STATE OF ILLINOIS
WILLIAM G. STRATTON, *Governor*
DEPARTMENT OF REGISTRATION AND EDUCATION
VERA M. BINKS, *Director*

DIVISION OF THE
STATE GEOLOGICAL SURVEY
JOHN C. FRYE, *Chief*
URBANA

REPORT OF INVESTIGATIONS 196

GROUNDWATER GEOLOGY OF WHITE COUNTY, ILLINOIS

BY

WAYNE A. PRYOR

AUG. 26th 1818

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

URBANA, ILLINOIS

1956

ERRATUM

Illinois State Geological Survey Report of Investigations 196, "Groundwater Geology of White County, Illinois," by Wayne A. Pryor. On pages 11 and 38: Reference "Bell et al., 1952," should be changed to read, "Meents et al., 1952."

STATE OF ILLINOIS
WILLIAM G. STRATTON, *Governor*
DEPARTMENT OF REGISTRATION AND EDUCATION
VERA M. BINKS, *Director*

DIVISION OF THE
STATE GEOLOGICAL SURVEY
JOHN C. FRYE, *Chief*
URBANA

REPORT OF INVESTIGATIONS 196

GROUNDWATER GEOLOGY OF WHITE COUNTY, ILLINOIS

BY

WAYNE A. PRYOR

AUG. 26th 1818

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

URBANA, ILLINOIS

1956

ORGANIZATION

STATE OF ILLINOIS
HON. WILLIAM G. STRATTON, *Governor*
DEPARTMENT OF REGISTRATION AND EDUCATION
HON. VERA M. BINKS, *Director*

GEOLOGICAL SURVEY DIVISION

JOHN C. FRYE, PH.D., *Chief*

(32473—2400—2-56) ALLIED PRINTING TRADES UNION COUNCIL DANVILLE 2

STATE GEOLOGICAL SURVEY DIVISION

Natural Resources Building, Urbana

John C. Frye, Ph.D., D.Sc., *Chief*
M. M. Leighton, Ph.D., D.Sc., *Chief, Emeritus*
Enid Townley, M.S., *Geologist and Assistant to the Chief*
Velda A. Millard, *Junior Assistant to the Chief*
Helen E. McMorris, *Secretary to the Chief*

RESEARCH

(not including part-time personnel)

GEOLOGICAL RESOURCES SECTION

Arthur Bevan, Ph.D., D.Sc., *Principal Geologist, Emeritus*
Frances H. Alsterlund, A.B., *Research Assistant*

Coal

Jack A. Simon, M.S., *Geologist and Head*
G. H. Cady, Ph.D., *Senior Geologist and Head, Emeritus*
Robert M. Kosanke, Ph.D., *Geologist*
Raymond Siever, Ph.D., *Geologist*
John A. Harrison, M.S., *Associate Geologist*
Paul Edwin Potter, Ph.D., *Associate Geologist*
William H. Smith, M.S., *Associate Geologist*
Kenneth E. Clegg, M.S., *Assistant Geologist*
Margaret A. Parker, M.S., *Assistant Geologist*
David L. Reinertsen, A.M., *Assistant Geologist*
Marcia R. Winslow, M.Sc., *Assistant Geologist*

Oil and Gas

A. H. Bell, Ph.D., *Geologist and Head*
Virginia Kline, Ph.D., *Associate Geologist*
Lester L. Whiting, B.A., *Associate Geologist*
Wayne F. Meents, *Associate Geological Engineer*
Margaret O. Oros, B.A., *Assistant Geologist*
Kenneth R. Larson, A.B., *Research Assistant*
Jacob Van Den Berg, B.S., *Research Assistant*

Petroleum Engineering

Paul A. Witherspoon, M.S., *Petroleum Engineer and Head*
Frederick Squires, A.B., B.S., D.Sc., *Petroleum Engineer, Emeritus*

Industrial Minerals

J. E. Lamar, B.S., *Geologist and Head*
Donald L. Graf, Ph.D., *Geologist*
James C. Bradbury, A.M., *Associate Geologist*
Donald L. Biggs, M.A., *Assistant Geologist*
Meredith E. Ostrom, M.S., *Assistant Geologist*

Clay Resources and Clay Mineral Technology

Ralph E. Grim, Ph.D., *Consulting Clay Mineralogist*
W. Arthur White, Ph.D., *Geologist*
Herbert D. Glass, Ph.D., *Associate Geologist*

Groundwater Geology and Geophysical Exploration

George B. Maxey, Ph.D., *Geologist and Head*
Merlyn B. Buhle, M.S., *Geologist*
Robert E. Bergstrom, Ph.D., *Associate Geologist*
James E. Hackett, M.S., *Assistant Geologist*
Wayne A. Pryor, M.S., *Assistant Geologist*
Lidia Selkregg, D.N.S., *Assistant Geologist*
Margaret J. Castle, *Assistant Geologic Draftsman* (on leave)
Arthur J. Zeizel, B.A., *Research Assistant*
Robert C. Parks, *Technical Assistant*

Engineering Geology and Topographic Mapping

George E. Ekblaw, Ph.D., *Geologist and Head*
William C. Smith, M.A., *Assistant Geologist*

Stratigraphy and Areal Geology

H. B. Willman, Ph.D., *Geologist and Head*
Elwood Atherton, Ph.D., *Geologist*
David H. Swann, Ph.D., *Geologist*
Charles W. Collinson, Ph.D., *Associate Geologist*
Donald B. Saxby, M.S., *Associate Geologist*
T. C. Buschbach, M.S., *Assistant Geologist*
Edwin H. Franklin, B.S., *Research Assistant*
Charles C. Engel, *Technical Assistant*
Joseph F. Howard, *Assistant*
Carol L. Wood, *Assistant*

Physics

R. J. Piersol, Ph.D., *Physicist, Emeritus*

EDUCATIONAL EXTENSION

George M. Wilson, M.S., *Geologist and Head*
Dorothy E. Rose, B.S., *Assistant Geologist*
Rosemary A. Mitchell, B.A., *Assistant Geologic Draftsman*

GEOCHEMISTRY SECTION

Frank H. Reed, Ph.D., *Chief Chemist*
Grace C. Johnson, B.S., *Research Assistant*

Coal Chemistry

G. R. Yohe, Ph.D., *Chemist and Head*
Guey H. Lee, M.S., *Research Assistant*
Earle C. Smith, B.S., *Research Assistant*

Physical Chemistry

J. S. Machin, Ph.D., *Chemist and Head*
Juanita Witters, M.S., *Assistant Physicist*
Kozo Nagashima, Ph.D., *Special Assistant Chemist*
Daniel L. Deadmore, B.S., *Research Assistant*

Fluorine Chemistry

G. C. Finger, Ph.D., *Chemist and Head*
Carl W. Kruse, M.S., *Special Research Assistant*
Richard H. Shiley, B.S., *Special Research Assistant*
Raymond H. White, B.S., *Special Research Assistant*

Chemical Engineering

H. W. Jackman, M.S.E., *Chemical Engineer and Head*
R. J. Helfinstine, M.S., *Mechanical Engineer and Supervisor of Physical Plant*
B. J. Greenwood, B.S., *Mechanical Engineer*
Robert L. Eissler, B.S., *Assistant Chemical Engineer*
James C. McCullough, *Research Associate* (on leave)
Walter E. Cooper, *Technical Assistant*
Cornel Marta, *Technical Assistant*
Edward A. Schaede, *Technical Assistant*

X-Ray

W. F. Bradley, Ph.D., *Chemist and Head*

Analytical Chemistry

O. W. Rees, Ph.D., *Chemist and Head*
L. D. McVicker, B.S., *Chemist*
Emile D. Pierron, M.S., *Associate Chemist*
Francis A. Coolican, B.S., *Assistant Chemist*
Donald R. Dickerson, B.S., *Assistant Chemist*
Charles T. Allbright, B.S., *Research Assistant* (on leave)
William J. Armon, B.S., *Research Assistant*
Joan M. Cederstrand, *Research Assistant*
Barbara Florini, A.B., *Research Assistant*
Joseph M. Harris, B.A., *Research Assistant*
JoAnne K. Wilken, B.A., *Research Assistant*
George R. James, *Technical Assistant*
Frances L. Scheidt, *Technical Assistant*
Harold E. Winters, *Technical Assistant*

MINERAL ECONOMICS SECTION

W. H. Voskuil, Ph.D., *Mineral Economist*
W. L. Busch, A.B., *Assistant Mineral Economist*
Ethel M. King, *Research Assistant*
JoAnn Munnis, *Technical Assistant*

RESEARCH AFFILIATES IN GEOLOGY

J Harlen Bretz, Ph.D., *University of Chicago*
John A. Brophy, M.S., *Research Assistant, State Geol. Survey*
Stanley E. Harris, Jr., Ph.D., *Southern Illinois University*
M. M. Leighton, Ph.D., D.Sc., *Research Professional Scientist, State Geol. Survey*
A. Byron Leonard, Ph.D., *University of Kansas*
Paul R. Shaffer, Ph.D., *University of Illinois*
Harold R. Wanless, Ph.D., *University of Illinois*

CONSULTANTS

Geology: George W. White, Ph.D., *University of Illinois*
Ralph E. Grim, Ph.D., *University of Illinois*
Ceramics: Ralph K. Hursh, B.S., *University of Illinois*
Mechanical Engineering: Seichi Konzo, M.S., *University of Illinois*

March 15, 1956

GENERAL ADMINISTRATION

(not including part-time personnel)

PUBLICATIONS

Barbara Zeiders, B.S., *Associate Technical Editor*
Meredith M. Calkins, *Geologic Draftsman*
Marlene Ponshock, *Assistant Geologic Draftsman*
Mearldine Sienknecht, *Assistant Geologic Draftsman*

GENERAL SCIENTIFIC INFORMATION

Genevieve Van Heyningen, *Technical Assistant*
Marian L. Wingard, *Technical Assistant*

LIBRARY

Olive Ruehe, B.S., *Technical Assistant*

MINERAL RESOURCE RECORDS

Vivian Gordon, *Head*
Margaret B. Brophy, B.A., *Research Assistant*
Sandra Mynlieff, B.A., *Research Assistant*
Sue J. Cunningham, *Technical Assistant*
Gretchen Dezelick, *Technical Assistant*
Hannah Fisher, *Technical Assistant*
Cora Hughes, *Technical Assistant*
Hazel H. T. Inada, *Technical Assistant*
Elizabeth Speer, *Technical Assistant*
Joan R. Younker, *Technical Assistant*

TECHNICAL RECORDS

Berenice Reed, *Supervisory Technical Assistant*
Marilyn DeLand, B.S., *Technical Assistant*
Miriam Hatch, *Technical Assistant*
Marjorie C. Mohr, *Technical Assistant*

Topographic Mapping in Cooperation with the United States Geological Survey

March 15, 1956

FINANCIAL RECORDS

Velda A. Millard, *In Charge*
Leona K. Erickson, *Clerk IV*
Virginia C. Sanderson, B.S., *Clerk-Typist II*
Patricia A. Northrup, *Clerk-Typist I*
Irma E. Samson, *Clerk-Typist I*

CLERICAL SERVICES

Mary M. Sullivan, *Clerk-Stenographer III*
Lyla Nofftz, *Clerk-Stenographer II*
Irene Rolseth, *Clerk-Stenographer II*
Lillian Weakley, *Clerk-Stenographer II*
Marion L. Kenney, *Clerk-Stenographer I*
Dorothy A. Ledbetter, *Clerk-Stenographer I*
Virginia L. Minnie, *Clerk-Stenographer I*
Laurel F. Griffin, *Clerk-Typist I*
William L. Mathis, *Messenger-Clerk II*
Lorene G. Wilson, *Messenger-Clerk I*

AUTOMOTIVE SERVICE

Glenn G. Poor, *In Charge**
David B. Cooley, *Automotive Mechanic*
Everette Edwards, *Automotive Mechanic* (on leave)
Robert O. Ellis, *Automotive Mechanic*

OTHER TECHNICAL SERVICES

Wm. Dale Farris, *Research Associate*
Beulah M. Unfer, *Technical Assistant*
A. W. Gotstein, *Research Associate*
Glenn G. Poor, *Research Associate**
Gilbert L. Tinberg, *Technical Assistant*
Wayne W. Nofftz, *Supervisory Technical Assistant*
Donovon M. Watkins, *Technical Assistant*
Mary Cecil, *Supervisory Technical Assistant*
Ruby D. Frison, *Technical Assistant*

*Divided time

CONTENTS

ILLUSTRATIONS

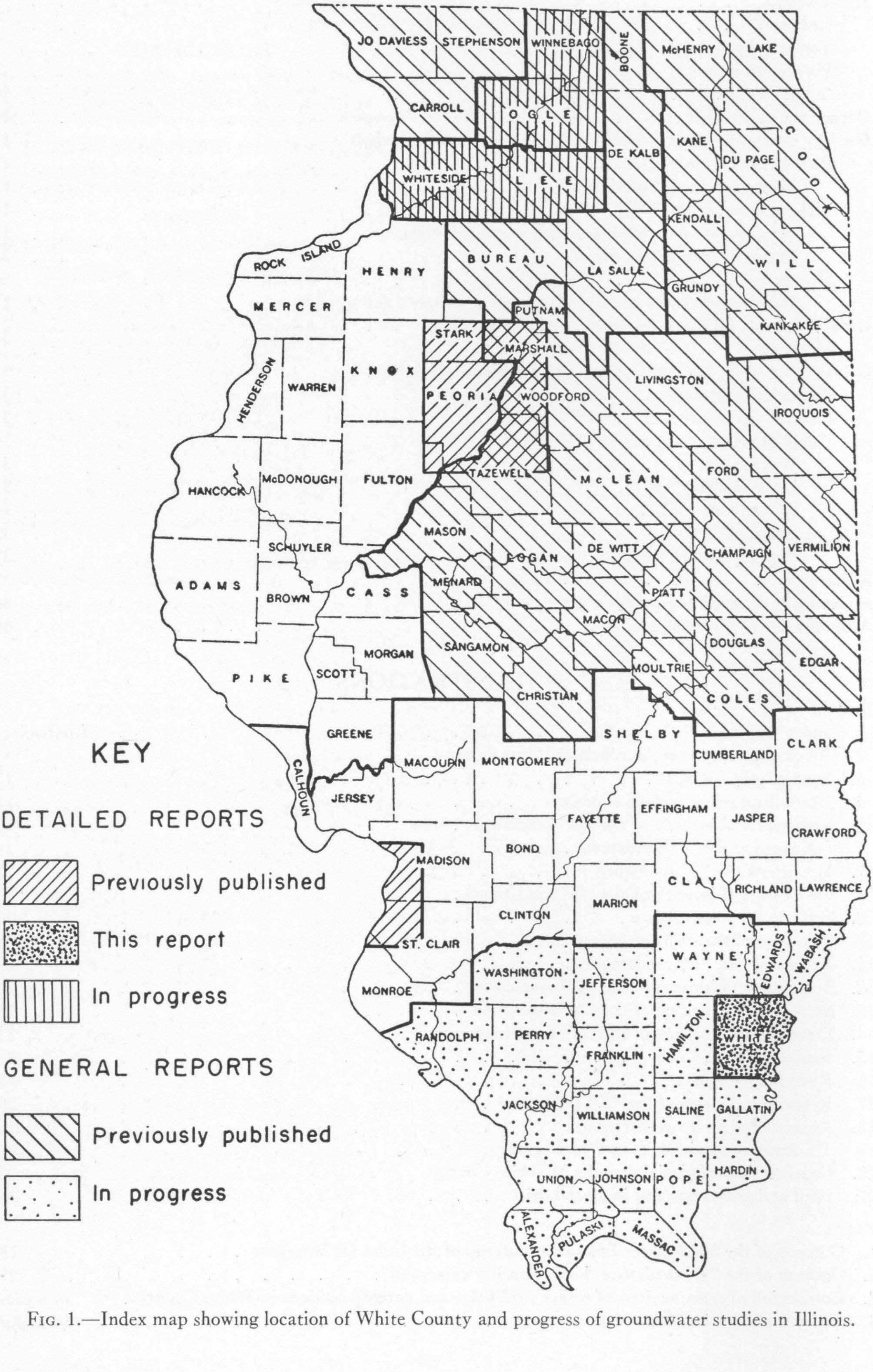


FIG. 1.—Index map showing location of White County and progress of groundwater studies in Illinois.

GROUNDWATER GEOLOGY OF WHITE COUNTY, ILLINOIS

BY

WAYNE A. PRYOR

ABSTRACT

Groundwater supplies are available in White County from unconsolidated glacial material associated with major drainage features, and limited supplies are locally available from sandstone bodies in the upper part of the Pennsylvanian bedrock.

The distribution of the sandstone aquifers is mapped on the basis of several thousand electric logs of wells. The upper part of the McLeansboro group is described with particular reference to water-bearing properties and to key marker beds. Only nine beds function as aquifers within this group and these only locally contain fresh water.

The quality of the water in the sandstone aquifers was estimated by determining the resistivity of the water in these aquifers from electric logs and calculating sodium-chloride equivalents in parts per million from the resistivity value. The quality of the groundwater in the bedrock is related to the lithologic characteristics of the aquifers, depth of burial, and structural features of the bedrock.

Glacial-outwash materials in the preglacial channels of the Wabash River and its preglacial tributaries are the principal unconsolidated deposits and water-yielding beds. Large deposits of undeveloped water-bearing sand and gravel are mapped and discussed according to their relative ranks.

INTRODUCTION

Location

White County, in southeastern Illinois (fig. 1), is about 24 miles long, 21 to 25 miles wide, and has an area of about 501 square miles. It is bounded on the east by the Wabash River, on the west by the meridian 88° 21′ 55″ W., on the south by the parallel 37° 15′ 20″ N., and on the north by the parallel 38° 15′ 20″ N. Carmi is the largest city, with a population of about 5574, and the principal villages include Crossville, Enfield, Grayville, Maunie, Mill Shoals, Norris City, and Springerton.

United States Geological Survey topographic maps of the county are issued for the following quadrangles: Albion, Carmi, Eldorado, Enfield, Fairfield, Mt. Carmel, New Harmony, and New Haven.

Topography

Large areas of bottomland along the Wabash and Little Wabash rivers, and gently rolling uplands or "prairies" interspersed with ridges or hills generally capped by sandstone characterize the topography (fig. 2).

The Little Wabash River, which crosses White County from northeast to southwest, and Skillet Fork, which crosses it from northwest to southeast, merge midway in the county and divide it into three extensive upland plains. The Little Wabash River Valley ranges from one-quarter to 5 miles in width and from 345 to 375 feet in altitude, which is 100 to 210 feet below the adjoining uplands. Skillet Fork Valley ranges from 1 to 4 miles in width and from 365 to 380 feet in altitude, which is 100 to 200 feet below the adjoining uplands. The Wabash River Valley ranges from half a mile in width at its northern extremity to 7 miles in the southern part of the county where it merges with the Little Wabash River Valley. It ranges in altitude from 345 to 355 feet above sea level, which is 100 to 175 feet below the adjoining uplands.

Nearly all the upland is underlain by Illinoian glacial drift, which exerts little control over the topography. Because of relatively thin Illinoian drift, the underlying bedrock topography is reflected in the present land surface, and bedrock is commonly exposed along ridges and hilltops and along stream and river valleys. Upland elevations range from 400 feet above sea level near the river bottoms to over 500 feet on the crests of most hills. The highest elevation in White County, 580 feet above sea level, is at the crest of Boyd Hill in Burnt Prairie Township.

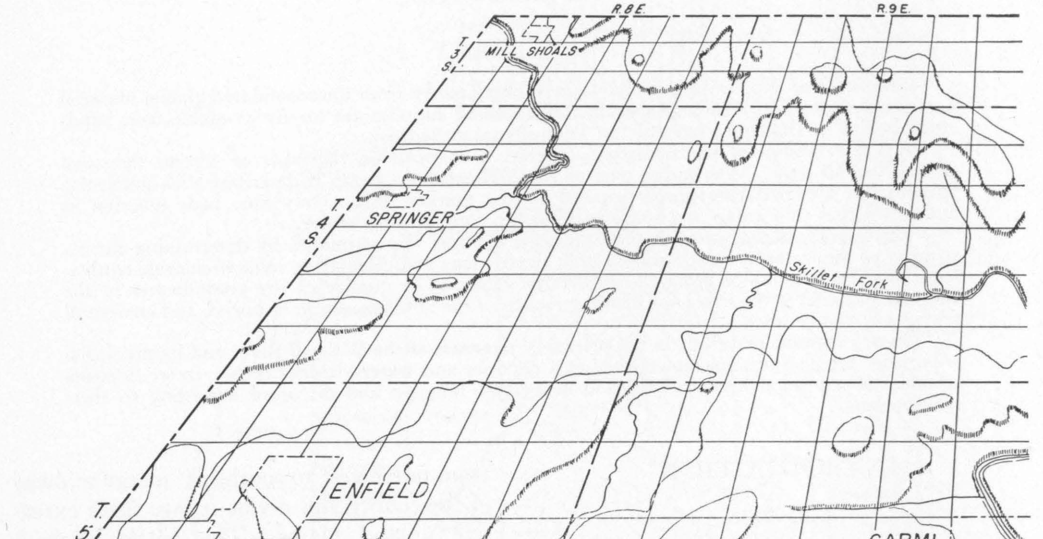


FIG. 2.—Block diagram of

northern half of White County.

Most of the region is drained by the Wabash and Little Wabash rivers and their principal tributaries, Big Hill Branch, Broad Run, Crooked Creek, Flander Creek, French Creek, Fox River, Grindstone Creek, Little Fox River, Prairie Creek, Seven Mile Creek, and Skillet Fork. Only the southwestern corner of the county lies in another drainage basin, that drained by Bear Creek, a tributary of the Saline River, which is in Saline and Gallatin counties.

Purpose of Report

This report is designed to place geological information regarding the occurrence of groundwater of the area in the hands of those interested in developing a water supply. I hope the report will be of aid to municipalities or industries wishing to develop new supplies or increase present supplies, to land owners and farmers interested in developing the groundwater resources that may underlie their properties, and to petroleum engineers interested in groundwater supplies for secondary recovery operations.

Acknowledgments

I am indebted to various members of the Illinois State Geological Survey staff for contributing suggestions and for constructive criticism of the manuscript. Frank C. Foley suggested the problem and George B. Maxey acted as advisor and critic in the preparation of the manuscript. David H. Swann offered many suggestions on electric-log interpretation. Many suggestions in regard to Pennsylvanian stratigraphy were offered by H. B. Willman, Jack A. Simon, and M. E. Hopkins of the Survey and by Harold R. Wanless of the University of Illinois.

