental limestone and dolomitic limestone.

Deep exploration and oil wells, drilled mostly in northwestern Cass County, have provided a record of the entire sequence of sedimentary rocks from the Traverse Formation (Middle Devonian) down to the Mount Simon Sandstone (Upper Cambrian) (fig. 3). Normal marine carbonate rocks and shale dominate approximately the upper 1,400 feet of the column, but from the St. Peter Sandstone (Middle Ordovician) down, the terrestrial (St. Peter Sandstone) and nearshore (Ironton Sandstone, parts of the Eau Claire Formation, and Mount Simon Sandstone) environments are represented by sandstone. Further reference to the subsurface stratigraphy in this report is made in the section on oil and gas resources.

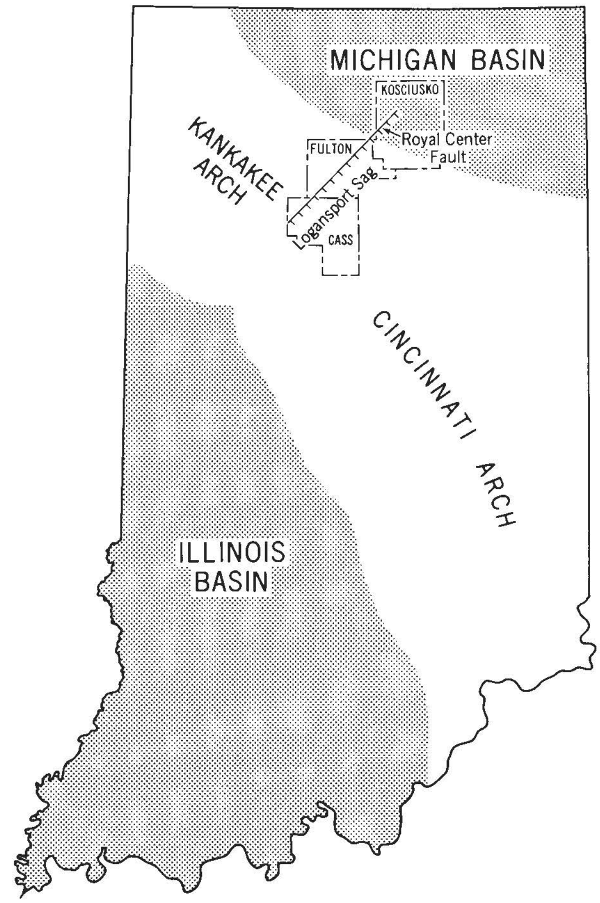


Figure 4. Map of Indiana showing major bedrock structural features.

STRUCTURE

Much of Cass County occupies a saddlelike structural depression called the Logansport Sag that lies within the area separating the Kankakee and Cincinnati Arches, which are actually two names for different parts of a single major structural feature (fig. 4). These arches divide the Michigan Basin to the northeast from the Illinois Basin to the southwest. The northeast-southwestward-trending Royal Center Fault crosses the northwest corner of Cass County, passes through Fulton County, and extends well into Kosciusko County. According to Conley (1961), the Royal Center Fault is on the southeast limb of a doubly plunging asymmetrical anticline.

Some geologists believe that the Kankakee and Cincinnati Arches were formed largely by regional tectonic forces that resulted in the gradual downwarping of the areas now occupied by the Illinois and Michigan Basins. The arches, subsiding at a lesser rate, remained as a relatively positive platform throughout much of Paleozoic time.

The fault plane of the Royal Center Fault cuts the entire Paleozoic sequence and may include some displacement of Precambrian rocks, although this is uncertain (Becker, oral communication, 1978). The time of faulting is unknown because the youngest rocks (subcrop of the Wabash Formation) near the fault have been displaced. Therefore, it can be assumed only that faulting took place sometime after Late Silurian time—perhaps during late Paleozoic time.

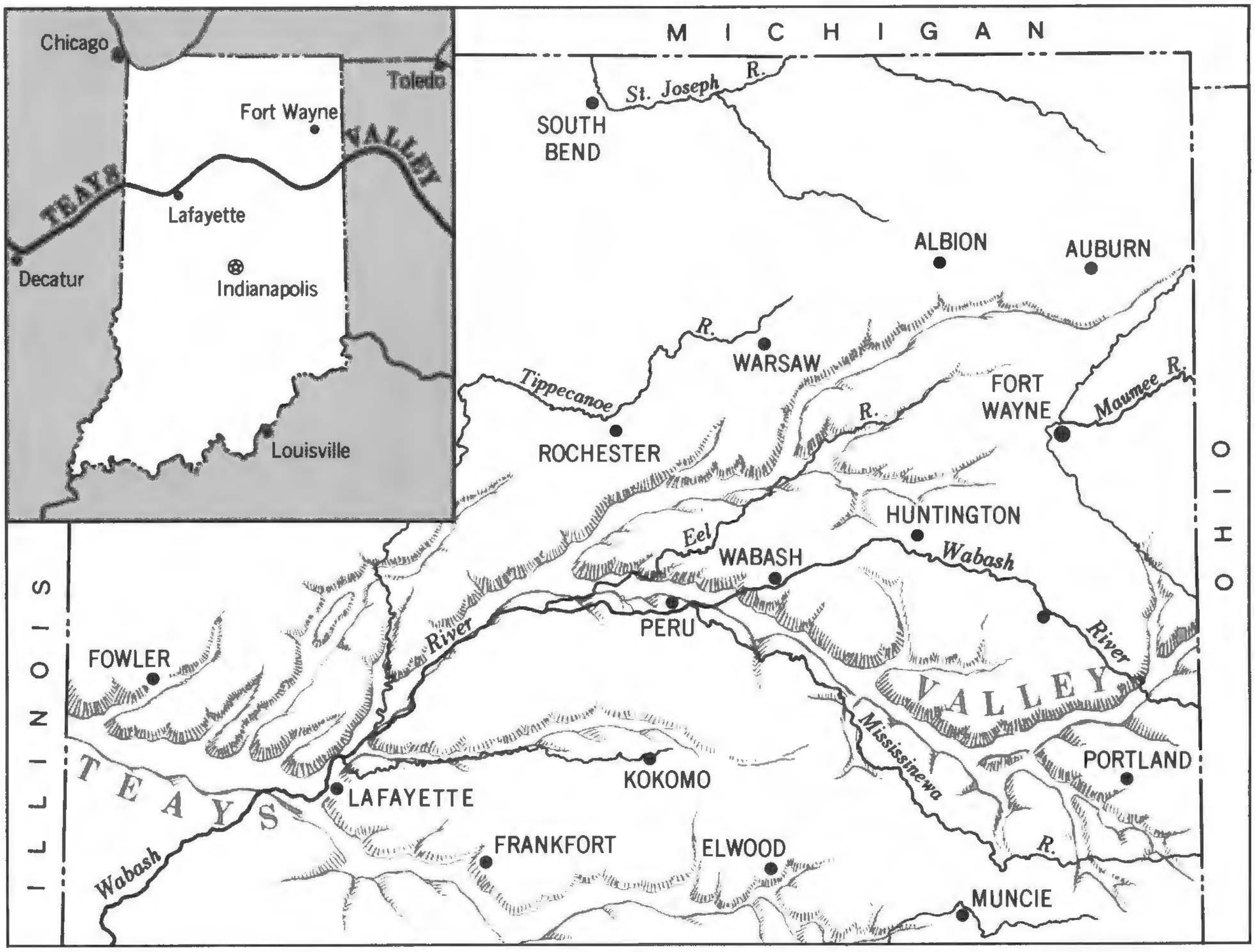


Figure 5. Map showing the Teays Valley in Indiana.

BEDROCK TOPOGRAPHY

The relief and form of the buried bedrock surface are largely the result of preglacial erosion of the Paleozoic rocks by stream action. A network of minor valleys tributary to a major east-westward-trending drainage-way is clearly illustrated in figures 5 and 6. Known as the Teays River, the stream that formed this valley complex was the principal drainageway of North America prior to the Quaternary Period.

The Teays River had its source in the Appalachian Mountains of North Carolina. From there it flowed northwestward across Virginia and into West Virginia, then across Ohio and into northeastern Indiana near Fort Wayne. Reaching its northernmost point in Fulton County, Ind., the Teays then flowed southwestward to Lafayette and on into Illinois, where it was joined near Lincoln by the precursor of the Mississippi River. The Teays eventually debouched into an embayment of the Gulf of Mexico near St. Louis (Janssen, 1953).

The bedrock surface gently rises from 450 feet above sea level within the Teays Valley north of Logansport to a broad upland, at 700 feet above sea level, in the southeast corner of the county. As shown by the drift-thickness map (fig. 8), the bedrock surface is exposed at many localities along the Wabash River where erosion has stripped away the veneer of glacial drift on the higher elevation bedrock. In Cass County the Wabash River closely follows the buried Teays Valley, probably as a result of the combined effect of bedrock topography and glacial deposition.

