WATER SUPPLY REPORT NUMBER FOUR

STATE OF MICHIGAN

DEPARTMENT OF CONSERVATION
Gerald E. Eddy, Director

GEOLOGICAL SURVEY DIVISION
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SUMMARY OF GROUND-WATER CONDITIONS IN MICHIGAN

1959

By

P. R. Giroux and Ted Thompson
U. S. Geological Survey

Prepared in cooperation with the
United States Department of the Interior
Geological Survey

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SUMMARY OF GROUND-WATER CONDITIONS IN MICHIGAN

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INTRODUCTION

This report is the fourth of a series covering ground-water levels and related hydrologic data in the State of Michigan. It summarizes and interprets, in part, the results of the program of measurement of ground-water levels and the collection of other pertinent hydrologic information by the United States Geological Survey. This program is a part of the overall water-resource investigations carried out in cooperation with the Geological Survey Division of the Michigan Department of Conservation.

Cooperative ground-water investigations by the U. S. Geological Survey in Michigan are directed jointly by P. E. LaMoreaux, Chief of the Ground Water Branch, U. S. Geological Survey, Washington, D. C., and W. L. Daoust, State Geologist, Michigan Department of Conservation, Lansing, and are supervised by Morris Deutsch, District Geologist, U. S. Geological Survey, Lansing.

Records and interpretations of water levels and artesian pressures from 1935 through 1955 have been published in the annual series of U. S. Geological Survey Water-Supply Papers entitled "Water Levels and Artesian Pressures in the United States". The following tabulation lists the papers containing water-level data for Michigan:

Year	No.	Year	No.	Year	No.
1935	777	1942	944	1949	1156
1936	817	1943	986	1950	1165
1937	840	1944	1016	1951	1191
1938	845	1945	1023	1952	1221
1939	886	1946	1071	1953	1265
1940	906	1947	1096	1954	1321
1941	936	1948	1126	1955	1404

Beginning in 1956, the U. S. Geological Survey discontinued publication of its series of annual reports and is now publishing, at 5-year intervals, a reduced number of water-level records without interpretive text or illustrations. The needs of the State, however, require more detailed and current ground-water information and, as a result, the first of the present series of Water Supply Reports was published by the Department of Conservation in 1957. These reports are designed to supplement data contained in the Federal report and also provide interpretive text and illustrations. By means of these ground-water summaries, basic information concerning ground-water conditions in Michigan are made readily available to the public.

Objectives of the Observation-Well Program

The observation-well program in Michigan is part of a nation-wide program, the purpose of which was summarized by Sayre (Water-Supply Paper 1404, 1957) as follows:

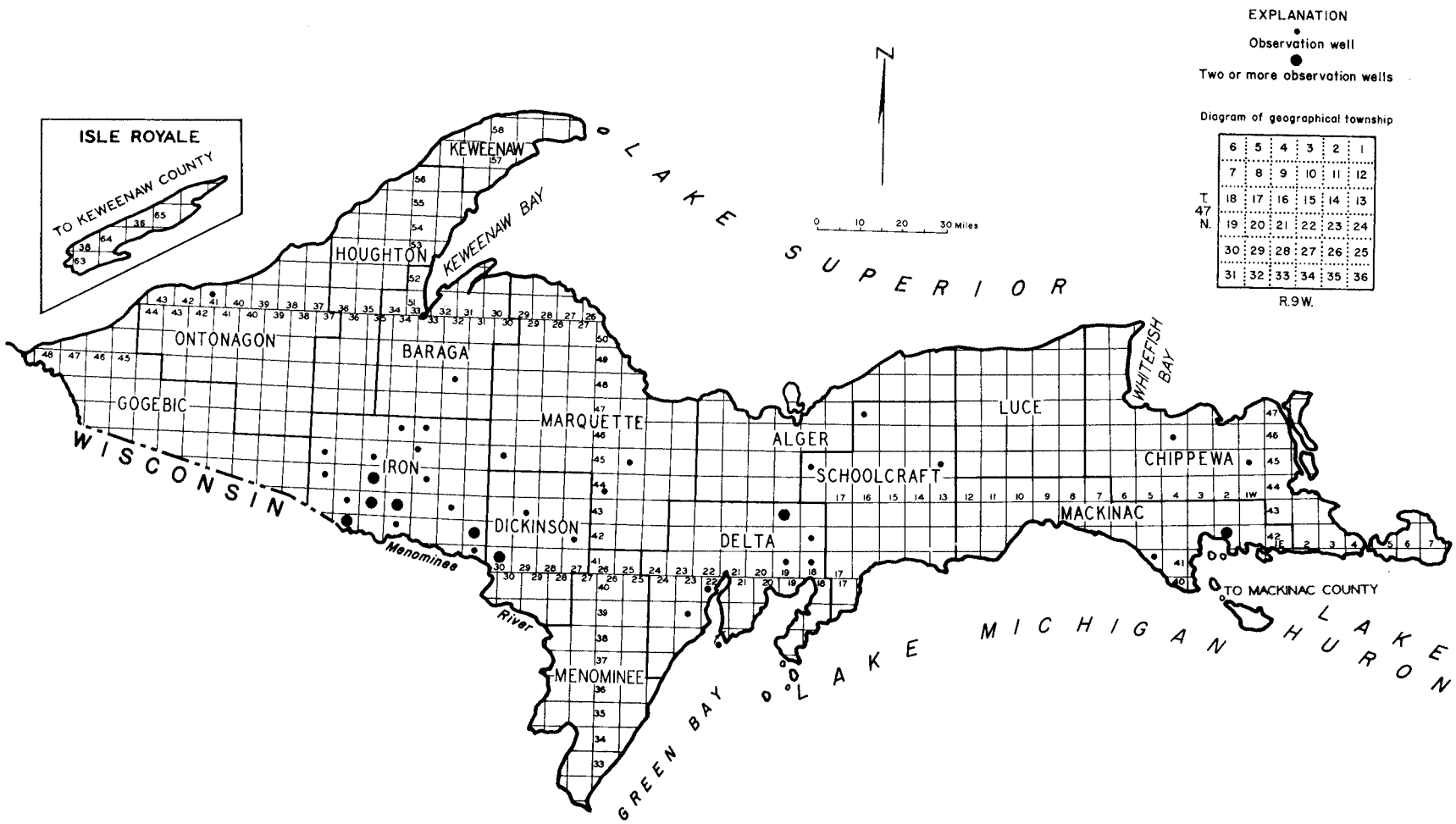
"The objectives of the observation-well program are to provide a day-to-day evaluation of available ground-water supplies, to facilitate the prediction of trends in ground-water levels that will indicate the probable status of important ground-water supplies in the future, to

delineate present or potential areas of detrimentally high or low ground-water levels, to aid in the prediction of the base flow of streams, to determine the several forces that act on a ground-water body, and to demonstrate the interplay of those forces in the ground-water regimen, to furnish information for use in basic research, and to provide long-term continuous records of fluctuations of water levels in representative wells. These selected records serve as a framework to which many short-term records collected during an intensive investigation may be related."

Scope of this Report

This report is based on periodic measurements of water levels made during 1959 in 188 wells of which 38 were equipped with continuous recording gages. Measurements of water level in some of the wells were discontinued in areas where intensive investigations had been in progress and where the results of findings have now been made public (See "Open-File Records"). The report summarizes water-level changes observed throughout the State, and analyzes these changes in selected areas. The distribution of wells in which water levels were observed in 1959 is shown in figure 1.

Table 1 lists the basic information for each observation well, and the extremes of water-level fluctuations in 1959 and for the previous period of record. Fluctuations of water levels in representative wells are shown by numerous hydrographs, and in many cases graphic interpretations of the changes in water level are made by including pertinent climatic and/or pumpage data. Table 2 lists reported monthly and annual ground-water pumpage for various municipalities, institutions, and industries in the State.


ISLE ROYALE
TO KEWEENAW COUNTY
EXPLANATION
Observation well
Two or more observation wells
Diagram of geographical township
T. 47 N.
R.9W.
N
0 10 20 30 Miles
KEWEENAW
KEWEENAW BAY
HOUGHTON
ONTONAGON
BARAGA
GOGEBIC
MARQUETTE
IRON
DICKINSON
MENOMINEE
DELTA
ALGER
SCHOOLCRAFT
LUCE
CHIPPEWA
MACKINAC
WHITEFISH BAY
TO MACKINAC COUNTY
WISCONSIN
Menominee River
GREEN BAY
LAKE MICHIGAN
LAKE SUPERIOR
LAKE HURON

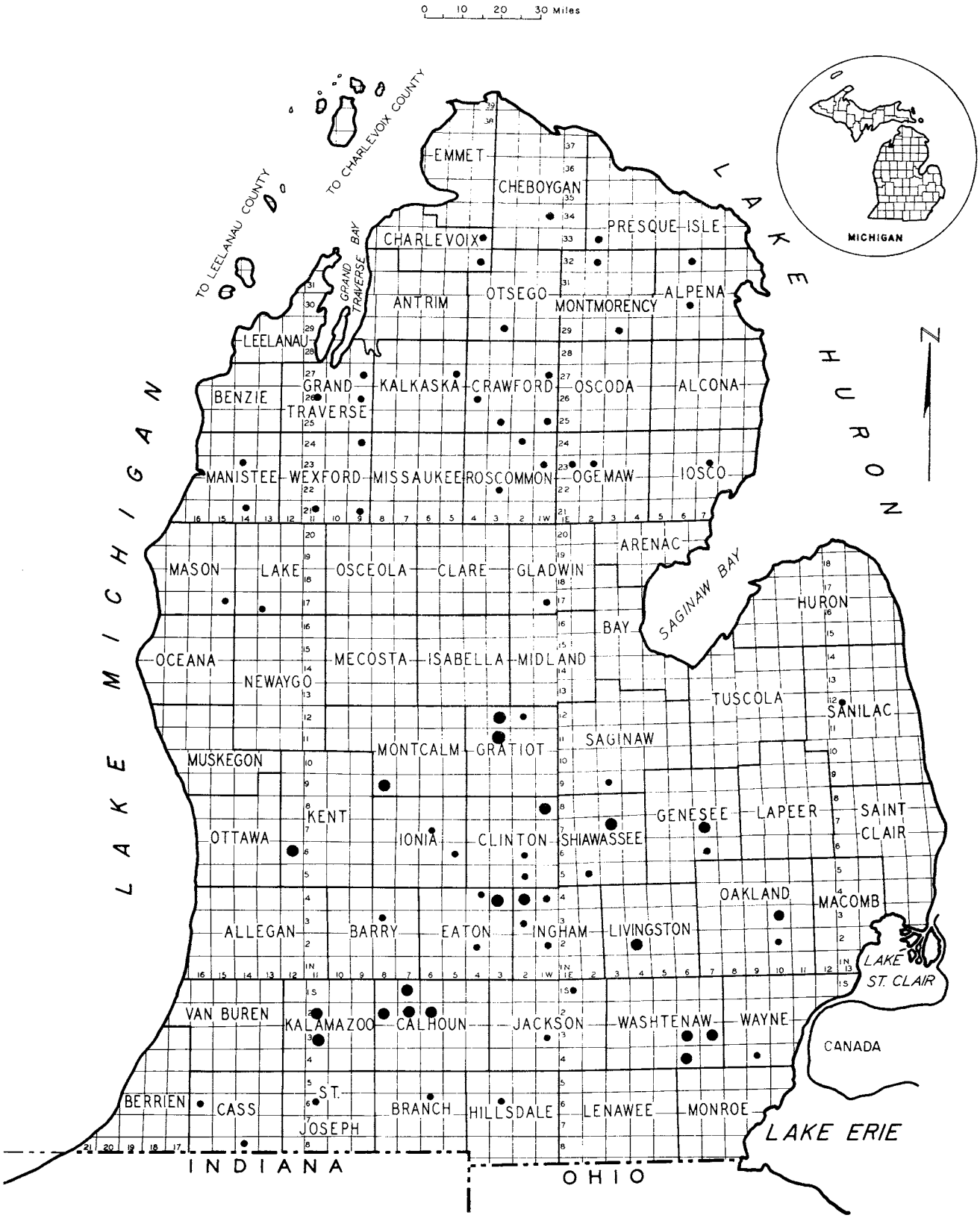


Figure 1. Location of observation wells in Michigan, 1959.

Open-File and Published Records

Complete tabulations of water-level measurements and hydrographs for each observation well, records of chemical quality of ground water, water-temperature measurements, well records including logs, aquifer tests, records of pumping for public supply and industrial use, and published and unpublished water-resource reports are on file for public inspection. They may be examined at the Michigan district office of the U. S. Geological Survey, Ground Water Branch, 407 Capitol Savings and Loan Building, Lansing, or at the Water Resources Section of the Michigan Geological Survey, 4th floor, Mason Building, Lansing. Records for the Northern Peninsula are kept on file also in the office of the Michigan Geological Survey, 203 State Office Building, Escanaba.

U. S. Geological Survey water-supply papers are for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., or can be consulted at the offices listed above and in major university or municipal libraries. The Federal Survey also issues a monthly publication entitled "Water Resources Review" which briefly summarizes ground-water levels and streamflow throughout the United States. The monthly issues plus spring and annual summaries can be obtained free of charge by application to the Director, U. S. Geological Survey, Washington 25, D. C. Publications of the Michigan Geological Survey can be purchased from the Michigan Department of Conservation, Publications Room, Mason Building, Lansing 26, Michigan.

Reports of cooperative ground-water investigations covering specific areas of the State are published from time to time by the Michigan Department of Conservation or the U. S. Geological Survey. These

reports are also available for inspection at the offices listed above. Recent publications containing ground-water information for various areas of Michigan have been published as Progress Reports by the Michigan Geological Survey as follows:

Progress Report	Area Covered	Reference 1/
17	Chippewa County	Vanlier and Deutsch, 1958a
19	Mackinac County	Vanlier and Deutsch, 1958b
20	Holland Area	Deutsch, Burt, and Vanlier, 1958
21	Luce County	Vanlier, 1959
22	Schoolcraft County	Sinclair, 1959
23	Kalamazoo Area	Deutsch, Vanlier, and Giroux, 1960
24	Delta County	Sinclair, 1961

1/ See "References" at end of report.

Well-Numbering System

The well-numbering system now used by the State and Federal Surveys in Michigan indicates the location of wells within the rectangular subdivision of the public lands with reference to the Michigan meridian and base line (fig. 1). The first two segments of a well number designate township and range; the third segment designates both the section and the well within the section. Thus, well number 32N 6E 16-1 is well number 1 in section 16, Township 32 North, Range 6 East. In the several small areas of the State where the rectangular subdivisions have not been made, wells are numbered as above by projection of the rectangular subdivisions to those areas.

Acknowledgments

Acknowledgment is made to personnel of Federal and State agencies, industrial concerns, municipalities, and public utilities whose cooperation has contributed to the accumulation of the basic data presented in this report.

Appreciation is also extended to Messrs. J. G. Rulison, Chief, Water Resources Section, Lansing, and A. E. Slaughter, Geologist, Escanaba, of the Michigan Geological Survey, for their assistance in the editing of this report series.

PRECIPITATION AND TEMPERATURE

Total precipitation in Michigan during 1959 was well in excess of average over all of the climatological divisions of Michigan as defined by the U. S. Weather Bureau. This was in sharp contrast to 1958 when general deficiencies in precipitation were recorded. Excesses over average ranged from 3 1/2 inches in the western part of the Northern Peninsula to more than 9 inches in the Saginaw Bay-Thumb area. Extremes in total precipitation ranged from 28 inches at Alpena in Alpena County to 46 inches at Williamston in Ingham County. Only a few scattered stations reported below average precipitation.

One of the most severe winters of record occurred. Precipitation fell almost entirely as snow, and remained on the ground all winter. Snow accumulated to record depths during February in the northern and western parts of the State and was heaviest along the shores of Lakes Michigan and Superior and in the northern part of the Southern Peninsula.

Temperatures during the winter of 1959 were the coldest recorded since 1936, and averaged 5 to 10 degrees below normal. In contrast, temperatures during May, August, and December averaged from about 3 to 6 degrees above normal.

PRINCIPLES AND SUMMARY OF GROUND-WATER OCCURRENCE

The initial source of most ground water is precipitation, and the average annual precipitation over Michigan is about 30 inches. However, much of this water is lost by evaporation, transpiration, and surface runoff before it can enter the underground reservoirs. The amount of precipitation which becomes ground water in any area is influenced by a number of factors; the duration, intensity, and type of precipitation; the density and types of vegetation; the topography; and the porosity, permeability, and degree of saturation of the soil, subsoil, and underlying rock formations.

Fresh ground water can be obtained throughout most of Michigan by wells drilled into one or more of the numerous aquifers of the State (table 1). An aquifer is a geologic formation or structure that transmits water in sufficient quantity to supply pumping wells and springs. In some areas of the State, ground water is relatively difficult to obtain, and aquifers yielding only a few gallons per minute of water or less, are of considerable importance. In other areas where aquifers may yield several hundred gallons per minute, formations capable of yielding small amounts may be classed as non-productive.

Aquifers may be classified as water table or artesian. In a water-table aquifer ground water is unconfined and the upper surface of the saturated zone is termed the water table. In an artesian aquifer ground water is confined between relatively impermeable strata (strata through which water does not move readily) and is under artesian pressure. The water in a tightly cased well finished in an artesian aquifer will rise above the bottom of the upper confining bed, and, if under sufficient pressure, will flow at or above land surface.

The movement of ground water is somewhat similar to that of surface streams in that the water moves by gravity from high to low levels. Percolation of water through the pores, crevices, and minute interstices between rock particles below the surface generates a large amount of friction and hence is much slower than flow of water upon the surface. Rates of ground-water movement range widely, from a few feet per year to many feet per day. Water may travel great distances underground from recharge areas (areas where precipitation can infiltrate into a ground-water reservoir), to areas downgradient where it may once more reach the surface and join the flow of streams, appear as a seep or spring, enter a lake, or escape directly to the atmosphere by means of evaporation and transpiration.

In Michigan, water-bearing rock formations are commonly classified into two broad categories; namely, bedrock and glacial drift aquifers. The bedrock or consolidated rock aquifers include both the igneous and metamorphic rocks of Precambrian age which form the bedrock surface in much of the western half of the Northern Peninsula and the sedimentary rocks of Paleozoic age which overlie the Precambrian rocks elsewhere in the State. Over all but 2 or 3 percent of the area of Michigan the bedrock is mantled by glacial drift or unconsolidated rocks of variable thickness deposited by various processes of glaciation during the Pleistocene epoch or Ice Age.

The Precambrian rocks commonly are very dense, and hence of low permeability. Where the rock is fractured, broken, or creviced, and connected with a source of recharge, water may circulate through these secondary openings, and be intercepted by wells drilled into such zones. Where mine shafts penetrate such permeable zones and are not dewatered, they are essentially large diameter wells.

In the remainder of the State consolidated rocks deposited by shallow seas during the Paleozoic era form the bedrock surface. These consolidated sediments consist of strata of limestone, dolomite, shale, sandstone, and breccia and are commonly interbedded with layers of evaporites such as rock salt or gypsum. Although these rocks were deposited in nearly horizontal layers, gradual subsidence and compaction of the beds produced a bowl-shaped structure. The youngest beds are exposed at the surface in the central part of the structure and the formations crop out in roughly concentric bands (fig. 2).

The chief sedimentary rock aquifers are composed primarily of sandstone, limestone, or dolomite. In a sandstone aquifer water moves through voids between individual sand grains and also along joints, other fractures, and bedding planes. Movement of water in limestone and dolomite aquifers is predominantly through cavities, fractures, and fissures developed by weathering and solution. Layers of shale are of low permeability and yield little water to wells. They are significant in the hydrologic system, however, because they impede vertical movement of ground water, and hence retard solution in underlying soluble rocks, and also act as confining beds in artesian systems.

In general most of the fresh water in the sedimentary rock aquifers is in the portions of the formation where they form the bedrock surface or are close to the surface. Where they are buried at depth beneath younger Paleozoic rock formations the water present is generally saline. For example, the Marshall formation is the principal source of fresh ground water at Battle Creek in Calhoun Co., where it forms the bedrock surface, but in Gratiot County where it is overlain by the Saginaw

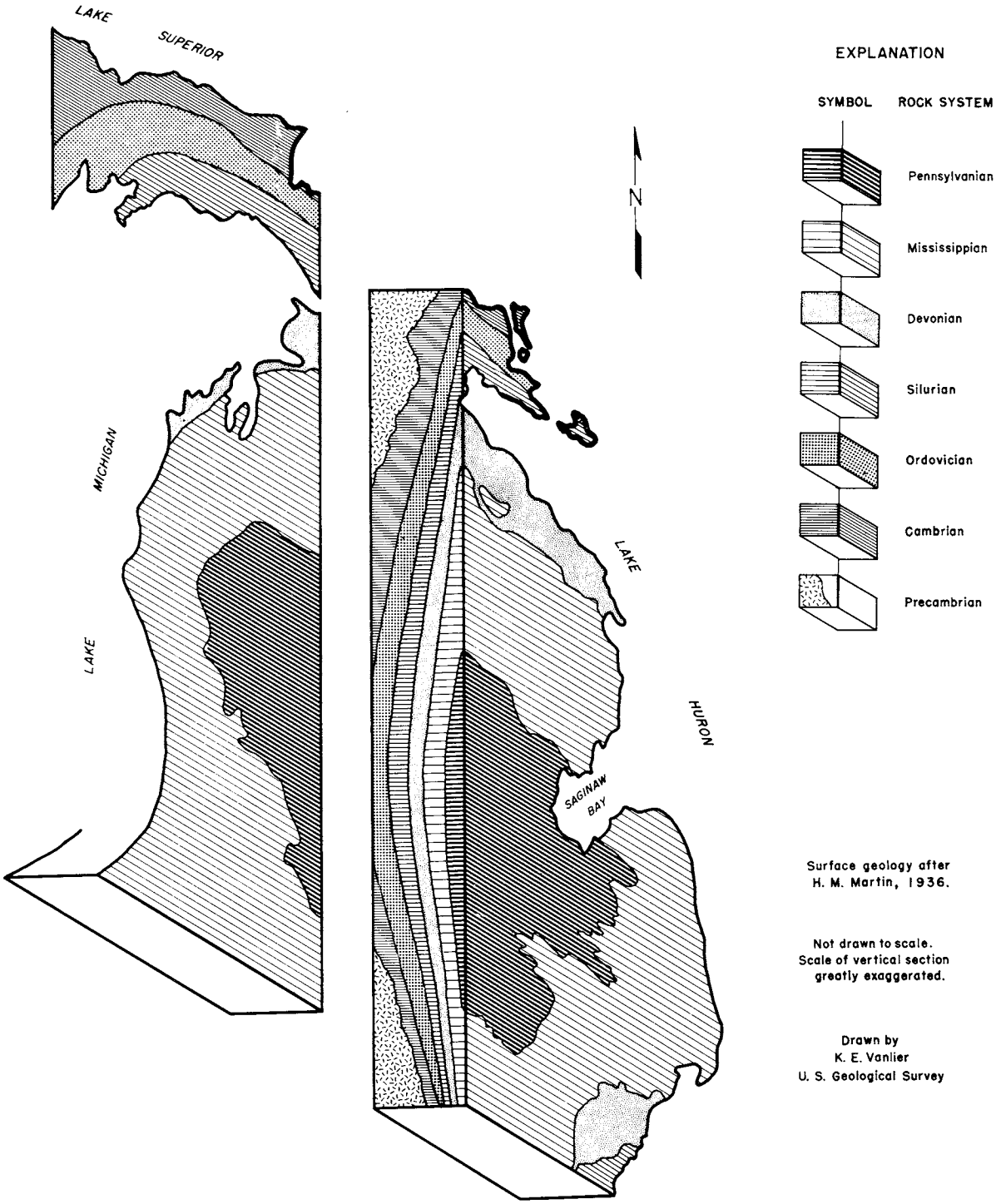


Figure 2. Block diagram showing schematic geological cross-section through the Michigan Basin.

formation, it yields saline water. The Trenton and Black River limestones are a major source of fresh water in Delta County in the Northern Peninsula, but in various areas of the Southern Peninsula, where these formations are present at great depth, they produce gas, oil, and brine.