OCCURRENCE OF GROUNDWATER

The surficial unconsolidated material and underlying bedrock which form the crust of the earth are saturated with groundwater from near the surface to depths of thousands of feet. They contain numerous open spaces, such as pores, joints, and channels, which hold water that is below the surface of the land and is recovered in part by wells and springs. Groundwater is nearly all supplied by precipitation in the form of rain or snow. Not all precipitation reaches the open spaces in the earth's crust. Much of it falls into the ocean, a part escapes by runoff over the earth's surface, and some is returned to the atmosphere by evaporation and transpiration.

Some of the water evaporates quickly; some of it penetrates the soil and is held in the unsaturated portion by molecular forces; the remainder percolates down into the zone of saturation.

Groundwater flows slowly through rocks. The rate of flow is reduced by friction between the water and the rock particles. It moves nearly always under the influence of gravity and in response to a pressure differential to some area of lower pressure, toward either natural or artificial points of discharge.

The upper surface of the zone of saturation in permeable soil or rock is called the water table, which is generally only a few feet below the land surface in White County. The water table is not a level surface but has irregularities comparable with and not unrelated to those of the land surface. It does not remain stationary but fluctuates from time to time owing to loss or gain of water. Groundwater is said to be under water-table conditions where the top of the zone of saturation is "free" or not confined under pressure other than surface atmospheric pressure. Under these conditions groundwater moves freely, hindered only by friction, under control of gravity in the direction of the slope of the water table.

Where water is confined in an aquifer below an impervious formation and is under hydrostatic pressure, artesian conditions exist, and water levels in wells will rise above the bottom of the impervious confining layer.

Aquifers in White County are classified below on the basis of groundwater occurrence and geologic character. Types of wells commonly used to recover water are also given.

A. Water-table aquifers
  1. Recent and Pleistocene unconsolidated materials
    a. Fine-grained alluvial deposits—clay, silt, and fine sand in bottomlands; chiefly shallow large-diameter dug wells.
    b. Coarse-grained alluvial deposits—sand and gravel in bottomlands; shallow wells, dug, driven, or drilled.
    c. Glacial till and loess—clay and silt mainly on the uplands; chiefly shallow large-diameter dug wells.
  2. Pennsylvanian bedrock
    a. Bedrock cropping out at surface — sandstone, limestone, and shale chiefly on the uplands; shallow wells, dug, driven, or drilled.

B. Artesian aquifers
  1. Recent and Pleistocene unconsolidated materials
    a. Sand and gravel, buried beneath less-permeable materials, chiefly in bottomlands; primarily driven or drilled wells.
  2. Pennsylvanian bedrock
    a. Sandstone aquifers, overlain by less-permeable materials, chiefly on the uplands; primarily driven or drilled wells.

GEOLOGY AND WATER-BEARING PROPERTIES OF THE BEDROCK FORMATIONS

White County is in the southeastern part of the Illinois basin where strata representing all periods of geologic time except the Permian, Triassic, Jurassic, Cretaceous, and Tertiary occur. All formations that are present (fig. 3), except the deep-lying Cambrian and pre-Cambrian rocks, have been penetrated by deep wells, by shallow wells, or are exposed at the surface.

The bedrock exposed in White County belongs to the McLeansboro group of the Pennsylvanian system. Most of the oil test borings in the county penetrate rocks of the Pennsylvanian system and enter deeper Paleozoic formations. The Shakopee formation in the lower part of the Ordovician system is the oldest rock penetrated by any of the borings. Information concerning the rock layers lying below the Shakopee formation must be obtained from rock outcrops and records of borings made outside the county.

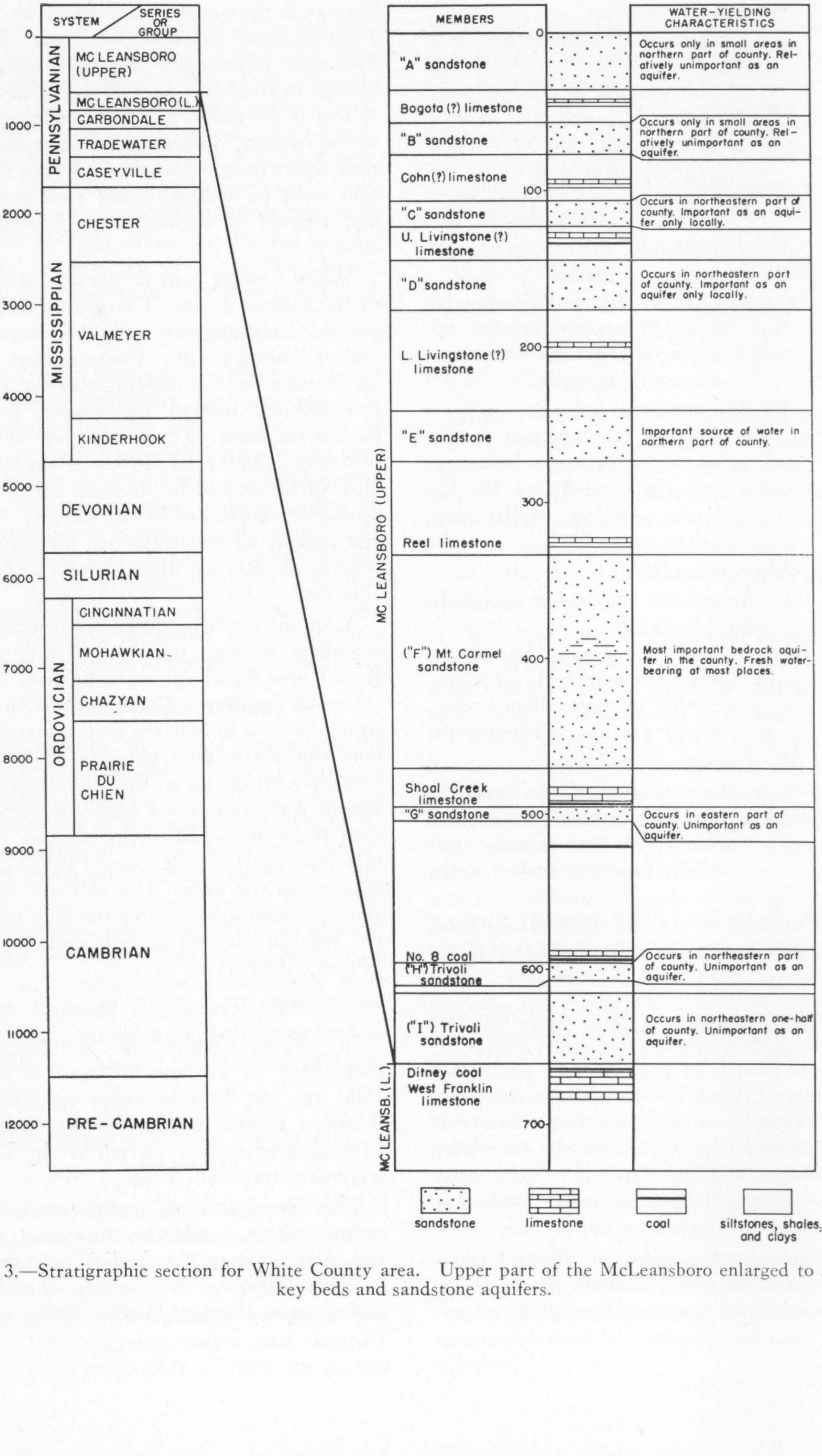
White County is in the structural center of the Illinois basin. The groundwater of the bedrock formations is highly mineralized and of limited utility. There appears to be an increase in the mineral content of the groundwater toward the deeper, central part of the basin. This is indicated by a recent study (Bell et al., 1952) of the Illinois oil-field brines and by study of the shallow sandstone aquifers of White County. Electric logs of oil test wells are the principal sources of data on the shallow sandstone aquifers.

Many of the brines used for injection in secondary recovery operations are obtained from Upper Mississippian and Lower Pennsylvanian aquifers. There appears to be a steady increase in both the total mineral content and the sodium chloride and sulfate content with depth, so that the deeper Niagaran waters are more highly mineralized than those of the Mississippian and Pennsylvanian aquifers (Bell et al., 1952). The aquifers in the upper part of the Pennsylvanian system appear to be the only ones in the bedrock that yield fresh groundwaters (Pryor, 1954).

PENNSYLVANIAN SYSTEM

In White County the Pennsylvanian rocks have an average thickness of about 1800 feet, but there are many variations in thickness caused in part by the irregular Mississippian surface on which the Pennsylvanian strata lie (Siever, 1951).

The Pennsylvanian system consists of beds of shale, sandstone, limestone, clay, and coal arranged in cyclical successions called cyclothems. The members of an ideal cyclothem in Illinois (Weller, 1930) are:



Occurs only in small areas in northern part of county. Relatively unimportant as an aquifer.

Occurs only in small areas in northern part of county. Relatively unimportant as an aquifer.

Occurs in northeastern part of county. Important as an aquifer only locally.

Occurs in northeastern part of county. Important as an aquifer only locally.

Important source of water in northern part of county.

Most important bedrock aquifer in the county. Fresh water-bearing at most places.

Occurs in eastern part of county. Unimportant as an aquifer.

Occurs in northeastern part of county. Unimportant as an aquifer.

Occurs in northeastern one-half of county. Unimportant as an aquifer.

FIG. 3.—Stratigraphic section for White County area. Upper part of the McLeansboro enlarged to show key beds and sandstone aquifers.

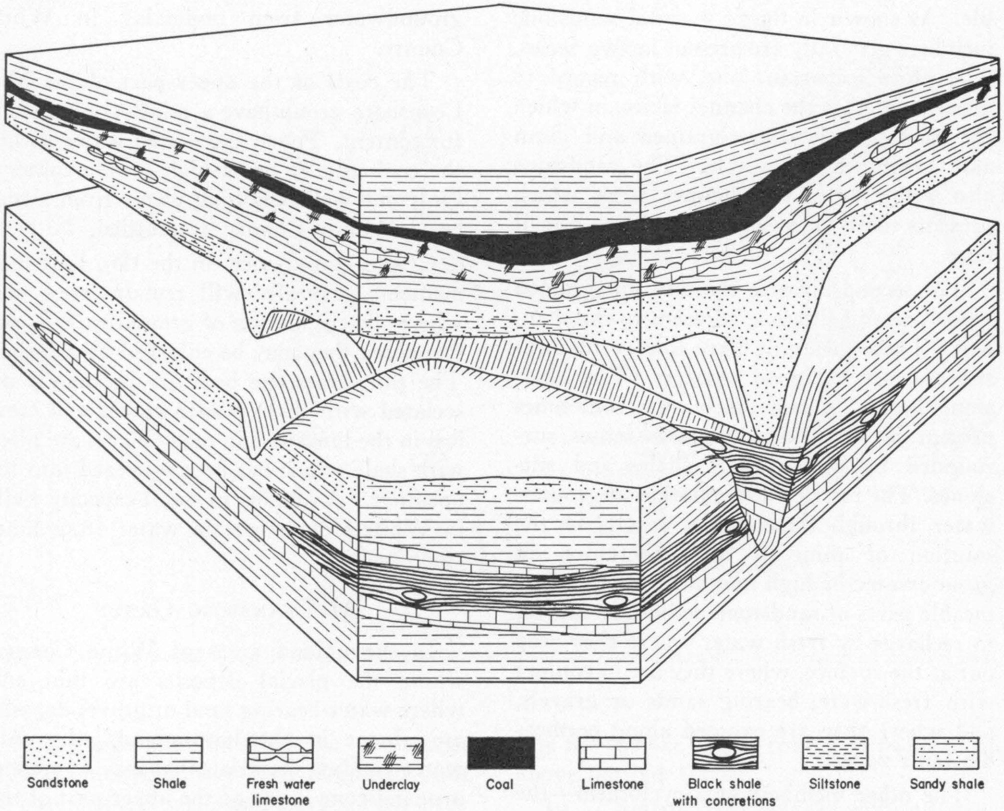


FIG. 4.—Block diagram of cyclical deposits showing sedimentary conditions.

Marine sediments

10. Shale; contains marine fossils and ironstone concretions, especially in lower part; sandy at top
9. Limestone; contains marine fossils
8. Shale, black, fissile; contains marine fossils
7. Limestone; contains marine fossils
6. Shale; ironstone concretions and plant fossils at base, marine fossils generally rare

Continental sediments

5. Coal
4. Underclay
3. Limestone, nodular, usually nonfossiliferous
2. Shale, sandy
1. Sandstone, massive to thin-bedded, commonly with an uneven lower surface.

All the members of a cyclothem are rarely present in one locality.

Figure 4 shows a complete cycle parted at the base of the sandstone unit. Typical lateral variations and localized thickening and thinning of the individual lithologic members are shown. Figure 2 shows the cyclic nature of the Pennsylvanian rocks.

In Illinois the Pennsylvanian system is divided into the Caseyville, Tradewater, Carbondale, and McLeansboro groups. These groups are composed of sequences of cyclothems representing the rhythmic changes in sedimentation.

WATER-BEARING PROPERTIES

The basal sandstone member is the principal aquifer of the cyclothem. Because the sandstones have lateral and vertical variations in composition and permeability, their water-yielding characteristics are also variable. As shown in figure 4, basal sandstone members generally are present in two facies. The more important one, with regard to groundwater, is the channel facies, in which the sandstone is coarse-grained and clean and, therefore, permeable. The sandstone also is thicker in the channel areas, which presents more permeable material to a well bore.

The second facies is the thin fine-grained sandstone and siltstone adjacent to the channels. These generally have low permeabilities and are not good aquifers. The sandstone bodies in both facies are sometimes present in small discontinuous lenses surrounded by impermeable shales and siltstones. The restricted circulation of groundwater through these bodies results in the solution of minerals and, therefore, in groundwater of high mineral content. Permeable parts of sandstone bodies are subject to recharge by fresh water where they crop out at the surface, where they are in contact with fresh-water-bearing sands or gravels, and where they are exposed along permeable fault zones.

The other members of a cyclothem—the argillaceous shales, the fissile black shale, the underclay, the coal, and the limestones—have very low permeabilities and transmit groundwater only by means of open cracks and crevices developed after deposition.

Because of the semiplastic state of water-saturated shale, open cracks tend to become closed and make the shale useless as an aquifer. In this part of Illinois water wells developed in shale are rare.

Cracks and crevices in fissile black shale generally will remain open where the black shale is saturated. There are scattered reports of development of water wells in black shale in White County, but owing to the extremely discontinuous nature of the black shale (fig. 4) they are not widespread, productive, or dependable aquifers. The black shale also contains much iron pyrite, and the quality of water obtained from it is generally high in sulfides.

The underclay generally does not have cracks and crevices because it is soft and plastic. No wells are known to obtain groundwater from underclay in White County.

The coals of the upper part of the McLeansboro group have a relatively high sulfur content. Poorly circulated water within the coal usually has a high sulfide content. Only one well obtaining water from a coal bed in White County is recorded.

Cracks and crevices in the thin limestone members generally will remain open, and where the circulation of groundwater is not hampered they may be enlarged by solution. The thin limestone beds are intimately associated with shale. Open cracks and crevices in the limestone in many places are filled with shale which has been squeezed into the openings. A number of small-capacity wells in White County obtain water from limestone beds.

McLeansboro Group

In the upland areas of White County, where the glacial deposits are thin and where water-bearing sand or gravel deposits are absent in the bottomlands, the only water-yielding materials that may be present are sandstone strata of the upper part of the McLeansboro group. At least nine of these sandstone bodies may be considered sources of fresh groundwater. Stratigraphically, the lowest stratum considered fresh-water-bearing in White County is the Trivoli sandstone, which lies directly above the Ditney coal and the West Franklin limestone.

Figure 3 contains an idealized section of the upper McLeansboro sequence with the sandstone aquifers shown in their relative positions to key limestone and coal beds.

The correlation and mapping of the sandstone bodies in the upper McLeansboro is based on the identification of key stratigraphic units between sandstone aquifers. Correlations of the West Franklin limestone, Shoal Creek limestone, and Reel limestone in this area and the surrounding region are reasonably dependable (pl. 3, A-A′). Correlation of the Lower and Upper Livingston, Cohn, and Bogota limestones with the type localities of these limestones has not been definitely established and is based primarily on their stratigraphic in-

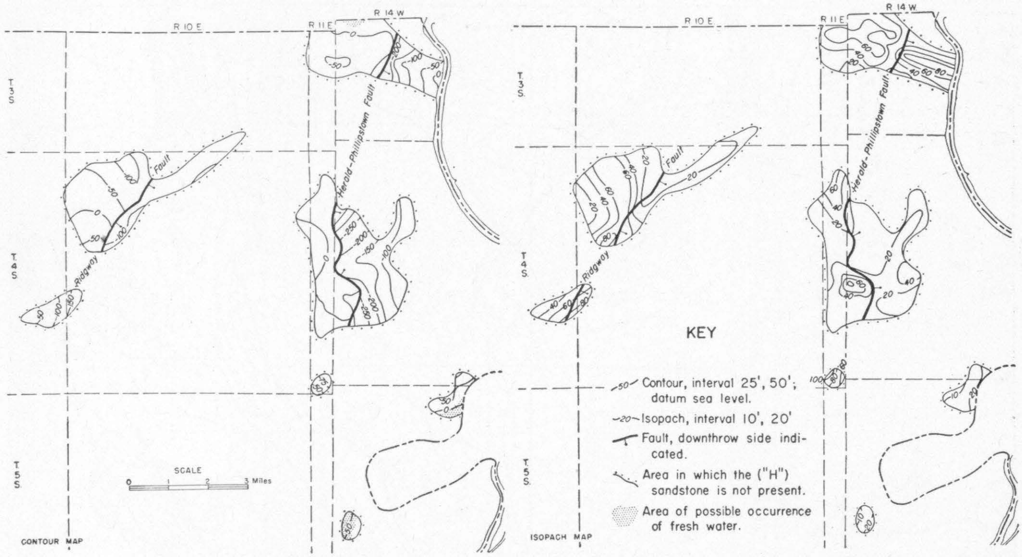


FIG. 5.—Structure and isopach of the "H" sandstone showing areas of possible occurrence of fresh water.

terval above the Shoal Creek limestone. These limestones have been identified both in outcrops and wells and are good key beds throughout the county (pl. 3).

Only two of the sandstone aquifers in White County have accepted stratigraphic names: the Trivoli sandstone, which occurs above the Ditney coal, and the Mt. Carmel sandstone, which occurs above the Shoal Creek limestone. No new names have been introduced for the sandstones in this study but for convenience letter designations are used.

The West Franklin and Shoal Creek limestones are the most reliable stratigraphic markers in White County. The Reel limestone, Lower and Upper Livingston(?) limestones, Cohn(?) limestone, and Bogota(?) limestone are considered as less useful key stratigraphic markers because of their thinness and erratic distribution.

STRATIGRAPHY OF SANDSTONE AQUIFERS AND KEY BEDS

West Franklin limestone.—The West Franklin limestone (Collet, 1884, p. 61-62) occurs at depths of 495 to 725 feet below the surface and is from 220 to 280 feet above the No. 6 coal.

In 17 control drill holes in White County (pl. 3), the West Franklin limestone, whether in one, two, or three benches, has been found from an examination of drill cuttings to be light gray, buff to brown, finely crystalline, and fossiliferous, with various types of associated shales. The limestone has an average thickness of about 12 feet.

At the position of the West Franklin limestone, electric logs usually show one or two pronounced resistivity peaks in the normal curve, with a minor peak above or below. A high negative self-potential is common.

("H") and ("I") Trivoli sandstones.—The upper and lower segments of the Trivoli sandstone are not exposed at the surface in White County and have been observed only in well logs and sample cuttings. The upper part of the Trivoli sandstone ("H" sandstone) is present in small isolated areas in the northeastern part of the county (fig. 5), whereas the lower part of the Trivoli sandstone ("I" sandstone) is widespread

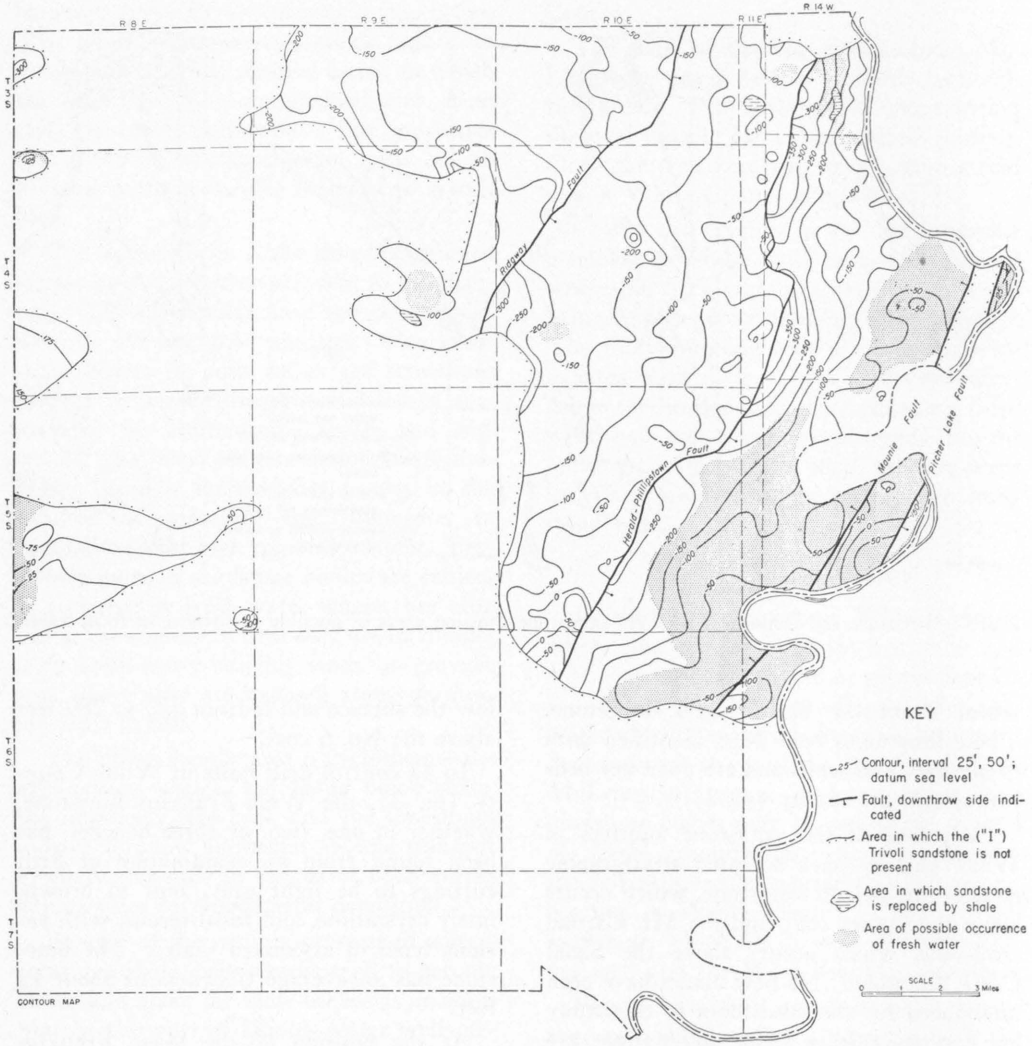


FIG. 6.—Structure of the ("I") Trivoli sandstone showing areas of possible occurrence of fresh water.

throughout the northeastern one-third of the county and in small areas in the western part (figs. 6 and 7). The Trivoli sandstones occur 100 to 150 feet below the Shoal Creek limestone and may lie directly on the West Franklin limestone or be as much as 100 feet above it.