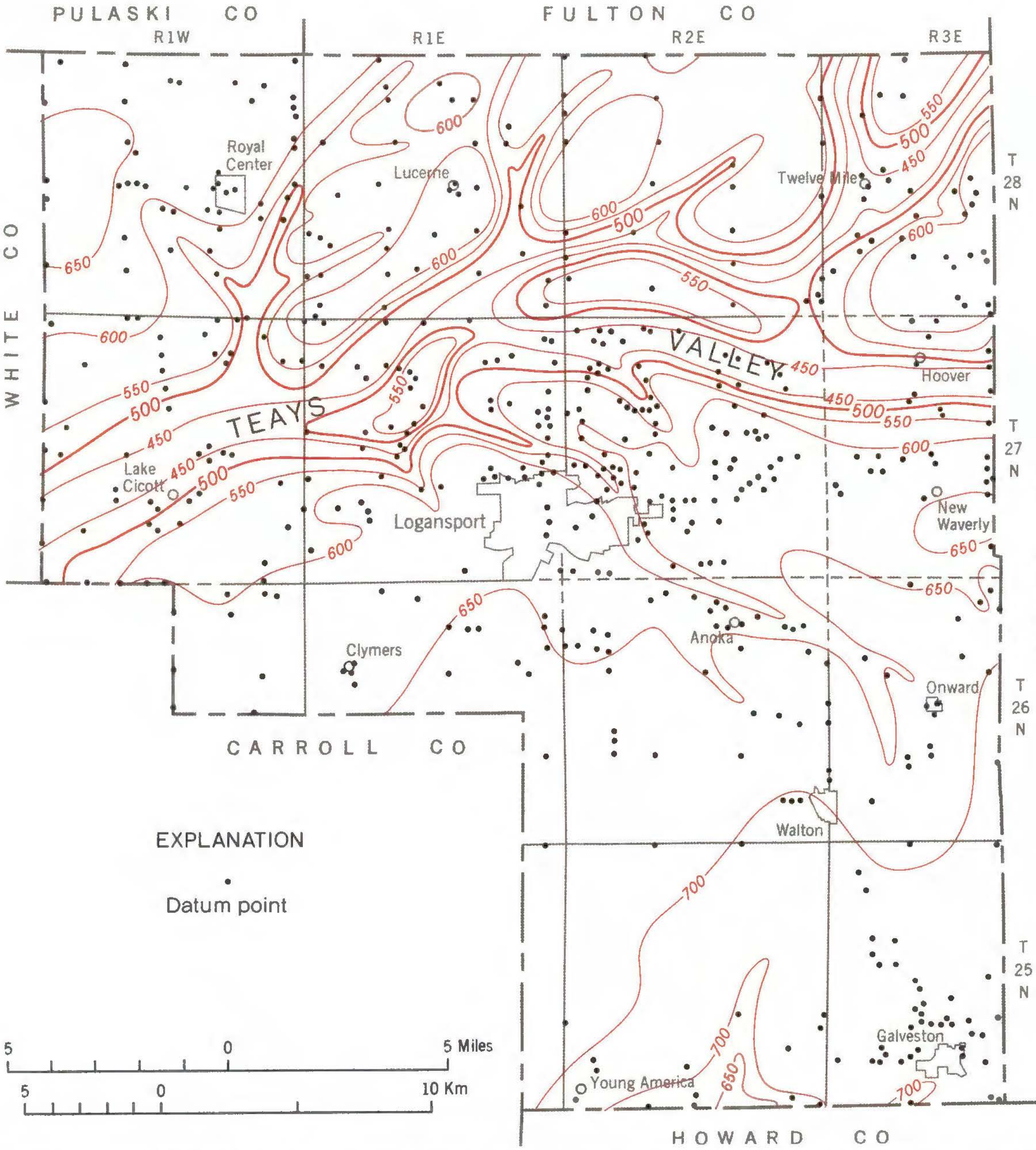


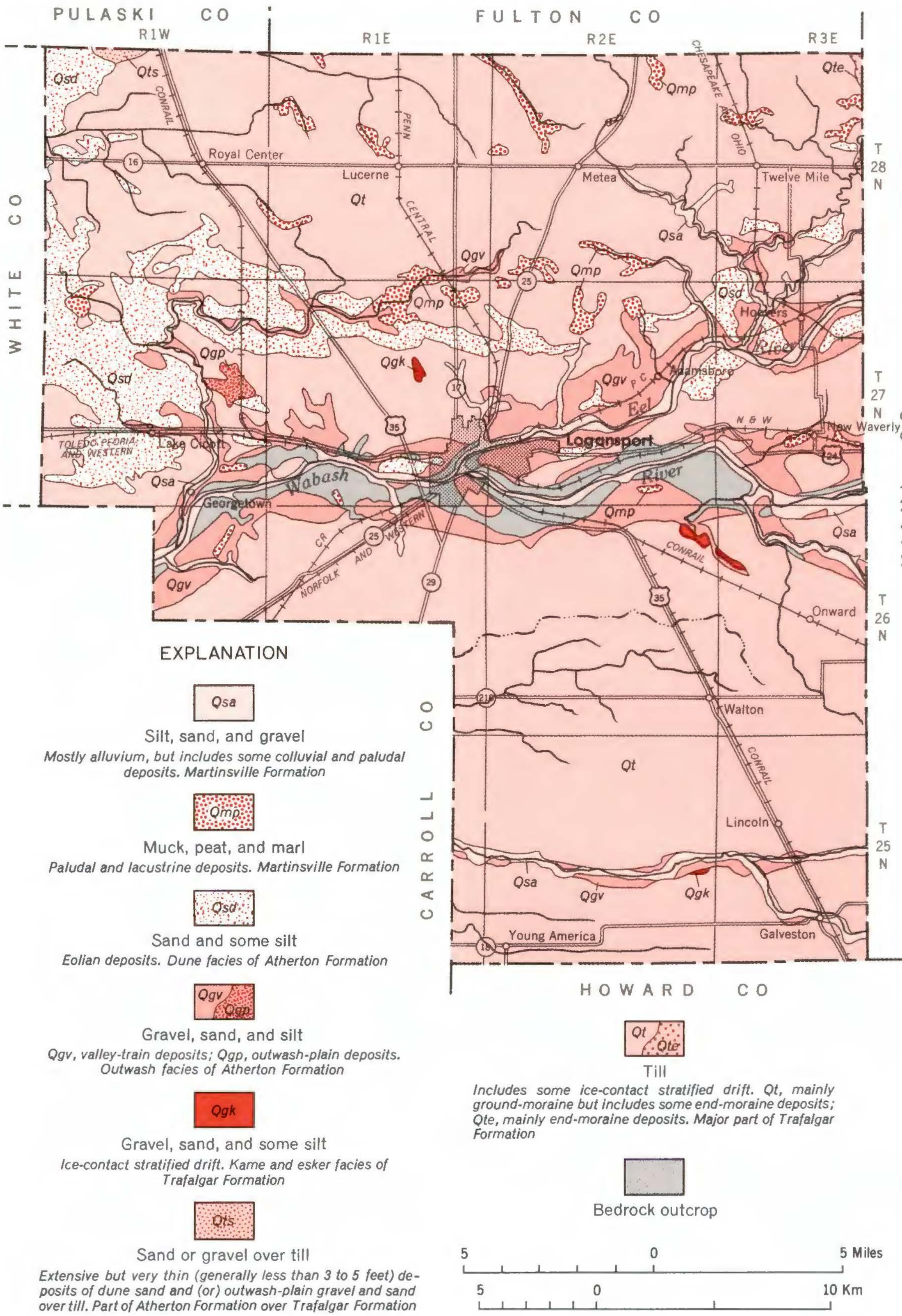
Figure 6. Map showing bedrock topography of Cass County. Contour interval is 50 feet. Datum is mean sea level. Modified from Burger and others, 1966.

Surficial Geology

DISTRIBUTION OF GLACIAL DEPOSITS

The unconsolidated sediments that blanket Cass County resulted either directly or indirectly from glaciation during the last ice advance (Wisconsinan) of the Pleistocene Epoch. Cass County, like most of the northern two-thirds of Indiana, was repeatedly covered by glacial ice. The complex history of these glaciations is recorded in some places by as much as 350 feet of drift. (See p. 9.)

The unconsolidated deposits are of four basic kinds: (1) glacial till, (2) outwash sand and gravel, (3) lake and swamp sediments, and


PULASKI CO
FULTON CO
WHITE CO
MIAMI CO
CARROLL CO
HOWARD CO
R1W
R1E
R2E
R3E
T 28 N
T 27 N
T 26 N
T 25 N
Royal Center
Lucerne
Metea
Twelve Mile
Lake Cicott
Logansport
Georgetown
Adamsboro
New Waverly
Onward
Walton
Lincoln
Young America
Galveston
Wabash River
Eel River
CONRAIL
PENN CENTRAL
CHESAPEAKE AND OHIO
TOLEDO, PEORIA, AND WESTERN
NORFOLK AND WESTERN
N & W
EXPLANATION
Qsa
Silt, sand, and gravel
Mostly alluvium, but includes some colluvial and paludal deposits. Martinsville Formation
Qmp
Muck, peat, and marl
Paludal and lacustrine deposits. Martinsville Formation
Qsd
Sand and some silt
Eolian deposits. Dune facies of Atherton Formation
Qgv
Qgp
Gravel, sand, and silt
Qgv, valley-train deposits; Qgp, outwash-plain deposits. Outwash facies of Atherton Formation
Qgk
Gravel, sand, and some silt
Ice-contact stratified drift. Kame and esker facies of Trafalgar Formation
Qts
Sand or gravel over till
Extensive but very thin (generally less than 3 to 5 feet) deposits of dune sand and (or) outwash-plain gravel and sand over till. Part of Atherton Formation over Trafalgar Formation
Qt
Qte
Till
Includes some ice-contact stratified drift. Qt, mainly ground-moraine but includes some end-moraine deposits; Qte, mainly end-moraine deposits. Major part of Trafalgar Formation
Bedrock outcrop
5 0 5 Miles
5 0 10 Km

(4) river deposits. By far the dominant material, till covers more than three-fourths of the county (Qt and Qte, fig. 7) in the form of ground and end moraines. Although the till is a heterogeneous mixture of sediments that range in size from boulders to fine clay, the predominant particle sizes are sand and silt, which give the till an overall loamy texture. The tills in this part of the state have been assigned to the Trafalgar Formation (Wayne, 1963) and are known to be the result of glaciation from a northeasterly source because the tills exhibit high magnetic susceptibility and high garnet-epidote ratio and form east-westward-trending topographic lineations. South of the Wabash River, the texture of the surficial till is somewhat less sandy than its counterpart to the north, and consequently the till is considered to be of a different age and depositional source—perhaps representing a more recent advance of eastern ice into the area. In the extreme northeast corner of the county, the till assumes a ridgelike configuration and is mapped as part of the end moraine (Packerton Moraine) shown as map unit Qte in figure 7. Most of the till, however, takes the form of gently rolling ground moraine (Qt, fig. 7).

Most of the outwash deposits in the county are sand and gravel deposited by glacial streams. Known as valley-train deposits (Qgv, fig. 7), these sorted glacial lag materials are found along the courses and flood plains of Deer, Crooked, and Indian Creeks and the Wabash and Eel Rivers. The other source of sand and gravel is on morainal material in the form of stratified ice-contact deposits called kames (Qgk, fig. 7). Kames, which are hill or moundlike features composed almost entirely of stratified sand and gravel, form adjacent to massive blocks of detached ice during glacial retreat.

Muck and peat deposits (Qmp, fig. 7) occur on the ground moraine north of the Wabash River and at localities along its southern flood plain. These decayed plant remains mark the position of both glacial and recent lakes and swamps that are infilled with aquatic vegetation.

Mostly silt and sand, river deposits called alluvium (Qsa, fig. 7), mark the flood plains of the rivers and streams that drain the county. The coarser alluvial sediments, such as fine gravel and sand, indicate abandoned channelways once occupied by streams as they meandered over their flood plains. Reworked valley-train deposits account for much of the coarser alluvium.

Extensive deposits of dune sand (Qsd and Qts, fig. 7) blanket a broad area in west-central Cass County and also are distributed in patches along the northern flank of the Wabash River. These deposits were originally derived from the valley-train outwash and have since been modified to their present form by prevailing westerly winds.