Glacial drift as great as 1,000 feet in thickness was deposited on the Precambrian and Paleozoic bedrock surface during the Pleistocene epoch following a long period of erosion prior to the glacial age. During the erosional period, which began at the close of the Paleozoic Era and lasted until the Pleistocene, a considerable volume of consolidated rock was removed and some of the physiographic features of Michigan, including the major valleys which are now part of the Great Lakes, were formed. The glacial drift comprises important aquifers, which in general, are the most accessible aquifers in many areas of the State. The water in these aquifers is contained in the voids between rock particles. The drift material was deposited primarily by ice, meltwater streams, lakes, and wind action during the glacial epoch. The best aquifers consist of water-laid sand and gravel outwash deposits. Till is generally unstratified drift that was deposited directly by ice, with water playing a minimum part in the process of deposition. Till deposits are not important as aquifers in most of the State as they contain large percentages of silt and clay that fill the voids between the larger rock particles. In the Lake Superior area, however, the till deposits are locally good sources of water where they are composed largely of sand and gravel with little clay and silt. Also included within the glacial drift are large quantities of clay, silt, and fine sand deposited in the waters of the numerous extinct glacial lakes. Most of these deposits comprise rather poor aquifers in

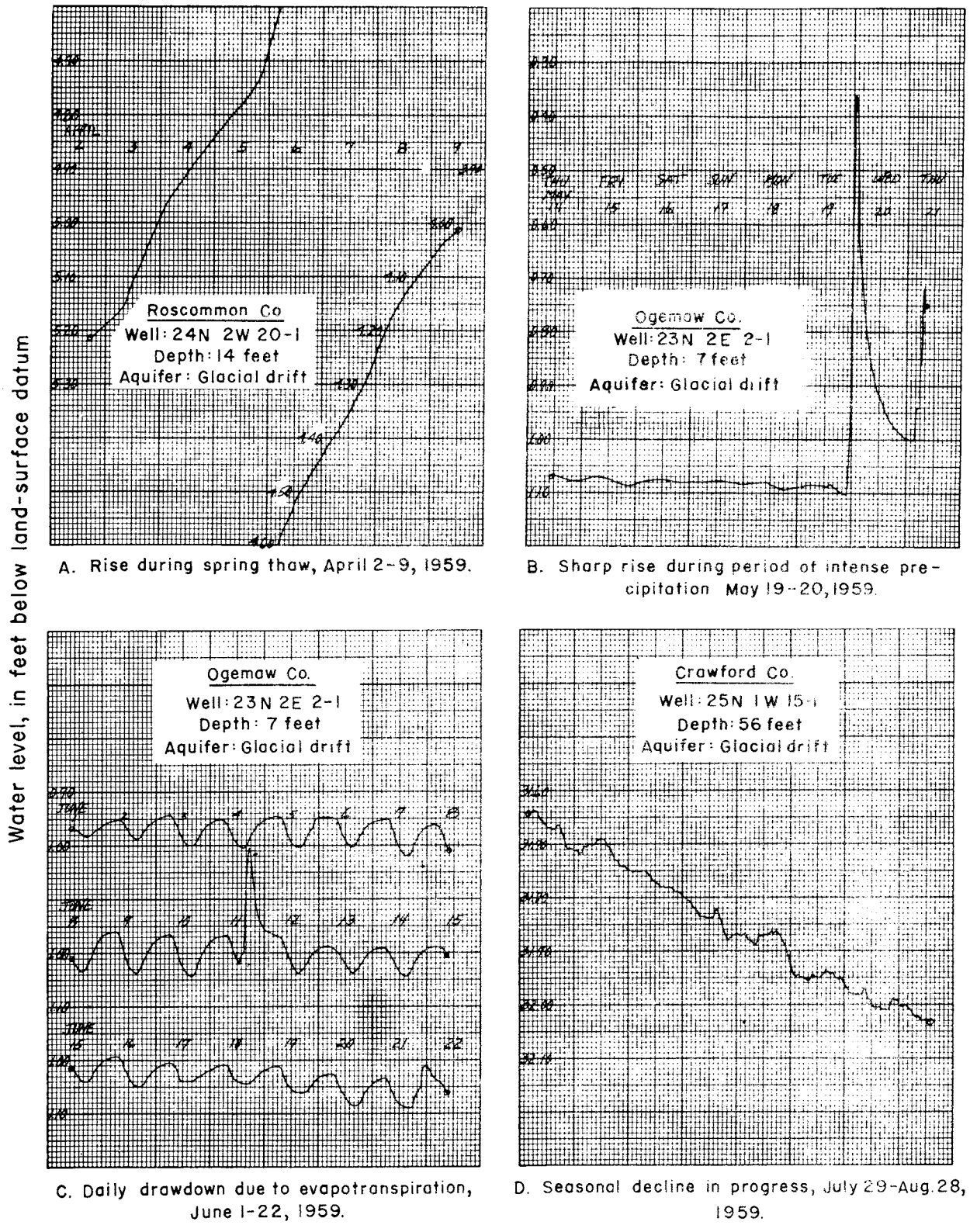
Michigan except locally where they are composed chiefly of fine sand and will yield small amounts of water to wells. Extensive dunes composed of well-sorted sand deposited by wind action during late and post-glacial times are present in various areas of the State, especially along the Great Lakes shorelines. Although permeable, they are not important as aquifers as they generally lie above the regional water table.

Causes of Water-Level Fluctuations

Water levels in wells are continually changing with movement up or down varying from fractions of an inch per day to many feet in a short time. The levels are influenced by many factors including direct recharge from rainfall and snowmelt, regional or nearby pumping, evaporation and transpiration of water by vegetation, and by changes in water levels in nearby streams or drains (fig. 13). In artesian wells, changes in water level or artesian pressure may occur quickly over large areas as the result of pumping or changes in pumping rate. Temporary influences on the levels in artesian wells result from changes in atmospheric pressure, earthquakes, earthtides, and other factors.

Climatic Influences

Water levels fluctuate mainly with seasonal changes in the rate of recharge to, and discharge from the aquifers. In figure 3 examples are given of fluctuations of ground-water levels in observation wells in response to climatic conditions. The figure consists of tracings of 4 original recorder charts (A, B, C, and D) taken from continuous recording gages in operation on observation wells.



A. Rise during spring thaw, April 2-9, 1959.

B. Sharp rise during period of intense precipitation May 19-20, 1959.

C. Daily drawdown due to evapotranspiration, June 1-22, 1959.

D. Seasonal decline in progress, July 29-Aug. 28, 1959.

(Charts about one-third actual size)

Figure 3. Selected recorder charts showing effects of natural climatic conditions on water levels in observation wells.

Chart A shows a typical rise of water levels in a shallow well in response to recharge from infiltration of water from rain and melting snow during the spring thaw.

In B and in lesser degree in C, the sharp rises in stage in a shallow well are the result of the occurrence of rainstorms of high intensity and short duration common during the summer months. The large rise on May 19 was the result of 4.6 inches of rain that fell in a few hours. Generally, however, much of the water from these summer storms tends to run off to surface streams and little benefit is derived especially in recharge to the deeper wells.

Chart C shows the effects of evapotranspiration during the daylight hours and the general downtrend of water levels or seasonal decline.

In D a typical month in the summer is shown while the seasonal decline is in progress. During the growing season little of the rainfall finds its way into the aquifer due to the effect of evaporation and transpiration by plant life.

This decline in stage during the growing season may be accelerated by deficiencies of precipitation during that time. Also the seasonal decline may continue into late fall by an early general freeze which tends to impede infiltration of water to the aquifers. Generally, however, after killing frosts end the growing season in the fall and transpiration ceases, precipitation will cause rises in water levels.

In 1959 the heavy snow cover that accumulated by late winter created favorable conditions for spring recharge to the ground-water reservoirs. However, direct evaporation of much of the snow cover reduced the recharge potential. In addition, where heavy soils remained frozen

especially in the southern half of the Southern Peninsula, spring thaws resulted in fast runoff and recharge was not as great as had been anticipated. In areas of sandy soil more of the snowmelt reached the underlying aquifers. Unusually warm temperatures in May were followed by considerable dryness in June and this accelerated the usual seasonal decline. The seasonal declines were reversed when heavy precipitation in late summer and fall replenished most of the aquifers (figs. 5 and 6). The higher precipitation totals for the year resulted in year-end stages well above those observed at the end of 1958.

Pumping Influences

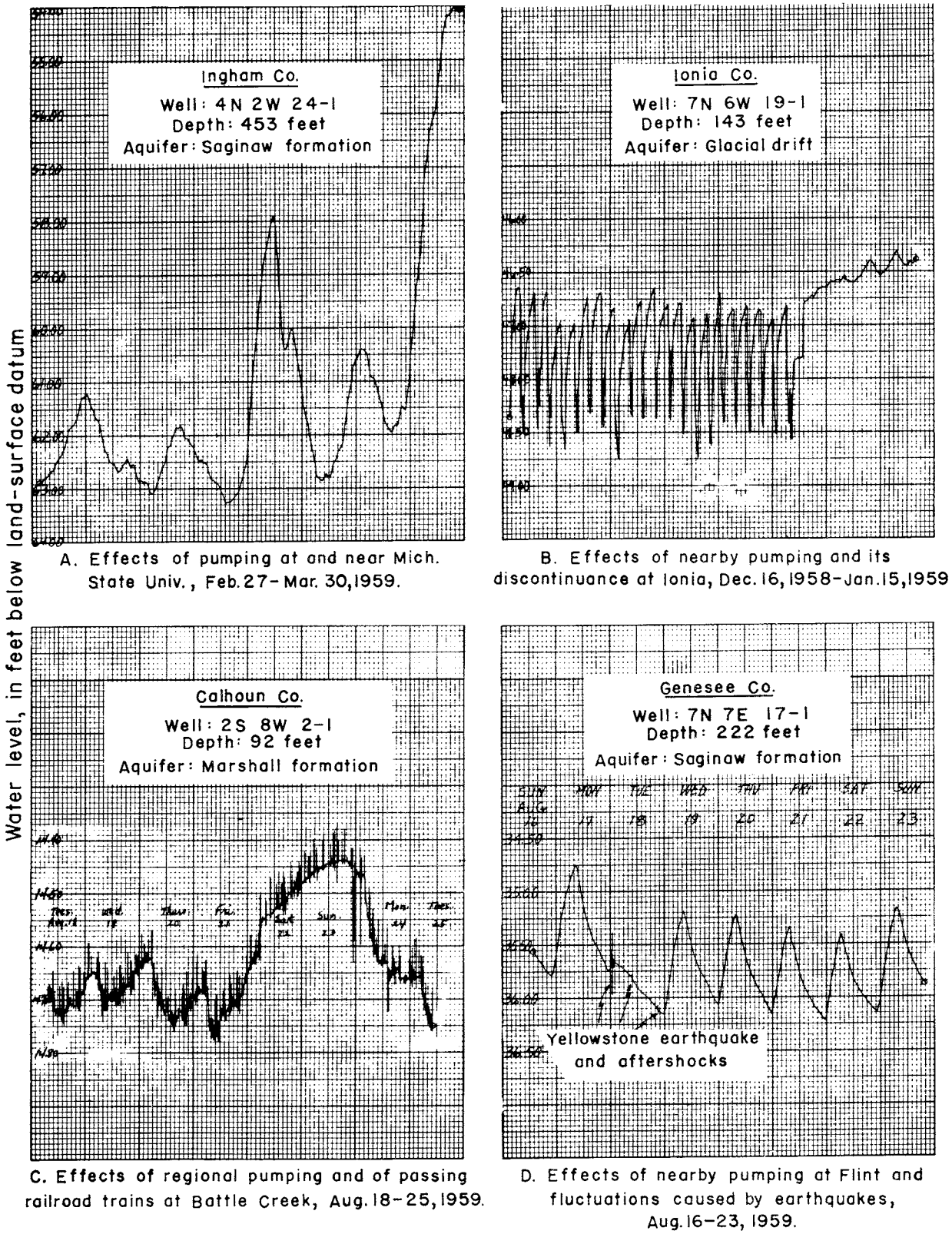
Generally, ground water is a renewable natural resource as it is intermittently or continually being replaced directly or indirectly by precipitation. If an aquifer is to be developed by means of wells so that a long-term yield may be obtained without substantially dewatering the aquifer, then equilibrium must exist between the rate of recharge to and the rate of discharge from the aquifer. Any aquifer in its natural state (before it is tapped by wells) is in approximate dynamic equilibrium. When water is discharged from an aquifer by means of a well, an increase results at least temporarily, in the rate of total discharge from the aquifer. The pumping causes a cone-shaped depression in the water table or piezometric surface that expands with time around the discharging well. With continued discharge, the cone of depression will continue to expand until the resultant lowering of water levels either causes a decrease in discharge from the aquifer, or an increase in recharge to the aquifer, or a combination of both, restoring the aquifer to a state of equilibrium.

Wells within this cone of depression are affected by the lowering of water levels or artesian pressures. Thus, a well tapping an aquifer may be affected by the discharge of other wells that tap the same aquifer. In the case of several or of many discharging wells, a composite cone of depression results that may extend over a large area. The result of the lowering of water levels over a large area may cause a considerable increase in the rate of recharge to, or a considerable decrease in the rate of natural discharge from the aquifer. A lowering of the water level, therefore, is necessary in the utilization of an aquifer.

The effects of withdrawals of ground water by some of the municipalities, institutions, and industries in the State are discussed under the county headings below, and their reported monthly and annual pumpage totals are listed in table 2. Many of the observation wells listed in table 1 are being observed because of their economic significance as their levels fluctuate primarily in response to pumping influences. Graphs showing the effect of pumping on water levels in nearby observation wells are used in many of the illustrations.

In general, most communities pumped more water in 1959 than in 1958. This was due to continued increases in urban and suburban populations creating more demand for water especially where cities expanded their facilities to annexed areas. Municipal pumpage was higher than usual in June due to warm dry weather and attendant increases in warm weather uses. Effects of industrial layoffs due to the steel strike were reflected in November pumpage figures of industrial communities (table 2).

Figure 4 shows examples of the effects of pumping of municipal and industrial wells on water levels in nearby observation wells. Charts



A. Effects of pumping at and near Mich. State Univ., Feb. 27 - Mar. 30, 1959.

B. Effects of nearby pumping and its discontinuance at Ionia, Dec. 16, 1958 - Jan. 15, 1959

C. Effects of regional pumping and of passing railroad trains at Battle Creek, Aug. 18-25, 1959.

D. Effects of nearby pumping at Flint and fluctuations caused by earthquakes, Aug. 16-23, 1959.

(Charts about one-third actual size)

Figure 4. Selected recorder charts of water levels in observation wells affected principally by nearby or regional pumping.

A and B cover a month's record while C and D are weekly records. The charts are tracings (except for C) of original recorder charts as taken from continuous recording gages in operation on observation wells.

In chart A the large fluctuations of water level in the observation well show weekend recovery with the highs occurring on Mondays as the result of decreased pumping on the weekends.

Chart B shows daily fluctuations of water level due to nearby municipal pumping and also the effect of the discontinuance of this pumping, at Ionia.

Chart C shows the daily fluctuations from regional municipal and industrial pumpage and the weekend recovery of water levels. The numerous sharp fluctuations shown are due to compressional loading on the aquifer from the weight of passing railroad trains.

Chart D shows the effect of pumping by a nearby air-conditioning well used by a local television station. The hours of operation of the pumping well are graphically shown by the daily drawdown and recovery of the water levels in the observation well. In addition, the effects of an earthquake and aftershocks that occurred at Yellowstone Park are also shown on the recorder chart. The pronounced and rapid vertical oscillations of water level (Aug. 18) were caused by the seismic compressional waves from the earthquake that occurred at Yellowstone at 1:37 a.m., E.S.T., and following aftershocks at 10:26 a.m. and 11:04 p.m., August 18. The earlier times indicated for the earthquakes by the recorder chart were due to minor inaccuracies in the timing mechanism of the gage.

SUMMARIES OF GROUND-WATER CONDITIONS

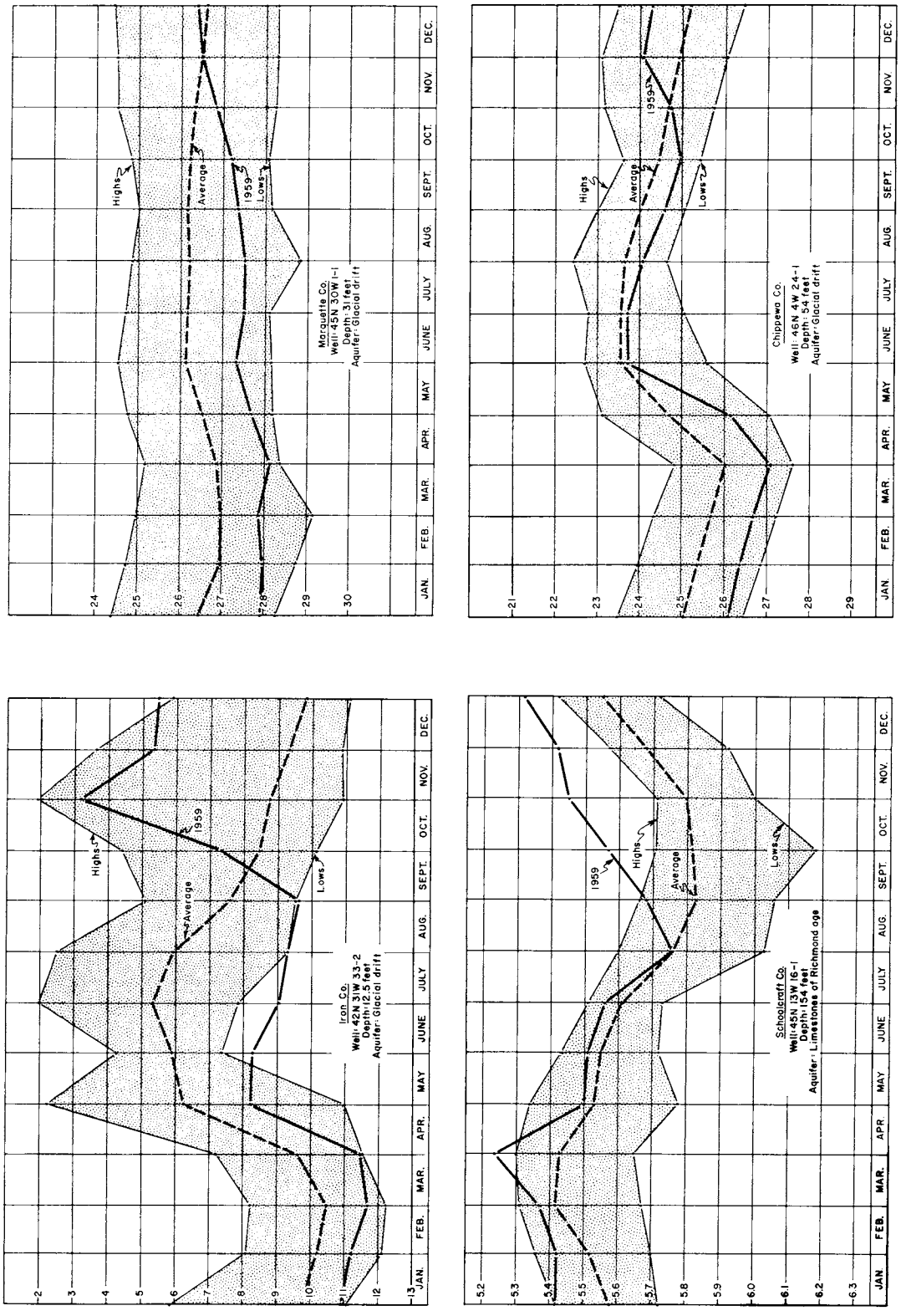
Statewide Changes in Natural Storage

Figures 5 and 6 show the hydrographs of month-end levels in 1959 and the extremes and average of month-end levels for the past record from selected observation wells in the State. These wells are located in areas of little or no pumping effect and reflect changes in aquifer storage primarily in response to climatic conditions. Those records of ground-water levels that reflect mainly climatic conditions serve as a basis for comparison with records of levels that are affected by pumping withdrawals.