The "H" or upper member of the Trivoli sandstone is white to gray, very fine to medium grained, micaceous, and pyritic, and grades into gray micaceous siltstone. The thickness ranges from 10 to 73 feet and averages 30 feet. The "I" or lower member of the Trivoli sandstone is white to light gray, fine to coarse grained, well cemented to friable, micaceous, pyritic, and sometimes slightly carbonaceous. Thicknesses are as much as 129 feet with an average thickness of about 50 feet.

"G" sandstone.—The "G" sandstone is exposed in sec. 36, T. 6 S., R. 10 E., White County, and at New Haven in Gallatin County (NE¼ sec. 20, T. 7 S., R. 10 E.) and extends to a depth of 150 feet. Its oc-

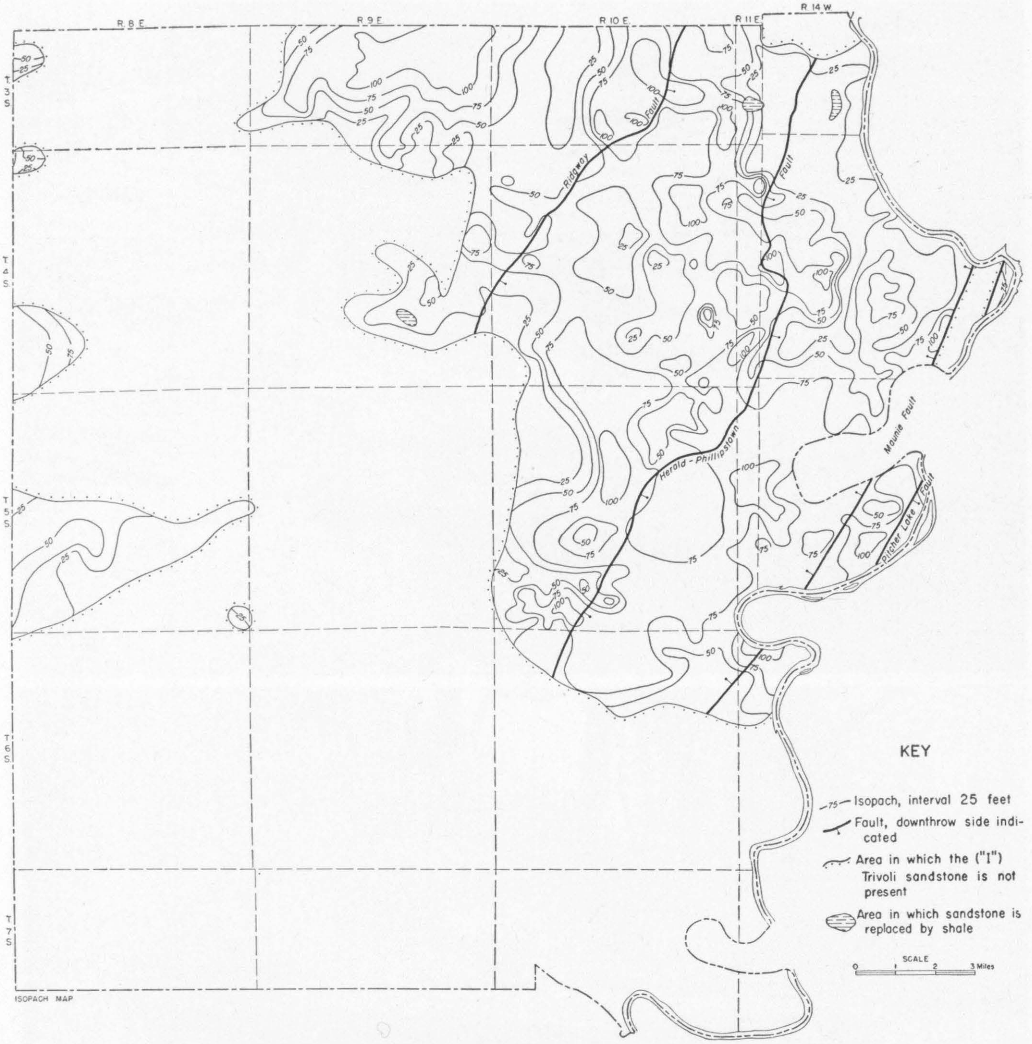


FIG. 7.—Isopach of the ("I") Trivoli sandstone.

currence is restricted to the eastern and southeastern parts of the county (fig. 8) where it lies 5 to 15 feet under the Shoal Creek limestone.

The "G" sandstone is gray to white, fine to medium grained, shaly to calcareous, micaceous, and ripple-marked along some bedding planes. Its maximum known thickness is 63 feet, its average about 30 feet.

Shoal Creek limestone.—The Shoal Creek limestone occurs in one exposure in White County (pl. 1A) and extends to a depth of 694 feet. The interval between the Shoal Creek and the West Franklin limestone ranges from 165 to 250 feet.

In drill cuttings the Shoal Creek limestone appears white to buff, finely crystalline, and dense, with fossils consisting of crinoid fragments and bryozoan remains. It has an average thickness of 6 feet and is almost always underlain by 1 to 3 feet of black fissile shale, which in turn is underlain by a thin coaly zone and underclay.

The Shoal Creek limestone is readily rec-

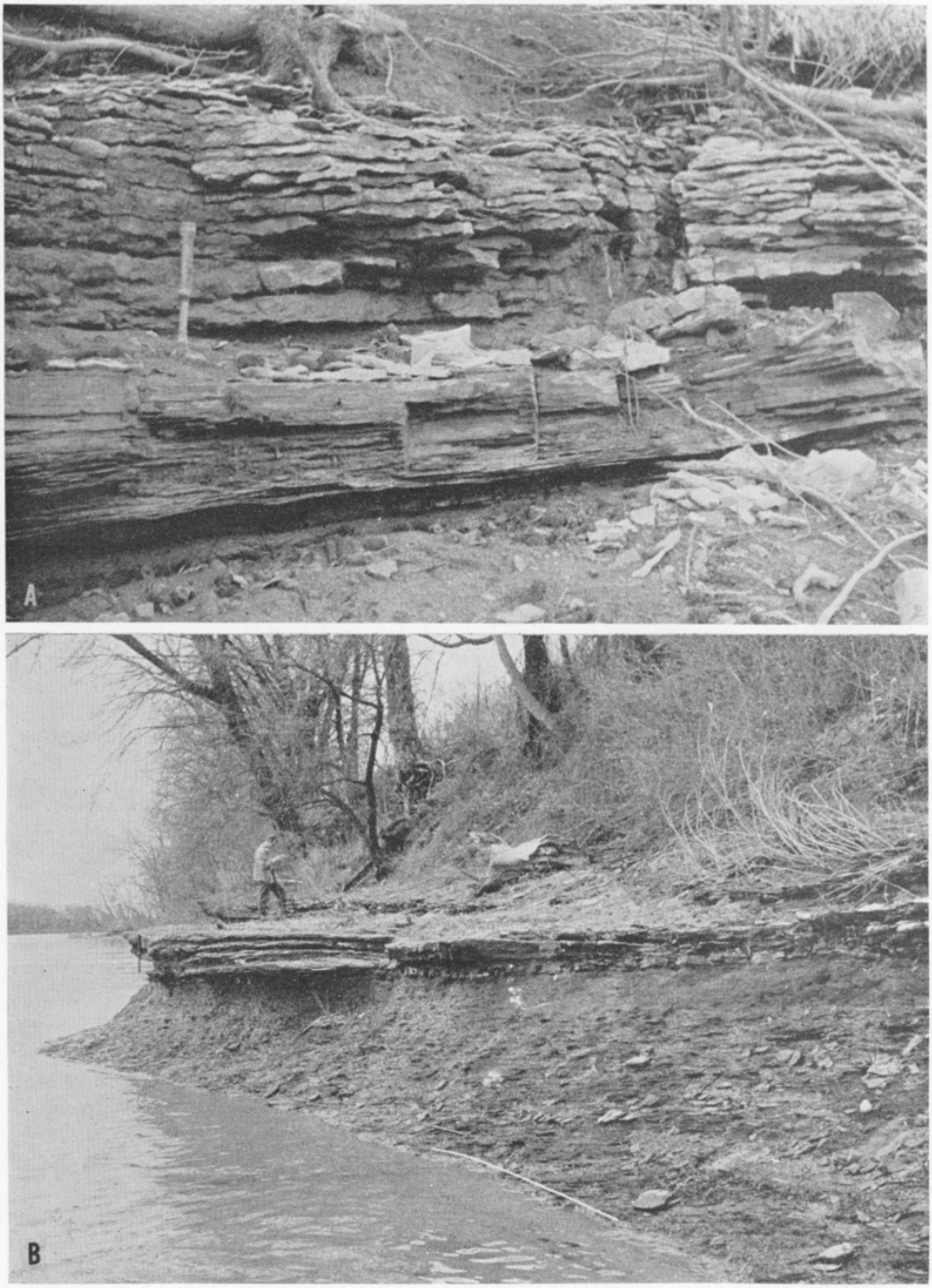


Plate 1.—A. Outcrop of Shoal Creek limestone and underlying black shale at New Haven. B. Outcrop of Cohn (?) limestone at Grayville.

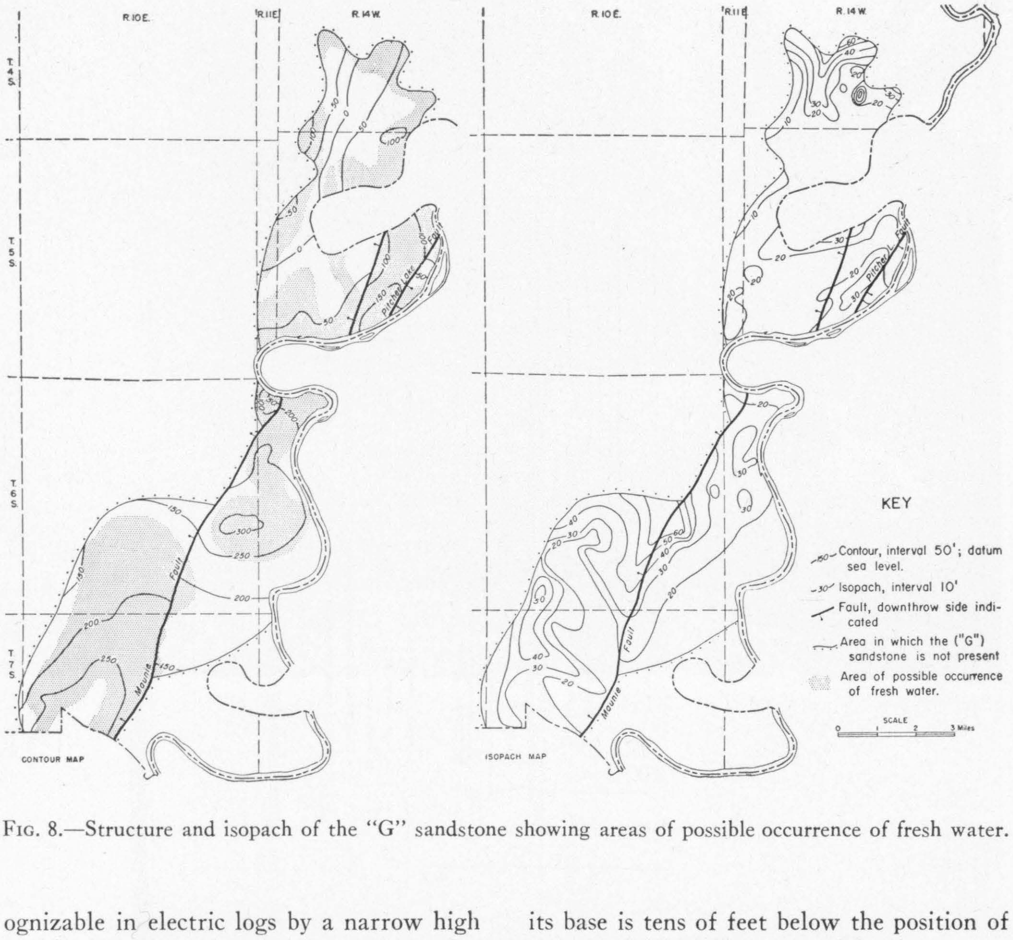


FIG. 8.—Structure and isopach of the "G" sandstone showing areas of possible occurrence of fresh water.

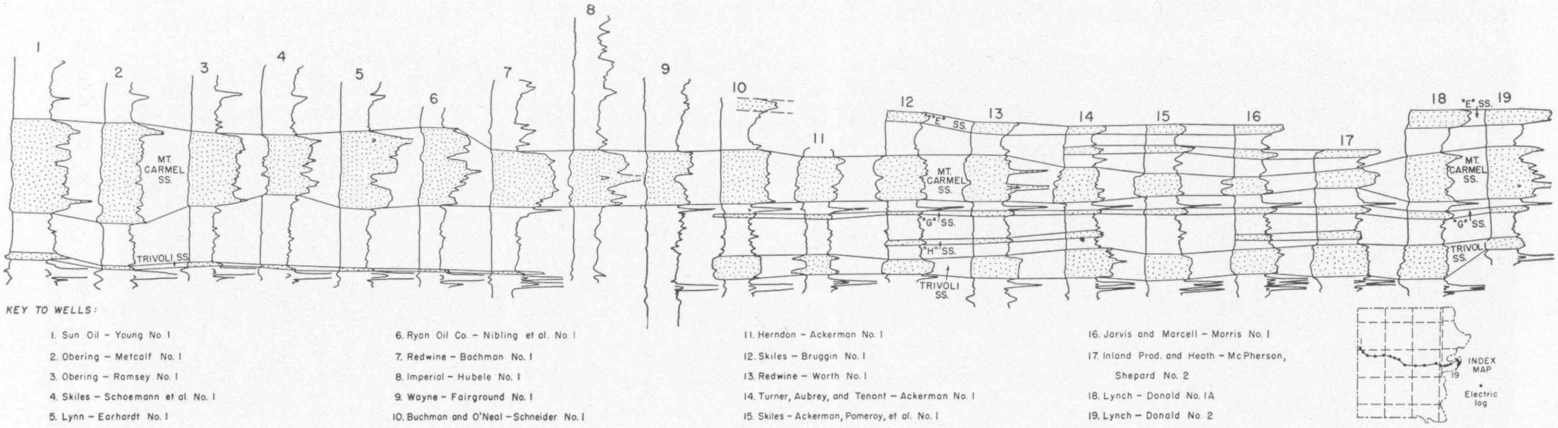
ognizable in electric logs by a narrow high peak in the normal resistivity curve and a high negative self-potential. A re-entrant of the normal resistivity curve is commonly shown in the position of the black shale and underlying underclay.

("F") Mt. Carmel sandstone.—The Mt. Carmel sandstone is the thickest and most widespread (pl. 3 and fig. 9) of the aquifers and occurs throughout the county (figs. 10 and 11) except in a small area in the southeastern part of White County where erosion has stripped it away. It is exposed at the surface in sec. 18, T. 6 S., R. 11 E., and extends to a depth of 490 feet. The Mt. Carmel sandstone occurs 5 to 150 feet below the Reel limestone. It may be found up to 100 feet above the Shoal Creek limestone, but in many places it cuts through it and its base is tens of feet below the position of the Shoal Creek limestone (pl. 3).

The Mt. Carmel sandstone is white to buff, fine to coarse grained, massive to thin-bedded, and micaceous, with a shaly and coaly zone locally present in the middle portion and a calcareous zone in the upper part. The thickness varies from 14 feet to 267 feet and averages about 110 feet.

Reel limestone.—The Reel limestone (Cady et al., 1955, p. 8-9) occurs in several exposures in White County and in some places is as deep as 460 feet. The interval between the Reel limestone and the West Franklin limestone ranges from 365 to 410 feet.

In outcrop and in control drill hole cuttings, the Reel limestone is medium gray to brown, dense to slightly crystalline, impure,



KEY TO WELLS:

1. Sun Oil – Young No. 1
2. Obering – Metcalf No. 1
3. Obering – Ramsey No. 1
4. Skiles – Schoemann et al. No. 1
5. Lynn – Earhardt No. 1
6. Ryan Oil Co. – Nibling et al. No. 1
7. Redwine – Bachman No. 1
8. Imperial – Hubele No. 1
9. Wayne – Fairground No. 1
10. Buchman and O'Neal – Schneider No. 1
11. Herndon – Ackerman No. 1
12. Skiles – Bruggin No. 1
13. Redwine – Worth No. 1
14. Turner, Aubrey, and Tenant – Ackerman No. 1
15. Skiles – Ackerman, Pomeroy, et al. No. 1
16. Jarvis and Marcell – Morris No. 1
17. Inland Prod. and Heath – McPherson, Shepard No. 2
18. Lynch – Donald No. 1A
19. Lynch – Donald No. 2

FIG. 9.—Electric log cross section showing continuity of sandstone aquifers.

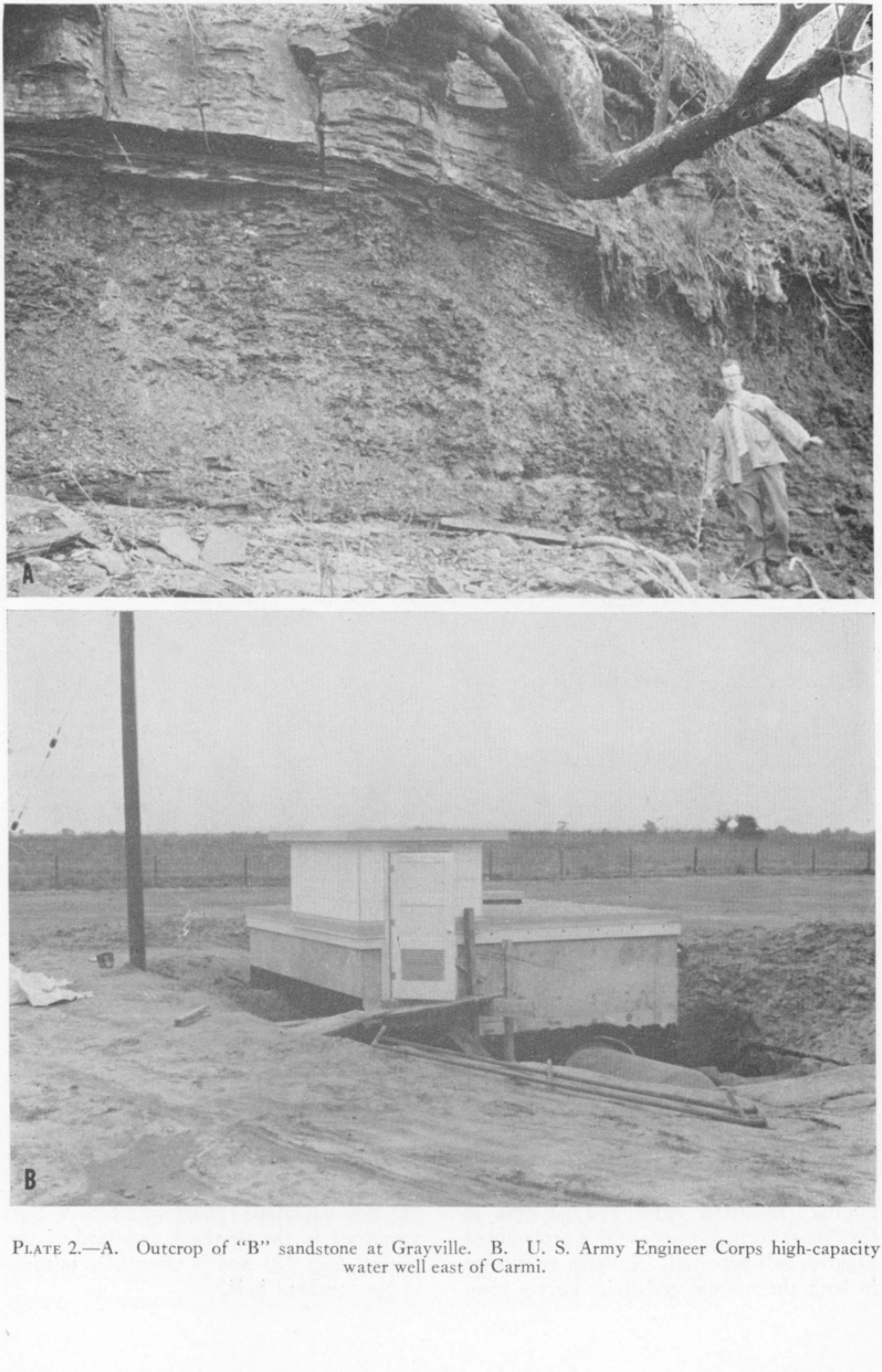


PLATE 2.—A. Outcrop of "B" sandstone at Grayville. B. U. S. Army Engineer Corps high-capacity water well east of Carmi.