DRIFT THICKNESS

Generally, the areas of greatest drift thickness correspond to the buried bedrock valleys (for example, the Teays Valley, p. 6) but also reflect rolling ground and end moraines (fig. 8). The glacial deposits thin or disappear altogether in places along the Wabash River as a result of glacial nondeposition and post-glacial erosion. South of the Wabash River the drift thickness averages only 50 to 60 feet and is not known to exceed 145 feet anywhere. North of the Wabash, however, the unconsolidated sediments thicken rapidly. At one locality, midway between Lucerne and Logansport, they are as much as 350 feet thick. In this area of thick drift, glacial tills and outwash deposits are preserved from two and possibly three major glaciations of the Pleistocene Epoch.

Most of the Logansport area lies on alluvial or glacial deposits that are less than 50 feet thick. In fact, bedrock crops out or is within a few feet of grade throughout most of downtown Logansport.

Figure 7 (*on facing page*). Map showing distribution of unconsolidated deposits in Cass County. Modified from Wayne and others, 1966.

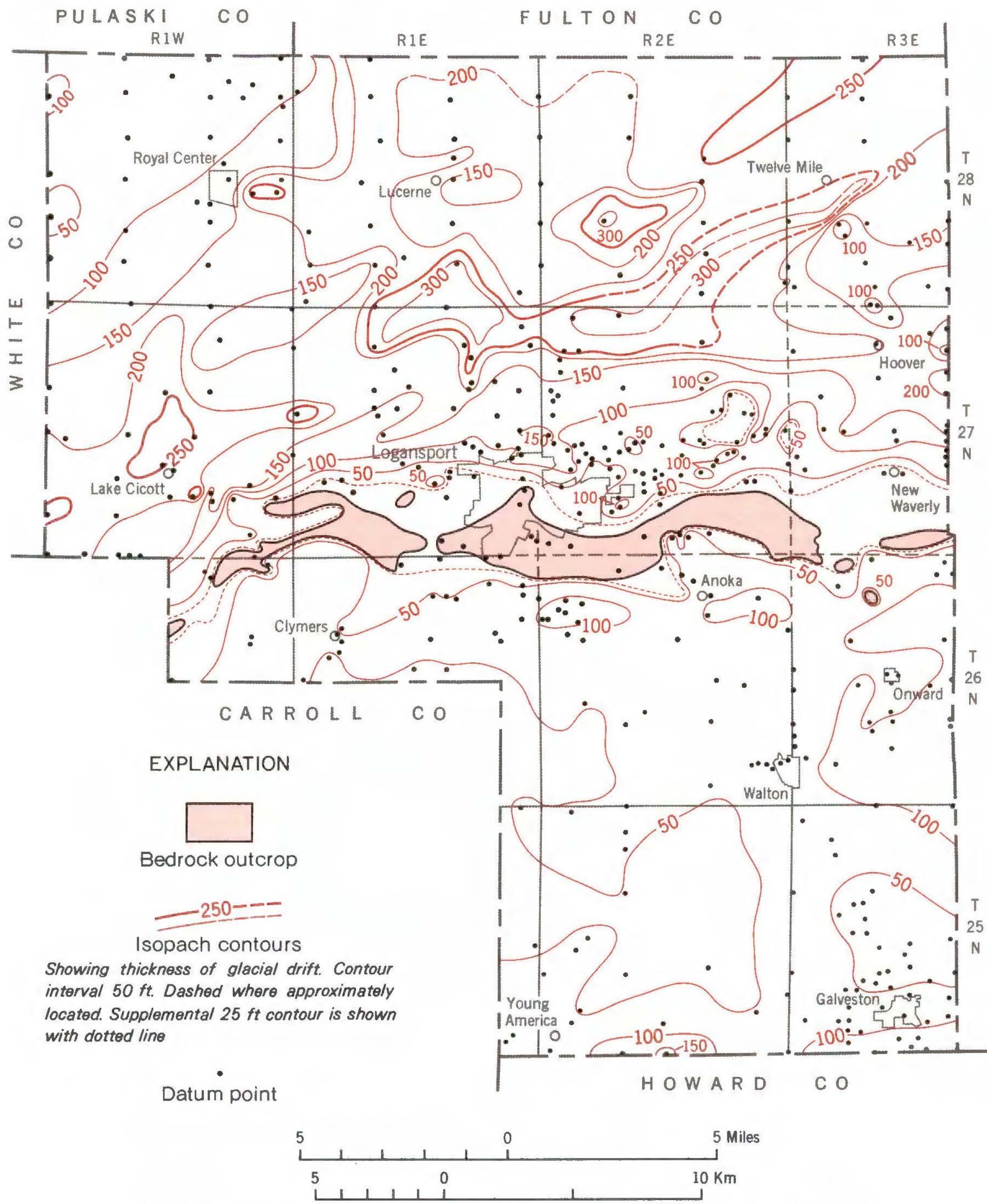


Figure 8. Map showing drift thickness in Cass County. Contour interval is 50 feet.

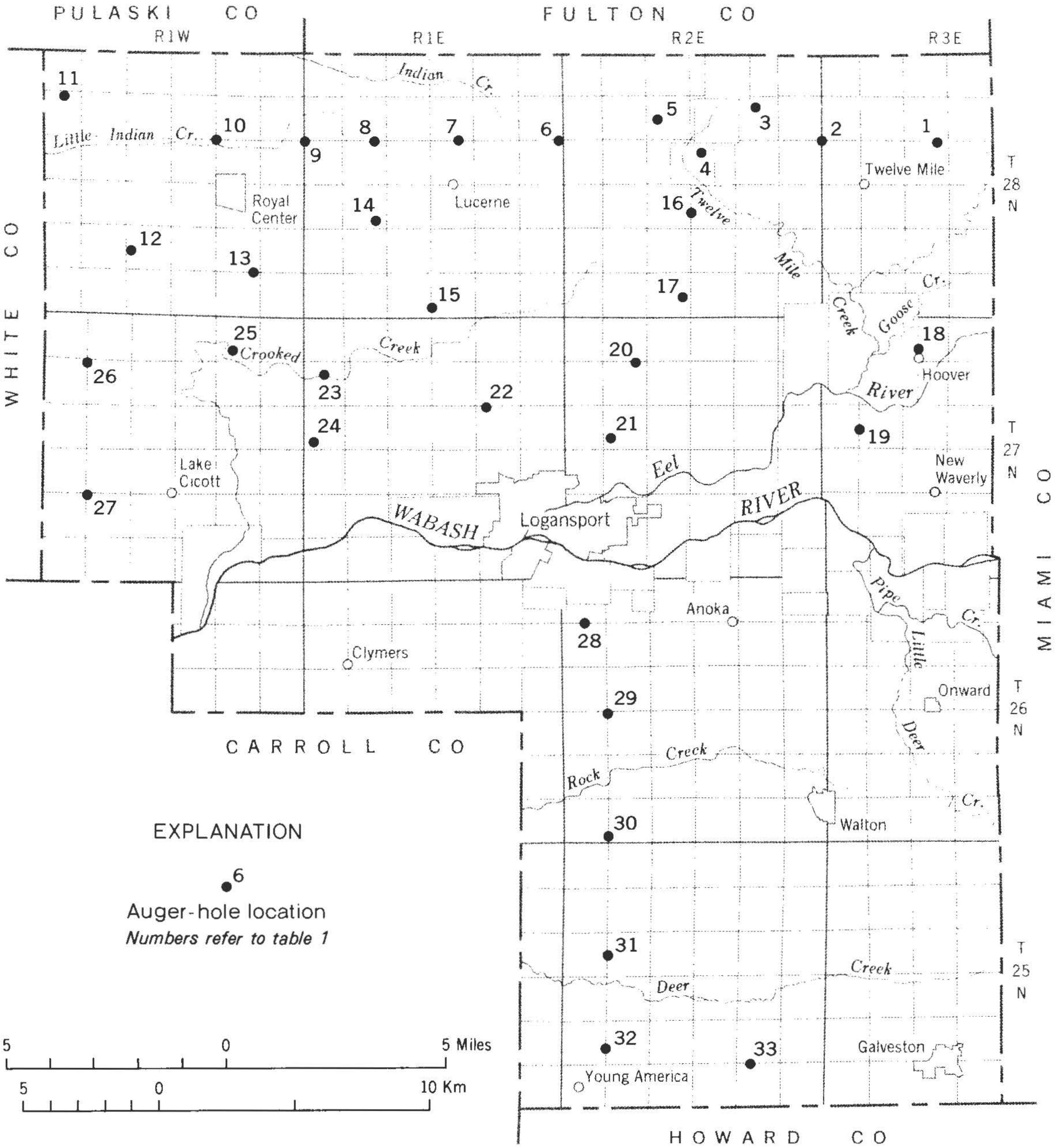


Figure 9. Map showing locations of auger-boring sites in Cass County. (See table 1.)

PHYSICAL PROPERTIES OF GLACIAL TILLS

The physical properties of the surface tills in Cass County were determined from analyses of 156 samples derived from 33 auger borings throughout the county (fig. 9 and table 1). The primary purpose of these borings, which average 29 feet in depth, was to determine the vertical and areal variability of the upper till sequence, primarily in terms of matrix texture, carbonate content, and compactness.