In the Northern Peninsula water levels were considerably below average at the beginning of the year in most wells finished at shallow depth in glacial drift (fig. 5 and table 1). However, heavy rains in August, September, and October reversed the seasonal decline and stages rose sharply so that by the end of the year levels in most wells were considerably above average. Water levels in wells finished in rock formations in the eastern part of the Northern Peninsula were above average and reached new highs for the period of record during the year.

In the northern half of the Southern Peninsula ground-water levels were relatively low during the winter. However, snowmelt from record amounts of snow and heavy precipitation in the spring caused water levels to rise sharply. Stages declined to about average by late summer but heavy precipitation in the fall reversed the seasonal decline and water levels rose to above average levels by the end of the year (fig. 6).

In the Thumb area (fig. 6, Sanilac Co.) stages in an observation well were at record lows for January and February, but rose sharply in the



High, average, and low readings are for the period of record through 1958.

Figure 5. Month-end water levels in key observation wells in the Northern Peninsula, 1959.

spring and fall so that year-end levels were much higher than at the beginning of the year.

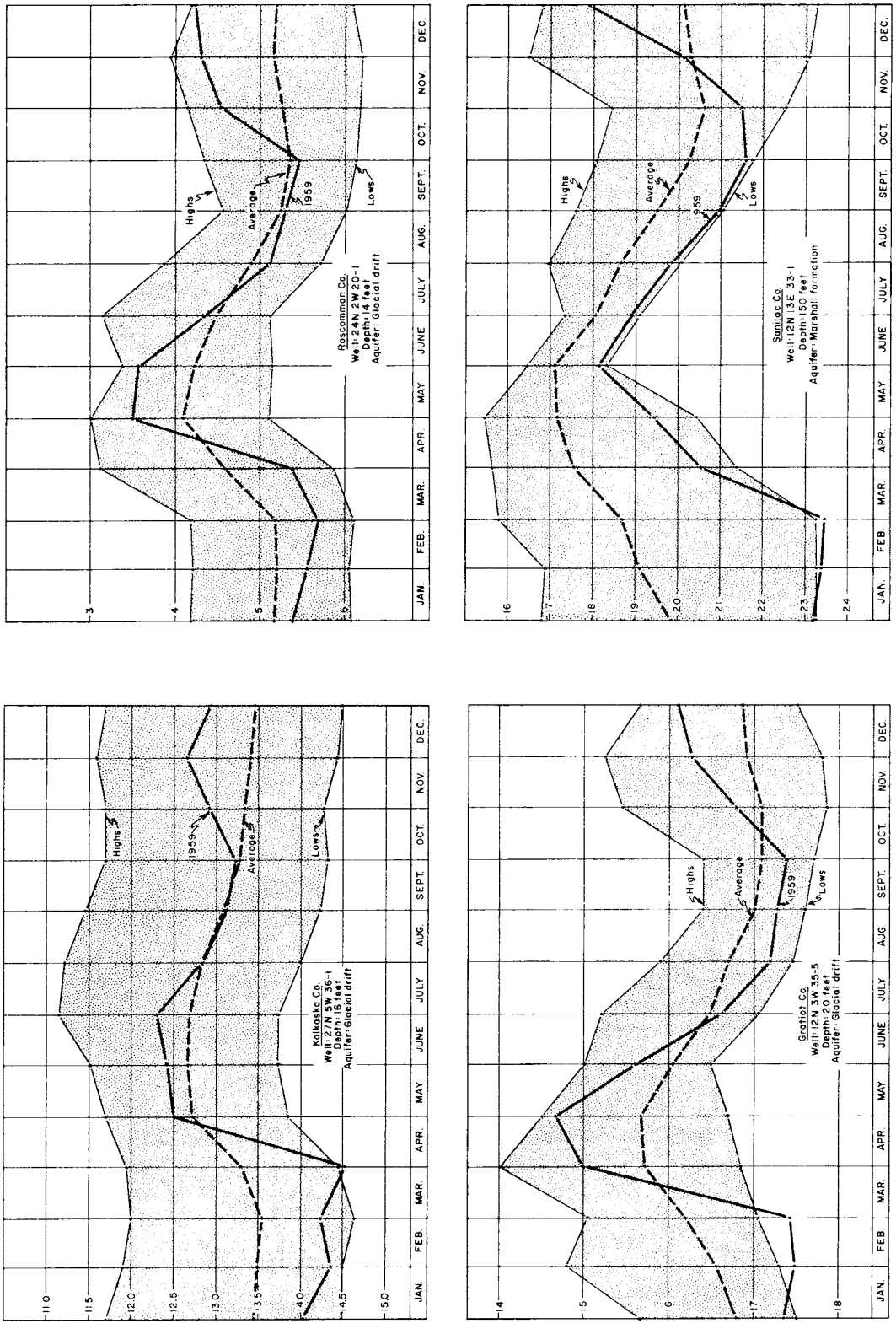
In the southern half of the Southern Peninsula low stages were also carried over from 1958. Although sharp rises occurred in the spring, from substantial recharge, it was less than anticipated as the result of runoff and evaporation of the large water content of the snow cover. Stages were low during the summer, but again rose during the fall because of favorable recharge conditions, so that by the end of the year, water levels in this area were generally above average.

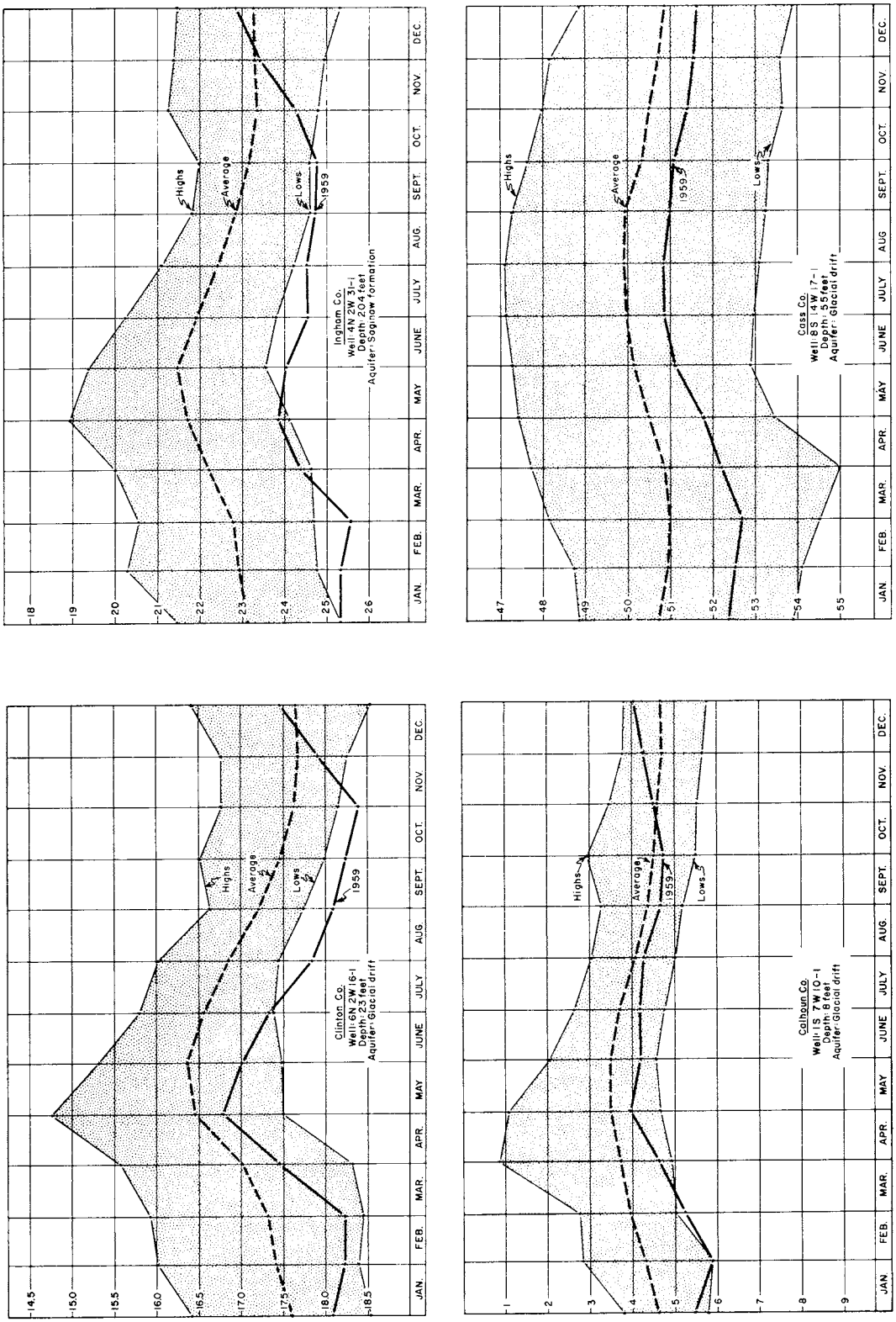
Northern Peninsula

Western Half

Most of the wells presently observed in the western half of the Northern Peninsula are those maintained by the Wisconsin-Michigan Power Co. to evaluate ground-water storage and to aid in the prediction of streamflows in the Menominee River Basin. These wells are finished at shallow depth in glacial drift deposits of Pleistocene age and reflect changes in natural storage in the water-table reservoirs of that area. The Wisconsin-Michigan Power Co. issues short monthly summaries of hydrologic conditions and also an annual report containing valuable information, such as weather, evapo-transpiration, and ground-water storage data.

In their 1959 annual report, Braun (1959, p. 199) states: "The role of ground water for the Menominee River in 1959 was an eventful one. It marked a rapid transition from 'want to plenty'. Near record low conditions at the end of July terminated in a most decisive fashion after the heavy August rains. If rainfall trends at the time had not reversed, conditions could have reached a point of drought status...."


Water level, in feet below land-surface datum
Kalkaska Co.
Well: 27N 5W 36-1
Depth: 16 feet
Aquifer: Glacial drift
Highs
1959
Average
Lows
Roscommon Co.
Well: 24N 2W 20-1
Depth: 14 feet
Aquifer: Glacial drift
Highs
1959
Average
Lows
Gratiot Co.
Well: 12N 3W 35-5
Depth: 20 feet
Aquifer: Glacial drift
Highs
Average
1959
Lows
Sanilac Co.
Well: 12N 13E 33-1
Depth: 150 feet
Aquifer: Marshall formation
Highs
Average
1959
Lows
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.



High, average, and low readings are for the period of record through 1958.

Figure 6. Month-end water levels in key observation wells in the Southern Peninsula.

Rainfall during the latter part of 1959 ended a 3-year period of deficiencies and resulted in above-average levels by the end of the year in most wells finished in glacial drift in the western part of the Northern Peninsula (fig. 5, Iron and Marquette Cos.).

Figure 7 shows fluctuations of water levels and monthly precipitation in an observation well finished in sandstone in Ontonagon County. The period of spring highs was prolonged by nearly 6 inches of precipitation in May. In September more than 5 inches of rain caused water levels to rise sharply, but a sharp decline followed in October. By the end of the year, the water level in the observation well was slightly below that observed at the end of 1958.

Eastern Half

Figure 8 shows fluctuations of water levels in 3 deep wells in Delta County finished in sandstone and limestone aquifers. These hydrographs were plotted from records obtained by continuous recording gages in operation on these wells. Net gains in water level for the year, from increased precipitation, were registered in each of the wells. A more detailed description and analysis of water-level fluctuations in Delta County is given by Sinclair (1960, p. 50-55).

Figure 9 shows the hydrographs of wells finished at shallow depth in dolomite and limestone formations in Mackinac and Schoolcraft Counties. Favorable spring and fall recharge conditions caused sharp rises, and net gains in water levels for the year were observed in each well.

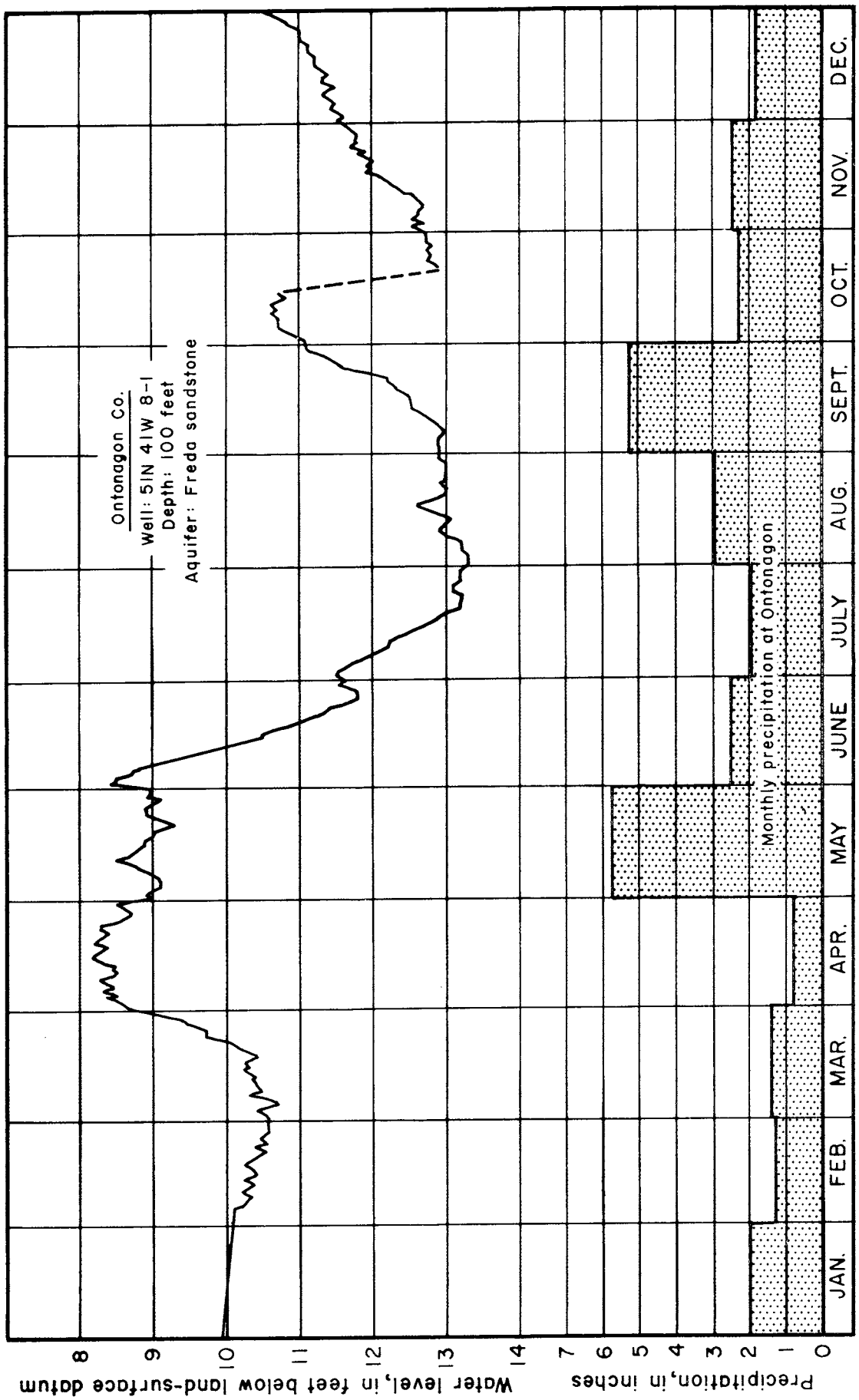


Figure 7. Hydrograph of Michigan Corrections Department well near Ontonagon and monthly precipitation, 1959.

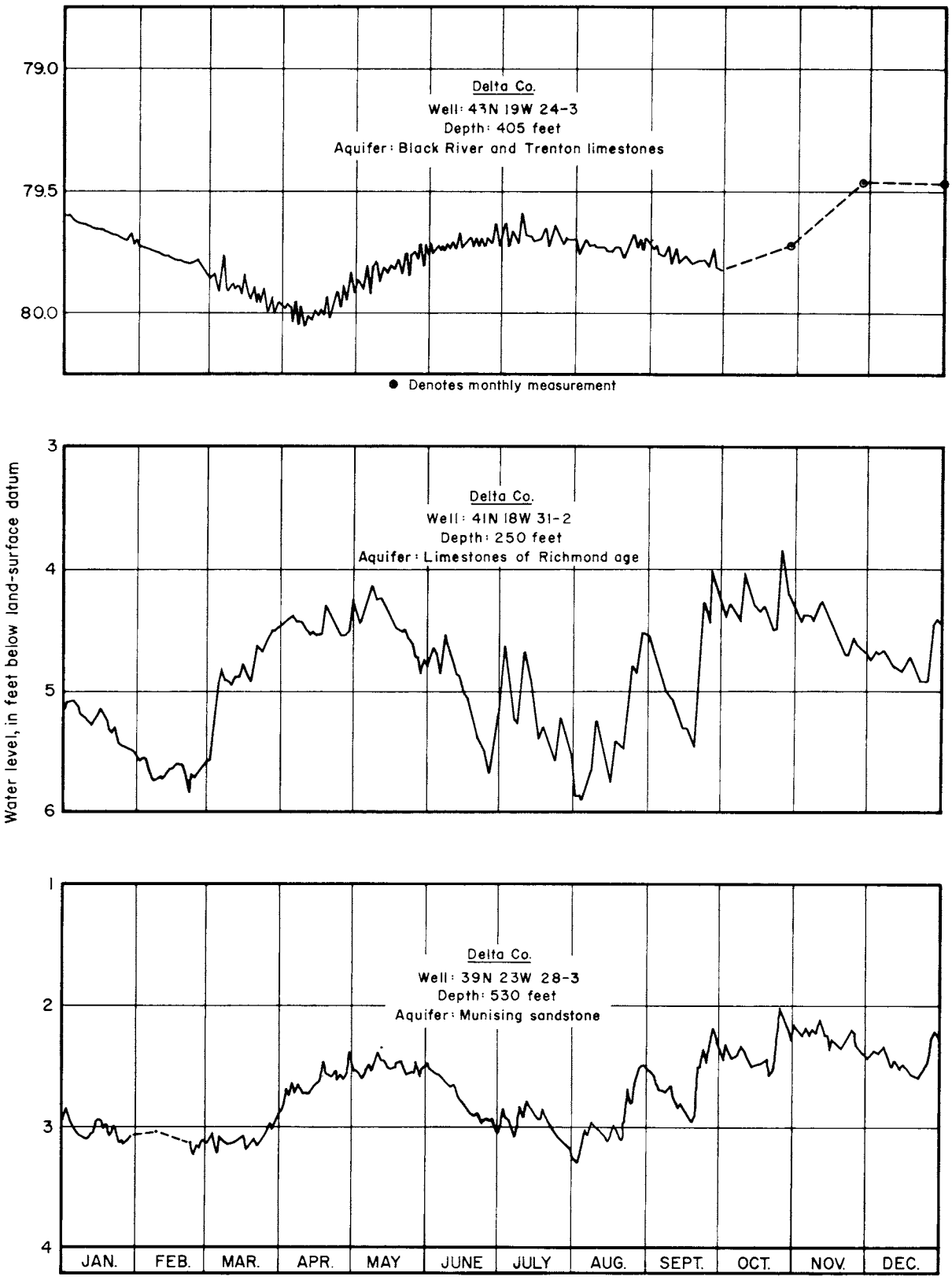


Figure 8. Hydrographs of selected wells in Delta County, 1959.

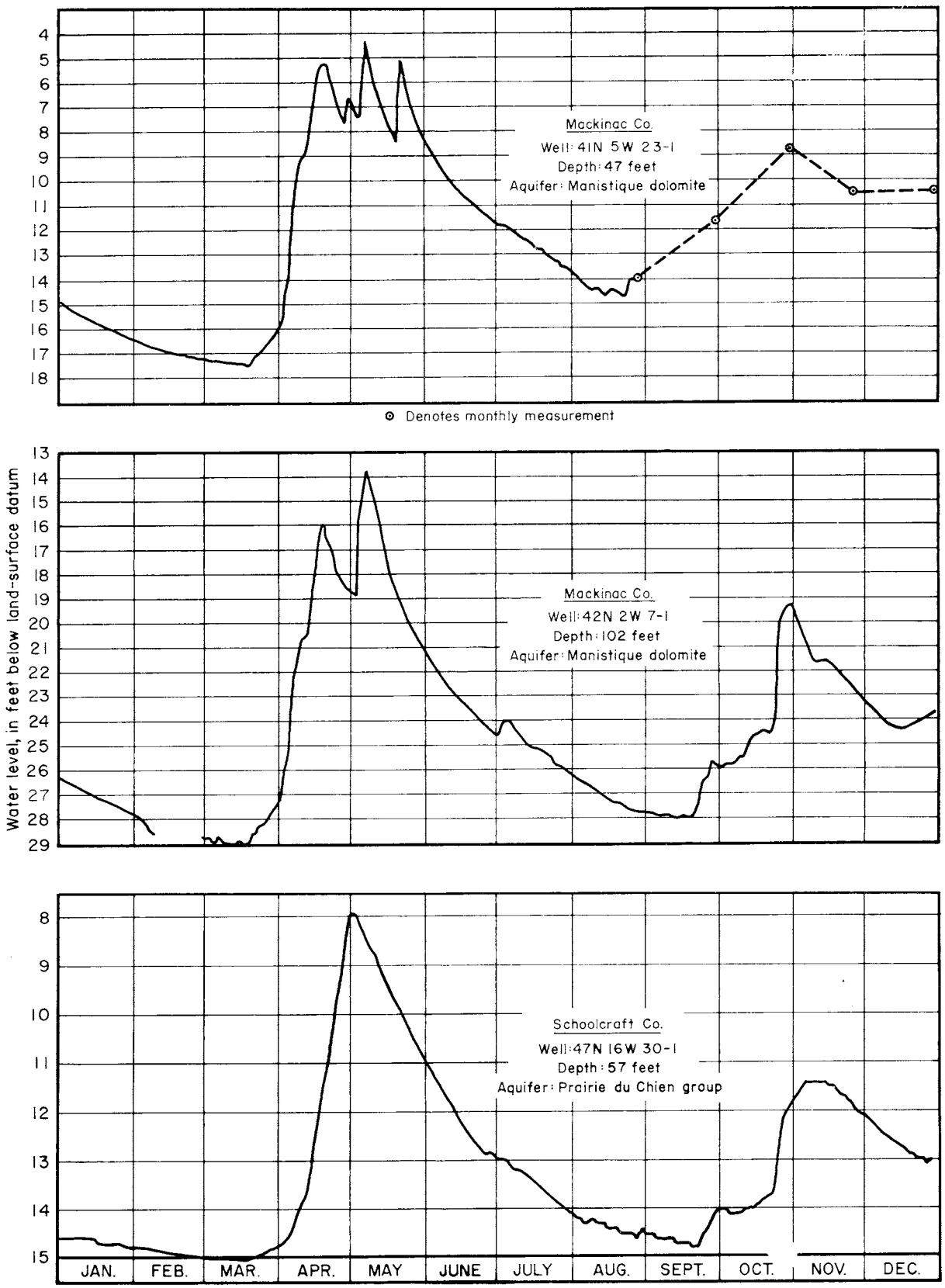


Figure 9. Hydrographs of selected wells in Mackinac and Schoolcraft Counties, 1959

In Chippewa County below-average levels in winter were followed by sharp rises in the spring and fall in an observation well tapping the glacial drift (fig. 5). As a result year-end levels were higher than the average.