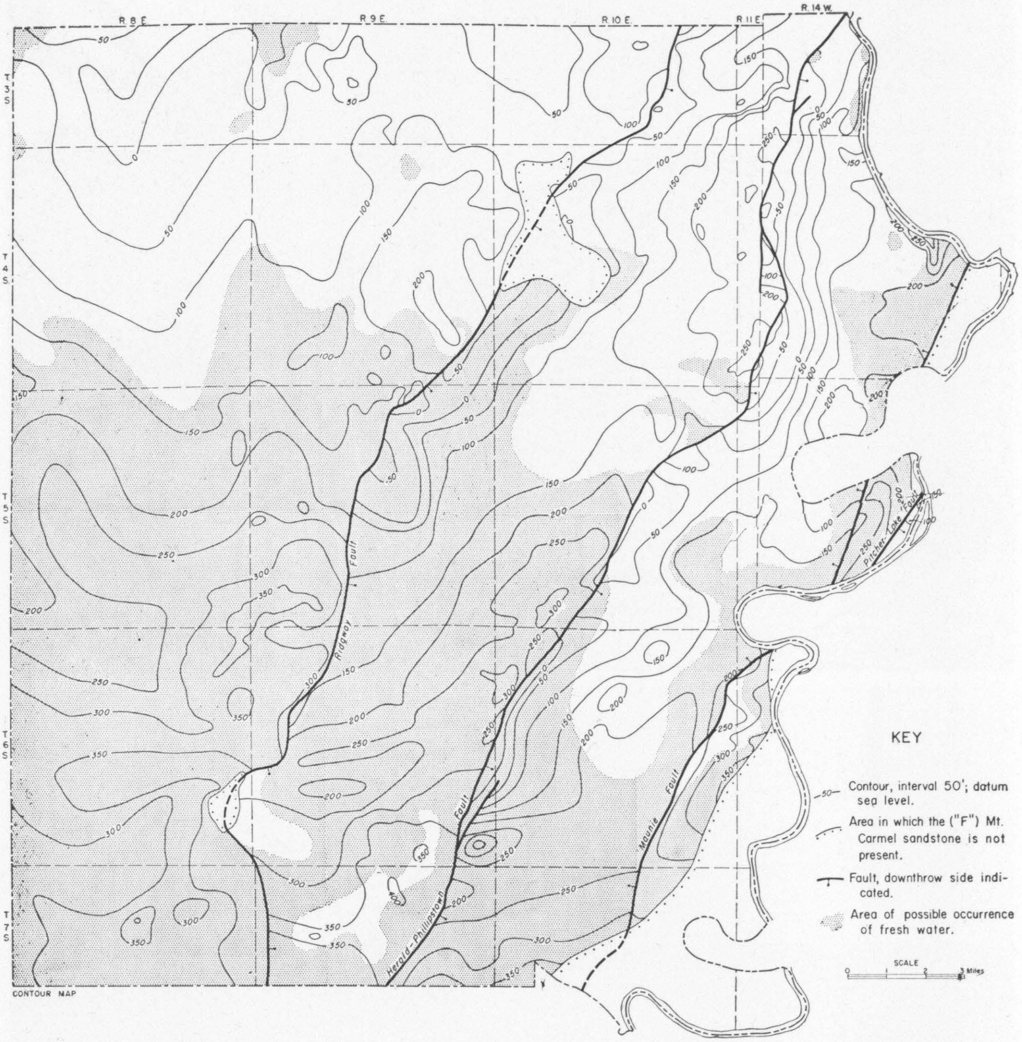


FIG. 10.—Structure of the ("F") Mt. Carmel sandstone showing areas of possible occurrence of fresh water.

massively bedded, and contains poorly preserved brachiopods, pelecypods, gastropods, ostracods, and crinoid stems. It is 6 inches to 3 feet thick and is usually underlain by a thin coal and underclay.

The Reel limestone is recognized in electric logs by a short blunt peak in the "long normal" resistivity curve and no peak in the "short normal" curve with a pronounced negative self-potential. A sharp re-entrant in both the normal resistivity curves commonly is shown in the position of the underclay.

"E" sandstone.—The "E" sandstone is exposed at several outcrops in White County and is found to a depth of 380 feet. It lies 25 to 40 feet below the Lower Livingston(?) limestone and 20 to 60 feet above the Reel limestone. This sandstone is best developed in the northern one-third of the county (fig. 12) and is essentially missing in the southern half.

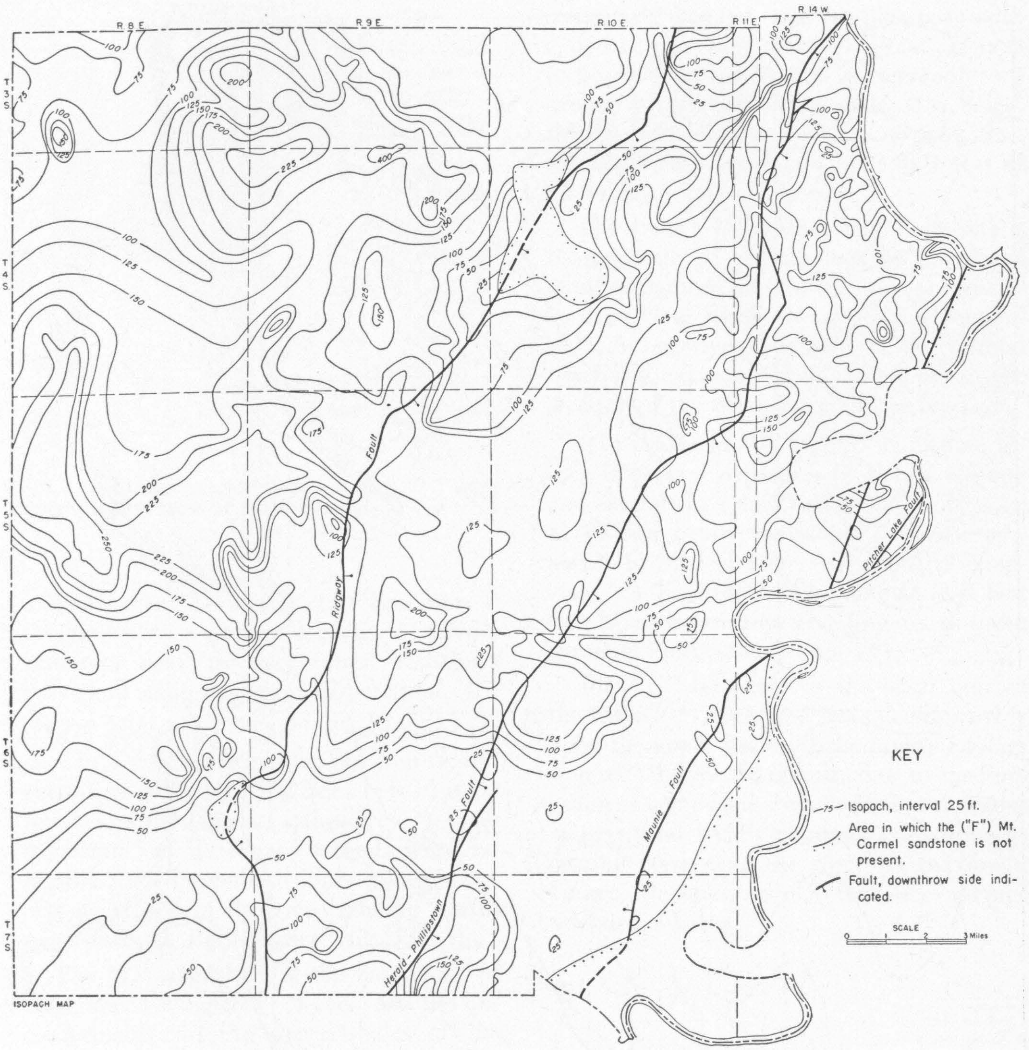


FIG. 11.—Isopach of the ("F") Mt. Carmel sandstone.

The "E'" sandstone is the basal unit of the Lower Livingston (?) cycle and lies unconformably upon the upper shale unit of the underlying cycle. It is buff, medium to coarse grained, massive to thin-bedded, locally crossbedded, and micaceous, and it locally has a siltstone at the base. The thickness varies from 0 to 114 feet and averages about 40 feet.

Lower Livingston (?) limestone.—The Lower Livingston (?) limestone ranges to a depth of 340 feet below the surface and is 460 to 515 feet above the West Franklin limestone.

The Lower Livingston (?) limestone, studied in outcrop and in cuttings from seven control drill holes, is brownish gray to light gray, finely crystalline, dense, slabby, and contains ostracods, pelecypods, and crinoid stems. It is 4 inches to 5 feet thick and is usually underlain by a thin coaly horizon and an underclay.

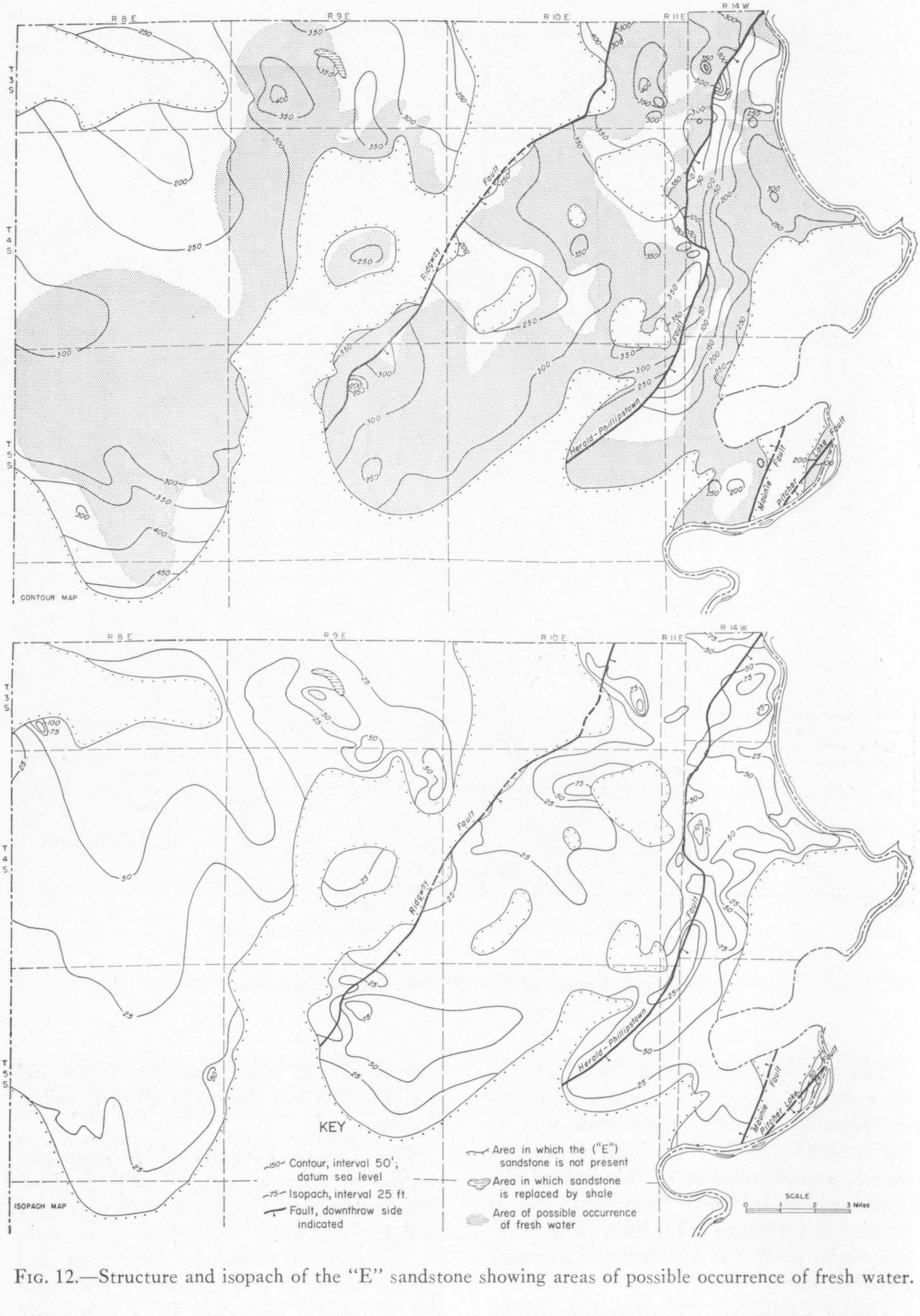


FIG. 12.—Structure and isopach of the "E" sandstone showing areas of possible occurrence of fresh water.

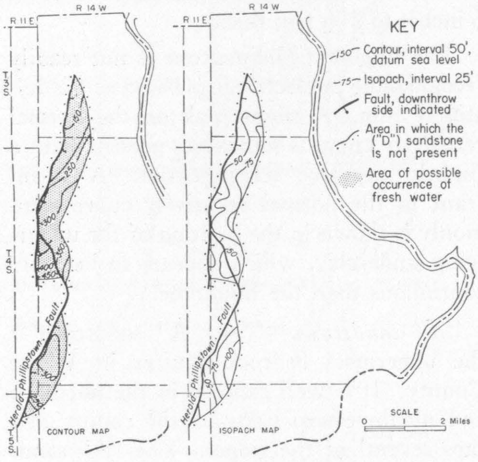


FIG. 13.—Structure and isopach of the "D" sandstone showing areas of possible occurrence of fresh water.

The Lower Livingston (?) limestone is recognizable in electric logs by a narrow moderate peak in the normal resistivity curve and small negative self-potential.

"D" sandstone.—The "D" sandstone occurs in a few exposures in the county and extends to a depth of 340 feet. It is 10 to 20 feet below the Upper Livingston (?) limestone and 5 to 30 feet above the Lower Livingston (?) limestone. This sandstone is best developed in the area trending north-south through Phillipstown (fig. 13).

The "D" sandstone is the basal unit of the Upper Livingston (?) cycle and lies unconformably on the upper shales of the Lower Livingston (?) cycle. It is buff, medium grained, medium to massive bedded, micaceous, partly calcareous, and sometimes contains poorly preserved plant remains. Its maximum known thickness is 100 feet, its average 40 feet.

Upper Livingston (?) limestone.—The Upper Livingston (?) limestone occurs in several exposures in the county and extends to a depth of 325 feet. The thickness of the interval between the Upper Livingston (?) limestone and the West Franklin limestone is from 478 to 534 feet.

Examination of outcrops in the county and sample cuttings of four control drill holes shows the limestone to be dark gray, irregularly bedded, and argillaceous, with a poorly preserved marine fauna. It is 3 inches to 5 feet thick and is commonly underlain by a black fissile shale 3 to 8 feet thick, underlain by coal up to 1½ feet thick, which is underlain by 2 to 3 feet of underclay.

The Upper Livingston (?) limestone is recognizable in electric logs by a narrow moderately high peak in the normal resistivity curve and moderate negative self-potential. A negative re-entrant in the normal resistivity curve commonly is shown in the position of the black shale and underclay.

"C" sandstone.—The "C" sandstone occurs in several exposures in White County and extends to a depth of 260 feet. It is 10 to 15 feet below the Cohn (?) limestone and 5 to 25 feet above the Upper Livingston (?) limestone. The sandstone is best developed in an area trending north-south through Phillipstown (fig. 14).

The "C" sandstone is the basal unit of the Cohn (?) cycle and lies unconformably upon the upper shales of the Upper Livingston (?) cycle. It is buff, fine to medium grained, somewhat crossbedded, calcareous in part, and locally contains a fossiliferous marine zone near the top. Its maximum known thickness is 75 feet, its average thickness 30 feet.

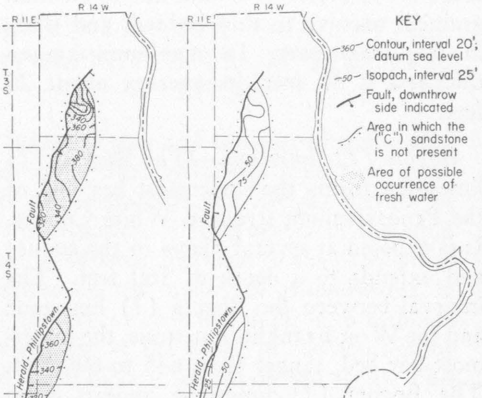


FIG. 14.—Structure and isopach of the "C" sandstone showing areas of possible occurrence of fresh water.

Cohn (?) limestone.—The Cohn (?) limestone occurs in at least seven known outcrops in the county (pl. 1B) and extends to a depth of 246 feet. It occurs 575 to 610 feet above the West Franklin limestone. The Cohn (?) limestone commonly is underlain by a thin coal and underclay sequence. The limestone is 8 inches to 4 feet thick. In places it is present in two benches separated by 1 to 2 feet of gray shale.

In three of the 18 control drill holes in the county (pl. 3), the Cohn (?) limestone has been found from examination of cuttings and outcrop samples to be medium brown to gray, fossiliferous, and argillaceous.

The Cohn (?) limestone is not readily recognizable in electric logs because it is relatively thin. A slight peak on the normal resistivity curve is sometimes present with a correspondingly slightly negative self-potential. A re-entrant in the normal resistivity curve commonly is shown in the position of the underlying underclay.

"B" sandstone.—The "B" sandstone is exposed at several places in White County (pl. 2A) and extends to a depth of 180 feet. It is 15 to 20 feet below the Bogota (?) limestone and 10 to 15 feet above the Cohn (?) limestone. This sandstone is overlain by a series of sandy shales and siltstone.

The "B" sandstone is the basal unit of the Bogota (?) cycle. It is buff, fine to medium grained, massive to thin bedded, and shaly in the lower part. Its maximum known thickness is 30 feet, its average about 20 feet.

Bogota (?) limestone.—The Bogota (?) limestone forms the uppermost key bed of the Pennsylvanian strata in White County. It is exposed at several places in the county and extends to a depth of 160 feet. The interval between the Bogota (?) limestone and the West Franklin limestone, the lowermost key bed, ranges from 645 to 690 feet. The Bogota (?) limestone appears from lithologic studies to be continuous but it is difficult to trace with electric logs (pl. 3).

The Bogota (?) limestone is dark to light gray, finely crystalline, compact to earthy, and contains ostracods. It is from 6 inches to 2½ feet thick.

The Bogota (?) limestone is not readily recognizable in electric logs because it is relatively thin. A slight peak on the normal resistivity curve is sometimes present with a slightly negative self-potential. A re-entrant in the normal resistivity curve commonly is shown in the position of the underlying underclay, which appears to be more continuous than the limestone.

"A" sandstone.—The "A" sandstone is the uppermost bedrock aquifer in White County. It is well exposed in the northern and northwestern parts of the county and caps several of the ridges. The "A" sandstone is 10 to 20 feet above the Bogota (?) limestone and is overlain by a series of shales and thin siltstones.

The "A" sandstone is the basal unit of the cyclothem overlying the Bogota (?) limestone. The basal beds are light brown coarse-grained massive crossbedded calcareous sandstones, which grade upward into gray and light brown, fine to medium grained, micaceous shaly sandstone at the top. It has an average thickness of about 30 feet and locally becomes as much as 75 feet thick.

WATER-BEARING PROPERTIES

The Upper Pennsylvanian sandstones generally are fine-grained and have low permeabilities; therefore, the movement of groundwater through them and into a well bore is relatively slow. Channel phases of the sandstones are thick and, because the grains are coarse and well-sorted, relatively permeable.

The sandstone aquifers of the Pennsylvanian system are important as sources of groundwater in areas where water-yielding sand and gravel deposits are absent. In areas where they are overlain by sand or gravel, all attempts should be made first to develop wells in the unconsolidated material.

STRUCTURE

The geologic structure in White County is characterized by generally northwest dipping beds and by conspicuous northeast-

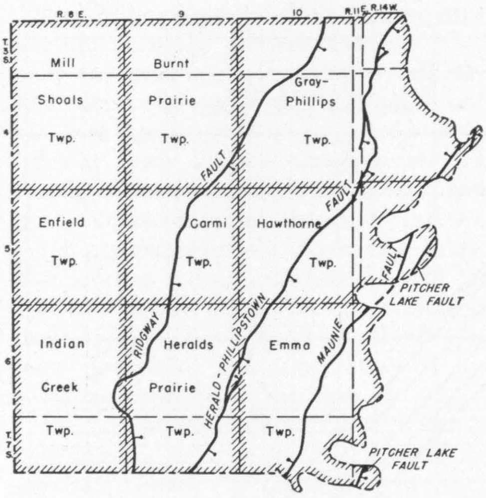


FIG. 15.—Position of faults in White County based on structure of the ("F") Mt. Carmel sandstone.

southwest trending faults. The average dip of the beds is 25 feet per mile. Reversals of dip and steepening occur locally. The major faults—the Ridgway, the Herald-Phillipstown, and the Maunie—cross the central and eastern parts of the county, whereas the Pitcher Lake fault crosses only the easternmost part of the county (figs. 15 and 2).

Generally the faults are single normal faults, but repeated faulting occurs locally along some fault zones in secs. 31 and 32, T. 3 S., R. 14 W., secs. 18 and 19, T. 4 S., R. 14 W., and secs. 25 and 36, T. 6 S., R. 9 E.

The Herald-Phillipstown and Maunie faults bound an intervening graben, whereas the Pitcher Lake and Maunie faults bound a horst.

The fault planes dip steeply, averaging 80 to 85 degrees (Harrison, 1951). The throw along the faults ranges from 25 feet in sec. 4, T. 4 S., R. 10 E., along the Ridgway fault to 425 feet in sec. 31, T. 4 S., R. 11 E., along the Herald-Phillipstown fault.

INFLUENCE OF STRUCTURE ON GROUNDWATER MOVEMENT AND QUALITY

Faulting brings some aquifers to the surface. Where these aquifers may formerly have contained highly mineralized water, they have been recharged by fresh waters, either by precipitation where they are exposed at the surface or by infiltration of fresh groundwater where they are overlain by fresh-water-bearing sand and gravel. The "F" and "E" sandstones are overlain by sand and gravel deposits in the buried valleys and in many places are very shallow or at the surface (figs. 10 and 12). The "C" and "D" sandstones have been exposed at the surface by faulting and erosion (figs. 13 and 14) and are fresh-water-bearing.

Faulting also may produce openings along fault zones, which allows introduction and circulation of fresh water into deep aquifers from overlying aquifers containing fresh water. Fresh water also can be introduced by direct precipitation on the fault zones, where permeable materials (such as sand and gravel) cover them, or by streams flowing over the exposed fault zones.

However, where hydrostatic pressures in deep formations containing mineralized water are sufficient, there may be upward movement of the water and contamination of the shallower fresh-water-bearing aquifers.

Folding and accompanying faults sometimes cause jointing of the more brittle rocks, thereby increasing their permeability. Displacement of aquifers and the formation of an impermeable fault gouge may produce barriers that cause poor circulation.