Table 1. Geologic data for auger-boring samples[1]

Location No.	Depth (ft)	Description	Texture[2]				Carbonate content[3]	
			Granule	Sand	Silt	Clay	Calcite	Dolomite
1	0- 3	Medium-gray sand						
	3- 5	As above						
	5- 8	Gray (10YR 4/1)[4] loam (sample at 8 ft)	2.0	48.8	32.6	18.6	15	20
	8-38	As above, but sand content increases with depth (sample at 38 ft)	4.2	49.5	32.1	18.4	15	24
2	0- 3	Medium-gray (10YR 7/2) leached sand (sample at 3 ft)	trace	92.2	2.7	5.1	2	1
	3- 6	As above						
	6- 8	Till						
	8-13	Sandy zone with till inclusions						
	13-18	Gray (10YR 5/1) loam till (sample at 18 ft)	3.5	50.0	29.8	20.2	15	22
	18-38	As above, but sand content increases with depth, and the till becomes softer (sample at 38 ft)	3.2	55.4	28.0	16.6	14	23
3	0- 3	Brown/tan (10YR 5/6 mottle smear) leached loam till (sample at 3 ft)	1.1	46.8	29.6	23.6	trace	1
	3- 8	As above, with increase in mud content (sample at 8 ft)	1.8	43.9	32.6	23.4	13	17
	8-13	Gray (10YR 5/1) loam till; soft and saturated (sample at 13 ft)	3.2	45.9	33.1	21.0	13	22
	13-18	As above with sand stringers at irregular intervals						
	18-23	As above						
	23-28	As above						
	28-32	As above, but denser (sample at 32 ft)	3.5	47.4	29.4	23.2	15	20

4	0- 3	Medium to fine sand with iron staining						
	3- 7	Reddish-brown oxidized loam till (core from 7 to 9 ft)						
	7-13	As above						
	13-18	Intratill sand and gravel; till at about 17 ft						
	18-23	Brown (10YR 4/2-4/3) calcareous loam till; numerous well-rounded pebbles; portions of the basal zone highly oxidized (sample at 23 ft)	4.0	48.8	43.0	8.2	15	21
5	0- 3	Brown (10YR 5/3 mottle smear) weakly calcareous sandy silt	1.0	45.4	32.0	22.5	1	1
	3- 8	Light-brown (10YR 5/6) calcareous soft loam till (sample at 8 ft)	2.0	44.7	38.1	17.2	8	18
	8-13	Loam till; in sand at 13 ft (sample at 13 ft)	3.3	44.6	38.9	16.5	9	19
	13-23	Gray calcareous loam till (sample at 23 ft)	3.5	43.8	37.0	19.2	15	19
	23-38	As above, but progressively sandier with much gravel (sample at 38 ft)	10.8	45.2	33.6	21.2	12	20
6	0- 3	Red-brown (10YR 5/6 mottle smear) sandy clay loam till (sample at 3 ft)	0.9	55.6	21.0	23.4	trace	1
	3- 8	Brown (10YR 5/4) calcareous loam till; slight increase in sand content with depth (sample at 8 ft)	3.0	39.6	41.5	18.8	10	19
	8-13	Loam till (sample at 11 ft)	1.8	43.4	36.2	20.4	11	17
	13-23	As above with saturated sand interval from 20 to 23 ft; gray (10YR 4/1) calcareous loam till from about 15 ft (sample at 18 ft)	2.6	42.6	37.3	20.1	15	20
	23-28	Sand and gravel with till inclusions						
	28-32	As above						
	32-38	Gray-brown (10YR 6/1-5/1) calcareous soft loam till (sample at 38 ft)	5.5	37.5	40.2	22.4	8	16

Footnotes for table 1 are on page 20.

Table 1. Geologic data for auger-boring samples—Continued

Location No.	Depth (ft)	Description	Texture				Carbonate content	
			Granule	Sand	Silt	Clay	Calcite	Dolomite
7	0- 3	Mottled (10YR 6/6 mottle smear) calcareous loam till (sample at 3 ft)	3.4	41.7	39.0	19.3	12	19
	3- 8	As above, but in sand and gravel from 8 ft						
	8-13	Till (sample at 12 ft)	0.2	72.6	11.5	15.9	----	----
	13-18	Gray (10YR 4/1) calcareous loam till (sample at 10 ft)	4.2	44.7	35.6	19.7	12	21
8	0- 3	Mottled (10YR 5/8 and 5/4) medium sand with mud binder; pebbles scattered throughout (sample at 3 ft)	1.7	54.6	25.6	20.2	0	1
	3- 8	Brown (10YR 5/6) sandy loam till with numerous pebbles (sample at 8 ft)	4.4	53.9	34.4	11.7	12	22
	8-13	Loam till with gravel						
	13-18	Sand and gravel						
	18-27	Gray (10YR 5/1) soft loam till (sample at 27 ft)	3.9	48.7	34.8	16.6	12	22
9	0- 4	Mottled (10YR to 5/8) loam till (sample at 4 ft)	1.7	38.2	40.8	21.0	11	19
	4- 8	Transition to gray (10YR 5/2) soft loam till at about 6 ft (sample at 8 ft)	3.3	44.2	36.9	18.8	11	21
	8-13	Similar to above but darker gray (10YR 5/1) with numerous shale pebbles (sample at 13 ft)	4.9	46.6	36.4	17.0	12	21
	13-28	As above with sandy zones within till; saturated						
	28-38	Till becoming increasingly sandy with depth; consistency is soft (sample at 33 ft)	3.9	50.3	29.3	20.4	11	22
10	0- 2	Sandy road fill						
	2- 6	Brown (10YR 5/6) till (sample at about 5 ft)	3.9	52.6	31.2	16.2	10	21
	6-15	Gray sandy loam till						
	15-30	As above, but very soft						

11	0- 4	Red oxidized medium dune sand (sample at 4 ft)	0.0	83.6	8.3	8.1	1.0	0.7
	4- 9	Sand and fine gravel						
	9-14	As above with probable till inclusions						
	14-18	Sand						
	18-25	Gray (10YR 5/1) sandy loam till (sample at 25 ft)	0.9	52.3	57.7	10.0	10	27
12	0- 4	Mottled (10YR 5/6 mottle smear) leached sandy clay loam till (sample at 4 ft)	4.1	61.7	14.9	23.3	1	1
	4- 9	Saturated muddy sand						
	9-19	Sand and gravel						
	19-25	Gray (2.5Y to 10YR 5/0-5/1) calcareous hard sandy loam till (sample at 25 ft)	6.5	54.0	32.1	13.9	11	22
13	0- 4	Brown (10YR 5/6 mottle smear) slightly calcareous loam till (sample at 4 ft)	1.7	40.9	31.5	27.6	1.2	0.7
	4- 9	As above with an increase in sandy content						
	9-14	Sand and gravel from 10 ft						
	14-25	Sand and gravel						
14	0- 4	Mottled leached loam till (sample at 4 ft)	1.8	41.5	36.7	21.8	1	1
	4- 9	Brown (10YR 5/3) calcareous soft loam till (sample at 9 ft)	3.5	41.7	40.7	17.6	23	13
	9-10	Silty till as above; rock at 10 ft						
15	0- 4	Brown (10YR 5/4) leached loam till (sample at 4 ft)	1.0	36.0	34.4	29.6	1.9	0.7
	4- 9	Muddy water sand						
	9-15	Light-brown (10YR 6/6) loam till (sample at 14 ft)	2.9	39.8	38.1	22.1	12	19
	15-25	Sand and gray till sheared together						

Table 1. Geologic data for auger-boring samples—Continued

Location No.	Depth (ft)	Description	Texture				Carbonate content	
			Granule	Sand	Silt	Clay	Calcite	Dolomite
16	0- 4	Mottled (10YR 5/1 to 5/6) leached loam till (sample at 4 ft)	0.7	47.9	30.1	22.0	1	1
	4- 8	Brown loam till						
	8-14	Gray (10YR 6/1 to 5/1) calcareous soft saturated loam till (sample at 14 ft)	1.0	31.4	55.8	12.7	16	23
	14-25	Gray (10YR 5/1) calcareous soft loam till (sample at 24 ft)	5.1	48.5	36.3	15.2	13	21
17	0- 4	Mottled brown (10YR 5/4 to 5/6) leached loam till (sample at 4 ft)	0.8	51.7	31.8	16.5	1	1
	4- 8	Above grades into slightly calcareous loam (sample at 8 ft)	2.9	50.8	34.3	14.9	6	15
	8-12	Muddy sand to 12 ft with gravel lens at 10 ft						
	12-19	Brown (10YR 5/4) moderately calcareous very sandy loam till (sample at 19 ft)	4.4	53.6	31.8	14.6	4	12
	19-24	Sand and gravel with 3- to 8-cm pebbles and cobbles common (sample at 24 ft)	6.8	64.2	25.8	10.0	7	18
	24-29	As above (sample at 29 ft)	8.5	67.3	23.0	9.7	5	15
	29-50	As above, but in pea gravel from about 40 ft; till blebs at 50 ft (sample at 50 ft)	4.7	72.1	19.7	8.2	9	20
	50-65	Water sand with pea gravel; stringers of sandy till recovered in outwash material						
18	0- 4	Mottled (10YR 5/6-4/3) leached loam till (sample at 4 ft)	1.7	35.7	38.3	26.9	0.5	0.7
	4- 8	Medium to coarse sand with till blebs (sample at 8 ft)	5.3	73.6	15.2	11.2	5	19
	8-18	Brown (10YR 4/4 mottle smear) moderately calcareous loam till; sheared sand and gravel lenses common (sample at 18 ft)	3.5	39.7	38.6	21.7	2	4
	18-23	Sand and gravel						
	23-48	Gray (10YR 5/1) calcareous sandy loam till with numerous sand and gravel lenses (representative sample taken)	2.4	63.4	23.8	12.8	13	19

19		No log						
20	0- 2	Fill						
	2- 3	Sandy loam till						
	3- 5	Weathered till						
	5- 8	Brown (10YR 5/3) sandy loam till (sample at 8 ft)	5.6	55.8	28.2	16.0	14	23
	8-13	As above						
	13-18	Gray (10YR 4/1) hard loam till (sample at 18 ft)	5.9	48.7	32.5	18.7	14	24
	18-30	As above, but very hard						
	30-38	Softer material; lost sample						
21	0- 4	Dark-brown (10YR 4/2) calcareous loam till at 3 ft (sample at 4 ft)	4.2	45.7	39.0	15.3	2	32
	4- 9	As above						
	9-14	As above, but grades into weathered till at about 10 ft						
	14-19	As above to 16 ft; very sandy from that point on (sample at 19 ft)	3.0	45.3	37.2	17.5	10	20
	19-33	Very soft muddy gravel (till?) to 33 ft						
22	0- 4	Light-brown (10YR 5/6) calcareous loam till (sample at 4 ft)	2.8	47.8	34.9	17.3	6	20
	4- 9	As above, but sand content decreases with depth						
	9-15	Brown (10YR 5/4) calcareous loam till (sample at 14 ft)	3.3	47.3	34.9	17.9	13	21
	15-20	Water sand						
	20-25	Gray (10YR 4/1) hard loamy to loam till (sample at 24 ft)	2.1	35.3	40.2	24.5	15	19
23	0- 4	Mottled gray to reddish-brown moderately calcareous loam till (sample at 4 ft)	1.1	41.6	37.2	21.2	1	17
	4- 9	Tan loam till						
	9-14	Brown (10YR 5/3) soft loam till						
	14-25	Gray (10YR 5/1) moderately calcareous soft loam till (sample at 24 ft)	1.3	34.4	39.3	26.3	4	19