Southern Peninsula

Northern Half

Temperatures averaged 5 to 10 degrees below normal and snowfall accumulated to record depths during February. The frigid temperatures and lack of snowmelt allowed little recharge to the ground-water aquifers, and, as a result, stages fell and remained low until early spring. In some wells record lows were observed. However, the large amount of snowmelt and above-average precipitation in April and May caused sharp rises in ground-water levels; in some cases levels rose to record highs (table 2). Unusually heavy precipitation during the last quarter of the year that amounted to nearly 5 inches in excess of the average, also resulted in high year-end stages for observation wells in this area (figs. 5 and 10).

The difference in effects of precipitation on water levels in shallow and deep wells is clearly shown by figure 10. Spring thaws and rain caused rapid and very pronounced rises starting in March in wells 24N 2W 20-1 and 26N 4W 11-1, but the effect in well 25N 1W 15-1 lagged until mid-April. The peak in water level in this well was not reached until mid-July, about 2-3 months later than in the shallow wells. On the other hand, the seasonal decline in the deeper wells lagged considerably behind and was of much smaller magnitude than that observed in the shallow wells.

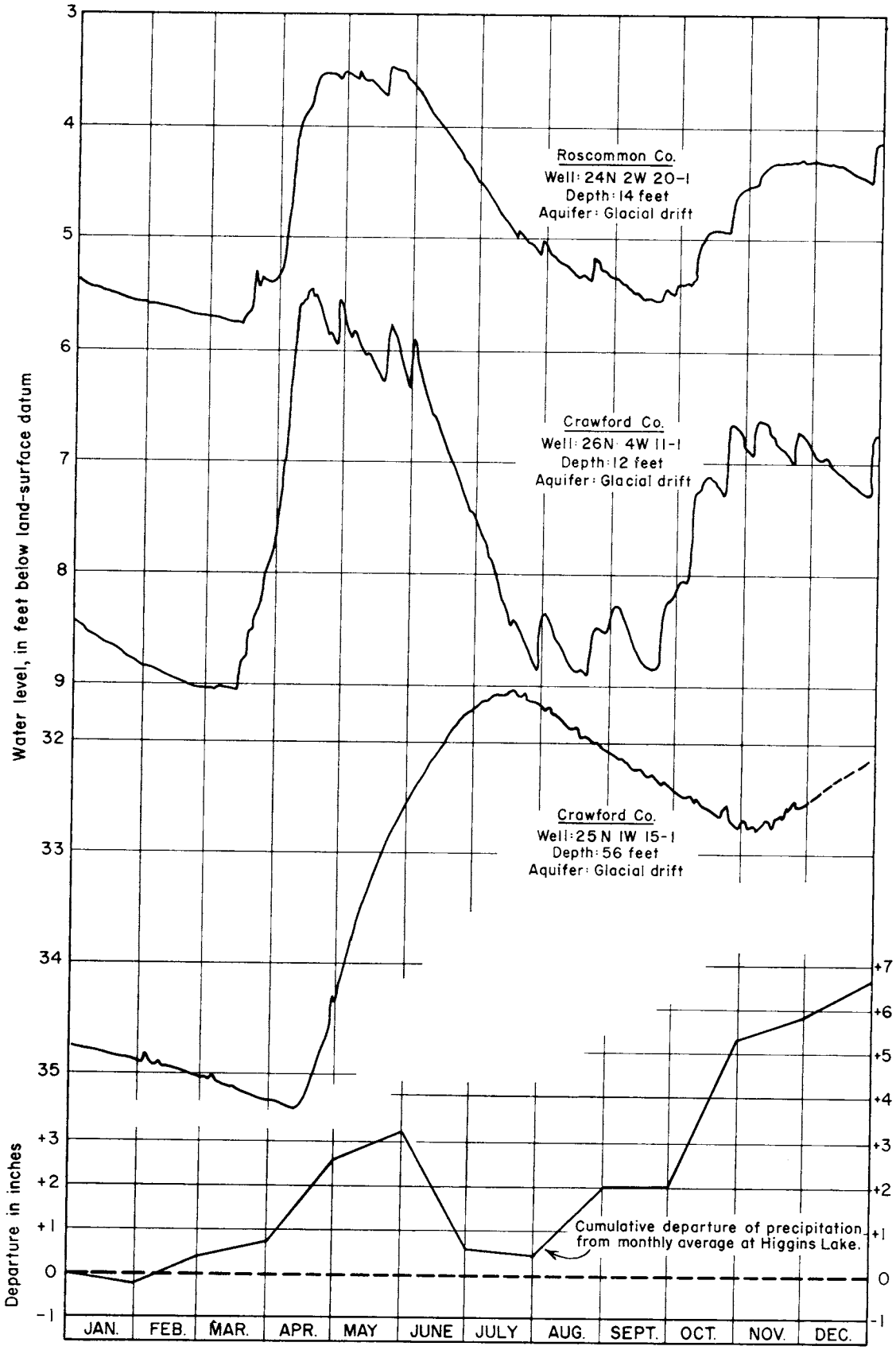


Figure 10. Hydrographs of selected wells in Crawford and Roscommon Counties and monthly precipitation departures, 1959.

Southern Half

Ground-water levels observed in areas of the southern half of the Southern Peninsula where little or no pumping occurs, were much lower at the beginning of 1959 than at the start of the year 1958. This was a carryover of low levels from 1958. However, sharp rises in the spring and fall occurred and as a result most of these wells had above-average stages by the end of the year and many were at the highest stages observed in several years (fig. 6).

Barry County

The city of Hastings obtains its water supply from wells finished in glacial drift. Observation well 3N 8W 18-1 in Hastings is also finished in drift and reflects pumping by the municipal wells.

Figure 11 shows the effects of precipitation and of pumping by the municipal wells, on the water levels in the observation well. One of the municipal well fields is about 1,500 feet from the observation well. As evidenced by the monthly chart from the continuous water-level recorder on the observation well, the fluctuations in stage are sharply accented by the starting and stopping of the municipal pumps. From September 1958 through December 1959 the total precipitation was about 5 inches below average. The period of rising water levels from 1959 spring recharge was followed by declining levels in response to increased pumping and also to deficient precipitation. In the fall of 1959 precipitation was above average and although measurements were not obtained in the late fall, a few measurements obtained in November indicated a rising trend until that time.

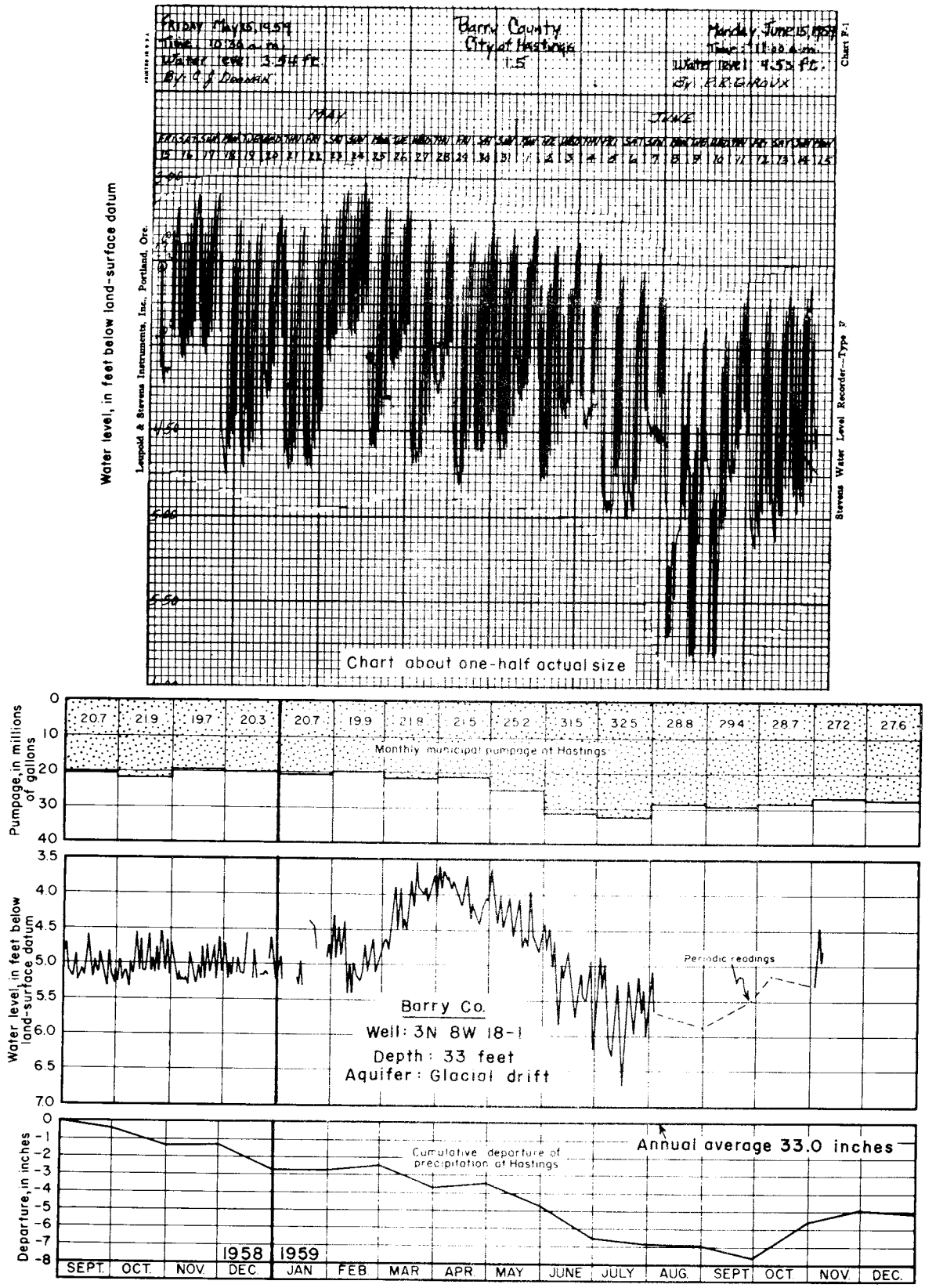


Figure 11. Typical monthly recorder chart, hydrograph of daily lows for well at Hastings, municipal pumpage, and precipitation departure, 1958-59.

Municipal withdrawals of ground water as reported by the city of Hastings for 1959 (table 2) totaled 315 million gallons. This was an increase of 20 percent over the year 1958. Pumpage averaged 0.86 mgd and ranged from 0.67 mgd in January to 1.05 mgd in both June and July.

Branch County

Observation well 6S 6W 22-1 is finished in glacial drift and located at the municipal well field in Coldwater. The water levels are affected by pumping of municipal wells tapping the same aquifer.

Figure 12 shows the graph of the fluctuations of water levels in the observation well plotted against the average month-end levels. The water levels rose to above-average in late winter and early spring when precipitation was above average and pumpage relatively low. A large increase in pumpage during the summer months and dryness in May and June caused water levels to dip sharply but then 9 inches of rain fell in July and brought about quick recovery. At the end of the year stages were above average principally due to the excess of precipitation in the fall and early winter. Note that the slope of the cumulative departure curve is upward during this period.

Annual municipal pumpage of 592 million gallons was a record high and exceeded the 1958 pumpage by 24 percent.

Calhoun County

Battle Creek metropolitan area.--Most observation wells and municipal and industrial wells in the Battle Creek area are finished in the Marshall formation of Mississippian age. A few are finished in the overlying glacial drift.

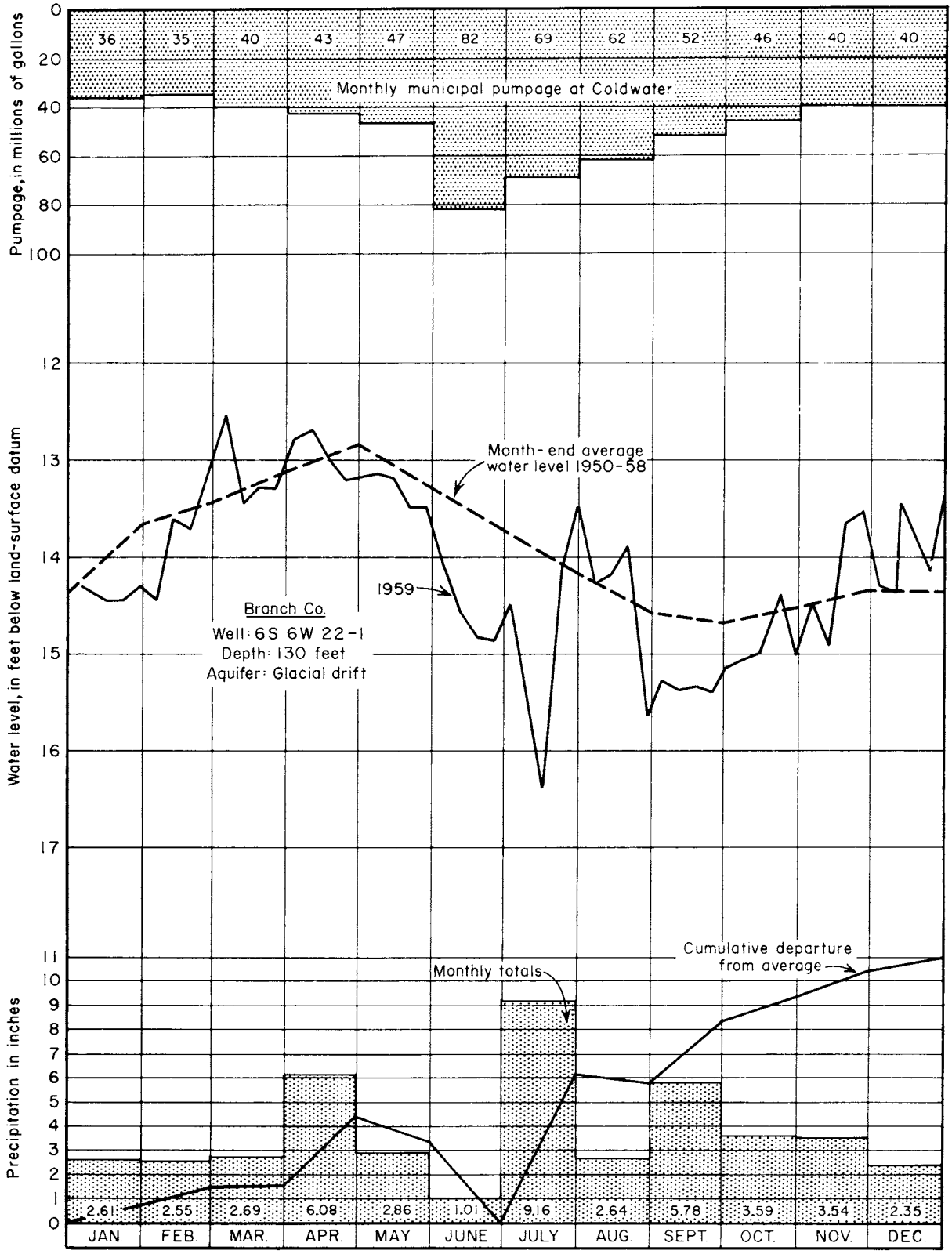


Figure 12. Hydrograph plotted against average water levels for well at Coldwater, municipal pumpage, and precipitation departures, 1959.

Although the water levels in most observation wells fell to record or near record low by late summer, there were sharp rises in the fall. Net rises for the year of about 0.1 to as much as 2.5 feet were observed. The gains were chiefly the result of recharge from more than 12 inches of precipitation during the fall months.

In the central and northwest part of the area the difference in water levels between 1957 and 1959 (fig. 13) were due to the lowering in mid-1958 of the base level of the Kalamazoo River (Giroux 1960, p. 43).

In the northeast part of the area stages fell to new lows in mid-summer, due mainly to the large increase in pumping at the Verona well field by the city of Battle Creek (fig. 14). Despite the summer lows, levels at the end of the year were about 3 feet higher than at the end of 1958 as a result of the excellent fall recharge to the aquifer.

Total municipal pumpage reported was a record 4.4 billion gallons in 1959. This marked the third consecutive year of large increases of municipal pumpage by the city of Battle Creek, and was an increase of 76 percent over 1956. The pumpage in 1959 averaged 12 million gallons per day (mgd) and ranged from 8.9 mgd in December to 15.1 mgd in June. Although about 75 billion gallons of water has been pumped at the Verona Station since June 5, 1914, no significant dewatering of the Marshall formation has occurred.

City of Marshall.--The three observation wells in the city of Marshall tap the Marshall formation and reflect municipal and industrial withdrawals of ground water from that aquifer.

In the spring, levels in the observation wells were the highest observed since 1954. Year-end levels were about a foot higher than at

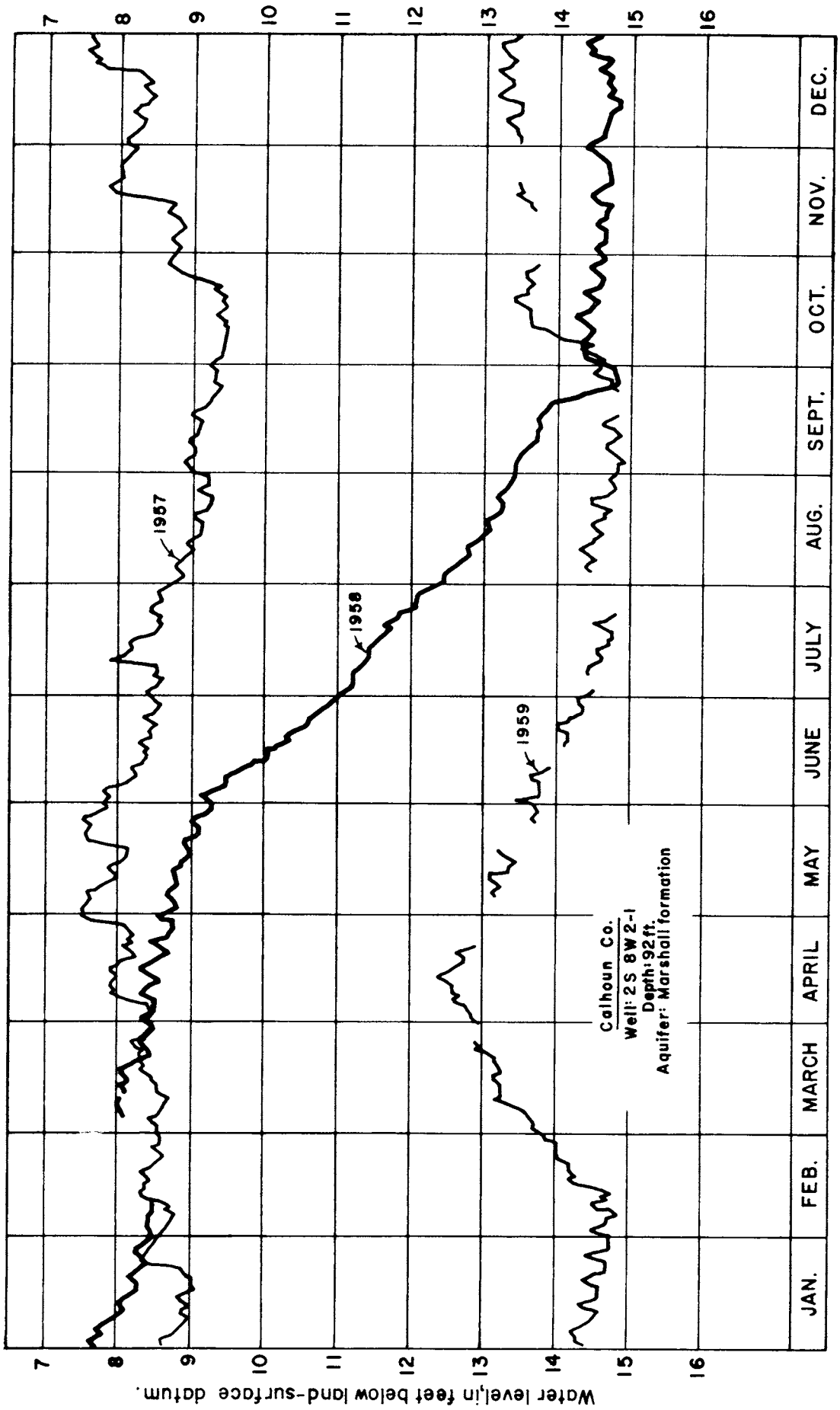


Figure 13. Annual hydrographs of well at Oliver Electrical Mfg. Co. plant, Battle Creek, 1957-59.