GROUNDWATER QUALITY AS INTERPRETED FROM ELECTRIC LOGS

Scattered chemical analyses of water samples from Pennsylvanian sandstone aquifers are inadequate for a clear picture of the distribution of fresh water in the aquifers. A feasible approach to the problem of determining the quality of groundwater, in the absence of chemical data, is to estimate the salinity of the water in the aquifers by the use of electric logs of oil test wells. This method is not a substitute for chemical analysis of groundwater, but in the absence of quantitative data it may be used to point out areas of fresh-water aquifers. White County is ideal for this type of investigation be-

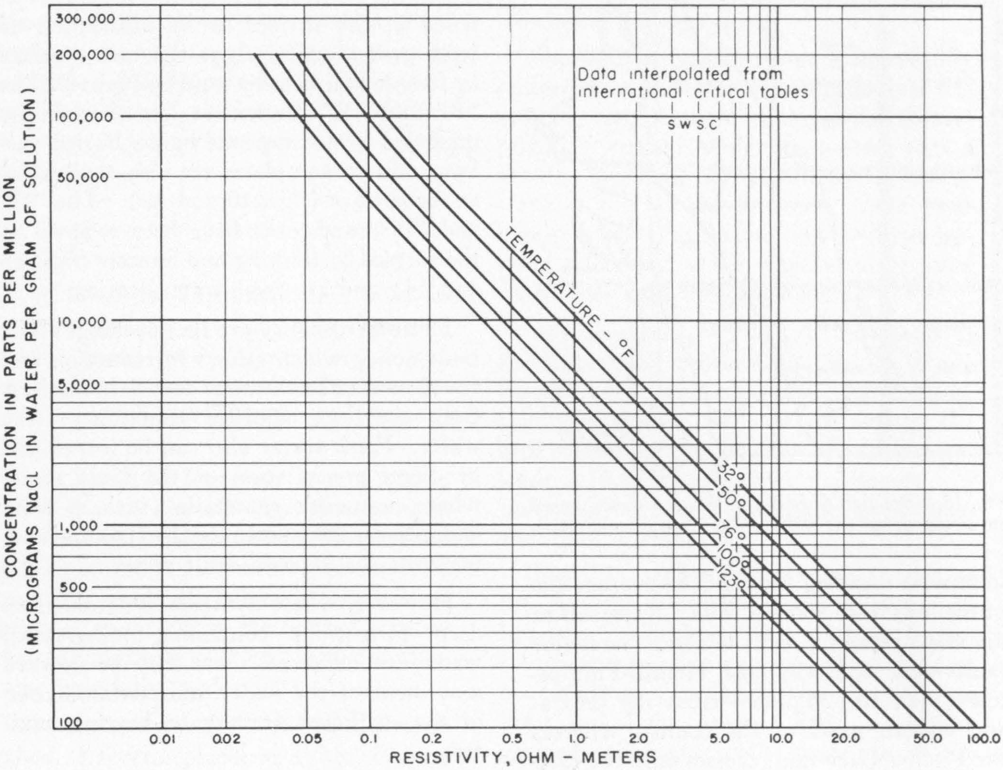


Fig. 16.—Resistivity graph showing relation between salinity and temperature of NaCl solution.

cause of the large number of closely spaced oil test wells that have been electrically logged. Copies of electric logs are filed at the State Geological Survey.

Methods

Electric logs are represented by two types of curves: a spontaneous potential curve and one or more resistivity curves.

The spontaneous potential curve (Doll, 1949), usually shown on the left-hand side of the electric log and expressed in millivolts, is in part affected by the ratio of the salinity of the drilling fluid to the salinity of the "formation water." In a fresh-water-bearing sandstone, the spontaneous potential curve becomes increasingly positive with a decrease in the salinity of the drilling fluid. When the salinity of the drilling fluid equals the salinity of the formation water, the spontaneous potential curve loses definition and the log becomes featureless.

The resistivity curves (Guyod, 1944), usually shown on the right-hand side of the electric log and expressed in ohms per meter per square meter, record differences in the apparent resistivity of the strata penetrated. The resistivity of the strata is recorded by one or more curves with different electrode spacings; these produce different amounts of penetration of the same bed, which results in slightly different resistivities for the same bed.

The "short normal" resistivity curve, recorded with a single electrode or with two electrodes spaced 16 to 18 inches apart, is essentially a measurement of the resistivity of the drilling fluid in the formation adjacent to the well bore.

The "long normal" resistivity curve, with an electrode spacing usually of five or six feet, is essentially a measurement of the resistivity of the formation water.

The drilling-fluid resistivity and the temperature at which the measurements were made are given on log headings. Drilling-fluid resistivities vary with temperature, and well-bore temperatures at depth are usually different from surface temperatures. In this region the temperature of the earth and of the fluids contained therein is variable and fluctuates seasonally from just below frost level to a depth of about 55 feet below land surface, where the temperature is about 55° F. (Benfield, 1950). From this point downward the temperature is believed to increase at a uniform rate of 1° F. for each hundred feet of depth. Corrections have to be made for drilling-fluid resistivities measured at the surface in order to determine their resistivities at depth. Figure 16 shows the variation of resistivity at various temperatures in a sodium chloride (salt) solution. In this study drilling mud is assumed to be a solution of sodium chloride.

The method used to determine the salinity of water contained in sandstone aquifers is: 1) determine the ratio of the resistivity value of the "long normal" curve to the resistivity value of the "short normal" curve, 2) convert the resistivity of the drilling fluid at surface temperature to the resistivity of the drilling fluid at a given depth by the use of a graph (fig. 16), 3) obtain the product of the ratio of the resistivity of the "long normal" curve to the resistivity of the "short normal" curve and the resistivity of the mud at a given depth; this product is the resistivity of the formation water, and 4) convert the resistivity value of the formation water at a given depth and temperature into concentration of sodium-chloride equivalents, in parts per million, by the use of the graph (fig. 16). The following expression (Pryor, 1956) is a summary of the above description:

$$\frac{\mathrm{Ra}\ 64''}{\mathrm{Ra}\ 16''} = \frac{\mathrm{Rw}}{\mathrm{Rm}} \qquad \mathrm{Rw} = \frac{\mathrm{Rm} \times \mathrm{Ra}\ 64''}{\mathrm{Ra}\ 16''}$$

where Ra 16″ = apparent resistivity, in ohms m^2/m, of "short normal" curve (16″ or 18″)

Ra 64″ = apparent resistivity, in ohms m^2/m, of "long normal" curve (64″ or 71″)

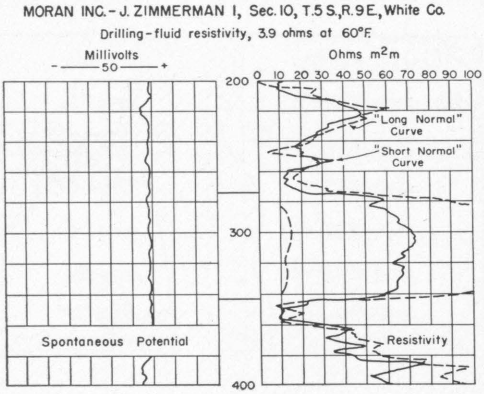


Fig. 17.—Electric log showing resistivity pattern of "E" sandstone.

Rm = resistivity, in ohms m^2/m, of drilling fluid, at a given formation temperature

Rw = resistivity, in ohms m^2/m, of formation water, at a given formation temperature

An example of the above described method is shown in the following description and in figure 17. The sandstone represented on this electric log has an average "short normal" apparent resistivity of 63 ohms and an average "long normal" apparent resistivity of 110 ohms. The drilling-fluid resistivity is given as 3.9 ohms at 60° F. on the log heading. The depth to the top of the sandstone is approximately 275 feet below land surface and the temperature at this depth is approximately 59° F. Figure 17 shows that the drilling fluid at this temperature has a resistivity of 4.0 ohms. To determine the resistivity of the water in the sandstone the formula in the preceding paragraph is:

where Rm = 4.0 ohms m^2/m
Ra 64″ = 110 ohms m^2/m
Ra 16″ = 63 ohms m^2/m

$$\mathrm{Rw} = \frac{4.0\ .\ 110}{63} = 7.0$$

Figure 16 shows that water at a temperature of 59° F. and with a resistivity of 7.0 ohms m^2/m has a concentration of approximately 890 parts per million of sodium-chloride equivalents.

This method of estimating the quality of water by use of electric logs is not a true

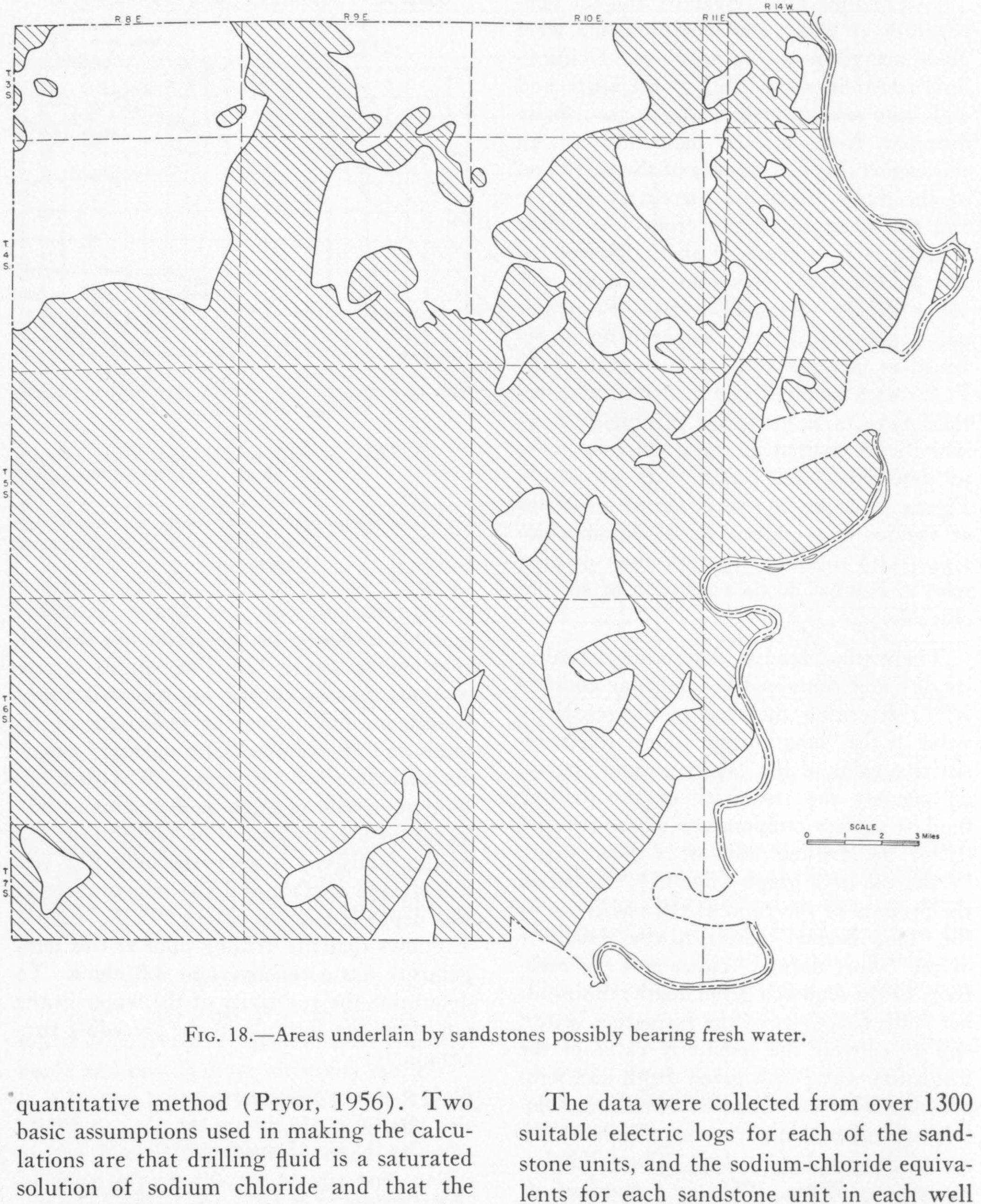


FIG. 18.—Areas underlain by sandstones possibly bearing fresh water.

quantitative method (Pryor, 1956). Two basic assumptions used in making the calculations are that drilling fluid is a saturated solution of sodium chloride and that the only dissolved salt in the formation water is sodium chloride.

Water-base drilling muds are not solutions of sodium chloride but are thixotropic suspensions of clay that may contain sodium chloride. The dissolved salts in the groundwater consist not only of sodium chloride but also of several other soluble salts that may influence the resistivity of water.

The data were collected from over 1300 suitable electric logs for each of the sandstone units, and the sodium-chloride equivalents for each sandstone unit in each well were estimated. The values of each unit were plotted on maps and contoured. The 1500 ppm./isocon was arbitrarily chosen to enclose the areas in which the sandstone aquifers are calculated to contain fresh water. Figure 18 shows the areas underlain by sandstone aquifers thought to contain fresh water.

Aquifer	*Location*	*Chemical Analyses* (chlorides)	*Computed values* (calculated NaCl)
"E"	8, T. 5 S., R. 8 E.	15 ppm.	750–1000 ppm.
"F"	28, T. 5 S., R. 8 E.	241 ppm.	800–1100 ppm.
"F"	26, T. 4 S., R. 9 E.	2050 ppm.	2200 ppm.
"F"	13, T. 5 S., R. 9 E.	295 ppm.	850–1100 ppm.
"F"	10, T. 7 S., R. 9 E.	230 ppm.	850–1500 ppm.
"E"	23, T. 4 S., R. 10 E.	63 ppm.	500– 950 ppm.

The one area where the computed values can be compared to chemical analyses is at Enfield in the western part of the county. Enfield obtains its municipal water supply from the ("F") Mt. Carmel sandstone, which at Enfield is at a depth of 205 feet and is 263 feet thick. Chemical analyses by the State Water Survey of water from two wells in sec. 8, T. 5 S., R. 8 E., report concentrations of 144 ppm. and 148 ppm. of chlorides. Calculations from electric logs of wells in secs. 5 and 9, T. 5 S., R. 8 E., result in estimated values ranging from 650 ppm. to 1200 ppm. of sodium-chloride equivalents.

Because the other samples may have been contaminated by the mixing of water from several aquifers and are probably not from a single aquifer, other less certain comparisons can be made. (See table above.)

These data show that the values computed from electric logs are somewhat higher than the concentrations of chlorides derived by chemical analysis of the water. Although the computed values are higher, they give a rather close approximation of the chloride content.

The "A" and "B" sandstones could not be mapped in White County. They occur only as scattered remnants, capping hills in the northern part of the county. Therefore no estimates on the quality of the water contained in them can be given, but it can be assumed, because they are very near or at the surface, that the groundwater they contain is fresh. The "C"' sandstone (fig. 14) and the "D" sandstone (fig. 13) occur in the northeastern part of the county and are thought to contain fresh water. The "E" sandstone (fig. 12) occurs in the northern half of the county; data from electric logs indicate that it is fresh-water-bearing, except in the northwestern part of the county. The ("F") Mt. Carmel sandstone (figs. 10 and 11) underlies all but the southeast corner of White County and is calculated to contain fresh water in the southern two-thirds of the county. The "G" sandstone (fig. 8) occurs in the southeastern part of the county and generally contains fresh water. The "H" sandstone (fig. 5) is found in the northeastern part of White County as disconnected lenses, and electric logs indicate only three small areas that contain fresh water. The ("I") Trivoli sandstone (figs. 6 and 7) underlies the northeastern one-half of the county; calculations from electric logs indicate that it is fresh-water-bearing only in the eastern part, which borders the Wabash River.

GEOLOGY AND WATER-BEARING PROPERTIES OF THE GLACIAL DEPOSITS

During the Pleistocene or glacial epoch great masses of ice formed in Canada in three large areas: the Cordilleran area in western Canada, the Keewatin area west of Hudson Bay, and the Labradorean area in eastern Canada. From the two eastern areas the ice advanced southward into the central part of the United States, and ultimately most of the upper Mississippi drainage basin as far south as the southern part of Illinois was glaciated. Four distinct

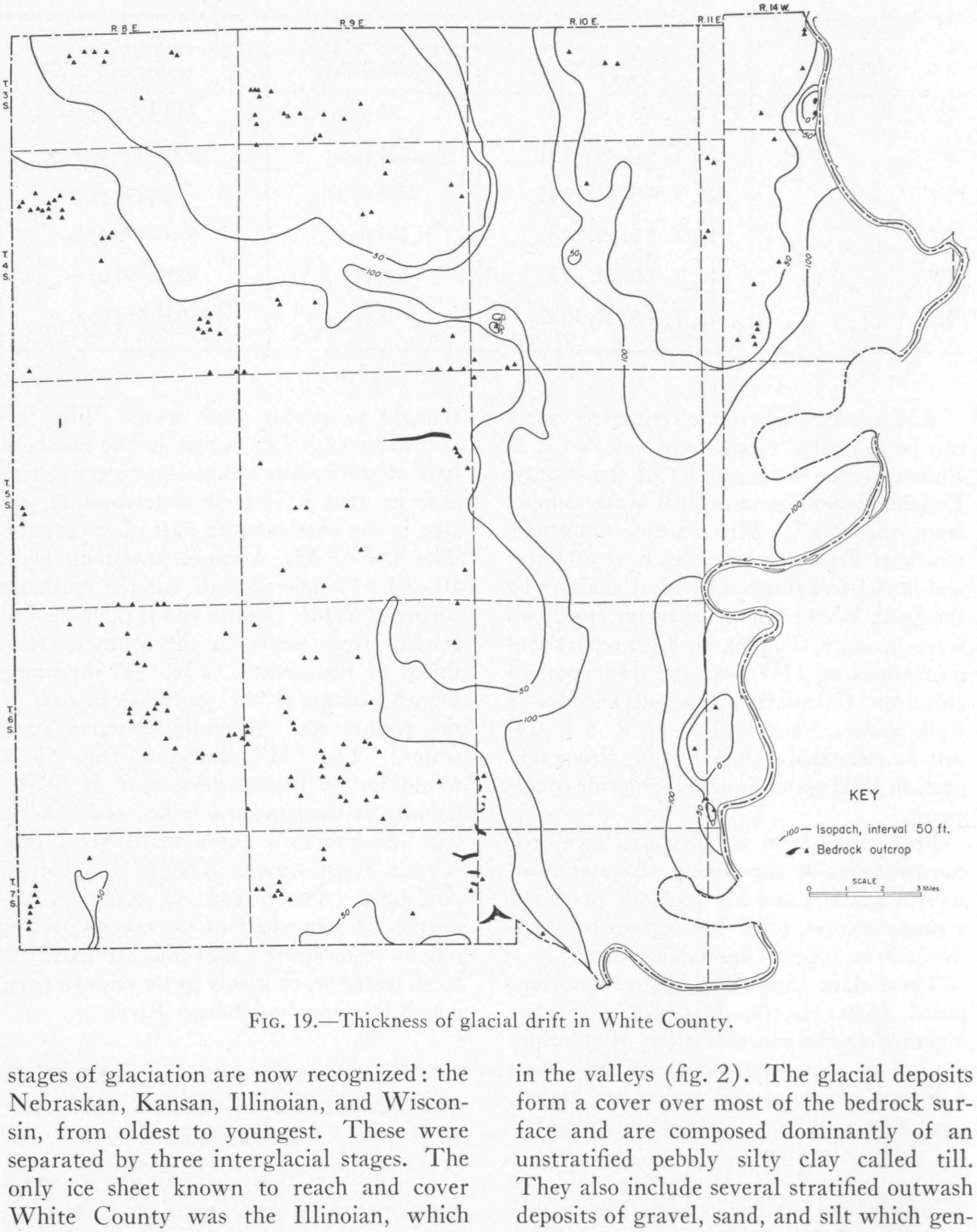


FIG. 19.—Thickness of glacial drift in White County.

stages of glaciation are now recognized: the Nebraskan, Kansan, Illinoian, and Wisconsin, from oldest to youngest. These were separated by three interglacial stages. The only ice sheet known to reach and cover White County was the Illinoian, which originated in the Labradorean area. The Illinoian ice reached the central part of Gallatin County, about 10 miles south of White County.

The ice sheets carried a large volume of rock debris, which was dumped on the preglacial landscape as the glaciers melted. The glacial rock debris or "drift" overlies the bedrock beneath the upland surfaces and in the valleys (fig. 2). The glacial deposits form a cover over most of the bedrock surface and are composed dominantly of an unstratified pebbly silty clay called till. They also include several stratified outwash deposits of gravel, sand, and silt which generally occur in the bedrock valleys. Windblown silt, called loess, derived principally from outwash in the main valleys, mantles the glacial deposits in thicknesses ranging from 2 to 9 feet (Smith, 1942, p. 152).

BEDROCK TOPOGRAPHY

The present upland landscape is covered by less than 50 feet of glacial material and

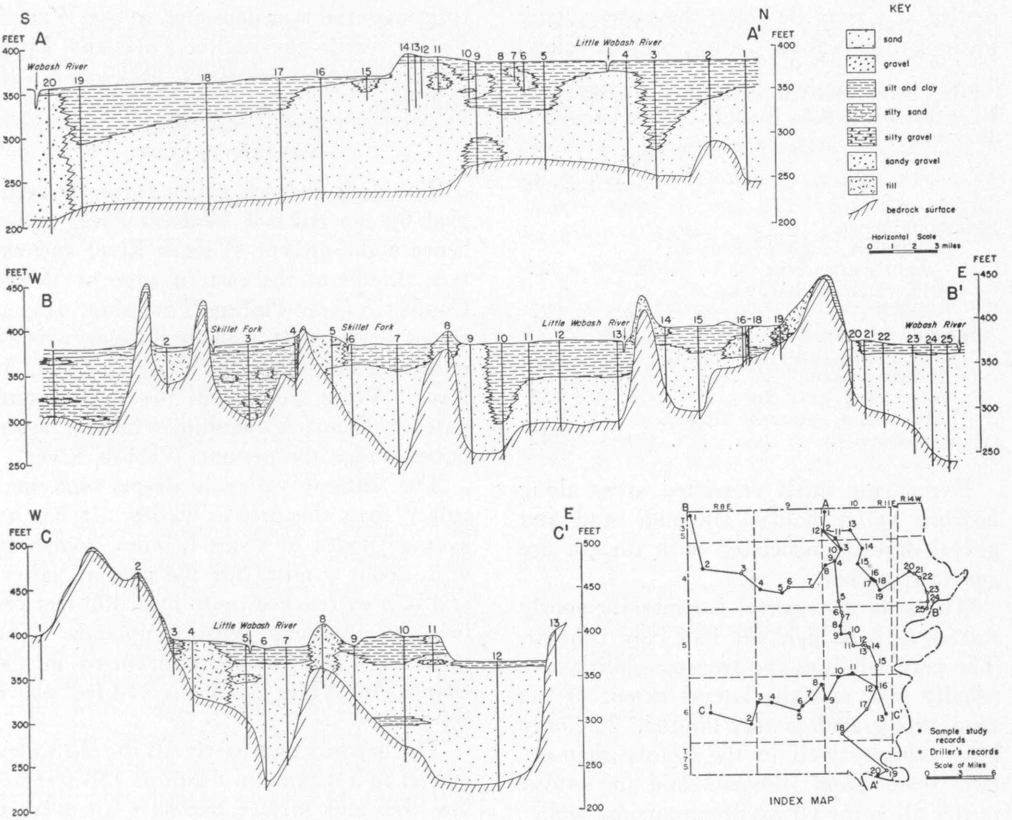


FIG. 20.—Cross sections of glacial deposits in White County.

the bedrock is exposed at many places. However, the unconsolidated alluvium in the bottomlands attains thicknesses that exceed 100 feet (fig. 19). Information derived from well records and other sources reveals old buried bedrock valleys, which would not be suspected from the present surface topography (pl. 4).