Table 1. Geologic data for auger-boring samples—Continued

Location No.	Depth (ft)	Description	Texture				Carbonate content	
			Granule	Sand	Silt	Clay	Calcite	Dolomite
24	0- 4	Red-brown (10YR 5/6 mottle smear) leached soft loam till (sample at 4 ft)	2.0	44.1	30.5	25.4	trace	1
	4- 9	Loam till						
	9-14	Sand and gravel with mud binder (possibly a gravel till?) (sample at 14 ft)	8.8	59.5	26.1	14.4	9	17
25	0- 4	Mottled brown (10YR 5/6 mottle smear) loam colluvium (sample at 4 ft)	0.0	43.7	38.0	18.2	0.2	0.7
	4- 9	As above						
	9-14	Light-brown (10YR 6/6) calcareous loam till (sample at 14 ft)	3.1	46.3	40.3	13.3	5	21
	14-25	Till grades into sand						
	25-30	Medium to coarse sand						
26	0- 4	Mottled gray-brown (10YR 4/3 mottle smear) calcareous loam till (sample at 4 ft)	2.2	44.8	38.4	16.7	11	22
	4-15	As above						
	15-17	As above						
	17-25	Gray (2.5Y 5/0) soft sandy loam till (sample at 25 ft)	3.3	54.1	32.8	13.1	12	23
27	0- 4	Mottled brown (10YR 5/6 mottle smear) leached soft loam (sample at 4 ft)	1.1	32.0	44.5	23.5	0.7	1.6
	4- 9	Very sandy mud to muddy sand						
	9-15	Brown (10YR 5/6) sandy till with numerous sand and gravel stringers (sample at 15 ft)	4.1	54.0	30.9	15.1	10	23
	15-25	Mostly sand and gravel with some till stringers						

28	0- 4	Brown (10YR 5/6) leached silt (possibly alluvium) (sample at 4 ft)	0.0	3.2	70.5	26.3	1	1
	4- 9	Sandy loam till						
	9-18	As above; moderately calcareous (sample at 14 ft)	2.3	36.8	42.6	20.6	6	24
	18-28	Gray (2.5Y 6/0 to 5/0) loam till mixed with brown (10YR 5/4) loam till; probably sheared together (sample at 24 ft)	7.6	40.6	39.5	19.9	5	16
	28-30	Auger refusal in reddish material (probably weathered bedrock surface)						
29	0- 4	Mottled (2.5Y 4/2 mottle smear) slightly calcareous silty clay loam till (sample at 4 ft)	1.2	19.8	47.4	32.8	1	1
	4- 9	As above, but very soft and saturated						
	9-15	Gray (2.5Y 6/0) sandy loam till (sample at 15 ft)	3.2	55.9	29.7	14.4	13	23
	15-23	As above; auger refusal at 23 ft						
30	0- 4	Mottled (2.5Y 5/4 mottle smear) slightly calcareous silt loam till (sample at 4 ft)	0.5	18.1	57.0	24.8	1	1
	4- 9	As above						
	9-14	Gray (2.5Y 5/0) calcareous soft loam till (sample at 14 ft)	3.2	37.4	44.9	17.7	13	20
	14-25	Gray (10YR 5/1) calcareous soft loam till (sample at 24 ft)	4.5	50.1	39.1	11.8	12	24
31	0- 4	Mottled (10YR 5/6 mottle smear) slightly calcareous silt loam till (sample at 4 ft)	0.8	17.3	54.1	28.6	0.2	0.7
	4-10	Brown to gray till						
	10-15	Dark-gray (2.5Y 4/0) hard loam till (sample at 15 ft)	2.8	35.7	40.8	23.6	13	18
	15-20	As above, but more silty						
	20-25	Gray (10YR 5/1) loam till (sample at 24 ft)	2.9	31.9	49.9	18.2	13	27

Table 1. Geologic data for auger-boring samples—Continued

Location No.	Depth (ft)	Description	Texture				Carbonate content	
			Granule	Sand	Silt	Clay	Calcite	Dolomite
32	0- 4	Mottled brown (10YR 5/4 mottle smear) leached loam till (sample at 4 ft)	1.8	45.2	29.3	25.5	0.2	0.9
	4-10	Very soft loam till						
	10-17	As above						
	17-25	Gray (7.5Y 5/0) loam till mixed with brown (10YR 5/3) loam till (sample at 24 ft)	6.4	50.4	35.6	14.0	14	23
33	0- 4	Mottled gray (10YR 4/1 to 6/6) leached clay loam till (sample at 4 ft)	0.8	23.9	39.3	36.8	2	1
	4- 9	Soft saturated loam till						
	9-12	As above						
	12-15	Gray (10YR to 2.5Y 5/1 to 5/0) hard sandy loam till (sample at 15 ft)	4.5	53.7	29.8	16.6	14	21
	15-20	As above						
	20-25	Gray-brown very dry till (sample at 24 ft)	3.8	44.6	36.0	19.4	11	17

[1]The locations of the 33 auger-boring sites are shown in figure 9.

[2]Texture refers to the percentages (expressed as weight percent of the total sample) of the different particle sizes of the sample (granule, 4- to 2-mm; sand, 2- to .063-mm; silt, .063- to .004-mm; and clay, .004- to .00006-mm).

[3]Carbonate content is the percentage by weight of calcium carbonate and calcium-magnesium carbonate of the sample that passes through a 200-mesh sieve.

[4]Color classification is based on the color code in the "Munsell Soil Color Charts" (1971 ed.), Munsell Color Co., Inc., Baltimore, Md. 21218.

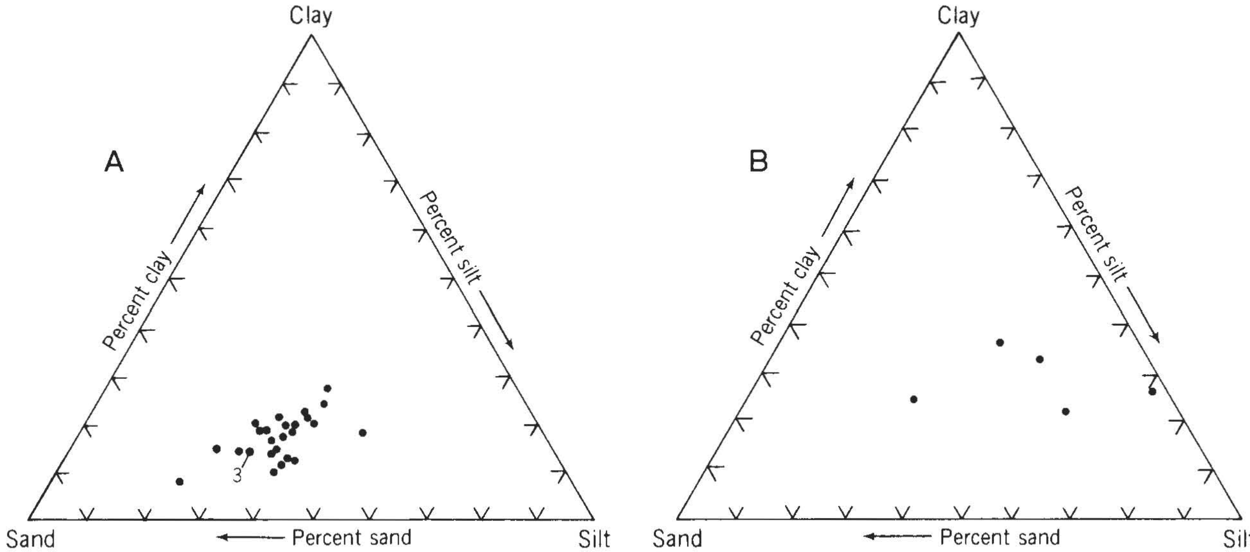


Figure 10. Ternary diagrams illustrating textural variation in the upper tills of Cass County. Part *A* shows the textural distribution of samples from each auger station for an average depth of 20 feet. Part *B* is a plot of the samples from borings south of the Wabash River at the 4-foot depth interval.

North of the Wabash River, the county is mantled by at least 25 feet of loam to sandy loam till. In most of the borings a slight increase in sand content is encountered with depth. Areal textural variation within a given horizon of the till is quite small when one considers that most tills are heterogeneous (fig. 10*A*).

The same loam till is found south of the Wabash, but there it is overlain by a veneer (15 feet at the most) of silty to silty clay loam till. Borings 28 through 31 and 33 (fig. 9 and table 1) confirm a sharp textural break in the near surface. In boring 30, for example, sand, silt, and clay percentages are 18.1, 57.0, and 24.8 at the 4-foot depth interval. Ten feet lower, however, sand content increases to 37.4 percent, and silt content and clay content drop to 44.9 and 17.7 percent. As mentioned above, this finer textured unit is probably a younger till that may have been deposited by an ice lobe different from that of the underlying loam till. Unlike the loam till, the upper silty till (on the basis of sampling south of the Wabash River) exhibits considerable textural scatter within the sampling horizon (fig. 10*B*). The textural variation is probably due to the removal of samples from the soil profile. This removal resulted in variable concentrations of clay because of downward migration of clay-size particles and chemical reactions within the solum.

The silty till has medium to stiff consistency, and the loam till has soft to very hard consistency, depending on depth, sand content, proximity to sand bodies, and elevation of the local water table. The sand bodies, which help to conduct water away from the till, when combined with a low water table, bring about desiccation of the till and a great increase in its hardness.

Near Metea (fig. 9, location 4), an extremely hard zone within the loam till was encountered at the 16- to 17-foot depth interval. A standard-penetration drive-sample test at this depth indicated that the till had an unconfined compressive strength well in excess of 4.0 tons per square foot. Such zones of hard consistency within the loam till were uncommon and probably resulted from glacial preconsolidation during deposition and dewatering as mentioned above. The loam till encountered in most of the borings has been classed as stiff, primarily on the basis of estimations made by observing the hydraulic-pressure variations within the auger drive motor while drilling through the given materials.

Geologic Resources

LIMESTONE AND DOLOMITE RESOURCES

In Indiana limestone and dolomite are mainly used as aggregate, dimension stone, and cement raw material. High-calcium limestone and high-magnesium dolomite also have many uses. Lime, the product obtained by heating high-purity limestone or dolomite, has more than a hundred applications in industry.

In Cass County two quarries owned by the Engineering Aggregates Corp. produce crushed-stone aggregate and agricultural limestone. The Louisville Cement Co. has restricted its operation to cement products. Lime, produced by the France Stone Co. before 1943, is no longer made in Cass County. Relatively low volumes of the raw material, high labor costs, and competition from large lime operations in other counties are reasons cited for local demise of the lime industry (Ault and others, 1974). The three active stone quarries (locations 1 through 3, table 2 and fig. 11) produce from the upper part of the Salina Formation (Kenneth and Kokomo Limestone Members).

Limestone reserves (arbitrarily chosen as those areas containing the desirable bedrock units where drift cover is 25 feet thick or less, fig. 11) are topographically high and are largely restricted to the Wabash River flood plain and adjacent uplands. The outcrop and inferred subcrop of the Traverse Formation occur at a few locations east of Logansport, mostly along the Wabash River and Pipe Creek.