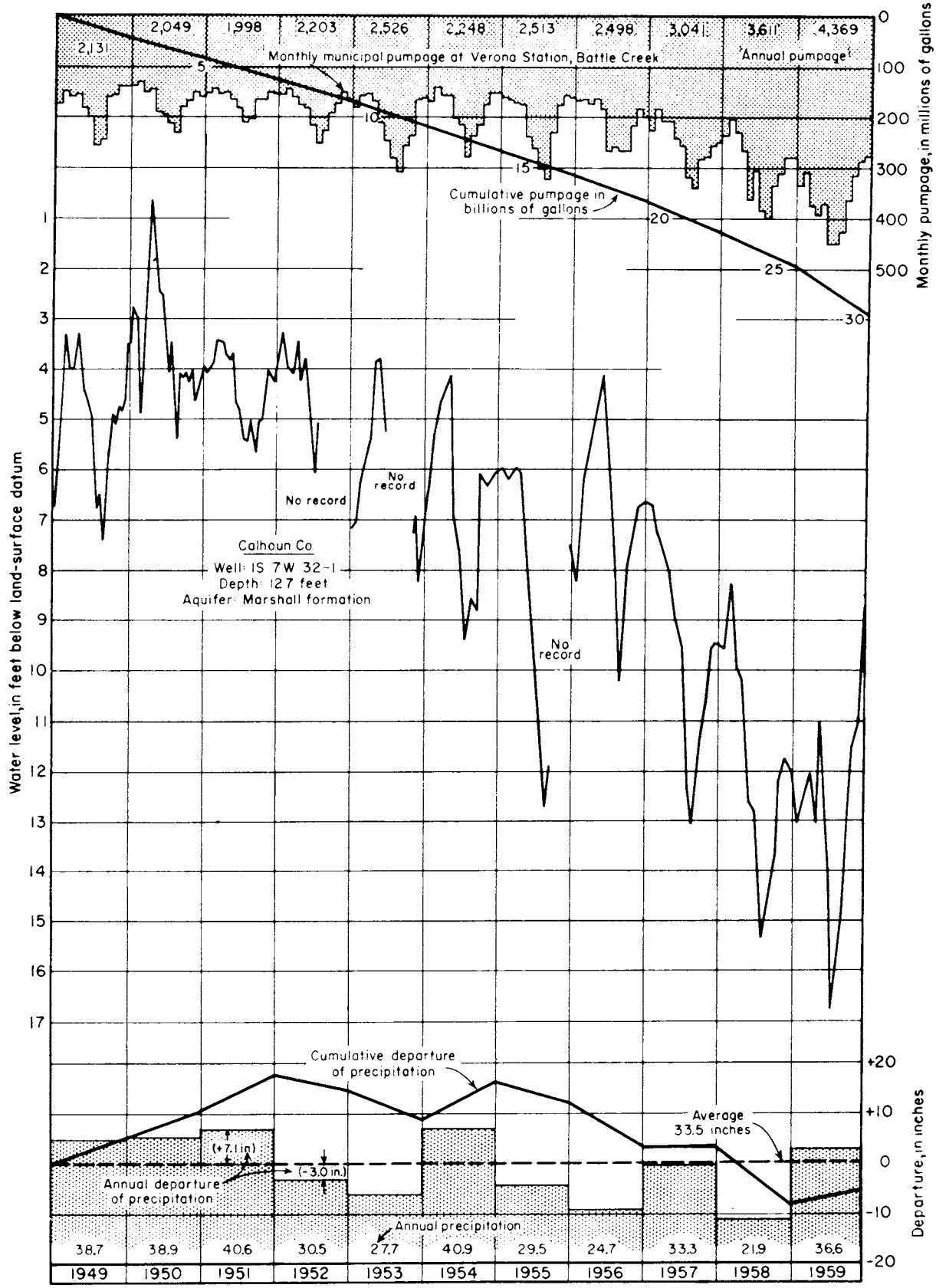


Figure 14. Hydrograph of well at Verona Station, municipal pumpage, and precipitation departures at Battle Creek, 1949-59.

the end of 1958. The recovery of water levels during the year was due to favorable conditions for recharge created by above-average precipitation during both the spring and fall. The observed rises in water level occurred despite a 10-percent increase in pumpage by the city of Marshall. The total municipal pumpage reported was 425 million gallons and was a new record high.

Cass County

Observation well 6S 16W 1-1, in the city of Dowagiac, is finished in glacial sand and gravel deposits and is affected by pumping from nearby municipal wells tapping these deposits. At mid-year the water levels in the observation well fell to the lowest stage since 1953 but by the end of the year rose to stages well above those observed at the beginning of the year. This was principally the result of about 46 inches of precipitation during the year, that was about 9 inches above average. Nearly 8 inches of this precipitation fell in October when conditions were favorable for ground-water recharge.

Municipal withdrawals of ground water by the city of Dowagiac were 240 million gallons, an increase of about 15 percent over 1958, but far less than the record total of 456 million gallons reported for 1953.

Elsewhere in the county observation well 8S 14W 17-1, also finished in the glacial drift, but not affected by pumping, (fig. 6), remained below average but at stages somewhat higher than in 1958.

Clinton County

At the village of Elsie the water levels in observation well 8N 1W 13-1 finished in the Saginaw formation and in observation well 13-3 finished in the glacial drift, are affected by municipal pumping from wells tapping these aquifers.

Heavy pumping from the glacial drift during the summer lowered the water levels in well 13-3 to their lowest stage since 1951. However, by the end of the year water levels in this well rose to the highest observed for the period of record that began in 1947. In well 13-1 stages were the highest observed since 1952.

Water levels in other observation wells observed in Clinton County are near Lansing and are included in the discussion "Ingham County, Lansing Metropolitan area."

Eaton County

City of Charlotte.--Observation well 2N 4W 19-1 and public supply wells at the Municipal Park in Charlotte are finished in glacial drift. The water levels in the observation well are affected by municipal pumping but also reflect natural conditions of recharge and discharge.

The observed water level in the spring was the highest since 1954. In marked contrast, at the end of the summer the observed level was the lowest of the 13-year record. This was probably caused by heavy summer municipal pumpage. However, stages at the end of the year were a foot above those observed at the end of 1958 reflecting good seasonal recharge from heavy fall rains.

Municipal withdrawals of ground water were the largest of record and totaled about 388 million gallons. This was an increase of about 13 percent over 1958.

City of Grand Ledge.--Observation well 4N 4W 2-1 and the municipal wells in Grand Ledge are finished in the Saginaw formation.

At the end of the summer water levels in the observation well fell to new lows of record due in part to the low levels that carried over

from 1958 when precipitation was deficient. Recharge from above-average precipitation in the fall, brought rises in the water levels and year-end stages were about the same as at the end of 1958.

Figure 15 shows the water levels, pumping magnitudes, and precipitation departures for the period of record of the observation well. The high pumpage figures in the period 1951-53 were caused by mechanical error when the flow meter on one of the wells became constricted by iron bacteria. The hydrograph tends to follow more closely the effects of precipitation than the effects of pumping by the municipal wells at the present rate of withdrawal.

Total municipal pumpage at Grand Ledge in 1959 was reported as 186 million gallons--an increase of about 7 1/2 percent over 1958.

Other observation wells in Eaton County are located in the Lansing area and are discussed under "Ingham County, Lansing Metropolitan area."

Genesee County

The city of Flint obtains its municipal water supply from the Flint River. However, Burton Township to the south, Beecher Metropolitan Water District to the north, and many industries in the Flint area obtain water from the Saginaw formation or from the overlying glacial drift. Observation wells in the Flint area reflect changes in water levels in the Saginaw formation, deep glacial drift aquifers, and the shallow drift deposits.

Observed water levels in the shallow drift rose several feet for the year in response to above-average precipitation. Water levels in

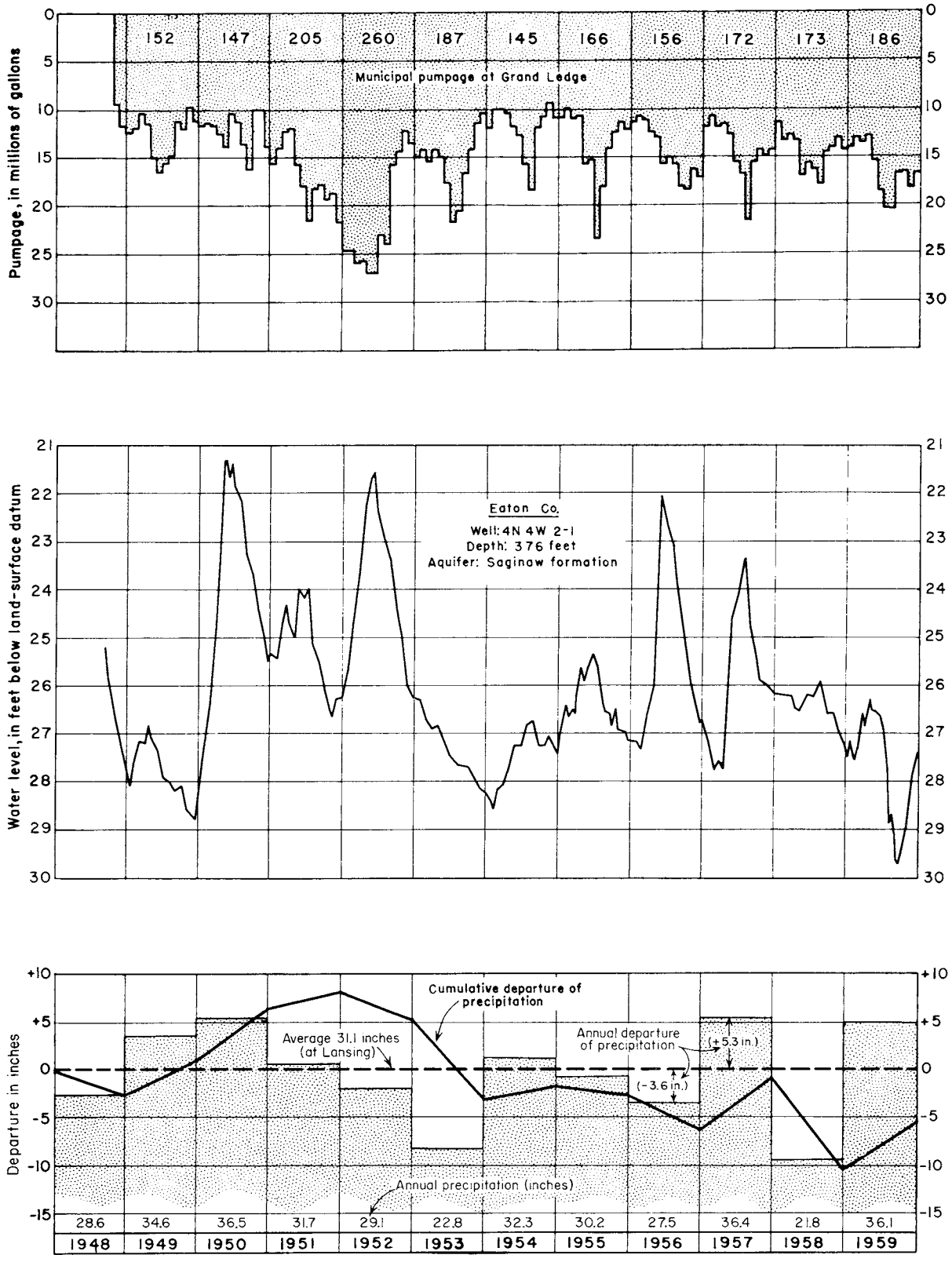


Figure 15. Hydrograph of well at Grand Ledge Chair Co., municipal pumpage at Grand Ledge, and precipitation data 1948-59.

well 7N 7E 32-1, tapping a deeper glacial drift aquifer, fell sharply as the result of nearby pumping by Burton Township. Water levels in well 7N 7E 20-2, tapping the same deposits, but located a considerable distance from heavy pumping, showed no appreciable change attributable to pumping.

Water levels in well 6N 7E 9-1 tapping the Saginaw formation at the Grand Blanc Fisher Body Plant dropped to the lowest stages of record during the summer month principally the result of a carryover of low stages from 1958 and also to increased pumping at the Plant's well field.

Gratiot County

Observation wells in the Alma area are finished in shallow drift and in deeply-buried sand and gravel outwash. Municipal and industrial wells tap the buried outwash. One deep municipal well taps the Saginaw formation but is seldom used as the water is of objectionable quality. Water levels in the shallow drift primarily reflect climatic conditions. In observation well 12N 3W 35-5 stages were the highest recorded since 1952 (fig. 6).

Artesian pressures in the buried outwash are affected by municipal and industrial pumping. Figure 16 shows the effect of pumping and precipitation on observation well 12N 3W 34-1. Water levels during the year followed closely trends in precipitation and rates of pumping. The summer decline was reversed during August and September, however, as a result of heavy precipitation late in July. Despite decreased pumping and above-average precipitation, the year-end stage was slightly lower than that observed at the beginning of the year.

Municipal withdrawals of ground water by the city of Alma were reported as 644 million gallons in 1959 (table 2), slightly less than in 1958.

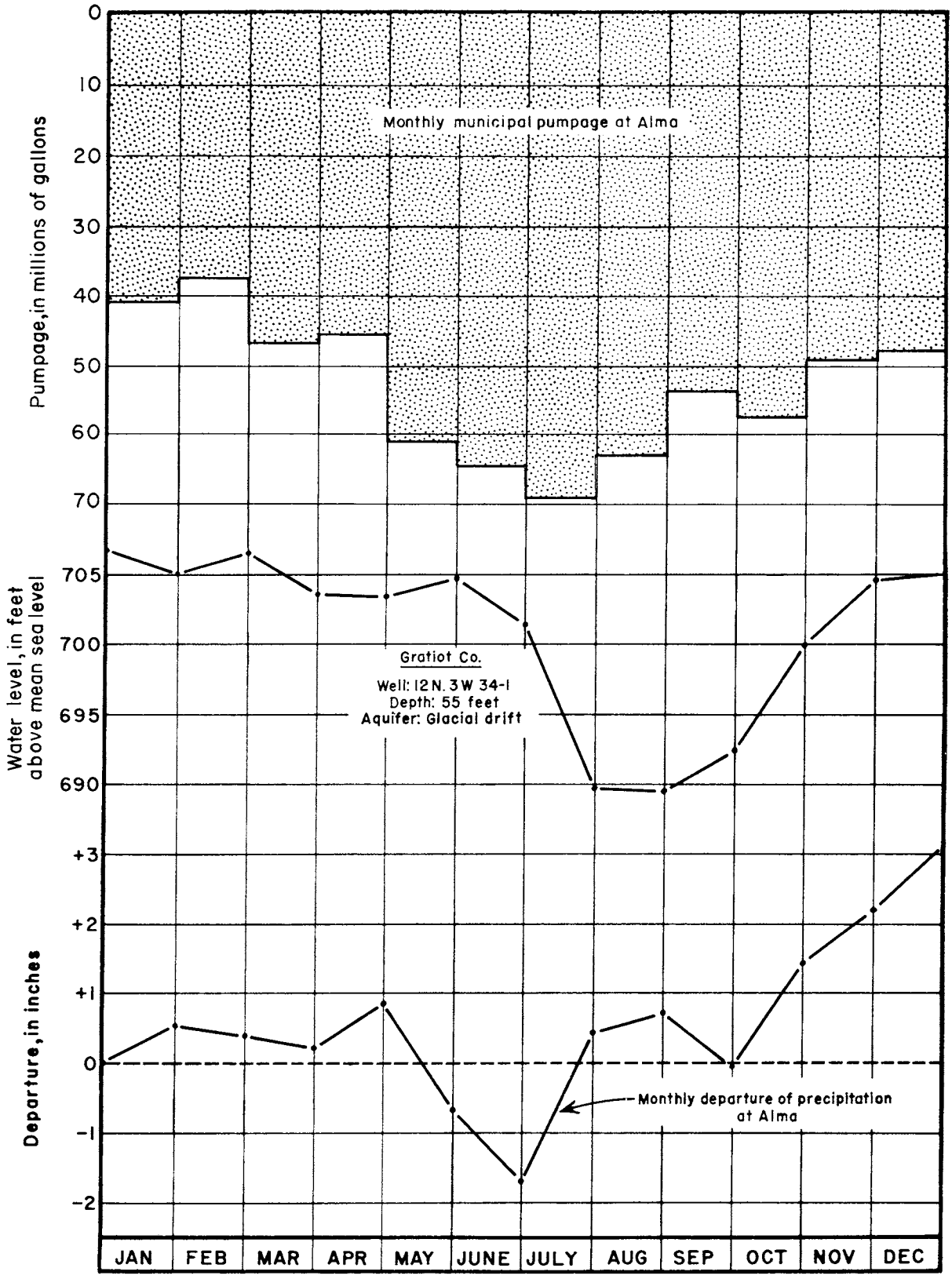


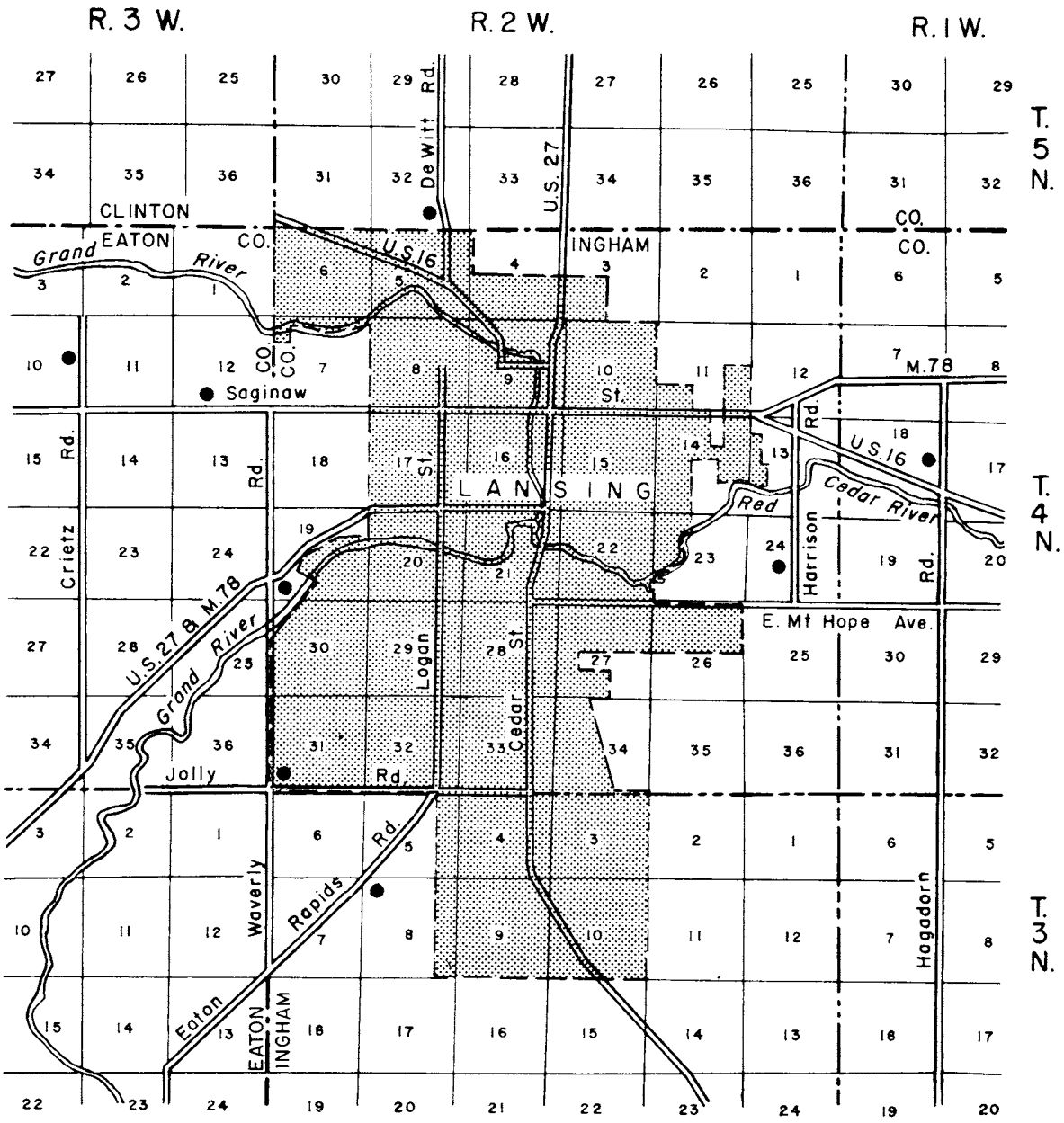
Figure 16. Hydrograph of Prospect Street well, municipal pumpage, and precipitation departures at Alma, 1959.

Ingham County

Lansing metropolitan area.--The Saginaw formation is the principal source of water for municipal, industrial, and domestic wells in the area, although a few wells obtain water from the overlying glacial drift. Most of the observation wells in the area are finished in the Saginaw formation and reflect changes in pattern and rate of pumping from the aquifer. A few, including those finished in the glacial drift, primarily reflect climatic conditions (fig. 6).

Generally, in the heavily pumped areas, long-term declines of water level continued and many new lows of record were observed. Due to changes in the pattern of Lansing's pumping in recent years stages did not reach record lows in the northwest part of Lansing--although they were lower than in 1958. The new lows observed in the remainder of the Lansing area occurred in late summer and early fall. However, favorable climatic conditions caused water levels to rise in late fall so that net gains over the end of 1958 were observed in most wells despite the low stages earlier in the year.

Figure 17 shows the long-term graphs of water levels in observation wells around the perimeter of Lansing along with precipitation and total municipal pumpage records. As illustrated the ground-water levels are highest in the southwest part of the area (wells 4N 2W 31-1 and 3N 2W 8-1) and lowest in the northwest and east sections (5N 2W 32-1, 4N 3W 12-1, and 4N 2W 24-1). The declines are slow but general throughout the area and reflect the increase in withdrawals of ground water from the Saginaw formation. From inspection of a similar graph showing the water levels of observation wells through 1958 within the city of Lansing (Giroux, 1960,



Well:		Depth (ft.):
5N 2W	32-1	135
4N 3W	10-1	121
	12-1	381
4N 2W	19-1	87
	24-1	453
	31-1	204
4N 1W	18-1	175
3N 2W	8-1	72

Aquifer: Saginaw formation

EXPLANATION

● Observation well

N

0 1 2 Miles

Location of observation wells used in fig. 17.