The outstanding features of the bedrock surface are three preglacial stream channels, which cross the central and eastern portions of the county. The main channel is the ancient course of the Wabash River; it is joined by its tributary channels, the Little Wabash and Skillet Fork, in the central part of the county. Bedrock uplands dissected by tributary valleys are present on both sides of the Little Wabash and Skillet Fork channels and west of the main Wabash channel. The bedrock upland to the west covers almost one-half of the county and reaches elevations of between 450 and 550 feet above sea level; the bedrock upland between the Skillet Fork and Little Wabash channels is much less extensive and reaches elevations between 400 and 580 feet above sea level. The bedrock surface ranges in elevation from 580 feet above sea level in the north-central part of the area to below 210 feet above sea level along the Ancient Wabash River Valley, giving a total maximum relief of more than 330 feet.

ILLINOIAN TILL PLAIN

The Illinoian till is restricted principally to the bedrock uplands, where it forms a cover up to 50 feet thick, with an average thickness of about 20 feet. Till covers the hills where it is thin and fills in small tributary valleys where it is thick. Some till may be present in the large bedrock valleys, but it has been identified only in the records of wells drilled along the sides of the valleys (fig. 20). The record of one of these wells, drilled at Crossville along the eastern flank of the Little Wabash Valley, is given below.

Stiers Bros.–Crossville village well 1, SE¼ SW¼ NE¼ sec. 23, T. 4 S., R. 10 E., White Co. Elev.: 396 feet.

	Thickness feet	Depth feet
Pleistocene series		
Silt, yellow, slightly oxidized, slightly calcareous . . .	25	25
Sand, clean, yellow, fine to coarse	2	27
Illinoian deposits		
Till, yellow, silty, compact, noncalcareous	5	32
Gravel, silty, gray, fine . . .	6	38
Sand, clean, grayish brown, medium	4	42

Except for small restricted areas along bedrock valley flanks, Illinoian sand and gravel deposits associated with the till are generally absent.

The sand and gravel is generally poorly sorted with a high silt and clay content. The permeabilities and transmissibilities are usually low, and the lateral extent of the sands and gravels is very limited. The only large-capacity well in the county that obtains water from Illinoian sand and gravel in the till is the Crossville municipal well.

VALLEY DEPOSITS

During Illinoian glaciation large volumes of meltwater, loaded with debris, were concentrated in the larger valleys. This meltwater deposited valley trains of sand and gravel, which extended many miles downstream from the ice front. Streams that had formerly eroded their valleys began to aggrade them with silt, sand, and gravel during glacial advances.

The Wisconsin ice sheet did not reach White County; it stopped many miles to the north. The far-reaching effects of the meltwater were felt by the Wabash and Little Wabash valleys, which were filled with valley-train material, whereas the Skillet Fork received only backwater silts and clays.

In the later stages of Wisconsin glaciation, when the ice sheet had withdrawn beyond the drainage basins of the Skillet Fork and Little Wabash valleys but was still in the Wabash Valley drainage basin, valley-train material was deposited in the Wabash Valley, while the Skillet Fork and Little Wabash valleys received backwater silts and clays.

WABASH VALLEY

The deep bedrock valley formerly occupied by the Ancient Wabash River passes beneath the present Wabash River and enters Illinois at the eastern edge of White County in Gray-Phillips Township. It continues southwest for about 8 miles, whence it takes a southerly course for 11 miles. It leaves White County in the southeastern part of Emma Township, where it again passes under the present Wabash River.

The ancient valley is deeper and narrower than the present valley. It has an average width of about 6 miles, compared with about 9 miles for the present valley, and it is entrenched more than 300 feet below the adjoining bedrock uplands. The lowest bedrock elevation measured in the channel in White County is 210 feet above sea level.

The deposits that partly fill the old valley extend to a maximum depth of 150 feet below the land surface but have an average thickness of about 125 feet. The material is composed largely of sand with thin beds of gravel, silt, and clay. Throughout most of the valley area the land surface is immediately underlain by deposits of silt and clay with thicknesses up to 60 feet (fig. 20). The silt and clay deposits are thinner and in some places are absent over the deepest parts of the valley. The record of the Dawson—Rodenberg well 1, based on a study of well cuttings, indicates the general character of the deposits in the deeper part of the valley.

Joe Dawson–Rodenberg well 1, NE¼ SE¼ NE¼ sec. 11, T. 6 S., R. 10 E., White Co. Elev.: 366 feet.

	Thickness feet	Depth feet
Pleistocene series		
Sand, medium fine, silty . . .	20	20
Sand, medium, iron-stained, clean	20	40
Sand, medium fine, iron-stained, clean	60	100
Sand, medium fine, clean . .	30	130
Pennsylvanian system		
Shale, gray	10	140

The record of the Hayes—U. S. Army Engineer Corps Hoosier well 1, based on a study of well cuttings, indicates the general character of the deposits along the flanks of the valley.

Hayes–U. S. Army Engineer Corps Hoosier well 1, SW¼ NE¼ NE¼ sec. 5, T. 5 S., R. 10 E., White Co. Driller, Charles Hayes. Elev.: 400 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Silt, reddish brown, sandy, slightly calcareous	15	15
Sand, fine, clean	25	40
Silt, brown, sandy, calcareous	10	50
Sand, medium, clean to slightly silty	35	85
Silt, brown, calcareous	35	120

The valley deposits are in an area where no large municipal supplies are needed. The only large industrial supplies that are withdrawn from the materials are used for injection water for water flood projects in and around several oil fields. The five major water flood projects in the Wabash Valley, obtaining water from gravel beds, injected approximately 330,817,024 gallons of fresh groundwater in 1954 or, calculated on a 24-hour pumping basis, 623 gallons per minute for 365 days (Witherspoon et al., 1954). Most of the farms situated on the valley deposits obtain water from sand and gravel at depths ranging from 20 to 80 feet.

The groundwater resources of the valley are apparently very large (fig. 21) and essentially undeveloped.

LITTLE WABASH VALLEY

The partly buried bedrock valley of the Little Wabash River coincides more or less with the valley of the present stream and enters the county from the north, in the north-central part of Burnt Prairie Township. It continues south for 12 miles where it enters the Ancient Wabash River Valley, about 4 miles east of Carmi.

The valley is 2½ to 4 miles wide and is entrenched 330 feet below the adjacent bedrock uplands. The lowest bedrock elevation found was 230 feet above sea level.

The deposits in the valley are a maximum of 135 feet thick and average about 100 feet thick. They consist of sand, silt, and clay in about that order of abundance. Small amounts of fine gravel also are present in the deeper parts of the valley (fig. 20). The sand and gravel deposits usually are overlain by thick sections of silt and clay, which have an average thickness of about 40 feet but are as thick as 80 feet.

The general character of sequence in the Little Wabash Valley is shown by the study of sample cuttings from the Tidewater—J. Elliot test well.

Tidewater–J. Elliot well 1, center N½ sec. 33, T. 3 S., R. 10 E., White Co. Elev.: 380 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Silt, yellow, calcareous	10	10
Silt, grayish brown, calcareous	30	40
Sand, silty, brown, medium, shell fragments	30	70
Sand, silty, reddish brown, medium fine	20	90
Sand, clean, grayish brown, coarse	15	105
Pennsylvanian system		
Siltstone and shale, gray, coaly	15	120

Large quantities of water are probably obtainable at most places along the deeper part of the valley, but with the exception of one water flood project there are no large withdrawals. The water flood project at the Centerville East pool in T. 4 S., R. 10 E., obtaining water from gravel beds, injected approximately 2,252,838 gallons of fresh groundwater in 1954 (Witherspoon et al., 1954) or an average of 4.2 gallons per minute for 365 days. Most of the farm wells in the Little Wabash Valley obtain water supplies from dug or driven wells with an average depth of 30 feet. A log of a typical dug well in this area is given below.

Spencer farm well, dug by owner, NE¼ SE¼ NE¼ sec. 5, T. 5 S., R. 10 E., White Co. Elev.: 390 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Loam, brown, sandy	8	8
Sand, reddish brown	17	25
Sand, yellow	3	28

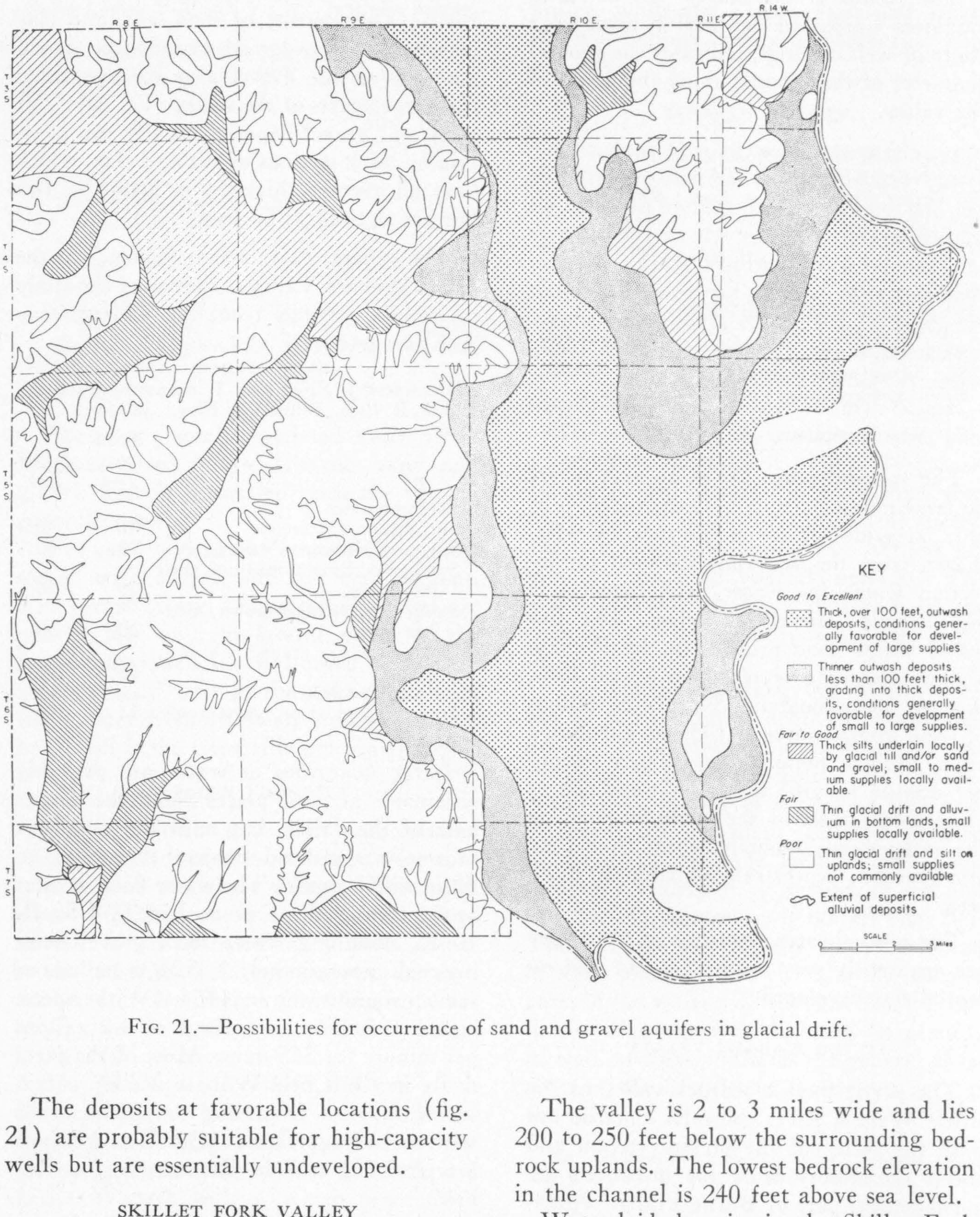


FIG. 21.—Possibilities for occurrence of sand and gravel aquifers in glacial drift.

The deposits at favorable locations (fig. 21) are probably suitable for high-capacity wells but are essentially undeveloped.

SKILLET FORK VALLEY

The partly buried bedrock valley of the Skillet Fork coincides with the valley of the present stream and enters the county from the northwest in Mill Shoals Township. The valley continues southeast under the present stream valley for 14 miles where it enters the channel of the Little Wabash Valley, 3½ miles north of Carmi.

The valley is 2 to 3 miles wide and lies 200 to 250 feet below the surrounding bedrock uplands. The lowest bedrock elevation in the channel is 240 feet above sea level.

Water-laid deposits in the Skillet Fork Valley attain thicknesses of more than 130 feet but average less than 70 feet. The sediments are silt, sand, and minor amounts of gravel. Small amounts of Illinoian valley-train material are present in the valley, but in general the deposits are backwater silts and sands with low permeabilities (fig. 20). A record based on study of sample well cuttings, showing the character of the fill in the Skillet Fork Valley, is given in the log of the Pure Oil Company—W. B. Fox test hole 1A.

Pure Oil Co.–W. B. Fox 1A, NE¼ SW¼ NW¼ sec. 19, T. 3 S., R. 8 E., White Co. Elev.: 379 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Silt and clay, yellow	10	10
Sand, very silty, brown, fine	5	15
Silt and clay, sandy, brown	5	20
Sand, silty, brown, fine	30	50
Sand, clean, gray, fine	5	55
Sand, silty, gray, fine	20	75
Pennsylvanian system		
Shale, gray, coaly	15	90

Small to medium quantities of water are probably obtainable at most places in the deeper part of the valley. Only small scattered deposits of sand or gravel occur along the valley flanks, but detailed prospecting may show that important aquifers are present locally. No large withdrawals of water are made from these valley deposits in White County, but a water flood project at the Mill Shoals oil field in Hamilton County, obtaining water from gravel beds in the Skillet Fork Valley, injected 10,872,960 gallons of fresh groundwater in 1953 (Witherspoon et al., 1954) or, calculated on a 24-hour pumping basis, an average of 21 gallons per minute for 365 days. Most of the farms in the Skillet Fork area obtain water supplies from dug or driven wells, which range in depth from 15 to about 40 feet.

The deposits at favorable locations probably could furnish medium to large quantities of water but are not as thick or continuous as the deposits in the main valleys (fig. 21). The groundwater resources in this valley are essentially undeveloped.

BEAR CREEK VALLEY

Bear Creek Valley, a tributary of the Ancient Saline River, which lies to the south in Gallatin County, is a partly buried bedrock valley. It heads in the southwestern part of White County in Indian Creek Township and continues south for about 7 miles, where it leaves White County and enters Gallatin County.

The valley is one-quarter to 1 mile wide and where most deeply buried it is entrenched 100 to 120 feet below the adjacent bedrock uplands. The upper extremities of the valley are not buried and are occupied by Bear Creek and its main tributary, Indian Creek.

Deposits in the valley attain thicknesses of more than 75 feet but average less than 50 feet. The valley-fill material is composed of silt, clay, till, sand, and gravel in about that order of abundance. The driller's log of the Byrd and Son—F. K. Taylor oil test well indicates the general character of the deposits in the deeper part of the valley.

Byrd and Son–F. K. Taylor well, NW¼ SE¼ SW¼ sec. 9, T. 7 S., R. 8 E., White Co. Elev.: 376 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Clay	29	29
Sand, clayey	12	41
Clay	33	74
Sand and gravel	2½	76½
Pennsylvanian system		
Shale	10	86½

The farms in this area obtain supplies from dug or driven wells, which range in depth from 20 to 50 feet. Small supplies are probably obtainable at most places in the deeper part of the valley; conditions are extremely variable in the flanking areas (fig. 21).

WATER-BEARING PROPERTIES

The sands and gravels of the outwash deposits are extremely variable in character. The gravels generally are fine-grained and poorly sorted with a limited lateral continuity. Because of the poorly sorted character of the gravels, the permeabilities and transmissibilities are low, which, in addition to the limited lateral extent of the gravel deposits, limits the development of high-capacity wells in gravel beds.

The sand deposits have grain sizes that range from very fine to coarse; medium grain size is average. There is a tendency for the deposits to be coarser in the lower part than in the upper part. A great deal of silt and clay is associated with the finer sand in the upper part of the deposits. The sand in the lower half of the outwash is fairly well sorted and generally has good lateral continuity. In the main outwash-filled valleys, where the sand is coarse, well sorted, widespread, and has high transmissibility, there are excellent possibilities for developing high-capacity wells.

REFERENCES

Bell, A. H., et al., 1952, Illinois oil field brines–their geologic occurrence and chemical composition: Illinois Geol. Survey Ill. Pet. 66.

Benfield, A. E., 1950, The earth's heat: Scientific American, v. 183, no. 6, p. 54-57.

Cady, G. H., et al., 1955, Subsurface geology and coal resources of the Pennsylvanian system in Wabash County, Illinois: Illinois Geol. Survey Rept. Inv. 183.

Collet, J., 1884, 13th Annual Report: Indiana Dept. Geol. and Nat. Hist.

Doll, H. G., 1949, The S. P. log; Theoretical analysis and principles of interpretation: Trans. Am. Inst. Min. Met. Eng., v. 179, p. 146-185.

Guyod, Hubert, 1944, Electric well logging: Reprint from 16 articles in Oil Weekly, Aug. 7-Dec. 4.

Harrison, J. A., 1951, Subsurface geology and coal resources of the Pennsylvanian system in White County, Illinois: Illinois Geol. Survey Rept. Inv. 152.

Pryor, W. A., 1954, Sandstone aquifers in the upper part of the Pennsylvanian system, White County, Illinois: unpublished Master's thesis, University of Illinois.

Pryor, W. A., 1956, Quality of groundwater estimated from electric resistivity logs: Illinois Geol. Survey Circ. 215.

Siever, Raymond, 1951, The Mississippian-Pennsylvanian unconformity in southern Illinois: Geol. Survey Rept. Inv. 152.

Smith, G. D., 1942, Illinois loess; variations in its properties and distribution: Univ. Illinois Agr. Exp. Sta. Bull. 490.

Weller, J. M., 1930, Cyclic sedimentation of the Pennsylvanian period and its significance: Jour. Geol., v. 38, no. 2, p. 97-135.

Witherspoon, P. A., et al., 1954, Summary of water flood operations in Illinois oil pools during 1953: Illinois Geol. Survey Circ. 193.

APPENDIX 1

Township Groundwater Summary

Appendix 1 is designed to summarize the groundwater possibilities of White County by section and township. The main subdivision of this appendix is the civil township, beginning in the northwestern part of the county with Mill Shoals Township. The civil townships are subdivided into the next major subdivision, the congressional township. The congressional township is 36 square miles in area and is divided into mile-square subdivisions called sections. Figure 15 shows the county divided into civil and congressional townships.

The townships are dealt with from east to west, starting in the northwestern corner of the county. The smallest subdivisions, the sections, are handled in groups where geologic conditions merit it. The groundwater possibilities of the glacial drift are summarized in the column on the left and the bedrock possibilities on the right.

Sections	Possibilities in unconsolidated material	Bedrock possibilities
	T. 3 S., R. 8 E.—Northern One-Third Mill Shoals Township	
19–24	Conditions variable for small to medium supplies in sec. 19 and W½ sec. 20. Conditions unfavorable in secs. 21–24 because of thin material. Best possibilities in W½ sec. 19 from sand and gravel.	Some possibilities in NW¼ sec. 19 from Mt. Carmel sandstone, 325 feet deep and 75 feet thick.
25–30	Conditions variable for small to medium supplies in secs. 28, 29, and 30. Small supplies locally available in southern sec. 25. Conditions unfavorable in secs. 26 and 27 because of thin material. Best possibilities from sand and gravel in sec. 30.	Poor possibilities because of highly mineralized water.
31–36	Conditions variable for development of small to medium supplies in secs. 31–34. Best possibilities from sand and gravel in secs. 31, 32, and 33. Small supplies locally available in secs. 35 and 36.	Some possibilities in east-central sec. 36 from Mt. Carmel sandstone, 375 feet deep and 150 to 200 feet thick.
	T. 4 S., R. 8 E.—Southern Two-Thirds Mill Shoals Township	
1–6	Conditions variable for small to medium supplies. Best possibilities from sand and gravel secs. 3 and 4 and in northern secs. 5 and 6.	Some possibilities in the SE corner sec. 1 from "E" sandstone, 142 feet deep and 50 feet thick. Some possibilities in northwestern part of sec. 6 from Mt. Carmel sandstone, 320 feet deep and 75 feet thick. Some possibilities in northern part of sec. 6 from Trivoli sandstone, 495 feet deep and 50 feet thick.
7–12	Conditions variable for small to medium supplies in secs. 9–12. Best possibilities in secs. 10 and 11. Conditions unfavorable in secs. 7 and 8.	Some possibilities in E½ sec. 12 from "E" sandstone, 145 to 160 feet deep and 50 feet thick.
13–18	Conditions variable for small to medium supplies in secs. 13–15. Best possibilities in sec. 14. Small supplies locally available in secs. 16 and 17. Conditions unfavorable in sec. 18.	Some possibilities in E½ sec. 13 from "E" sandstone, 145 feet deep and 50 feet thick.
19–24	Conditions variable for small to medium supplies in secs. 22–24. Best possibilities in northern secs. 23 and 24. Small supplies locally available in northern sec. 20. Conditions unfavorable in secs. 19 and 21.	Some possibilities in E½ sec. 24 from Mt. Carmel sandstone, 270 feet deep and 125 feet thick.
25–30	Small supplies locally available in secs. 26 and 27. Conditions generally unfavorable in secs. 25, 28, 29, and 30.	Some possibilities in secs. 26–30 from "E" sandstone, 80 to 100 feet deep and 25 feet thick, and in secs. 25 and 29 from the Mt. Carmel sandstone, 250 to 280 feet deep and 175 to 200 feet thick.
31–36	Small supplies locally available in secs. 32–35.	Some possibilities from "E" sandstone, 80 to 100 feet deep and 25 feet thick, and in secs. 31, 32, 33, and 36 from the Mt. Carmel sandstone, 250 to 280 feet deep and 175 to 300 feet thick.