Chert has a deleterious effect on the quality and type of aggregate produced. The Kenneth, for example, is plagued by locally high percentages of chert. On the average, however, the Kenneth is still considered to be a source of class-A aggregate by the Indiana State Highway Commission.

Solution features are also a problem for quarry operators. Dominantly in the Kenneth, but also to a lesser degree in the Kokomo, the karst features (mostly grykes) are generally filled with clay and rubble, both of which contaminate the stone. Conventional methods of detecting karst features, such as close-grid test boring, are expensive and time consuming. Electromagnetic prospecting may provide a means of quickly detecting areas of *relative*

Table 2. Rock formations and their thicknesses at three active limestone quarries in Cass County

Reference No.[1]	Quarry name	Stratigraphy	
		Unit	Thickness (ft)
1	Engineering Aggregates Corp.	Glacial drift	6.0
		Salina Formation	82.0
		Kenneth Limestone Member	38.0
		Kokomo Limestone Member	44.0
2	Louisville Cement Co.	Salina Formation	35.0
		Kenneth Limestone Member	35.0
3	Engineering Aggregates Corp.	Sand and gravel	15.0
		Salina Formation	101.0
		Kenneth Limestone Member	28.7
		Rubble zone	15.0
		Kokomo Limestone Member	57.3

[1] Locations of these reference numbers are shown in figure 11.

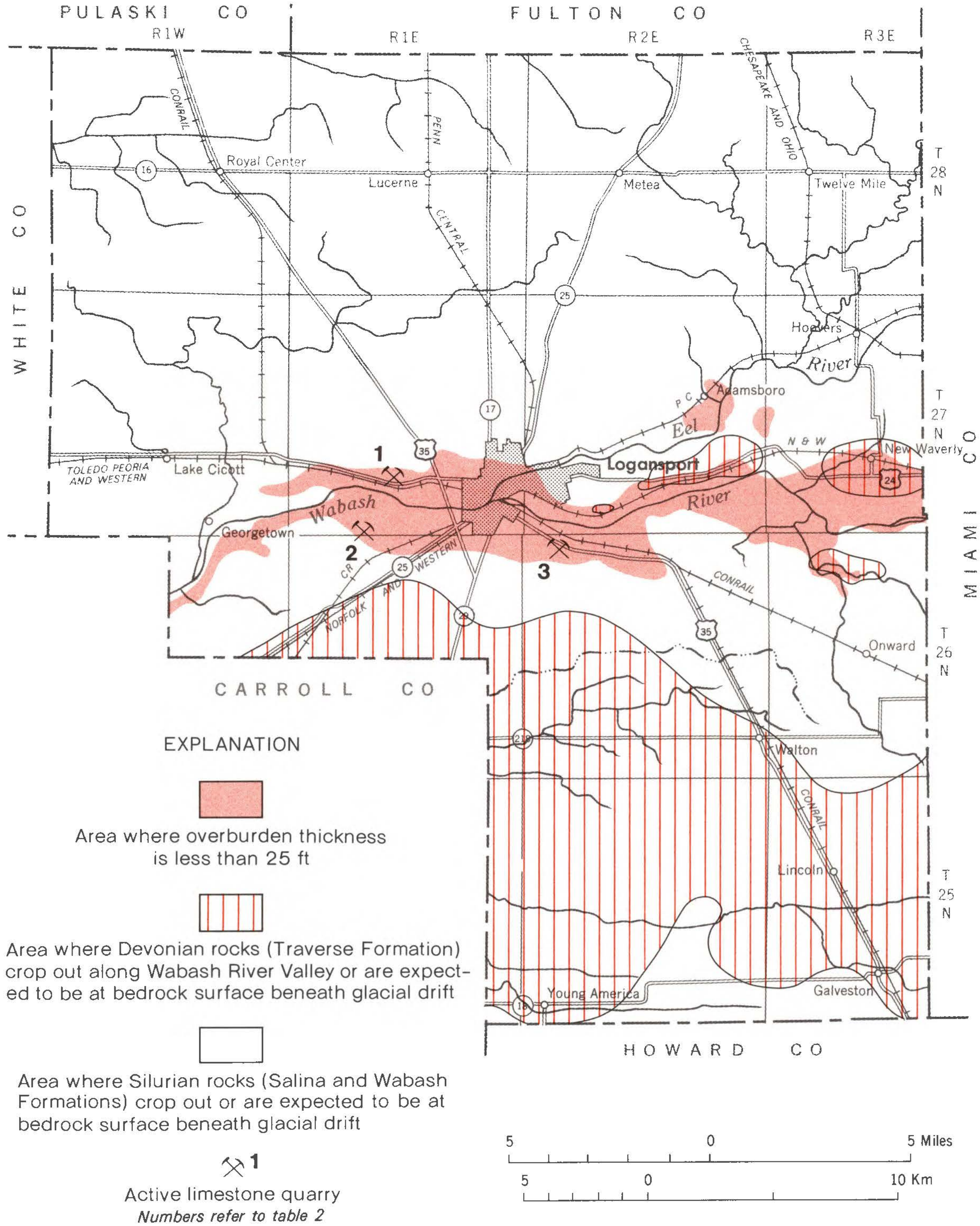


Figure 11. Map showing quarries and limestone and dolomite production potential in Cass County. (See table 2.)

karst density where the solution features are exposed at the bedrock surface (Grant and West, 1965).

OIL AND GAS RESOURCES

Oil production in Cass County has been modest since the first well was sunk in 1897 on the property of J. Baumgardner (NW¼NW¼NE¼ sec. 36, T. 26 N., R. 2 E.). The well had an initial output of about 35 barrels per day and was completed in the Trenton Limestone 1,024 feet below the surface. This was the first well in what was to become the Walton Field (fig. 12). In all, 10

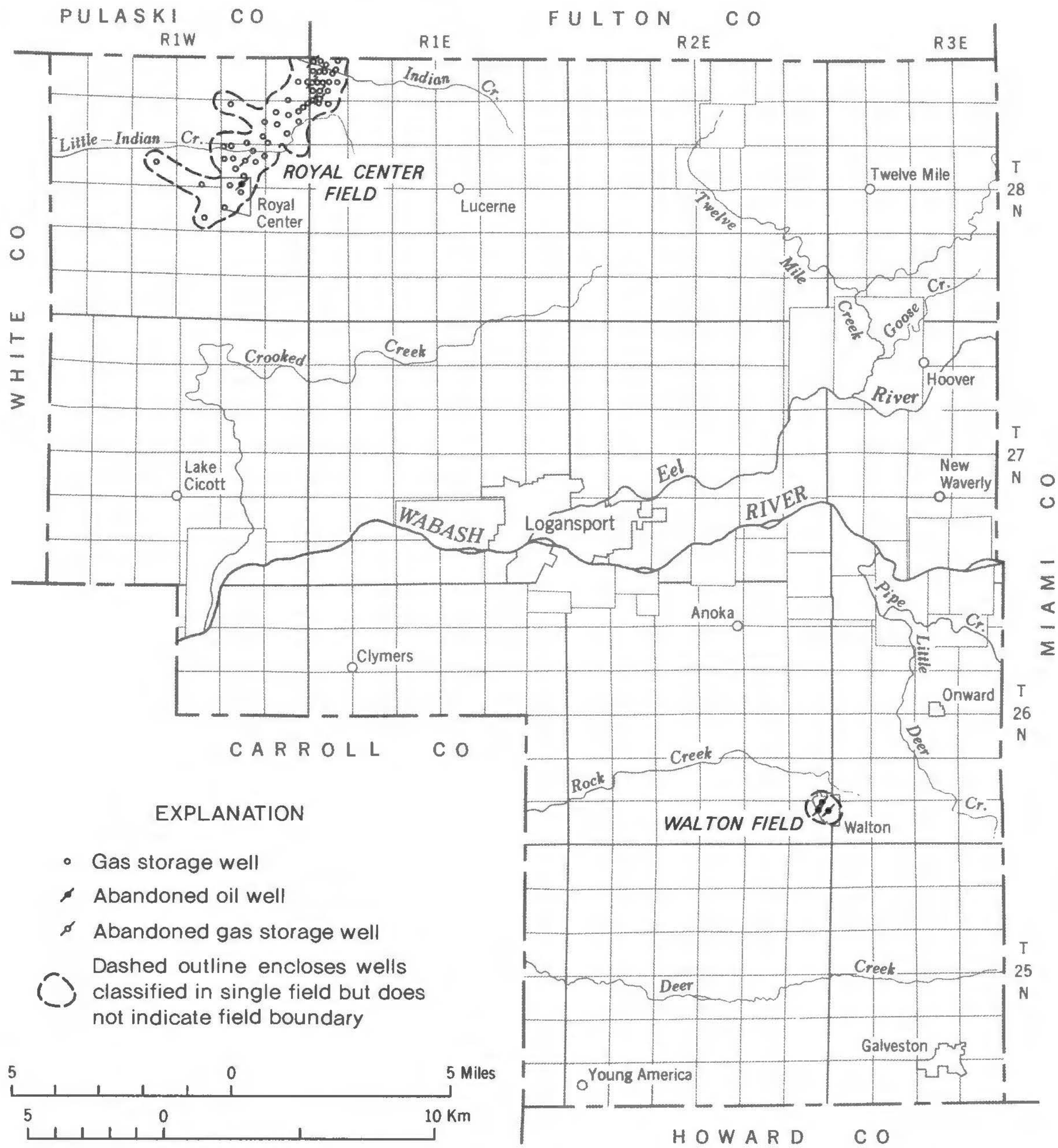


Figure 12. Map showing locations of gas storage and abandoned oil wells in Cass County. Modified from Keller and Walker, 1960.

wells were drilled in the general area, only three of which produced oil. The second active well, for which production figures have been lost, was drilled in 1900. In June 1948 the third and last producer was drilled into the Trenton. It was abandoned, as were the other two, not long after going into operation. A single producing well was sunk in 1909 at Royal Center. Like those at Walton, this well extracted oil from the Trenton Limestone, but it was soon abandoned.

Future production of oil and gas, except in minor shows that would probably not even cover the drilling costs, is unlikely. No active oil wells are known in the county.

In terms of storage potential, Royal Center (fig. 12) is the site of Indiana's largest gas-storage project. Owned by the Northern Indiana Public Service Co., the Royal Center gas-storage field is capable of storing between 2 million and 10 million Mcf (thousand cubic feet) of gas within an aquifer in the St. Peter Sandstone. The maximum daily deliverability of the system is estimated at 20,000 to 80,000 Mcf. Storage in the St. Peter is made possible by a structural entrapment in the form of a large anticline bounded on the southeast by the Royal Center Fault (Dawson and Carpenter, 1963).