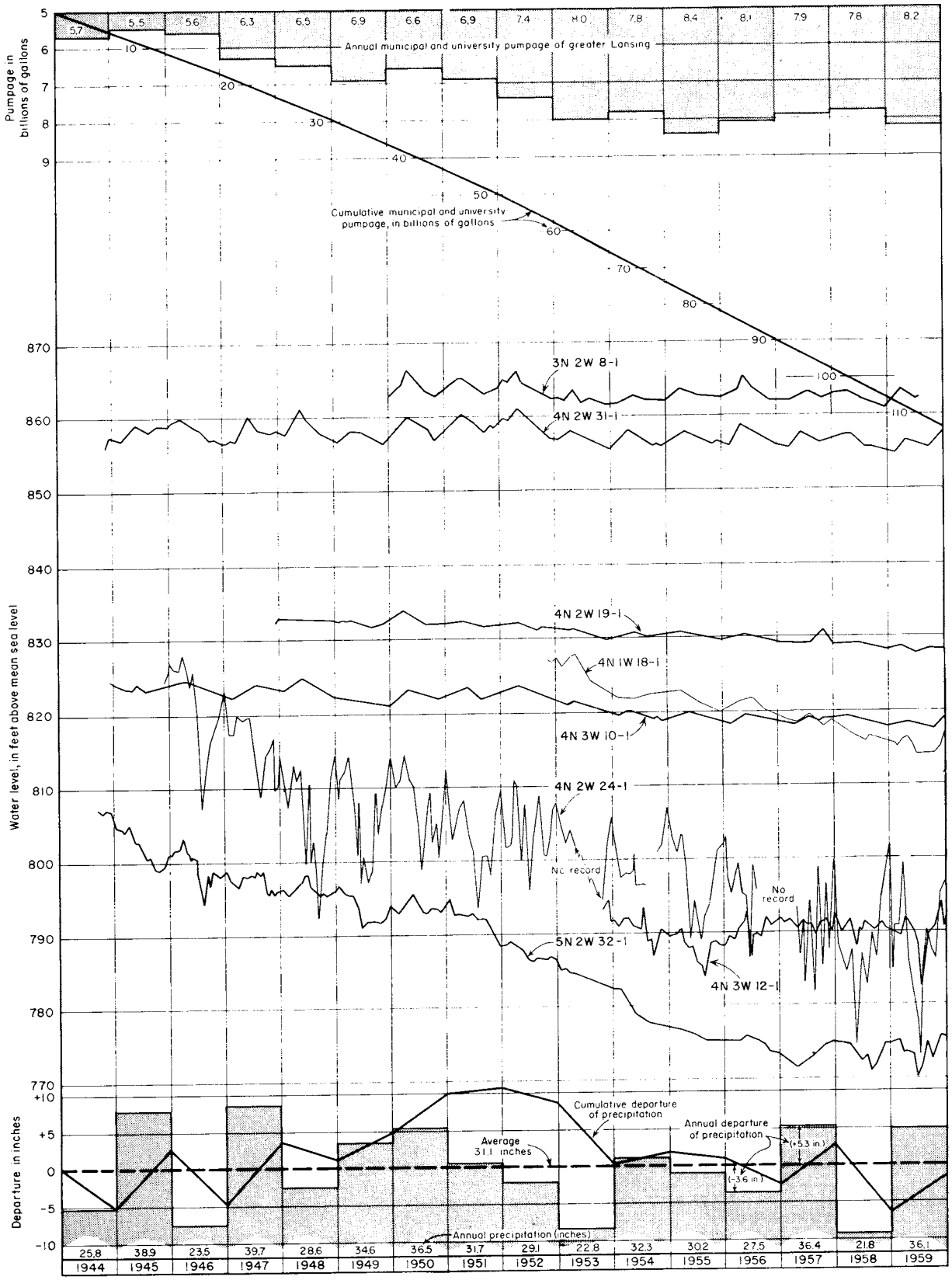


Figure 17. Hydrographs of wells around the perimeter of Lansing, municipal pumpage, and precipitation data, 1944-59.

fig. 18), it is evident that water levels near the center of the cone of depression within the city range from about 90 to 170 feet below stages in wells along the outskirts of the city.

Water levels in observation well 6N 2W 16-1 finished at shallow depth in the glacial drift, 10 miles north of Lansing in Clinton County, were below average as a result of dry weather in 1958, and fell to record low levels in the period July - October 1959 (fig. 6). The year-end stage was above average as the result of about 10 inches of precipitation during the late fall when conditions were favorable for ground-water recharge.

Average daily withdrawals of ground water for municipal use by Lansing, East Lansing, Lansing and Meridian Townships, and Michigan State University were about 22.6 million gallons in 1959. The total pumpage for the year of 8.2 billion gallons was the highest since 1955 and about a 5 percent increase over 1958.

City of Mason.--Observation well 2N 1W 5-1 in Mason is finished in the Saginaw formation. The water levels in the well are affected mainly by industrial pumping from the same formation as the municipal supply is obtained from wells tapping glacial sands and gravels. The water levels in the observation well fell to new record lows in late summer (table 1). However, by the end of the year stages were higher than at the end of 1958.

The total municipal pumpage of about 138 million gallons was slightly more than that reported in 1958.

Jackson County

Most municipal, industrial, and institutional wells in and near Jackson obtain water from the Saginaw formation, Parma sandstone, and the Marshall formation.

Observation well 3S 1W 11-2 is finished in the bedrock formations at the Belden Road municipal well field and reflects withdrawals of ground water from the bedrock by the city of Jackson.

Figure 18 shows the generalized graph of water levels plotted from daily measurements furnished by the city, along with municipal pumpage, and cumulative precipitation departures at Jackson. Although precipitation was slightly below normal, above-average precipitation occurred when conditions were favorable for ground-water recharge. Water levels fell to their lowest point of the 3-year record in late summer, but no net decline for the year occurred as pumping decreased and precipitation increased during the fall months.

Municipal withdrawals of ground water by the city of Jackson (table 2) were reported as 4.5 billion gallons for the year. Daily pumping ranged from an average of 9.7 mgd in November to 16 mgd in July, and 12.4 mgd for the year.

Kalamazoo County

All wells in the greater Kalamazoo area obtain water from the glacial drift aquifers.

Stages in most observation wells reached record or near record lows in 1959 for the 3rd consecutive year (table 1) as the result of the large deficiencies in precipitation of recent years. Figure 19 shows the 14-year record of fluctuation of water levels in 3 observation wells maintained in the area. The hydrograph for well 2S 11W 22-6, located in the central pumping or Axtell Creek area of Kalamazoo, was constructed from records obtained from a continuous recording gage. The graphs for observa-

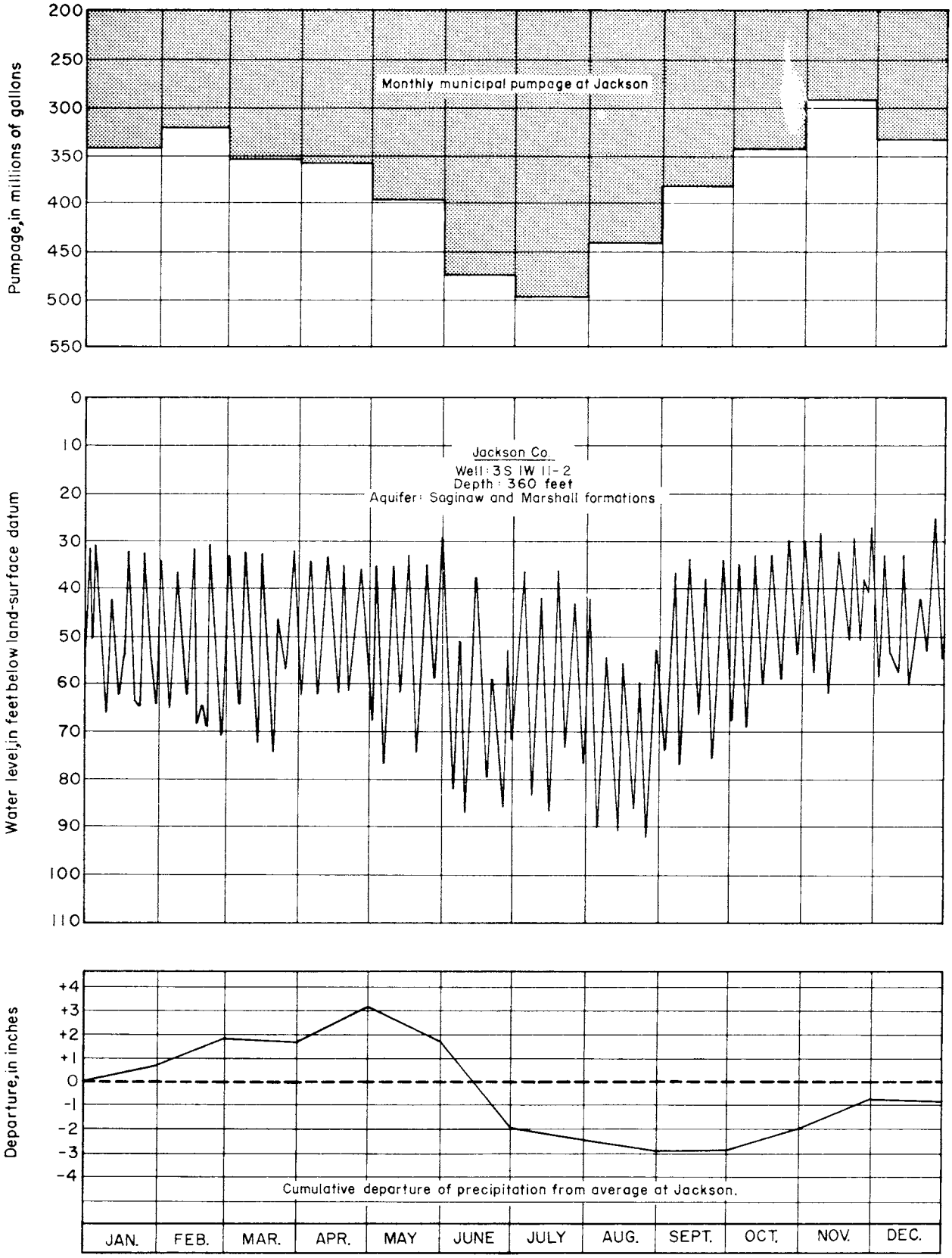


Figure 18. Hydrograph of well at Belden Road Station, municipal pumpage, and precipitation departures at Jackson, 1959.

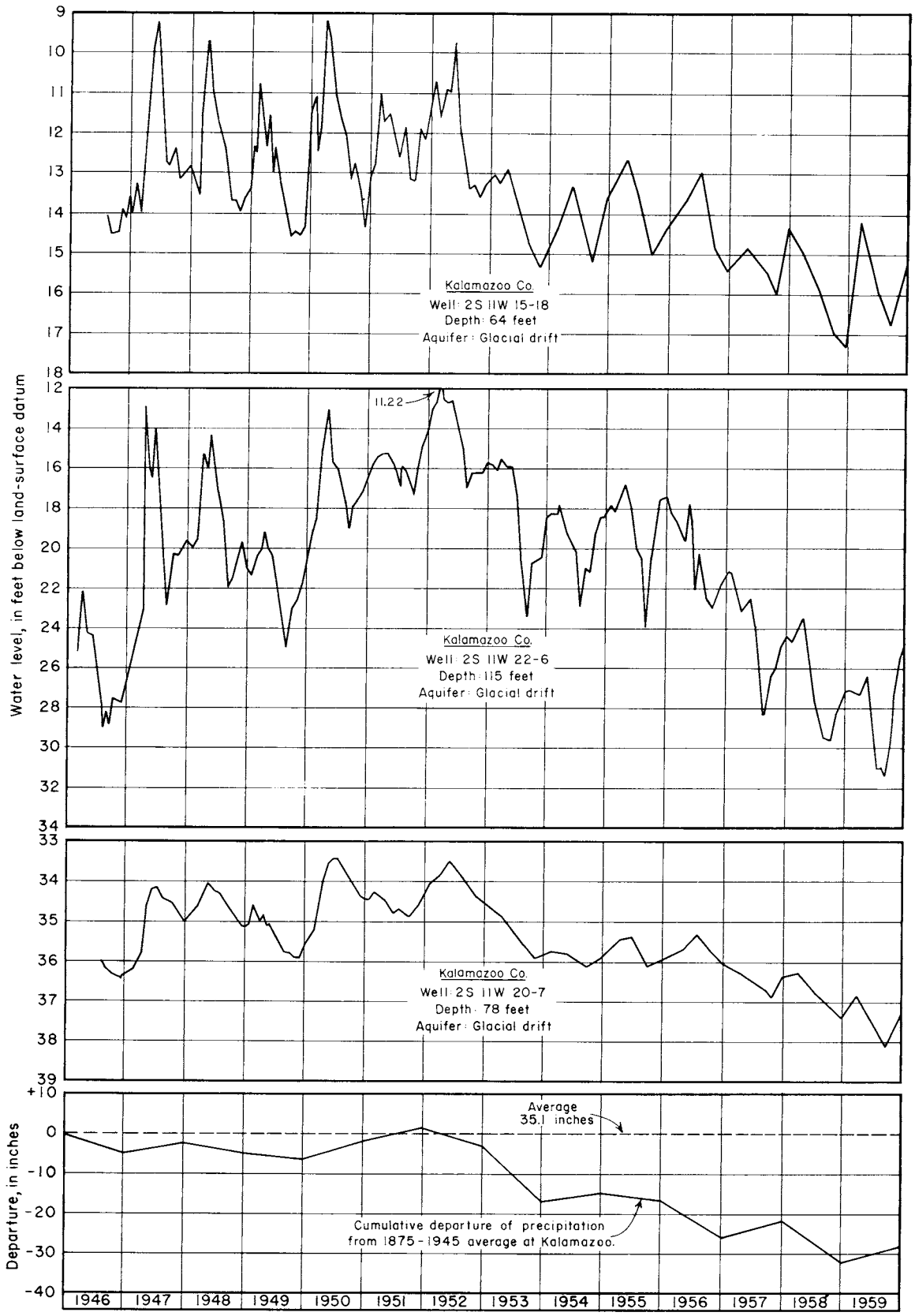


Figure 19. Hydrographs of selected wells, and precipitation departures at Kalamazoo, 1946-59.

tion wells 15-18 and 20-7 are based on seasonal measurements during the last several years.

In 1959 the most favorable periods for recharge occurred in the fall when rainfall was much above average. As a result stages in some wells were higher at the end of 1959 than at the end of 1958.

Although stages have fallen in recent years in this area, it would appear from the precipitation departure graph that the declines are more the result of deficient precipitation, than the effects of increased pumping by municipal and industrial wells. Although levels have fallen the losses have been moderate in terms of actual feet.

Municipal withdrawals of ground water in Kalamazoo (table 2) were reported as a record 5.1 billion gallons for the year, an increase of 0.5 billion gallons or about 10 percent more than in 1958. Daily pumping averaged 14.0 mgd for the year and ranged from 11.1 in March to 19.1 mgd in July.

Oakland County

The observation wells in Pontiac are finished in glacial-drift aquifers, as are the municipal and most of the industrial wells in the area.

Figure 20 shows the effect of municipal pumpage and precipitation on water levels in observation well 3N 10E 32-1 at the city's Walnut Street Station for the 1958-59 period. In 1958, a net increase in water levels of about 1 foot occurred despite a deficiency of 10 inches of precipitation for the year while in 1959, water levels fell about 4 feet although precipitation was 8 inches above normal. Pumpage in 1959, however,

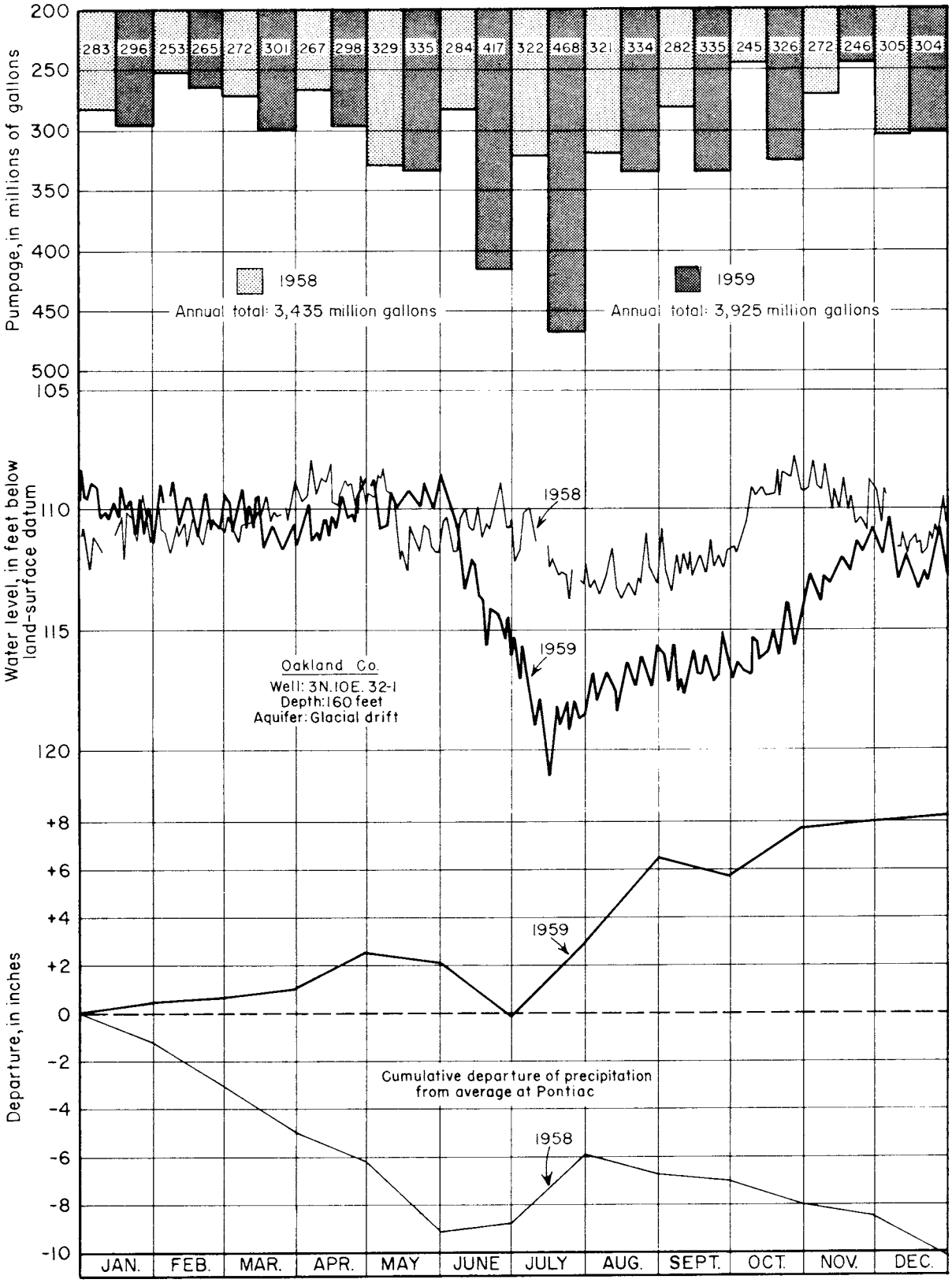


Figure 20. Annual hydrographs of well at Walnut Street Station, total municipal pumpage, and precipitation departures at Pontiac, 1950-59.

exceeded 1958 pumpage by about 0.5 billion gallons. This data demonstrates that water levels in this observation well are affected primarily by pumping.

However, stages in the two Pontiac observation wells have been higher in recent years and in 1959 were several feet above the lows of record observed in 1955 (table 2).

Municipal withdrawals of ground water as reported by the city of Pontiac averaged 10.8 mgd during 1959 and ranged from 8.2 mgd in November to 15.1 mgd in July.

Washtenaw County

All the observation wells in the county are finished in glacial drift and reflect withdrawals of ground water from the drift aquifers by municipal and institutional well fields.

City of Ann Arbor.--The city obtains its water supply from the Huron River and supplements this supply by pumping water from wells tapping the glacial-drift aquifer at the Steere Farm well field south of the city.

Water levels observed in 1959, although somewhat lower than in previous years, were generally higher than in 1958. This was the result of slightly less pumping and more precipitation during 1959.

Municipal withdrawals of ground water by Ann Arbor were reported as 913 million gallons for the year (table 2) as compared to 960 million gallons in 1958. The 1959 pumpage averaged 2.5 mgd and ranged from 1.4 mgd in April to 4.0 mgd in July.

Ypsilanti State Hospital.--Water levels in the two observation wells at the hospital reflect pumping by the institution and also climatic changes.

Stages in the two observation wells were generally the highest of the past several years. This was principally the result of decreased pumpage and increased precipitation during the year.

Institutional withdrawals of ground water were reported as 227 million gallons in 1959--10 percent less than in 1958.

Ypsilanti Township.--The water levels in most of the observation wells at the township well field fell to new lows for the period of record (fig. 21) despite above-average precipitation for the year. Although pumpage increased in 1959 over 1958, it was at about the average for the past five years of record. No measurements were made during the latter part of 1959 but measurements made early in 1960 showed stages to have recovered to about the same levels as at the end of 1958.

The 1959 pumping averaged 5.5 mgd and ranged from 3.7 mgd in November to 6.9 mgd in July.