Sections	Possibilities in unconsolidated material	Bedrock possibilities
T. 3 S., R. 9 E.—Northern One-Third Burnt Prairie Township		
19–24	Conditions generally favorable for small to large supplies in secs. 21–24. Best possibilities for large supplies in secs. 23 and 24. Conditions unfavorable in secs. 19 and 20.	Some possibilities in secs. 19, 20, and 21 from "E" sandstone, 100 to 125 feet deep and 25 feet thick, and in secs. 19 and 20 from Mt. Carmel sandstone, 400 feet deep and 100 feet thick.
25–30	Conditions generally favorable for small to large supplies in secs. 25, 26, and northern sec. 28. Best possibilities for large supplies in sec. 25. Conditions unfavorable in secs. 27, 29, and 30.	Some possibilities in secs. 28, 29, and 30 from "E" sandstone at depth of 25 feet, and in northern sec. 30 from Mt. Carmel sandstone, 400 feet deep and 125 feet thick.
31–36	Conditions generally favorable for small to large supplies in NE¼ sec. 35 and sec. 36. Best possibilities for large supplies in NE¼ sec. 36. Conditions unfavorable in secs. 31–34 and in SW¼ sec. 35.	Some possibilities in secs. 31–33 and 35 from "E" sandstone, 100 to 125 feet deep and 25 to 50 feet thick.
T. 4 S., R. 9 E.—Southern Two-Thirds Burnt Prairie Township		
1–6	Conditions variable for small to large supplies in NE¼ sec. 1. Small supplies locally available in southern secs. 4 and 5. Conditions unfavorable in SW 2/3 sec. 1 and in secs. 2, 3, and 6.	Some possibilities in secs. 1–6 from "E" sandstone, 100 to 200 feet deep and 25 to 50 feet thick, and in secs. 2 and 3 from Mt. Carmel sandstone, 550 to 580 feet deep and 175 feet thick.
7–12	Small supplies locally available in secs. 8 and 9 and in SW¼ sec. 7. Conditions unfavorable in secs. 10–17.	Some possibilities in secs. 7, 8, and 12 from "E" sandstone, 100 to 150 feet deep and 50 feet thick.
13–18	Conditions variable for small to medium supplies except in northern secs. 13–15. Best possibilities in SE¼ sec. 13 and in sec. 18.	Some possibilities in sec. 17 and 18 from "E" sandstone, 90 to 100 feet deep and 50 feet thick.
19–24	Conditions variable for small to medium supplies in secs. 19–23 and conditions favorable for small to large supplies in sec. 24.	Some possibilities in secs. 19, 20, 22, and 23 from "E" sandstone, 100 feet deep and 25 feet thick, and in sec. 19 from Mt. Carmel sandstone, 300 feet deep and 125 feet thick.
25–30	Conditions variable for small to medium supplies in secs. 25–28. Best possibilities in N½ of these sections. Conditions unfavorable in secs. 29 and 30.	Some possibilities in secs. 29 and 30 from "E" sandstone, 100 feet deep and 25 feet thick, and in secs. 26–30 from Mt. Carmel sandstone, 300 feet deep and 175 to 200 feet thick.
31–36	Conditions variable for small supplies in secs. 32 and 33. Conditions unfavorable in secs. 31, 34, 35, and 36.	Some possibilities in secs. 31 and 36 from "E" sandstone, 100 to 150 feet deep and 25 feet thick, and in secs. 31–35 from Mt. Carmel sandstone, 250 to 275 feet deep and 125 to 175 feet thick.
T. 3 S., R. 10 E.—Northern Part of Gray-Phillips Township		
19–21 28–33	Conditions generally favor development of large supplies. Conditions favorable for small to large supplies in secs. 21, 30, and 33.	Poor possibilities because of highly mineralized water.
22–27 34–36	Small supplies locally available in sec. 27.	Some possibilities from "E" sandstone, 80 to 100 feet deep and 50 to 100 feet thick.

Sections	Possibilities in unconsolidated material	Bedrock possibilities
	T. 3 S., R. 11 E.—Northern Part of Gray-Phillips Township	
19, 30 and 31	Conditions generally unfavorable.	Some possibilities from "E" sandstone, 90 to 110 feet deep and 50 feet thick.
	T. 3 S., R. 14 W.—Northern Part of Gray-Phillips Township	
19–21 28–33	Conditions generally favorable for small to large supplies in secs. 28 and 31.	Some possibilities in secs. 31 and 32 from "C" and "D" sandstone at depths of 50 and 250 feet, respectively, both 50 feet thick. Some possibilities in secs. 19, 20, 21, 29, 30, and 31 from "E" sandstone, 100 to 250 feet deep and 50 to 75 feet thick; in sec. 33 from Mt. Carmel sandstone, 300 feet deep and 75 feet thick; some possibilities from Trivoli sandstone in secs. 29 and 30, 500 feet deep and 25 feet thick.
	T. 4 S., R. 10 E.—Southern Part of Gray-Phillips Township	
1–6	Conditions generally favorable for small to large supplies in secs. 4–6. Best possibilities for large supplies in sec. 5. Limited possibilities for small supplies in SE¼ sec. 2 and SE¼ sec. 3. Conditions unfavorable in secs. 1, 2, 3, and E½ sec. 4.	Some possibilities in secs. 1–4 from "E" sandstone, 50 to 70 feet deep and 50 feet thick.
7–12	Conditions generally favorable for small to large supplies in secs. 7–10. Best possibilities for large supplies in sec. 8. Conditions unfavorable in W½ sec. 7, E½ sec. 11, and sec. 12.	Some possibilities in secs. 8–10 from "E" sandstone, 70 to 100 feet deep and 25 feet thick.
13–18	Conditions favorable for small to large supplies in secs. 14–18. Best possibilities for large supplies in secs. 16 and 17. Conditions unfavorable in NE¼ sec. 14 and sec. 13.	Some possibilities in secs. 14–17 from "E" sandstone, 150 to 170 feet deep and 25 feet thick.
19–24	Conditions favorable for small to large supplies in secs. 19–24. Best possibilities for large supplies in secs. 19 and 20.	Some possibilities in secs. 21–24 from "E" sandstone, 150 to 180 feet deep and 25 feet thick.
25–30	Conditions favorable for small to large supplies in secs. 25–30. Best possibilities for large supplies in secs. 28 and 29.	Some possibilities in secs. 25, 26, and 28 from "E" sandstone, 150 to 170 feet deep and 25 feet thick.
31–36	Conditions favorable for small to large supplies in secs. 32–36. Best possibilities for large supplies in secs. 32–34. Conditions unfavorable in sec. 31 except for small supplies in northern part.	Some possibilities in secs. 31, 32, 33, and 35 from "E" sandstone, 160 to 180 feet deep and 25 feet thick, and in secs. 31 and 36 from Mt. Carmel sandstone, 200 to 300 feet deep and 75 to 100 feet thick.
	T. 4 S., R. 11 E.—Central Part of Gray-Phillips Township	
6–7 18–19 30–31	Conditions variable; small supplies locally available in sec. 31. Conditions unfavorable in secs. 6, 7, 18, 19, and 30.	Some possibilities in secs. 6, 7, 19, 30, and 31 from "E" sandstone, 100 to 150 feet deep and 25 feet thick.

Sections	Possibilities in unconsolidated material	Bedrock possibilities
T. 4 S., R. 14 W.—Southeastern Part of Gray-Phillips Township		
5–7 18–19 30–31	Conditions generally unfavorable; small supplies locally available.	Some possibilities in secs. 5, 6, 7, 30, and 31 from "C" sandstone, 50 to 100 feet deep and 50 feet thick; from "D" sandstone, 150 to 200 feet deep and 75 to 100 feet thick; and in secs. 7, 18, 19, 30, and 31 from "E" sandstone, 350 to 400 feet deep and 50 to 100 feet thick.
4–9 14–17 20–29 32–35	Conditions generally favorable for small to large supplies. Best possibilities for large supplies in secs. 14–15, 22–28, 32–35.	Some possibilities in secs. 4, 9, 10, 13, and 14 from "E" sandstone, 100 to 150 feet deep and 25 to 50 feet thick; in secs. 23, 26, 27, 28, 33, and 34 from Mt. Carmel sandstone, 170 to 210 feet deep and 75 to 100 feet thick; and in secs. 22, 23, 26, 27, 28, 33, and 34 from Trivoli sandstone, 400 feet deep and 50 to 100 feet thick.
T. 5 S., R. 8 E.—Enfield Township		
1–6	Small supplies locally available in secs. 4–6. Conditions unfavorable in secs. 1–3.	Some possibilities in secs. 1–29 and 32–36 from "E" sandstone, 100 to 150 feet deep and 25 feet thick, and in secs. 1–36 from Mt. Carmel sandstone, 200 to 250 feet deep and 175 to 225 feet thick.
7–12	Small supplies locally available in secs. 7 and 12. Conditions unfavorable in secs. 8–11.	
13–18	Small supplies locally available in secs. 13 and 14. Conditions unfavorable in secs. 15–18.	
19–24	Small supplies locally available in secs. 23 and 24. Conditions unfavorable in secs. 19–22.	
25–30	Small supplies locally available in northern sec. 26. Conditions unfavorable in secs. 25 and 27–30.	
31–36	Conditions generally unfavorable.	
T. 5 S., R. 9 E.—Carmi Township		
1–6	Small supplies locally available in secs. 1, 5, and 6. Conditions unfavorable in northwestern sec. 1 and in secs. 2–4.	Some possibilities in secs. 1–3, 9–15, 22–24, and 25–26 from "E" sandstone, 100 to 120 feet deep and 25 to 50 feet thick, and in secs. 1–36, from the "E" sandstone, 300 to 400 feet deep and 100 to 225 feet thick.
7–12	Small supplies locally available in sec. 7. Conditions favorable for small to medium supplies in E½ sec. 12. Conditions unfavorable in secs. 8–11 and in W½ sec. 12.	
13–18	Conditions generally unfavorable.	
19–24	Conditions variable for small to medium supplies in southern secs. 23 and 24. Conditions unfavorable in secs. 19–22.	
25–30	Conditions variable for small to medium supplies in secs. 25, 26, and eastern sec. 27. Conditions unfavorable in secs. 27–30.	
31–36	Conditions variable for small to medium supplies in secs. 34 and 35. Conditions unfavorable in secs. 31–33 and 36.	

Sections	Possibilities in unconsolidated material	Bedrock possibilities
T. 5 S., R. 10 E.—Western Part of Hawthorne Township		
1–6		Some possibilities from "E" sandstone, 100 to 150 feet deep and 25 feet thick, and in secs. 2 and 6 from Mt. Carmel sandstone, 250 to 275 feet deep and 100 feet thick.
7–12	Conditions generally favorable for small to large supplies. Best possibilities for large supplies in central portion of the township.	Some possibilities in secs. 7, 8, 9, 11, and 12 from "E" sandstone, 150 feet deep and 25 feet thick, and in secs. 7 and 12 from Mt. Carmel sandstone, 225 to 250 feet deep and 100 feet thick.
13–18		Some possibilities from "E" sandstone, 150 to 175 feet deep and 25 feet thick; in secs. 15–18 from Mt. Carmel sandstone, 125 feet deep and 125 feet thick; and in sec. 13 from Trivoli sandstone, 510 feet deep and 75 feet thick.
19–36		Some possibilities in secs. 19, 22, 23, and 24 from "E" sandstone, 175 feet deep and 25 feet thick; in secs. 19–21, 24–26, and 28–33 from Mt. Carmel sandstone, 175 to 200 feet deep and 125 feet thick; and in secs. 23–26, 35, and 36 from Trivoli sandstone, 450 feet deep and 75 feet thick.
T. 5 S., R. 11 E. and 14 W.—Eastern Part of Hawthorne Township		
T.5S., R.11E. 6–7 18–19 30–31	Conditions favorable for development of small to large supplies.	Some possibilities in secs. 18 and 19 from "E" sandstone, 170 feet deep and 50 feet thick; in secs. 30 and 31 from Mt. Carmel sandstone, 225 feet deep and 75 feet thick; in secs. 18 and 30 from "G" sandstone, 375 feet deep and 20 feet thick; and in secs. 7, 18, 19, 30, and 31 from Trivoli sandstone, 475 feet deep and 75 feet thick.
T. 5 S., R. 14 W. 3–6 8–9 15–22 27–32	Conditions favorable for development of small to large supplies.	Some possibilities in secs. 5–7, 18–20, 29, and 30 from "E" sandstone, 175 feet deep and 25 to 50 feet thick; in secs. 3, 4, 15, 16, 21, 22, and 28–32 from Mt. Carmel sandstone, 150 to 175 feet deep and 50 feet thick; in secs. 3, 4, 6, 7, 9, 10, 15, 16, 18, 19, 21, 22, and 27–32 from "G" sandstone, 350 feet deep and 20 feet thick; and in secs. 18–32 from Trivoli sandstone, 450 feet deep and 75 feet thick.

Sections	Possibilities in unconsolidated material	Bedrock possibilities
	T. 6 S., R. 8 E.—Northern Two-Thirds Indian Creek Township	
1–6	Small supplies locally available in sec. 5. Conditions unfavorable in secs. 1–4 and 6.	Some possibilities in secs. 1–24 and 26–36 from Mt. Carmel sandstone, 150 to 200 feet deep and 50 to 150 feet thick.
7–12	Small supplies locally available in secs. 7, 8, and 9. Conditions unfavorable in secs. 10–12.	
13–18	Small supplies locally available in secs. 16–18. Conditions unfavorable in secs. 13–15.	
19–24	Small supplies locally available in sec. 20. Conditions unfavorable in secs. 19 and 21–24.	
25–30	Small supplies locally available in sec. 29. Conditions unfavorable in secs. 25–28 and 30.	
31–36	Small supplies locally available in secs. 32 and 34. Conditions unfavorable in secs. 31, 33, 35 and 36.	
	T. 6 S., R. 9 E.—Northern Two-Thirds Heralds Prairie Township	
1–6	Conditions variable for small to medium supplies in sec. 3. Conditions unfavorable in secs. 1–2 and 4–6.	Some possibilities in secs. 31–36 from Mt. Carmel sandstone, 150 to 200 feet deep and 50 to 100 feet thick.
7–12	Conditions favorable for small to medium supplies in secs. 10–12. Conditions unfavorable in secs. 7–9.	
13–18	Conditions favorable for small to large supplies in secs. 13–15. Best possibilities for large supplies in sec. 13. Conditions unfavorable in secs. 16–18.	
19–24	Conditions favorable for small to medium supplies in secs. 22–24. Best possibilities for large supplies in NE¼ sec. 24. Conditions unfavorable in secs. 19–21.	
25–30	Conditions favorable for small to medium supplies in northern secs. 25 and 26. Conditions unfavorable in S2/3 secs. 25 and 26 and in secs. 27–30.	
31–36	Conditions unfavorable in secs. 31–36.	

Sections	Possibilities in unconsolidated material	Bedrock possibilities
T. 6 S., R. 10 E.—Northern Part of Emma Township		
1–6	Conditions generally favorable for development of small to large supplies. Conditions unfavorable in NW¼ sec. 1, NE¼ sec. 24, and secs. 30 and 31.	Some possibilities in secs. 1, 4, 5, and 6 from Mt. Carmel sandstone, 175 to 300 feet deep and 50 to 125 feet thick, and in secs. 1 and 2 from Trivoli sandstone, 425 feet deep and 50 feet thick.
7–12		Some possibilities in secs. 7, 8, 11, and 12 from Mt. Carmel sandstone, 175 to 325 feet deep and 50 to 125 feet thick, and in secs. 10, 11, and 12 from Trivoli sandstone, 425 feet deep and 50 feet thick.
13–18		Some possibilities in secs. 13, 14, 17, and 18 from Mt. Carmel sandstone, 225 to 275 feet deep and 50 to 125 feet thick.
19–24		Some possibilities in secs. 19–24 from Mt. Carmel sandstone, 175 to 275 feet deep and 50 feet thick, and in secs. 21, 22, and 24 from "G" sandstone, 100 to 210 feet deep and 40 to 60 feet thick.
25–30		Some possibilities in secs. 25–30 from Mt. Carmel sandstone, 175 to 210 feet deep and 50 feet thick, and in secs. 25, 27, 28, and 29 from "G" sandstone, 100 to 200 feet deep and 40 feet thick.
31–36		Some possibilities in secs. 31–35 from Mt. Carmel sandstone, 150 to 200 feet deep and 50 feet thick, and in secs. 32–35 from "G" sandstone, 135 feet deep and 20 feet thick.
T. 6 S., R. 11 E.—Northeastern Part of Emma Township		
5–7 18–20 29–31	Conditions favorable for development of small to large supplies in secs. 5, 6, 7, 20, 29, 30 and 31. Best possibilities for large supplies in sec. 29. Conditions unfavorable in S½ sec. 18, W2/3 sec. 19, and NW¼ sec. 30.	Some possibilities in secs. 6, 7, 18, and 19 from Mt. Carmel sandstone (which lies at the surface in secs. 18 and 19), 100 feet deep and 50 feet thick; in secs. 5, 6, 7, 18, 19, 20, and 30 from "G" sandstone, 75 to 150 feet deep and 30 feet thick; and in secs. 5, 6, and 7 from Trivoli sandstone, 275 feet deep and 75 to 100 feet thick.
T. 7 S., R. 8 E.—Southern One-Third of Indian Creek Township		
1–6	Small supplies locally available in secs. 3, 4 and 5. Conditions unfavorable in secs. 1, 2 and 6.	Some possibilities in secs. 1–18 from Mt. Carmel sandstone, 50 to 100 feet deep and 25 to 50 feet thick.
7–12	Small supplies locally available in secs. 8 and 9. Conditions unfavorable in secs. 7, 10, 11 and 12.	
13–18	Small supplies locally available in secs. 14, 16, and 17. Conditions unfavorable in secs. 13, 15, and 18.	

Sections	Possibilities in unconsolidated material	Bedrock possibilities
T. 7 S., R. 9 E.—Southern One-Third of Heralds Prairie Township		
1–12	Conditions generally unfavorable.	Some possibilities in secs. 1 and 12 from "D" and "E" sandstones, 10 to 70 feet deep and less than 25 feet thick, and in secs. 1, 2, 4, 5, 6, 7, 10, 11, and 12 from Mt. Carmel sandstone, 50 to 150 feet deep and 75 to 100 feet thick.
13–18	Conditions variable; small supplies locally available in secs. 13, 14, 15, 16 and 17.	Some possibilities from Mt. Carmel sandstone, 10 to 100 feet deep and 75 to 100 feet thick.
T. 7 S., R. 10 E.—Southern Part of Emma Township		
1–18 20–24	Conditions favorable for development of small to large supplies in secs. 1–17 and 20–24. Conditions unfavorable in western secs. 6 and 7 and SW2/3 sec. 18.	Some possibilities in secs. 2–10, 17, and 18 from Mt. Carmel sandstone, 150 feet deep and 50 feet thick, and in secs. 3–5, 7–10, and 16–18 from Trivoli sandstone, 180 to 200 feet deep and 30 to 40 feet thick.

APPENDIX 2

Well Sample Studies

Appendix 2 lists my studies of all well samples of unconsolidated materials available at the time of this report. Most samples came from oil-well test borings, and the validity of the depths of samples and materials in the samples is sometimes questionable.

1. Pure–W. B. Fox well 1A, NE¼ SW¼ NW¼ sec. 19, T. 3 S., R. 8 E. (Mill Shoals Township), White Co. Sample set 7120. Elev.: 379 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Silt and clay, yellow	10	10
Sand, silty, brown, fine	5	15
Silt and clay, sandy, brown	5	20
Sand, silty, brown, fine	30	50
Sand, clean, gray, fine	5	55
Sand, silty, gray, fine	20	75
Pennsylvanian system		
Shale, gray, coaly	15	90

2. Tidewater seismic hole on road, SE¼ SE¼ NE¼ sec. 21, T. 3 S., R. 9 E. (Burnt Prairie Township), White Co. Sample set 16481. Elev.: 390 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Illinoian drift		
Till, silty, yellowish brown, calcareous	20	20
Pennsylvanian system		
Shale, gray	30	50

3. Tidewater seismic hole on road, NW¼ NW¼ SE¼ sec. 23, T. 3 S., R. 9 E. (Burnt Prairie Township), White Co. Sample set 16480. Elev.: 384 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Silt, yellow, calcareous	10	10
Sand, silty, yellow, fine, abundant shell fragments	20	30
Silt, brown, calcareous, shell fragments	10	40
Sand, very silty, brown, fine	15	55
Sand, clean, reddish brown, medium to coarse	45	100
Sand, clean, brown, fine	15	115
Pennsylvanian system		
Shale, gray, coaly	25	140

4. Tidewater seismic hole on road, center W. line sec. 19, T. 3 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 16479. Elev.: 383 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Silt, yellowish brown, calcareous	35	35
Sand, silty, brown, fine to medium	15	50
Sand, clean, gray, coarse	10	60
Sand, clean, gray, medium	30	90
Sand, reddish brown, fine to medium	30	120
Gravel, brown, chert and igneous rock fragments ¼″–½″	15	135
Pennsylvanian system		
Sandstone, gray, calcareous	35	170
Shale	10	180

5. Tidewater–W. Curtis, NW¼ NE¼ NW¼ sec. 22, T. 3 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 16509. Elev.: 385 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Illinoian drift		
Till, sandy, yellowish brown, noncalcareous	15	15
Pennsylvanian system		
Sandstone, gray, fine, micaceous	15	30

6. Tidewater seismic hole, SW¼ SW¼ SW¼ sec. 23, T. 3 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 16499. Elev.: 385 feet.

Pleistocene series		
Illinoian drift		
Till, silty, brown, noncalcareous	8	8
Pennsylvanian system		
Sandstone, red, weathered	12	20
Sandstone, gray, fine, micaceous	20	40

7. Tidewater–H. Daniels, NW¼ NW¼ NW¼ sec. 25, T. 3 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 16470. Elev.: 450 feet.

Pleistocene series		
Illinoian drift		
Till, sandy and gravelly, yellowish brown, calcareous	15	15
Pennsylvanian system		
Shale, gray, coaly	15	30

8. Tidewater seismic hole, NW¼ NW¼ NW¼ sec. 31, T. 3 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 16484. Elev.: 383 feet.