More than 50 injection wells are in operation in Cass County, and additional wells have been installed for observation. Twenty-four test borings were made to gain stratigraphic and structural information about the area. On this information, gas-storage wells have also been completed in the Trenton Limestone, the Knox Dolomite, and the Mount Simon Sandstone, so that four formations are presently being used for gas storage in Cass County (Stanley J. Keller, oral communication, 1979).

SAND AND GRAVEL RESOURCES

Sand and gravel as mineral commodities are defined in terms of particle size. All particle sizes betwen 1/16 and 2 millimeters in diameter are considered sand, and the coarser fractions from 2 millimeters to as much as 10 centimeters in diameter are commonly gravel. In Cass County sand and gravel occur principally as outwash terraces and valley-train deposits along the Wabash River and its tributaries, Eel River, Goose Creek, Pipe Creek, and Crooked Creek. Valley-train deposits also are along Deer Creek in the southern part of the county (fig. 13).

Hill and moundlike structures (kames) composed of stratified sand and gravel are found at a few localities, mostly in the northwest quarter of the county. But these features contain only minor amounts of aggregate material.

Aggregate quality, which is monitored both by the producers and by such consumers as the State Highway Department, varies throughout the county. For example, two of the four active pits are producing coarse aggregate with an A-1 rating and sand with an A-5. A third operation, however, is selling coarse aggregate under a D-1 classification. I am unaware of other classification ratings for sand and gravel deposits in Cass County.

Areas that have potential for production of sand and gravel (fig. 13) include:

(1) Recent flood plains and terraces of Deer Creek.

(2) The Wabash-Eel-Pipe Creek system in the central part of the county. This area has by far the greatest potential in the county.

(3) Kame deposits on the morainic area in the northeastern and northwestern parts of the county. These deposits are limited in areal extent and are insignificant as sand and gravel resources when compared with the extensive valley-train deposits elsewhere in the county. Exploration and exploitation of these resources will depend on demand within a 15- to 20-mile radius of the gravel plant and transportation costs.

SUITABILITY OF LAND FOR SANITARY LANDFILLS

The primary geologic requirements for a sanitary landfill are:

(1) The base of a landfill should be in relatively fine-grained materials and more than 10 to 15 feet above the shallowest aquifer; therefore the site should not be in an abandoned sand and gravel pit.

(2) The base of a landfill should be above the highest level of the water table.

(3) The site should not be subject to flooding; therefore it should not be on a flood plain.

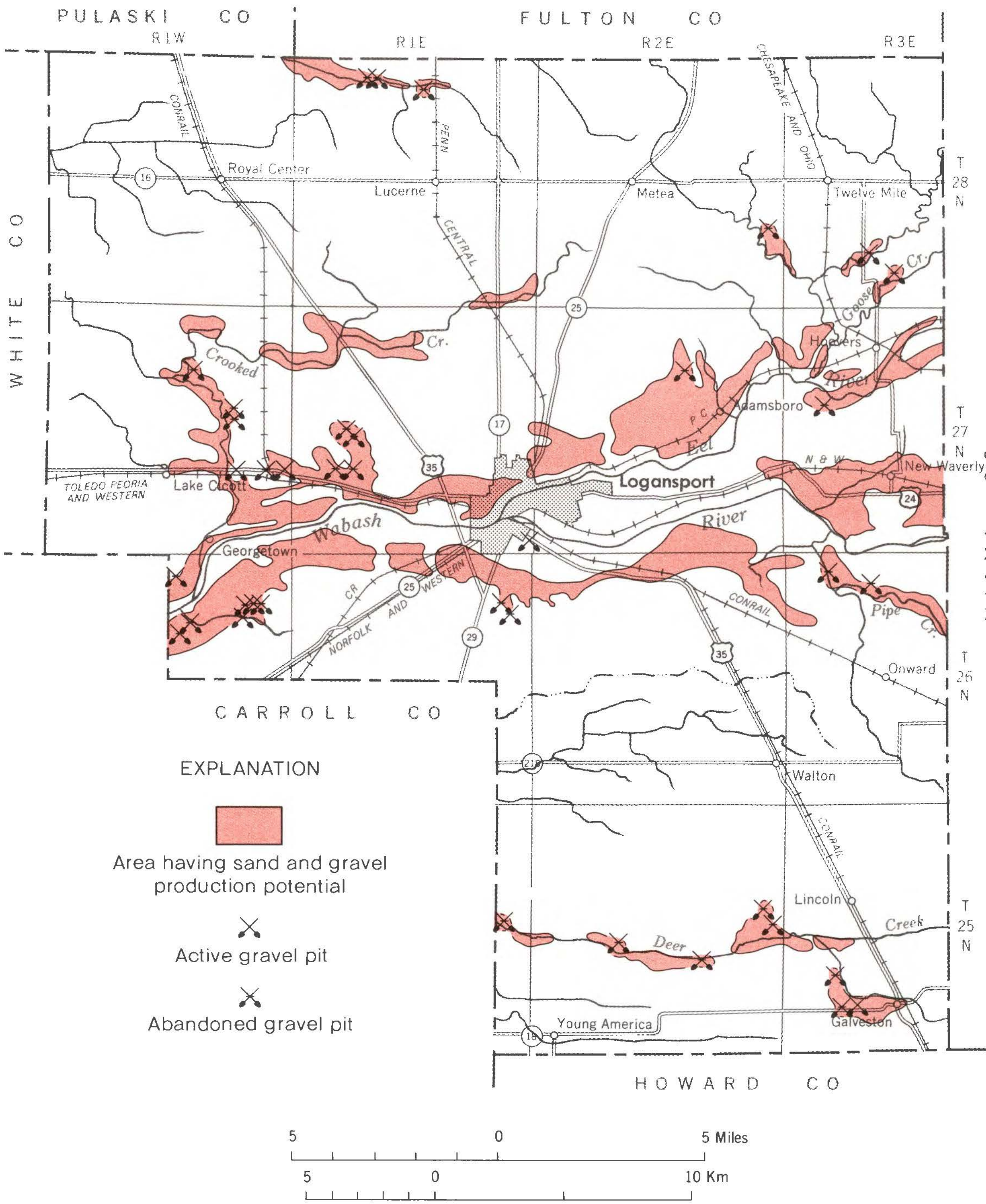


Figure 13. Map showing active and abandoned sand and gravel operations and production potential in Cass County.

(4) Adequate cover material must be available near the site. A sanitary landfill should be in an area that has a minimum depth of 20 feet of low-permeability materials within the fill area. This is an absolute minimum for trench-type fills and an adequate thickness for area-type fills.

Much of the land in Cass County is well suited for sanitary landfills. The glacial tills, which provide most of the suitable fill area, range from loam to sandy loam texturally (see table 1) and should be of sufficiently low permeability in most places to prevent rapid migration of leachate (fig. 14). The part of the county south of the Wabash River is generally best suited for landfilling.

Those areas least adaptable to landfilling include the flood plains of the Eel and Wabash Rivers and the adjacent outwash and valley-train deposits (fig. 14). High flood potential, a high water table, and very permeable sand and gravel deposits make these areas undesirable for all types of landfills. For these same reasons, a narrow band of land on either side of Deer Creek is also undesirable.

A third category, which is fairly well suited for landfilling, consists mainly of dune sand and muck and peat deposits (fig. 14). The variable thickness of the dune sands prohibits landfilling in some places but offers only a minor impediment in others. This also applies to muck and peat deposits, which range from a thin veneer to many feet in thickness. While on-site borings are highly recommended in evaluating any potential landfill site, they are essential if a fill is planned for land falling within this category.

GROUND-WATER RESOURCES

Logansport, Galveston, Royal Center, Walton, and Georgetown have municipal water supplies. Logansport derives its water directly from the Eel River, but Georgetown has an impoundment. The water supplies of the remaining communities and the water supply for the entire rural population and the small towns that do not have municipal supplies come from wells. Reliance on ground water is likely to increase because, among other reasons, ground water is less easily contaminated than surface water and generally requires less treatment.

Water wells in Cass County are completed either in bedrock aquifers, consisting mainly of limestone and dolomite, or in glacial-drift aquifers that are composed of sand and gravel. The bedrock aquifers (refer to drift-thickness map for information on depth to bedrock) occur in carbonate-rock formations of the Silurian System. Relatively impermeable shales exist both above and below the aquifers, but they are not suitable sources of potable ground water. Ground-water extraction from bedrock is concentrated primarily along and south of the Wabash River where the drift cover thins to about 50 feet.

North of the Wabash River, the thick drift cover makes installation of bedrock wells economically unattractive. The glacial aquifers, which consist mainly of sand and gravel zones that generally lie above or beneath a low-permeability till unit, provide excellent yields. Recharge of the drift aquifers, especially those that have surface exposure, is generally rapid, which allows much greater depletion recovery than their bedrock counterparts.

Gillies (1981) and Noel (1978) have discussed the characteristics, hydraulics, and related water quality of bedrock and drift aquifers. Since this information is beyond the scope and intent of this report, the interested reader is encouraged to obtain copies of these reports from the U.S. Geological Survey and Purdue University. (See "Literature Cited" for details on publication source.)

The bedrock and glacial aquifer systems have surface exposure at various localities throughout the county. Cropping out along the Wabash River (see fig. 1), the limestone aquifer receives direct recharge from surface waters. Glacial aquifers consisting of dune and sheet sands and outwash sand and gravel bodies also receive direct recharge by infiltration of surface drainage. Because these ground-water sources, either directly or interconnectedly with underlying aquifers, provide a significant source of water, they should be protected from surface contamination by leachates from sanitary landfills, salt piles, and waste-disposal areas (fig. 15). The