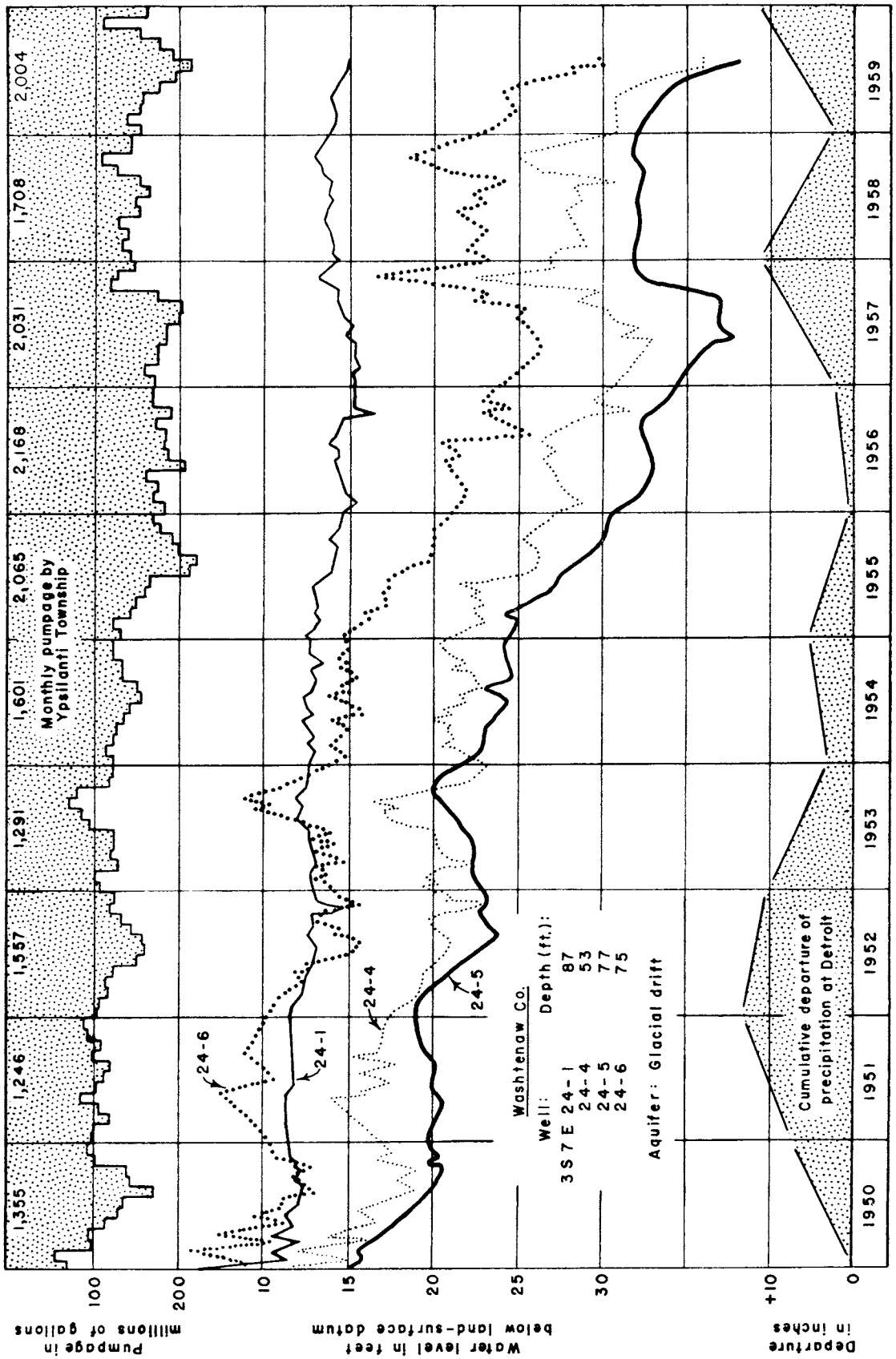


Figure 21. Hydrographs of wells at Ypsilanti Township Waterworks, Township pumpage, and precipitation departures, 1950-59.

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Table 1.--Records of Michigan observation wells and extremes in water levels observed in 1959 and for the period of record.

Owner: MDC - Mich. Dept. of Conservation; WMP - Wisconsin-Michigan Power Co.; MSHD - Mich. State Highway Dept.; USFS - U. S. Forest Service.

Chief Aquifer:

Qgd - Glacial drift deposits of Pleistocene (Quaternary) age
Ps - Saginaw formation of Pennsylvanian age
Mb - Bayport limestone of Mississippian age
Mm - Marshall formation of Mississippian age
Dtb - Thunder Bay limestone of Middle Devonian age
Ds - Sylvania sandstone of Middle Devonian age
Ss - Salina formation of Late Silurian age
Sm - Manistique dolomite of Middle Silurian age
Or - Limestones of Richmond age (Late Ordovician)
Otb - Black River and Trenton limestones of Ordovician age
Op - Prairie du Chien group of Early Ordovician age (previously designated as Au Train formation)
Cm - Munising sandstone of Cambrian age
pC - Rocks of Precambrian age (undifferentiated)
pCf - Freda sandstone of Keweenawan age (Precambrian)

Altitude: Land-surface datum in feet above mean-sea level.

F - 59: Frequency of measurement in 1959. R - Continuous recorder; D - Daily; W - Weekly; M - Monthly; Q - Quarterly; S - Semiannual; A - Annual.

Observed water-level extremes: 1959 measurements underscored are new extremes for entire period of record (in feet below or above (+) land surface).

Remarks: P - water level affected by pumping. Water-level measurements are made by the U. S. Geological Survey unless otherwise noted.

Well number	Location in section (¼ ¼)	Owner	Depth (ft.)	Dia. (in.)	Chief aquifer	Altitude	Years of record	F 59	Observed water level extremes: Through 1958 Highest	Through 1958 Date	Through 1958 Lowest	Through 1958 Date	In 1959 Highest	In 1959 Date	In 1959 Lowest	In 1959 Date	Remarks
Alpena County																	
32N 6E 16-1	NW SW	Harlo Mellon	53	6	Dtb	-	1948-59	M	5.46	4-15-55	16.67	11-12-48	5.40	4-1	10.80	2-1	Record stopped 4-1-59.
30N 6E 6-1	NW NE	R. E. James	19	18	Qgd	785	1946-59	A	0.90	4-13-52	10.12	12- 2-58	*(13.42	4-1)			*1959 Meas. affected by pumping.
Baraga County																	Record stopped 4-1-59.
48N 32W 12-1	SE SE	MSHD (WMP 14)	10	1¼	Qgd	-	1948-59	M	4.19	5- 3-51	6.72	3-15-49	4.43	11-3	6.50	2-26	
Barry County																	
3N 8W 18-1	SE NE	City of Hastings	33	6	Qgd	-	1958-59	R	3.55	8-27-58	5.32	10- 7-58	2.32	4-5	6.71	7-16	P, Recorder removed 11-7-59
Branch County																	
6S 6W 22-1	NE SW	City of Coldwater(3)	130	6	Qgd	-	1949-59	W	10.08	4- 8-50	16.67	1-15-54	12.59	3-6	16.40	7-16	P, Meas. by owner
Calhoun County																	
1S 7W 10-1	NW NW	K. N. Sabin	8	15	Qgd	907.99	1946-59	W	0.89	3-28-50	5.90	1-27-54	3.57	6-3	5.98	2-11	
31-1	NE SW	City of Battle Creek (TW 1)	140	2	Mm	838.92	1945-59	A	+0.08	5-23-50	6.75	10- 6-58	(7.50	9-23)			
32-1	NE SE	do. (Verona 22)	127	8	Mm	830.79	1939-59	D	0.7	4-26-50	15.35	8- 5-58	8.95	12-30	16.75	7-16	P, Meas. by owner
32-2	NE NW	Mrs. Harriett Rice	43	2	Mm	842.88	1946-59	Q	8.98	4-25-50	18.10	10- 6-58	16.77	4-10	18.93	9-23	P
2S 8W 1-1	SW SE	Sherman Mfg. Co.	22	2	Qgd	825.19	1946-59	Q	10.49	4-11-47	18.15	12-17-58	16.20	4-10	18.82	9-23	
2-1	NW SE	Oliver Elec. Mfg.Co. (formerly Post Products Co.)	92	10	Mm	819.99	1946-59	R	4.75	4- 9-47	14.90	12-12-58	12.39	4-12	14.95	9-11	P, Meas. by Battle Creek.

2S 8W 3-1	SE SE	Dominic Conto	12	2	Qgd	862.02	1946-59	Q	1.75	4-28-50	9.24	10- 6-58	5.84	4-10	9.89	9-23				
3-2	SE NE	Eaton Mfg. Co.	80	10	Mm	833.39	1946-59	Q	13.43	4-25-50	24.73	10- 6-58	21.25	12-30	25.41	9-23	P			
3-3	NE SE	P. E. Slayton	64	4	Mm	849.51	1945-59	Q	0.26	4-25-50	10.00	12-17-58	8.39	4-10	12.54	7-6	P, Well destroyed Dec., 1959			
14-1	NE SE	City of Battle Creek (TW 3)	62	2	Qgd	916.05	1939-59	Q	9.10	5-31-52	32.76	3-26-41	11.61	4-10	12.42	9-18	P			
14-2	SE SE	do. (TW 1)	89	26	Qgd	914.97	1945-59	Q	6.22	5-29-50	12.86	10-18-46	8.33	4-10	9.28	9-18	P			
2S 7W 7-1	SW NE	Oliver Farm Implement Co.	74	6	Mm	834.30	1946-59	Q	15.00	4-11-47	23.86	9-19-55	18.50	4-10	24.68	9-23	P			
17-1	NW SW	City of Battle Creek	87	2	Mm	841.78	1945-59	Q	6.57	4-25-50	11.31	10- 6-58	8.45	4-10	11.38	9-23	P			
18-1	SW SW	do.	87	2	Mm	832.49	1945-59	Q	+0.50	4-25-50	3.24	9-21-49	0.39	4-10	2.74	9-18	P			
2S 6W 25-1	NE NE	City of Marshall (Ferguson)	59	6	Mm	904.85	1950-59	M	5.46	5- 9-50	9.59	10- 6-58	7.50	5- ?	9.52	1- ?	P, Meas. by owner			
25-2	SE NW	do.(Egeler)	67	6	Mm	901.15	1950-51, 56-59	Q	6.50	9-14-50	9.00	8-14-57	7.55	4-10	8.86	9-23	P			
25-3	SW SE	do.(Filkin)	82	4	Mm	914.15	1950-59	Q	19.71	5- 3-50	26.32	12-19-56	22.59	4-10	24.40	9-23	P			
Cass County																				
6S 16W 1-1	SW NE	City of Dowagiac	159	10	Qgd	750.19	1949-59	W	+4.20	11-30-51	5.97	7-24-53	+4.60	12-25	5.64	7-17	P, Meas. by owner			
8S 14W 17-1	NE NW	Ted Little	55	28	Qgd	-	1945-59	W	46.20	7-16-50	55.03	3-10-47	50.80	7-26	52.74	3-8				
Charlevoix County																				
33N 4W 2-1	SW NE	MDC	94	6	Qgd	-	1948-59	Q	70.85	7-19-52	75.85	4-16-56	70.48	7-9	73.25	4-16				
32N 4W 10-1	NE SE	MDC (33)	17	2	Qgd	-	1934-41, 48-59	M	1.19	3-30-58	7.02	10- 7-58	3.75	5-13	7.42	2-12				
Cheboygan County																				
34N 1W 1-1	NW SW	MDC (7)	11	2	Qgd	-	1938-41, 48-52, 55-59	Q	2.75	3-28-38	5.55	10-13-55	3.31	4-14	4.36	9-30				
Chippewa County																				
46N 4W 24-1	NE SE	USFS	54	6	Qgd	-	1952-59	R	e22.45	7-25-57	27.77	4-12-56	23.52	6-12	27.26	4-16	e/ estimated			
45N 1W 28-3	SW SW	MDC	28	1¼	Qgd	-	1958-59	M	25.74	11- 7-58	25.97	12-30-58	24.80	12-29	26.37	3-30				
Clinton County																				
8N 1W 13-1	SW NW	Village of Elsie	298	12	Ps	699.68	1947-59	M	+3.78	6- 3-50	37.55	10-15-57	5.19	11-30	19.60	5-28	P			
13-3	SW NW	do. (3)	45	12	Qgd	706.17	1947-59	M	8.3	4- 5-50	26.4	10-11-49	7.33	12-28	22.79	8-27	P			
6N 2W 16-1	SE SE	MSHD	23	14	Qgd	803.32	1948-59	M	14.59	4-19-52	18.53	12-29-53	16.80	4-30	18.39	10-30				
5N 2W 32-1	SW SE	Mich. Health Dept.	135	4	Ps	849.21	1944-59	M	42.02	9-14-44	78.47	8-28-58	73.55	11-30	79.06	6-29	P			
Crawford County																				
27N 1W 22-1	NE NE	MDC (27)	12	2	Qgd	-	1934-59	S	3.51	4-18-52	6.38	1-27-56	2.67	9-30	3.82	4-20				
26N 4W 11-1	NW SW	MDC	12	15	Qgd	1147.59	1942-59	R	4.03	6- 1-43	9.85	9- 3-58	5.46	4-16	9.06	3-2				
25N 3W 28-1	SW SW	MDC (8)	13	1¼	Qgd	1175.14	1934-37, 39-59	Q	8.70	6-15-43	11.28	10-22-58	9.93	4-21	10.51	9-30				
25N 1W 15-1	SE SE	USFS	56	6	Qgd	-	1948-59	R	29.44	8- 4-53	35.97	4- 4-51	31.53	7-18	35.31	4-11				
Delta County																				
43N 19W 24-3	NW NW	Harry Clarage	405	4	Otb	-	1958-59	R,M	79.27	10-10-58	79.64	12-29-58	79.46	11-27	80.06	4-9	Recorder removed 9-30-59.			
42N 19W 20-3	NE NE	USFS	134	6	Or	-	1958-59	M	25.42	7-23-58	25.84	8-27-58	25.47	11-27	25.86	3-31				
42N 18W 17-2	SW NE	USFS	60	6	Qgd	-	1958-59	M	23.77	7-22-58	24.62	11-28-58	23.78	11-27	24.97	3-31				
41N 19W 17-1	NE SW	USFS	58	6	Or	635±	1958-59	M	1.75	11-28-58	3.62	8-27-58	0.89	10-28	3.82	8-26				

Table 1.--Records of Michigan observation wells and extremes in water levels observed in 1959 and for the period of record.--Continued

Well number	Location in section (¼ ¼)	Owner	Depth (ft.)	Dia. (in.)	Chief aquifer	Altitude	Years of record	F 59	Observed water level extremes: Through 1958 Highest	Through 1958 Date	Through 1958 Lowest	Through 1958 Date	In 1959 Highest	In 1959 Date	In 1959 Lowest	In 1959 Date	Remarks
Delta County (Continued)																	
41N 18W 31-2	SE SW	Charles Thompson	250	4	Or	-	1958-59	R	4.08	9- 6-58	5.65	12-17-58	3.84	10-25	5.91	8-3	
40N 22W 4-2	NE NW	USFS	40	5	Qgd	-	1958-59	M	22.86	8- 6-58	23.19	11-24-58	22.84	12-31	23.50	4-28	
39N 23W 28-3	SW NE	Marshall and Sherman Blake	530	5	€m	680±	1958-59	R	2.08	7-10-58	3.86	9-28-58	1.99	10-24	3.33	8-1	
38N 22W 24-1	NW SE	USFS (3)	36	6	Or	585±	1958-59	M	2.91	7-24-58	5.53	10-27-58	1.12	4-28	4.96	8-26	
Dickinson County																	
43N 29W 32-1	NW NE	Dickinson Co.(WMP 11)	12	1¼	Qgd	-	1948-59	M	5.12	4-18-51	dry	10-12-48	7.70	4-30	dry	9-1	Meas. by WMP
42N 27W 33-1	NE NW	E.W. La Freniere (WMP 10)	12	36	Qgd	-	1945-46, 48-59	M	3.08	4-29-54	10.75	10- 3-55	4.03	10-1	9.33	2-26	Do.
41N 30W 25-1	NE SW	Dickinson Co.(WMP 1)	20	1¼	Qgd	-	1948-59	M	3.51	10-30-51	dry	10- 3-55	6.17	11-3	dry	1-30	Do.
25-2	NW SE	Wm. Carrolo (WMP 2)	16	36	Qgd	-	1945-46, 48-59	M	2.61	10-30-51	dry	1-30-59	3.10	11-3	dry	1-30	Do.
25-3	SE NE	Oscar Martinson (WMP 3)	12	48	Qgd	-	1945-46, 48-59	M	1.73	7- 6-53	dry	11- ?-48	2.27	11-3	9.24	2-26	Do.
Eaton County																	
4N 4W 2-1	SW SW	City of Grand Ledge	376	12	IPs	846.59	1948-59	W	21.34	5- 5-50	28.79	12- 3-49	26.32	4-27	29.72	9-14	P, Meas. by owner
4N 3W 10-1	SE NE	John Schneeberger	121	3	IPs	855.99	1944-59	M	31.28	5-27-48	38.41	12-30-58	37.34	12-29	38.59	10-28	P
12-1	SE SW	F. A. Wheeler (formerly Mrs. Harold Worden)	381	6	IPs	861.91	1953-59	R	67.51	11-23-53	78.10	8-19-55	68.2	11-24	79.4	7-16	P
24-1	SE SE	J. R. McLaughlin	22	12	Qgd	851.96	1944-59	S	0.14	4-24-50	dry	12-12-55	16.63	3-31	21.16	6-29	Often dry. Record stopped 6/29/59.
2N 4W 19-1	NW SW	City of Charlotte	25	240	Qgd	889.44	1947-59	Q	8.04	4- 7-47	15.90	10- 6-58	13.02	4-10	16.48	9-23	P
Genesee County																	
7N 7E 9-1	SE SW	Consumers Power Co.	288	12	IPs	761.83	1946-59	Q	17.50	4-11-48	45.48	7-20-57	24.08	3-30	30.93	9-2	P
17-1	SE NE	do.	222	12	IPs	757.83	1946-59	R	24.23	2-12-50	37.99	8-24-55	25.88	12-29	35.9	8-19	P
20-2	SW SW	City of Flint	169	2	Qgd	749.48	1947-59	Q	1.09	4-26-50	9.07	9-15-55	4.50	4-29	7.75	9-2	
29-1	SE SW	C. F. Crain	14	1½	Qgd	776.63	1946-59	Q	1.69	12-22-49	10.46	9-23-58	4.20	9-2	9.31	6-24	
29-2	SW SE	Jack Palmer	8	18	Qgd	779.86	1946-59	Q	+0.20	6-29-48	8.50	12-15-58	2.83	4-29	7.74	6-24	
32-1	SW SW	A. W. Arndt	140	2	Qgd	792.27	1946-59	Q	18.51	6- 2-47	32.66	12-15-58	32.70	4-29	35.36	9-2	
6N 7E 9-1	SW SE	Fisher Body Div.,GMC (formerly Grand Blanc Tank Plant (6)	375	6	Ps	841.71	1952-59	R	37.79	11-24-52	52.9	8- 3-55	46.2	12-28	57.8	7-15	P
Gladwin County																	
17N 1W 7-1	SW NW	City of Beaverton	93	12	Qgd	721.50	1950-59	D	28.90	5-14-56	49.35	6-26-50	27.94	4-6	47.36	2-16	P, Meas. by owner
Grand Traverse County																	
27N 9W 4-1	NW NE	MDC (18)	15	2	Qgd	687.01	1934-37, 41-44, 48-52, 55-59	M	0.91	9-20-44	2.54	7-26-35	0.80	4-14	1.83	8-4	
26N 11W 27-1	NW SW	MDC (2)	14	2	Qgd	914.25	1935-37, 41-44, 48-59	Q	1.32	10-30-51	4.02	8-18-36	1.20	4-14	3.24	9-30	
26N 9W 13-1	SW SW	MDC (2)	14	2	Qgd	961.78	1934-37, 41-44, 48-59	M	4.72	7-17-57	7.87	10-11-49	5.16	4-14	7.70	2-19	