Pleistocene series		
Silt, sandy, yellowish brown, shell fragments, calcareous	40	40
Sand, silty to clean, grayish brown, medium	40	80
Sand, clean, brown, coarse	12	92
Pennsylvanian system		
Shale, gray	8	100

9. Tidewater–Powell, SW¼ SW¼ SW¼ sec. 32, T. 3 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 16475. Elev.: 382 feet.

Pleistocene series		
Silt, yellow, calcareous	30	30
Sand, clean, grayish brown, fine	25	55
Pennsylvanian system		
Sandstone, white, fine, micaceous	25	80

10. Tidewater–W. Curtis, SW¼ SW¼ SW¼ sec. 33, T. 3 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 16510. Elev.: 383 feet.

Pleistocene series		
Silt, yellowish brown, calcareous	35	35
Gravel, silty, igneous fragments (⅛"–½")	30	65
Sand, clean, brown, coarse	15	80
Pennsylvanian system		
Sandstone, gray, micaceous	20	100

11. Tidewater–J. Elliot, NW¼ NW¼ NW¼ sec. 33, T. 3 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 16472. Elev.: 380 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Silt, yellow, calcareous	10	10
Silt, grayish brown, calcareous	30	40
Sand, silty, brown, medium, shell fragments	30	70
Sand, silty, reddish brown, medium fine	20	90
Sand, clean, grayish brown, coarse	15	105
Pennsylvanian system		
Siltstone and shale, gray, coaly	15	120

12. Tidewater–Blackford Heirs, NE¼ NE¼ NE¼ sec. 34, T. 3 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 16471. Elev.: 388 feet.

Pleistocene series		
Silt, sandy, yellowish brown, slightly calcareous	20	20
Sand, clean, gray, fine to medium	30	50
Pennsylvanian system		
Shale, gray	30	80

13. Tidewater–A. Fearn, SW¼ NW¼ NW¼ sec. 19, T. 3 S., R. 11 E. (Gray-Phillips Township), White Co. Sample set 16473. Elev.: 395 feet.

Pleistocene series		
Illinoian drift		
Till, sandy, yellow, noncalcareous	10	10
Till, very sandy, yellow, calcareous	10	20
Sand, silty, brown, fine	10	30
Pennsylvanian system		
Sandstone and siltstone, oxidized	15	45
Shale, gray	5	50

14. Tidewater–A. Fearn, NW¼ NW¼ NW¼ sec. 19, T. 3 S., R. 11 E. (Gray-Phillips Township), White Co. Sample set 16469. Elev.: 395 feet.

Pleistocene series		
Illinoian drift		
Till, silty, grayish brown, calcareous	25	25
Silt, sandy, yellowish brown, gastropod fragments, calcareous	20	45
Pennsylvanian system		
Shale, gray, coaly	45	90

15. Watson–Hunter Packing Co., NE¼ SW¼ NW¼ sec. 17, T. 4 S., R. 8 E. (Mill Shoals Township), White Co. Sample set 23326. Elev.: 405 feet.

Pleistocene series		
Loess, light brown, slightly calcareous	5	5
Illinoian drift		
Till, green, noncalcareous	10	15
Till, grayish green, calcareous	10	25
Till, sandy and gravelly, grayish brown, calcareous	15	40
Pennsylvanian system		
Shale, black to gray	5	45

	Thickness feet	*Depth feet*
16. Hughes–W. N. Sumpter 1, NE¼ NW¼ SW¼ sec. 28, T. 4 S., R. 9 E. (Burnt Prairie Township), White Co. Sample set 21574. Elev.: 385 feet.		
Pleistocene series		
Illinoian drift		
Till, silty, brown, calcareous	5	25
Till, sandy, brownish gray, calcareous	10	35
17. Travis–Davis 1, SE¼ SW¼ NE¼ sec. 30, T. 4 S., R. 9 E. (Burnt Prairie Township), White Co. Sample set 5740. Elev.: 390 feet.		
Pleistocene series		
Sand, silty, brown, fine to medium	30	30
Sand, clean, gray, fine	20	50
Pennsylvanian system		
Shale, gray	20	70
18. Tidewater–F. Riley, NE¼ SE¼ NE¼ sec. 2, T. 4 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 16474. Elev.: 430 feet.		
Pleistocene series		
Illinoian drift		
Till, sandy, yellow, noncalcareous	10	10
Till, sandy, yellow, calcareous	10	20
Sand, silty, brown, fine	10	30
Pennsylvanian system		
Sandstone, brown, oxidized, noncalcareous	10	40
Shale, dark gray	10	50
19. Tidewater–McKnight, SE¼ SE¼ SE¼ sec. 3, T. 4 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 16477. Elev.: 380 feet.		
Pleistocene series		
Silt, yellow, calcareous	20	20
Sand, silty, yellow, very coarse, shell fragments	10	30
Sand, clean, reddish brown, medium	30	60
Sand, clean, gray, coarse	10	70
Pennsylvanian system		
Siltstone, gray	10	80
Sandstone, gray, fine	20	100
20. Tidewater–E. Spencer, SE¼ SE¼ SE¼ sec. 5, T. 4 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 16476. Elev.: 383 feet.		
Pleistocene series		
Silt, light brown, clayey, shell and wood fragments, calcareous	95	95
Sand, slightly silty, grayish brown, fine	35	130
Pennsylvanian system		
Sandstone, gray, fine	30	160
21. Tidewater–F. Gidcumb, SW¼ SW¼ SW¼ sec. 5, T. 4 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 16511. Elev.: 380 feet.		
Pleistocene series		
Silt, brown, calcareous	50	50
Sand, silty, brown, fine	15	65
Sand, clean, gray, medium to coarse	55	120
Pennsylvanian system		
Shale and siltstone, gray, coaly	10	130

	Thickness feet	*Depth feet*
22. Gulf–Gidcumb 1, SW¼ SW¼ SW¼ sec. 8, T. 4 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 8408. Elev.: 375 feet.		
Pleistocene series		
Sand, very silty, grayish brown, fine, calcareous	30	30
Sand, clean, gray, fine	60	90
Sand, clean, gray, medium to coarse	35	125
Pennsylvanian system		
Shale, gray	35	160
23. Tidewater–W. Elliot, NE¼ NE¼ NW¼ sec. 15, T. 4 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 16478. Elev.: 383 feet.		
Pleistocene series		
Silt, brown, calcareous	30	30
Sand, clean, gray, coarse	40	70
Sand, silty, brown, coarse	15	85
Pennsylvanian system		
Sandstone, gray, fine	15	100
24. Gulf–J. W. Carter 1, NE¼ NW¼ sec. 18, T. 4 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 7518. Elev.: 379 feet.		
Pleistocene series		
Silt, yellow, calcareous	20	20
Pennsylvanian system		
Shale, gray	30	50
25. Stiers–Crossville 1, SE¼ SW¼ NE¼ sec. 23, T. 4 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 5286. Elev.: 400 feet.		
Pleistocene series		
Silt, yellow, noncalcareous	8	8
Silt, yellow, sandy, calcareous	17	25
Sand, clean, yellow, fine to coarse	2	27
Illinoian drift		
Till, sandy, pebbly, yellow, calcareous	2	29
Till, sandy, gray, calcareous	3	32
Gravel, silty, gray, fine (1/16″–½″)	6	38
Sand, clean, grayish brown, medium	4	42
26. Stiers–Crossville 2, SE¼ SW¼ NE¼ sec. 23, T. 4 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 5287. Elev.: 400 feet.		
Pleistocene series		
Silt, brown, noncalcareous	2	2
Silt, sandy, brown, calcareous	23	25
Illinoian drift		
Till, sandy, pebbly, yellow, noncalcareous	3	28
Till, sandy, pebbly, dark gray calcareous	3	31
Gravel and sand, clayey, gray, fine (1/16″–½″)	6	37
Sand, silty, gray, medium to coarse	4	41
27. Stiers–Crossville 3, SE¼ SW¼ NE¼ sec. 23, T. 4 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 5531. Elev.: 400 feet.		
Pleistocene series		
Silt, clayey, yellowish brown, noncalcareous	7	7

	Thickness feet	Depth feet
Sand, silty, grayish brown, fine to medium	3	10
Gravel, clean, gray, fine (⅛"–¼")	1	11
Sand, silty, grayish brown, fine to medium	14	25
Silt, sandy, grayish brown, calcareous	11	36
Sand, very silty, brown, fine	5	41

28. Exchange–Bramlet 1, SE¼ SE¼ SW¼ sec. 25, T. 4 S., R. 10 E. (Gray-Phillips Township), White Co. Sample set 3980. Elev.: 409 feet.

	Thickness feet	Depth feet
Pleistocene series		
No sample	10	10
Gravel, silty, gray, fine (1/16"–¼")	10	20
Pennsylvanian system		
Shale, gray	35	55

29. Hayes–Sims–Warren Petroleum Co. T-1, SW¼ SW¼ NE¼ sec. 20, T. 4 S., R. 14 W. (Gray-Phillips Township), White Co. Sample set 18195. Elev.: 380 feet.

	Thickness feet	Depth feet
Pleistocene series		
Silt, clayey, brown, noncalcareous	10	10
Silt, clayey, yellowish brown, calcareous	5	15
Sand and gravel, clean, brown, very coarse	25	40
Sand, clean, gray, coarse	10	50
Sand, clean, gray, fine to medium	25	75

30. Hayes–Sims–Warren Petroleum Co. T-2, SE¼ NW¼ NE¼ sec. 20, T. 4 S., R. 14 W. (Gray-Phillips Township), White Co. Sample set 9933. Elev.: 380 feet.

	Thickness feet	Depth feet
Pleistocene series		
No samples	20	20
Sand, clean, brown, medium	10	30
Sand, clean, gray, medium to coarse	22	52

31. Lancaster–Norris City, SW¼ SE¼ sec. 21, T. 5 S., R. 8 E. (Enfield Township), White Co. Sample set 1780. Elev.: 405 feet.

	Thickness feet	Depth feet
Pleistocene series		
Illinoian drift		
Till, pebbly, yellowish brown, calcareous	28	28
Pennsylvanian system		
Shale	7	35

32. Angle–E. A. Pyle 1, NE¼ NE¼ NE¼ sec. 24, T. 5 S., R. 8 E. (Enfield Township), White Co. Sample set 14976. Elev.: 395 feet.

	Thickness feet	Depth feet
Pleistocene series		
Sand, silty, gray, fine	10	10
Pennsylvanian system		
Sandstone, gray, fine, micaceous	20	30

33. Gulf–Henry Gates 1, SW¼ NE¼ SE¼ sec. 4, T. 5 S., R. 9 E. (Carmi Township), White Co. Sample set 7701. Elev.: 440 feet.

	Thickness feet	Depth feet
Pleistocene series		
Sand, silty, brown, fine	20	20
Pennsylvanian system		
Sandstone, gray, fine, micaceous	20	40

34. Haynes–Brownfield School, NE¼ NE¼ NE¼ sec. 31, T. 5 S., R. 9 E. (Carmi Township), White Co. Sample set 21604. Elev.: 416 feet.

	Thickness feet	Depth feet
Pleistocene system		
Illinoian drift		
Till, silty, reddish brown, noncalcareous	10	10
Till, silty, yellowish brown, calcareous	10	20
Pennsylvanian system		
Shale, gray	10	30

35. Hughes–Cecil Brown 1, NE¼ SE¼ SW¼ sec. 8, T. 5 S., R. 10 E. (Hawthorne Township), White Co. Sample set 21579. Elev.: 390 feet.

	Thickness feet	Depth feet
Pleistocene series		
Silt, sandy, brown, noncalcareous	20	20
Silt, sandy, reddish brown, calcareous	25	45
Silt, clayey, light brown, calcareous	15	60

36. Hayes–J. Heasier, SE¼ NE¼ NE¼ sec. 17, T. 5 S., R. 10 E. (Hawthorne Township), White Co. Sample set 24571. Elev.: 385 feet.

	Thickness feet	Depth feet
Pleistocene series		
Silt, sandy, brown, noncalcareous	10	10
Silt, sandy, reddish brown, calcareous	5	15
Sand, clean, brown, very fine	25	40
Silt, brown, calcareous	10	50
Sand, clean, gray, medium	35	85
Silt, sandy, brown, calcareous	35	120

37. Sinclair–Aldridge 1, NW¼ SE¼ SE¼ sec. 1, T. 6 S., R. 9 E. (Heralds Prairie Township), White Co. Sample set 14862. Elev.: 417 feet.

	Thickness feet	Depth feet
Pleistocene series		
Illinoian drift		
Till, sandy, gray, calcareous	35	35
Pennsylvanian system		
Shale, gray	40	75

38. Exchange–Ohio–Rudolph 1, NE¼ NE¼ sec. 14, T. 6 S., R. 9 E. (Heralds Prairie Township), White Co. Sample set 3827. Elev.: 395 feet.

	Thickness feet	Depth feet
Pleistocene system		
Sand, clean, brown, fine, shell fragments	70	70
Sand, clean, gray, fine to medium	45	115
Pennsylvanian system		
Sandstone, gray, fine	25	140

39. Skelly–North Storms 4, NW¼ NW¼ SW¼ sec. 14, T. 6 S., R. 9 E. (Heralds Prairie Township), White Co. Sample set 4529. Elev.: 373 feet.

	Thickness feet	Depth feet
Pleistocene series		
Sand, clean, gray, fine to medium	80	80
Sand, slightly silty, gray, medium	50	130
Pennsylvanian system		
Sandstone and siltstone, gray, medium	50	180

40. Pure–E. A. Pyle B-1, NW¼ SW¼ NW¼ sec. 17, T. 6 S., R. 9 E. (Heralds Prairie Township), White Co. Sample set 9241. Elev.: 379 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Illinoian drift		
Till, silty, brown, calcareous	30	30
Silt, light brown, calcareous	20	50
Till, silty, brown, calcareous	20	70
Pennsylvanian system		
Shale, gray	50	120

41. Pure–E. A. Pyle C-1, SE¼ SE¼ SW¼ sec. 18, T. 6 S., R. 9 E. (Heralds Prairie Township), White Co. Sample set 10631. Elev.: 436 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Silt, red, noncalcareous	20	20
Pennsylvanian system		
Sandstone, brown, fine, micaceous	10	30

42. Wilson–McAllister 1, SE¼ NE¼ NW¼ sec. 22, T. 6 S., R. 9 E. (Heralds Prairie Township), White Co. Sample set 5210. Elev.: 356 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Silt, brown, shell fragments, calcareous	15	15
Sand, silty, gray, fine	20	35
Gravel, sandy, brown, fine (1/16″–½″)	5	40
Sand, clean, gray, fine	45	85
Pennsylvanian system		
Sandstone, gray, medium, calcareous	15	100
Shale, gray, coaly	10	110

43. Pure–Brimble Comb 1, NE¼ NW¼ NW¼ sec. 5, T. 6 S., R. 10 E. (Emma Township), White Co. Sample set 8349. Elev.: 395 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Silt, yellow, calcareous	30	30
Sand, clean, light brown, fine	60	90
Silt, brown, calcareous	10	100
Sand, very silty, brown, fine	20	120
Silt, brown, calcareous	10	130
Pennsylvanian system		
Shale and coal, gray	10	140

44. Joe Dawson–Rodenberg 1, NE¼ SE¼ NE¼ sec. 11, T. 6 S., R. 10 E. (Emma Township), White Co. Sample set 6207. Elev.: 366 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Sand, silty, calcareous, gray, fine	20	20
Sand, calcareous, brown, medium	80	100
Sand, calcareous, gray, fine	30	130
Pennsylvanian system		
Shale, gray	10	140

45. Midwest–Orman 1, NW¼ NE¼ NW¼ sec. 18, T. 6 S., R. 10 E. (Emma Township), White Co. Sample set 4075. Elev.: 385 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Sand, clean, gray, fine	30	30
Sand, silty, gray, fine, gastropod fragments	20	50

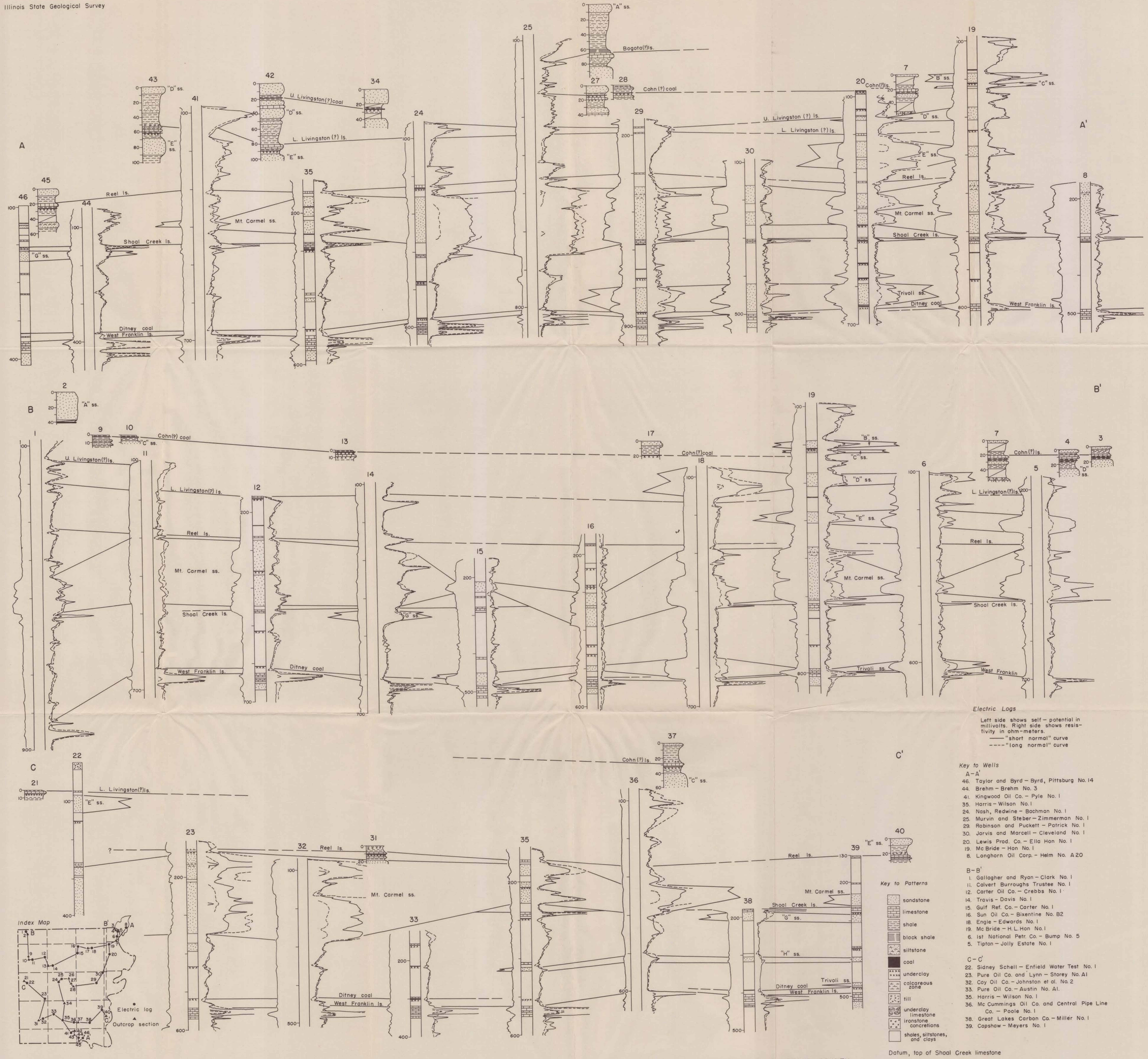
46. Gulf–J. E. Moore 3, SE¼ NW¼ sec. 12, T. 7 S., R. 8 E. (Indian Creek Township), White Co. Sample set 7643. Elev.: 420 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Sand, very silty, grayish brown, medium, calcareous	25	25
Pennsylvanian system		
Sandstone and limestone, gray, fine	15	40

47. McBride–L. Wassem, SW¼ SE¼ NE¼ sec. 23, T. 7 S., R. 10 E. (Emma Township), White Co. Sample set 17652. Elev.: 355 feet.

	Thickness feet	*Depth feet*
Pleistocene series		
Gravel, very sandy, gray, coarse (½″–1″), igneous pebbles	50	50
Gravel, sandy, gray, coarse (1″–2″), igneous pebbles	100	150
Pennsylvanian system		
Limestone, grayish green, coarse, fossiliferous	3	153

Illinois State Geological Survey, Report of Investigations 196
50 p., 4 pls., 21 figs., 1956



Electric Logs

Left side shows self — potential in millivolts. Right side shows resistivity in ohm-meters.

—— "short normal" curve

---- "long normal" curve

Key to Wells

A—A'

46. Taylor and Byrd — Byrd, Pittsburg No. 14
44. Brehm — Brehm No. 3
41. Kingwood Oil Co. — Pyle No. 1
35. Harris — Wilson No. 1
24. Nash, Redwine — Bachman No. 1
25. Murvin and Steber — Zimmerman No. 1
29. Robinson and Puckett — Patrick No. 1
30. Jarvis and Marcell — Cleveland No. 1
20. Lewis Prod. Co. — Ella Hon No. 1
19. Mc Bride — Hon No. 1
8. Longhorn Oil Corp. — Helm No. A 20

B—B'

1. Gallagher and Ryan — Clark No. 1
11. Calvert Burroughs Trustee No. 1
12. Carter Oil Co. — Crebbs No. 1
14. Travis - Davis No. 1
15. Gulf Ref. Co. — Carter No. 1
16. Sun Oil Co. — Bixentine No. B2
18. Engle — Edwards No. 1
19. Mc Bride — H. L. Hon No. 1
6. 1st National Petr. Co. — Bump No. 5
5. Tipton — Jolly Estate No. 1

C—C'

22. Sidney Schell — Enfield Water Test No. 1
23. Pure Oil Co. and Lynn — Storey No. A1
32. Coy Oil Co. — Johnston et al. No. 2
33. Pure Oil Co. — Austin No. A1.
35. Harris — Wilson No. 1
36. Mc Cummings Oil Co. and Central Pipe Line Co. — Poole No. 1
38. Great Lakes Carbon Co. — Miller No. 1
39. Capshaw — Meyers No. 1

Datum, top of Shoal Creek limestone

CORRELATIONS OF CROSS SECTIONS OF ROTARY DRILL HOLES AND OUTCROP SECTIONS IN WHITE COUNTY AND PART OF WABASH COUNTY

STRUCTURE OF BEDROCK SURFACE IN WHITE COUNTY, ILLINOIS