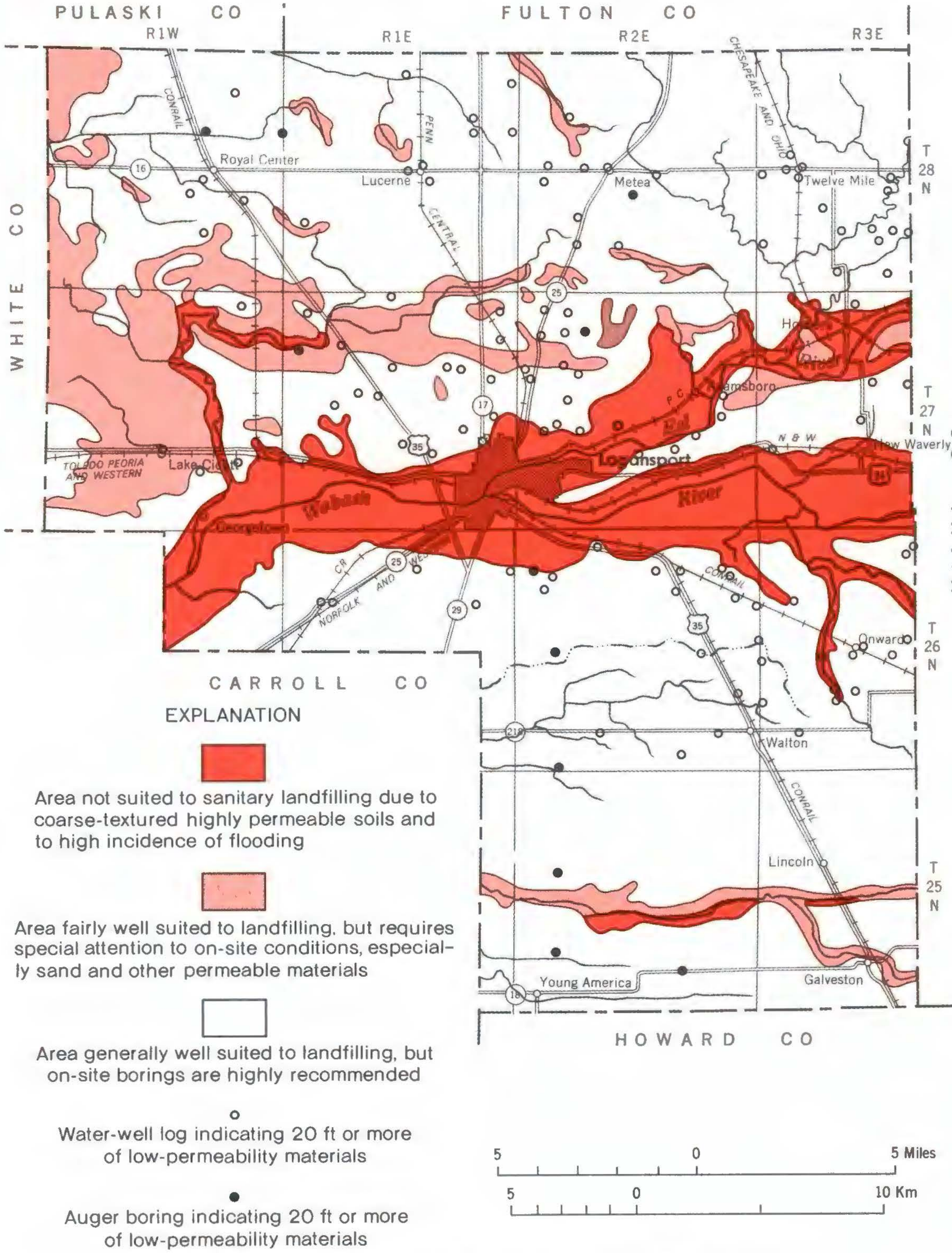


Figure 14. Map showing suitability of land for sanitary landfills in Cass County.

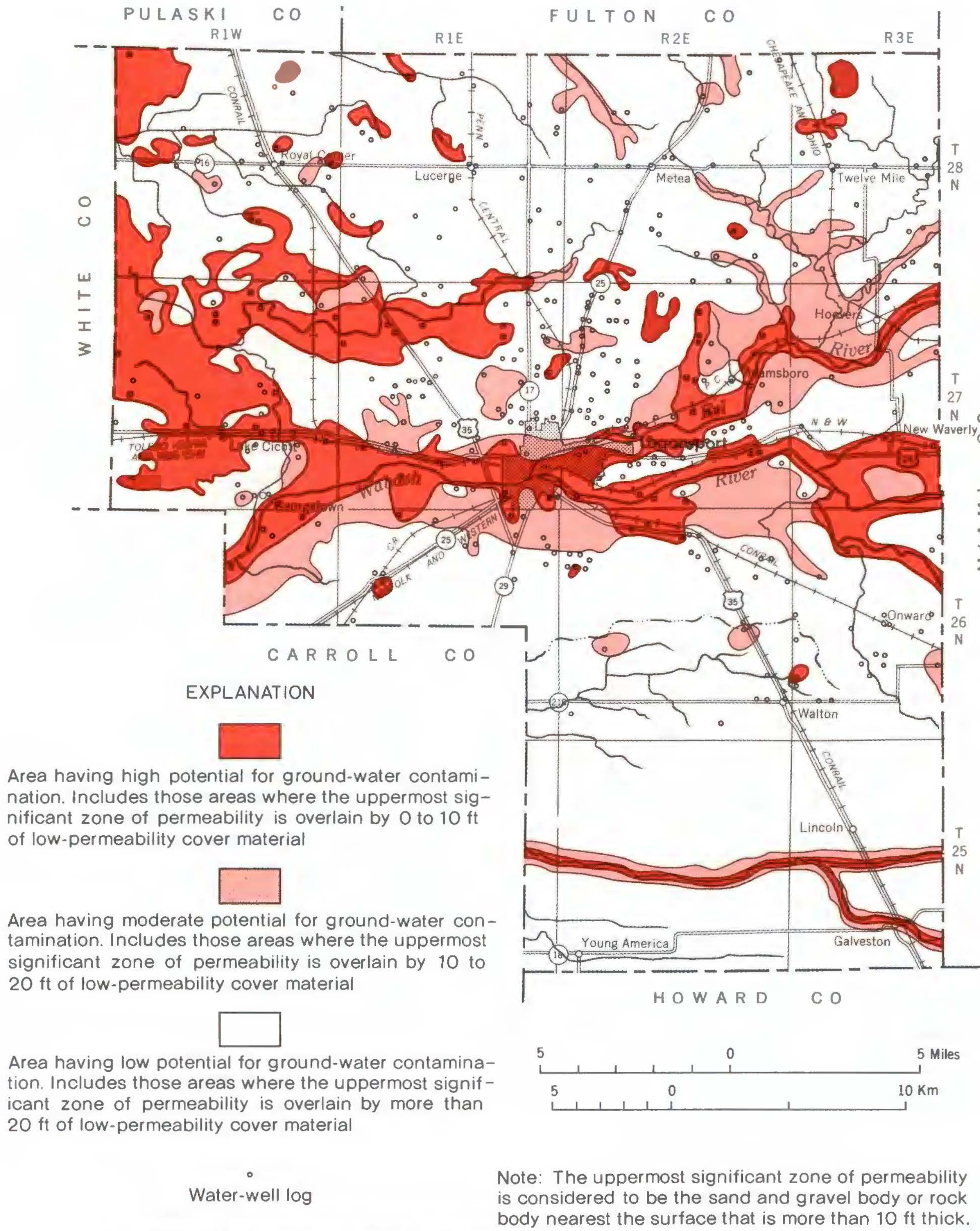


Figure 15. Map showing potential for ground-water contamination in Cass County.

alluvial fill and adjacent valley-train deposits, especially along the Wabash River, but also along Eel River, Deer Creek, and Twelve Mile Creek, are areas with a high potential for ground-water contamination.

The aquifers beneath the upland till areas are the most isolated from surface-derived contamination (fig. 15). High bulk density, a relative abundance of clay and silt in the till matrix, and a low water table ensure slow percolation rates and reasonably high ion-exchange capacity. Therefore, contaminant concentrations are reduced as they infiltrate to the underlying aquifers.

The generally loamy tills in Cass County should be a minimum of 10 feet thick over the highest known aquifer in any given area to ensure minimal protection from potential sources of ground-water contamination. As a general guideline, 15 to 20 feet of loam to silt loam cover material over the uppermost producing aquifer may be considered a safe buffer between the ground water and most types of surface contamination.

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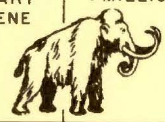
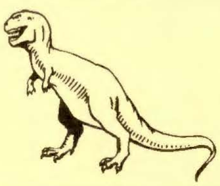
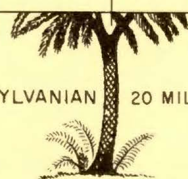
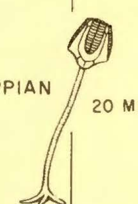
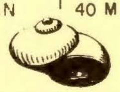
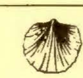
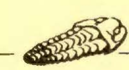
1966 - Geologic map of the 1° X 2° Danville Quadrangle, Indiana and Illinois, showing bedrock and unconsolidated deposits: Indiana Geol. Survey Regional Geol. Map 2.

ERAS	PERIODS	APPROXIMATE LENGTH IN YEARS	ROCK TYPES IN INDIANA	PRINCIPAL MINERAL PRODUCTS
CENOZOIC	QUATERNARY (PLEISTOCENE EPOCH) 	I MILLION	*Glacial drift: till, gravel, sand, silt (including loess), clay, marl, and peat* *(Till and gravel contain boulders of many kinds of sedimentary, igneous, and metamorphic rocks)* Thickness 0 - 500 ft.	*Sand and gravel* *Clay* *Marl* *Peat* *Ground water*
	TERTIARY	60 MILLION	*Cherty gravels* / *Sand and clay* } *Scattered deposits* 0-80 ft.	*Glass sand*
MESOZOIC	CRETACEOUS JURASSIC TRIASSIC	70 MILLION 35 MILLION 30 MILLION	No deposits in Indiana 	
PALEOZOIC	PERMIAN	25 MILLION		
	PENNSYLVANIAN 	20 MILLION	*Shale (including carbonaceous shale), mudstone, sandstone, coal, clay, limestone, and conglomerate* 1,500 ft.	*Coal* *Ceramic clay, shale* *Oil and gas* *Crushed stone* *Building sandstone* *Refractory gravel*
	MISSISSIPPIAN 	20 MILLION	Upper Part: *alternating beds of shale, sandstone, and limestone* 500 ft. Middle Part: *limestone, dolomite; beds of chert and gypsum* 300 ft. Lower Part: *shale, mudstone, sandstone; and some limestone* 600 ft.	*Oil and gas* *Building limestone* *Crushed stone* *Gypsum* *Ceramic shale*
	DEVONIAN 	60 MILLION	Upper Part: *carbonaceous shale* 100 ft. Lower Part: *limestone, dolomite; a few sandstone beds* 40 - 80 ft.	*Oil and gas* *Crushed stone*
	SILURIAN 	40 MILLION	*Dolomite, limestone, chert, siltstone, and shale* 100 - 300 ft.	*Crushed stone*
	ORDOVICIAN  	70 MILLION	*Shale, limestone, and dolomite* 700 ft. *Limestone, dolomite, and sandstone* } Not exposed at the surface in Indiana	*Crushed stone* *Oil and gas*
	CAMBRIAN	80 MILLION	*Sandstone and dolomite* } Not exposed at the surface in Indiana	
PRECAMBRIAN ERAS		3 BILLION	*Granite, marble, gneiss, and other igneous and metamorphic rock types* } Not exposed at the surface in Indiana	

GEOLOGIC TIMESCALE AND INDIANA ROCK CHART