Gratiot County																			
12N	3W	34-1	SW SE	S. J. Brown	55	2	Qgd	727.12	1947-59	M	6.08	4-26-48	40.87	6-28-50	20.65	2-27	37.64	8-26	P
		35-3	NW SW	Walter Stone	26	2	Qgd	732.62	1947-59	M	10.07	5- 3-48	24.30	8-27-58	19.57	5-1	22.74	9-25	P
		35-5	SW NW	Reed Excavating Co.	20	36	Qgd	738.78	1950-59	M	13.74	4- 7-50	17.91	11-12-53	14.67	5-1	17.48	1-30	
12N	2W	18-1	NE NW	Mich. Chemical Co.	1350	5½	Mm	-	1957-59	R	242.3	12-31-58	267.7	8-30-57	227.5	12-28	242.3	1-1	
11N	3W	2-2	NW NE	Layne Water Co.(2)	130	8	Qgd	744.15	1947-59	M	25.0	4-29-48	72.5	8-26-50	67.23	2-27	68.49	1-30	P, Record stopped 2-27-59.
		3-6	NW NW	E. H. Waber	49	2	Qgd	733.20	1946-59	M	7.64	2-27-51	32.98	12-16-55	4.99	2-27	30.36	9-25	P
		5-1	SE NE	John Pfarr	162	4	Qgd	740.97	1955-59	M	11.01	7-10-56	16.45	8-13-57	13.21	5-1	16.30	7-24	P, Record stopped 7-24-59.
		36-1	SE SE	Village of Ithaca	785	8	Ps	804.50	1947-59	M	78.25	1-22-52	83.96	9- 4-49	79.88	5-1	81.55	9-25	
Hillsdale County																			
6S	3W	23-2	NW NW	City of Hillsdale (TW 6)	26	6	Qgd	-	1957-59	W	2.24	4-12-57	12.96	9-18-57	1.72	2-16	11.07	9-21	P
Ingham County																			
4N	2W	4-1	NW SW	C&O R.R. (East 1)	38	12	Qgd	842.19	1953-59	M	25.98	3- 3-53	33.57	12-30-58	33.11	12-29	34.38	12-28	P
		9-1	SE NW	City of Lansing (Seymour 1)	401	14	Ps	828.81	1929-59	M	15.63	3-26-31	154.77	4-10-56	132.6	12-21	147.8	6-19	P, Meas. by owner
		9-2	SW NW	Consumers Power Co.	370	12	Ps	820.69	1945-59	Q	61.26	3-23-46	143.27	12-12-55	123.91	12-29	132.34	6-29	P
		16-1	NE SE	City of Lansing (Cedar)	417	12	Ps	829.11	1945-59	Q	42.01	3-11-46	67.0	8-22-49	58.70	3-31	61.39	9-24	P
		17-1	NW NE	City of Lansing (Logan)	424	20	Ps	858.72	1929, 31, 33-59	Q	34.34	12- ?-29	149.64	4-11-56	131.72	12-29	142.0	7-23	P
		17-2	NW NW	Olds Drop Force (4)	417	12	Ps	872.55	1946-59	Q	104.86	12-10-46	148.47	4-10-56	134.31	12-29	143.24	9-24	P
		19-1	SW SW	Waverly Hills Assoc.	87	2	Ps	833.94	1947-59	Q	0.00	3-29-50	5.77	12-30-58	5.42	3-31	6.31	6-29	P
		21-1	NE NW	City of Lansing (Townsend)	410	14	Ps	834.10	1906, 19, 29-59	Q	2.0	5- 9-06	63.64	7-30-57	65.23	12-29	74.33	8-21	P
		22-1	SW NW	City of Lansing (P-5)	338	12	Ps	823.64	1930-59	M	7.1	7- ?-32	57.62	12-30-58	50.18	12-21	58.68	10-16	P
		23-1	NE NW	City of Lansing (RS-7)	467	12	Ps	824.86	1930-32, 36-59	M	7.55	11-17-30	105.28	7-17-56	88.11	1-?	116.28	7-23	P, Meas. by owner
		24-1	NE SW	Mich. State Univ.	453	10	Ps	853.45	1945-59	R	25.47	3-25-46	78.4	5-30-58	50.2	1-5	e80.0	7-17	P, e - estimated
		28-1	NE NW	Atlas Drop Forge(2)	425	8	Ps	849.20	1944-45, 48-59	Q	30.28	4-23-48	54.40	8-19-48	49.83	3-31	53.90	9-24	P
		31-1	SW SW	C. A. Weber	204	3	Ps	880.15	1944-59	M	18.92	4-26-52	25.35	12-30-58	22.87	12-29	25.57	2-27	P
4N	1W	18-1	SE NE	Marble School	175	3	Ps	847.85	1952-59	M	20.09	4-27-53	32.56	10-30-58	31.53	12-29	34.05	7-31	P
3N	2W	8-1	NW NW	F. H. Kraus	72	3	Ps	876.67	1950-59	M	10.43	5- 1-50	15.70	12-30-58	13.28	3-31	14.62	6-29	Record stopped July, 1959.
		23-2	SE NE	Delhi Twp.	268	8	Ps	-	1959	R	-	-	-	-	3.75	11-15	4.90	10-29	P, Record started 10-14-59.
2N	1W	5-1	SE SE	City of Mason (old 2)	150	6	Ps	-	1948-59	W	0.08	6-29-49	7.37	9-17-55	2.54	3-21	7.79	8-1	P, Meas. by owner
Ionia County																			
7N	6W	19-1	NE NE	City of Ionia (8)	143	12	Qgd	-	1957-59	R	46.29	4- 5-58	49.27	11- 9-57	45.39	4-28	48.07	1-6	P, Record stopped 7-20-59.
6N	5W	33-1	- NE	Barley-Earhart Co.	15	180	Qgd	-	1957-59	R	7.23	3- 1-58	10.16	8-18-58	6.19	3-21	10.25	7-17	
Iosco County																			
23N	7E	7-1	NE SE	USFS	341	6	Qgd	-	1948-59	Q	25.13	8- 3-52	27.94	1- 3-50	26.37	12-15	28.10	4-27	
Iron County																			
46N	34W	14-1	NE NW	Oliver Iron Mining Co. (WMP 18)	12	1¼	Qgd	-	1945-59	M	3.65	6- 2-54	8.60	3-15-49	5.37	4-30	7.64	2-26	Meas. by WMP.
46N	33W	18-1	SW NW	MSHD (WMP17)	12	1¼	Qgd	-	1948-59	M	2.80	4-18-49	dry	2-28-56	4.80	11-3	7.40	2-26	Do.
45N	37W	23-1	SW NE	USFS (WMP 28)	8	1¼	Qgd	-	1948-59	M	0.75	8-31-51	4.72	9-11-48	1.26	10-2	3.52	7-31	Do.

Table 1.--Records of Michigan observation wells and extremes in water levels observed in 1959 and for the period of record.--Continued

Well number	Location in section (¼ ¼)	Owner	Depth (ft.)	Dia. (in.)	Chief aquifer	Altitude	Years of record	F 59	Observed water level extremes: Through 1958 Highest	Date	Lowest	Date	In 1959 Highest	Date	Lowest	Date	Remarks
45N 35W 33-1	SE NW	MSHD (WMP 34)	12	1¼	Qgd	-	1948-59	M	1.93	7- 6-53	8.44	3-15-49	3.90	11-30	7.27	3-31	Meas. by WMP.
45N 33W 8-1	SW SW	Basilo Prandi	33	36	Qgd	-	1945-59	M	23.39	10-30-51	32.16	3-15-49	24.81	11-3	27.75	4-30	Do.
44N 37W 14-1	NW NW	USFS (former James Lake CCC)	102	6	Qgd	-	1959	R	-	-	-	-	94.80	10-24	95.75	10-22	Record started 9-16-59.
44N 35W 6-1	SW SW	USFS (Paint R. 1)	6	1¼	Qgd	1468.15	1948-59	M	+0.10	5- 2-51	2.26	11-15-48	0.41	10-2	2.18	7-30	Meas. by WMP.
6-2	SW SW	USFS (do. 2)	13	1¼	Qgd	1475.14	1948-59	M	5.08	7- 6-53	8.92	11-15-48	6.11	10-2	8.67	10-30	Do.
7-1	NW NW	USFS (do. 4)	4	1¼	Qgd	1469.28	1948-59	M	1.12	5- 2-51	3.73	8- 1-47	1.69	10-2	3.58	7-30	Do.
7-2	NW NW	USFS (do. 5)	13	1¼	Qgd	1471.25	1948-59	M	2.50	7- 6-53	9.44	10-26-48	3.42	10-2	5.43	7-30	Do.
7-3	NW NW	USFS (do. 6)	17	1¼	Qgd	1475.83	1948-59	M	8.48	5- 2-51	13.40	10-26-48	10.64	10-1	12.90	7-30	Do.
44N 33W 10-1	SW SW	Iron Co. (WMP 21)	8	1¼	Qgd	-	1948-59	M	1.95	4-29-54	7.94	1-12-51	2.40	10-1	6.46	2-26	Do.
43N 36W 1-1	SW NE	do. (WMP 27)	9	1¼	Qgd	-	1948-59	M	6.67	4-29-54	9.02	6-30-52	7.36	10-2	8.70	4-30	P, Do.
43N 35W 11-1	SE NE	J. J. Javoroski (WMP 23)	47	36	Qgd	-	1945-59	M	39.33	1-11-52	47.08	8-15-49	41.90	10-30	43.92	7-30	P, Do.
13-1	SW SE	F. V. Gendzwill (5)	65	36	pS	-	1945-59	A	47.90	9-11-46	63.68	11-30-46		(53.05, 9-25)			Mine drainage study.
13-2	SW SE	Boyington (hole 4-44)	?	?	?	-	1945, 47-59	A	66.39	1-14-52	71.56	3-24-49		(69.90, 9-25)			Do.
20-1	SW SE	Mrs. B. Henriksen (WMP 25)	48	1¼	Qgd	-	1945-59	M	41.66	6-20-53	48.29	8-15-49	46.96	6-1	46.43	3-31	Well destroyed 7-30-59.
24-1	SE NE	Spies-Johnson No. 73 (7)	?	3	Qgd?	-	1945-59	A	70.42	11-20-56	86.05	1-19-49		(71.34, 10-10)			Mine drainage study.
26-1	SW NE	City of Iron River (1)	130	2	Qgd	-	1945-59	A	22.48	10-10-58	44.58	3-24-50		(21.91, 9-16)			P
43N 34W 19-1	NW SW	Spies-Johnson No. 3004 (8)	?	3	Qgd?	-	1945-59	A	63.37	12-20-56	89.5	10-20-45		(64.53, 9-16)			Mine drainage study.
19-2	NE SW	Spies-Johnson No. 3c (9)	?	3	Qgd?	-	1945-59	A	69.35	12-20-56	84.10	12-21-48		(70.79, 9-16)			Do.
29-1	SW NE	Rogers Mine (11)	?	48	Qgd	-	1947-53, 56-59	A	10.31	8-15-53	20.69	3-24-50		(18.64, 9-16)			Do.
43N 32W 26-2	NE SW	Caya Mine (17)	?	?	Qgd?	-	1952-59	M	1.04	5-12-55	86.03	3-18-53	5.29	11-23	8.17	9-25	Do.
42N 36W 15-1	NE SW	MSHD (Brule R. 1)	6	1¼	Qgd	1543.92	1948-59	M	0.81	4-29-54	3.17	10-26-48	1.38	10-2	3.05	7-30	Meas. by WMP.
15-2	NE SW	MSHD (do. 2)	7	1¼	Qgd	1545.60	1948-59	M	0.46	7- 6-53	3.10	10-26-48	0.99	10-2	2.71	7-30	Do.
15-3	NW SW	W. Young Estate (Brule R. 3)	14	1¼	Qgd	1554.36	1948-59	M	3.67	4-29-54	8.29	10-26-48	4.61	10-2	7.97	2-26	Do.
42N 34W 7-1	SW NE	Zimmerman No. 1(15)	171	12	Qgd	1165.32	1945-59	A	131.46	10-10-58	153.27	4-21-50		(136.29, 9-25)			Mine drainage study.
42N 31W 33-1	NW SE	Iron Co. (WMP 7)	11	1¼	Qgd	-	1948-59	M	+0.03	7- 3-56	6.28	10-13-48	0.24	11-2	4.85	2-26	Meas. by WMP.
33-2	NW SE	Joseph Giachino (WMP 8)	12	15	Qgd	-	1945-59	M	1.89	10-30-51	12.22	2-25-53	3.16	11-2	11.72	2-26	Do.
41N 31W 10-1	SW NE	Iron Co. (WMP 5)	17	1¼	Qgd	-	1948-59	M	8.47	1- 3-52	dry	12-15-48	12.00	11-30	dry	4-30	Do.
							Jackson County										
1S 1E 36-9	SE SE	MDC (9)	9	1¼	Qgd	920.28	1956-59	W	0.42	5-10-56	6.80	12-30-58	1.09	4-10	5.81	8-13	
3S 1W 11-2	NE NE	City of Jackson (4a)	360	6	IPs, Mm	-	1957-59	D	21.1	7- 7-57	71.5	8-14-57	25.0	12-27	93.0	8-26	P, Meas. by owner
							Kalamazoo County										
2S 11W 3-60	NE NE	KVP Co. (61)	36	6	Qgd	763.18	1956-59	W	10.05	3-10-58	12.05	10-14-57	10.17	4-6	12.82	9-18	Do.
15-18	NE SE	Consumers Power Co.	64	12	Qgd	766.17	1946-59	Q	9.20	3-28-50	17.29	12-17-58	14.22	3-25	16.74	9-17	P
20-7	SW SE	Western Mich. Univ.	78	8	Qgd	868.68	1946-59	Q	33.44	6-19-50	37.40	12-18-58	36.85	3-25	38.15	9-17	

2S 11W 22-6	NE SW	City of Kalamazoo	115	6	Qgd	777.45	1946-59	R	11.22	3-11-52	29.77	10-10-58	24.74	12-28	31.48	9-11	P, Meas. by owner
27-52	NE NE	Bryant Paper Co.(7)	113	12	Qgd	802.59	1946-59	R	34.46	5- 5-50	64.37	9- 1-46	45.08	12-28	48.45	8-25	P, Meas. by city of Kalamazoo.
29-3	SW SE	Oakwood, Inc.	47	2	Qgd	880.72	1946-59	Q	26.12	8- 1-52	30.26	12-18-58	30.02	7-7	30.58	12-30	
4S 11W 21-2	NW SW	Willis Chamberlain	19	1¼	Qgd	-	1957-59	W	13.25	4-19-58	14.88	12-29-58	12.49	6-10	15.12	2-8	
3S 11W 4-35	SE NE	City of Kalamazoo	135	3	Qgd	854.03	1959	R	-	-	-	-	5.46	10-13	12.89	11-3	Record started 10-13-59., P
4-36	SE NE	do.	40	3	Qgd	854.01	1959	R	-	-	-	-	4.93	10-13	9.12	11-4	Do.
Kalkaska County																	
27N 5W 36-1	SE NW	MDC (100)	16	1¼	Qgd	-	1939-59	W	11.12	7-11-43	14.69	3-12-40	12.30	6-26	14.54	3-20	
Kent County																	
6N 12W 17-1	SE NE	Jervis Corp. (1)	30	12	Qgd	-	1950-59	M	6.88	6- 8-56	16.45	2-12-54	8.83	4-28	13.05	2-3	P, Meas. by owner
17-2	SE NE	do.	26	6	Qgd	606.05	1950-59	M	7.34	6- 1-56	16.32	2-12-54	8.76	4-28	12.92	2-3	P, Do.
Lake County																	
17N 13W 4-1	SE NE	C&O RR (West Well)	83	8	Qgd	-	1957-59	Q	19.34	7-18-57	20.36	5-23-58	18.23	4-14	19.32	9-30	
Livingston County																	
2N 4E 3-1	NW SW	Howell State Sanitarium	148	8	Ps	-	1958-59	R	11.1	7- 9-58	27.8	12-13-58	10.2	4-30	26.2	6-9	P, Meas. by owner
9-1	NW NE	Howell State Sanitarium (TW 3)	280	6	Ps	-	1958-59	R	110.6	7-12-58	115.2	5-23-58	109.9	4-3	120.1	9-4	P, Do.
Mackinac County																	
42N 2W 7-1	NE NE	USFS (Pontchartrain)	102	6	Sm	-	1956-59	R	15.15	7- 5-57	29.35	11- 5-57	13.80	5-7	29.11	3-18	
9-1	NE NW	Kenneth Kerr	84	2	Sm	-	1956, 59	M	+1.0	*	3.83	8-28-58	*		3.87	2-26	*Often flows. Not meas. in winter
41N 5W 23-1	SW NW	MDC (Round Lake)	47	6	Ss	-	1956-59	R,M	5.80	4-13-57	17.09	11- 8-57	4.30	5-7	17.48	3-19	
Manistee County																	
23N 14W 21-1	NE SW	Village of Kaleva	70	8	Qgd	-	1959	R	-	-	-	-	9.50	11-10	10.65	9-22	P, Record started 6-17-59.
21N 14W 13-1	NE NE	MDC	63	6	Qgd	-	1949-54, 59	M	12.54	5- 8-51	16.45	10- 7-58	12.84	5-12	16.22	3-10	Record stopped 6-8-59.
Marquette County																	
45N 30W 1-1	SW NW	Arnold Janofski (WMP 4)	31	36	Qgd	-	1945-59	R	24.38	12-13-51	29.28	3-15-49	26.38	12-29	28.14	3-31	Meas. by WMP
45N 25W 28-1	NE NW	MDC (Gwinn CCC)	18	6	Qgd?	-	1958-59	M	4.10	8- 5-58	4.72	8-27-58	2.60	10-29	4.82	3-31	Not meas. in winter.
44N 26W 28-1	NE SE	MDC (Escanaba R. CCC)	31	6	Qgd	-	1953-59	M	2.05	5-10-54	2.83	8-30-57	2.11	12-28	2.64	7-30	
Mason County																	
17N 15W 3-1	SE SW	USFS	32	6	Qgd	737.37	1948-59	M	14.44	5-15-52	19.45	8-24-58	14.65	5-25	18.16	2-24	
Montcalm County																	
9N 8W 10-1	SW NW	City of Greenville(1)	29	12	Qgd	-	1957-59	R	3.35	11-17-57	7.76	6-13-58	4.36	12-29	7.90	8-6	P
15-1	SW NW	do. (9)	65	12	Qgd	-	1950-59	M	11.40	4- 1-50	17.40	8- 1-58	14.05	5-1	15.70	7-1	P, Meas. by owner

Table 1.--Records of Michigan observation wells and extremes in water levels observed in 1959 and for the period of record.--Continued

Well number	Location in section ¼ ¼	Owner	Depth (ft.)	Dia. (in.)	Chief aquifer	Altitude	Years of record	F 59	Observed water level extremes: Through 1958 Highest	Date	Lowest	Date	In 1959 Highest	Date	Lowest	Date	Remarks
							Montmorency County										
32N 2E 34-1	NW NE	MDC	24	2	Qgd	-	1948-59	Q	17.41	5-15-52	21.12	12- 3-58	19.83	12-3	20.60	4-15	
29N 3E 21-1	NW NE	MDC (32)	14	2	Qgd	-	1945-59	Q	2.63	5-15-52	5.91	1-27-56	4.45	12-2	5.90	4-1	
							Oakland County										
3N 10E 31-1	NE SW	City of Pontiac (Orchard L.)	173	12	Qgd	-	1952-59	R	109.2	1- 5-53	128.0	8- 6-55	107.7	2-16	122.5	7-17	P, Meas. by owner
32-1	SE NW	City of Pontiac (6)	160	8	Qgd	921.88	1939-59	R	59.55	4-22-40	129.5	8- 5-55	108.3	1-2	121.0	7-17	P, Do.
2N 10E 22-1	NE NW	Cranbrook School(3)	65	6	Qgd	-	1950-59	W	11.00	4-30-56	17.60	9-26-55	11.30	4-6	17.05	10-5	P, Do.
							Ogemaw County										
23N 1E 4-1	SE NE	MDC (15)	21	4	Qgd	-	1934,55-59	Q	1.73	7-15-57	4.26	10-10-55	1.49	4-21	2.97	9-30	
23N 2E 2-1	NE NW	Charles Hudson	7	36	Qgd	-	1951-59	R	0.37	5- 5-52	4.16	11- 5-58	0.53	5-20	4.30	3-5	
							Ontonagon County										
51N 41W 8-1	SE NW	Mich. Corrections Dept.	100	6	pEf	620±	1958-59	R	9.90	12-27-58	11.87	10-18-58	8.18	4-15	13.3	7-31	
							Otsego County										
29N 3W 29-1	SW SE	MDC (106)	15	2	Qgd	-	1933-59	Q	5.56	5-14-47	9.74	10- 7-58	7.97	9-30	8.59	7-9	
							Presque Isle County										
33N 2E 30-1	NE SE	MDC (19)	14	2	Qgd	-	1934-44, 48-59	Q	**1.80**	5-23-38	5.69	1-27-56	2.40	7-7	3.64	4-15	
							Roscommon County										
24N 2W 20-1	NE NW	MDC (1)	14	8	Qgd	1145.30	1934-59	R	2.78	5- 3-51	6.23	12- 6-49	3.48	5-20	5.77	3-14	Federal key well.
23N 1W 3-1	SE SE	MDC (50)	12	2	Qgd	1188.95	1939-59	Q	1.62	6-15-43	7.31	12-14-49	3.06	4-21	4.80	9-30	
22N 3W 22-1	SE NE	MDC (7)	14	2	Qgd	1170.58	1934-59	Q	3.25	4-17-52	8.25	12-13-49	4.01	12-16	5.23	9-30	
							Saginaw County										
9N 3E 16-2	SE NW	Ray Ellis	129	3	Ips	-	1958-59	W	40.15	4-15-58	52.27	8- 3-58	35.41	1-27	53.84	9-8	P
							Sanilac County										
12N 13E 33-1	SE SE	MSHD	150	3	Mm	-	1948-59	W	15.45	4-25-51	23.42	2- 1-56	17.85	6-3	23.60	2-11	
							Schoolcraft County										
47N 16W 30-1	NW NW	MDC (Cusino)	57	6	Op	-	1957-59	R	10.71	5-16-58	15.51	11- 7-57	7.95	4-30	15.04	3-18	
45N 18W 31-1	NE SW	USFS	229	5	Otb	-	1958-59	M	16.11	8-25-58	16.54	12-29-58	15.65	11-27	16.69	1-27	
45N 13W 16-1	SW SW	U. S. Fish and Wildlife Serv.	154	4	Or	-	1952-59	R	5.09	4-12-54	6.28	9-26-55	5.13	4-5	5.82	8-2	

										Shiawassee County									
7N	3E 19-1	SE NW	City of Owosso	55	16	Qgd	-	1958-59		R	28.90	9-10-58	32.09	12-31-58	29.27	4-16	33.47	3-8	P, Record stopped 9-3-59.
	19-2	SE NW	do.	50	16	Qgd	-	1959		R	-	-	-	-	41.08	12-28	43.44	10-4	P, Record started 7-2-59.
5N	2E 16-1	NE SE	A. B. Cobb	26	1½	Qgd	896.00	1948-59		M	17.28	5- 3-50	22.11	12-15-58	20.04	4-29	22.18	2-27	
										Washtenaw County									
3S	6E 16-1	SW NW	City of Ann Arbor	23	2	Qgd	817.43	1920-59		W	e+2.5	2- ?-30	e10.0	11- ?-27	1.21	5-27	7.80	10-21	P, Meas. by owner
	16-2	SE NW	do.	23	192	Qgd	-	1948-59		W	+2.00	6-30-51	15.50	8-21-57	2.65	3-4	13.35	8-19	P, Do.
3S	7E 24-1	NE SW	Ford Motor Co. (104)	87	4	Qgd	665.56	1943-45, 49-59		M	5.79	1- 5-50	16.43	10-16-56	13.95	4-15	15.02	7-10	P, Meas. by Ypsilanti Twp.
	24-2	NE SW	do. (106)	53	4	Qgd	664.51	1943-45, 49-59		M	11.81	7-13-43	31.57	5-10-57	29.45	4-15	34.37	7-10	P, Do.
	24-4	NE SW	do. (107)	53	4	Qgd	664.05	1943-45, 49-59		M	11.55	1- 5-50	33.0	5-10-57	30.86	4-15	36.32	7-10	P, Do.
	24-5	NW SW	do. (109)	77	4	Qgd	665.56	1943-45, 49-59		M	15.15	6- 6-45	37.76	5-22-57	32.15	1-12	38.54	7-31	P, Do.
	24-6	SW SW	Federal Works Agency (117)	75	6	Qgd	657.83	1944-45, 49-59		M	5.69	2-15-50	26.22	5-10-57	23.65	1-12	30.06	7-10	P, Do.
	24-7	- SW	Ford Motor Co.(124)	90	24	Qgd	686.5	1955-59		M	23.47	12-29-55	36.05	10-16-56	34.75	1-12	35.48	7-10	P, Do.
4S	6E 9-1	NW NW	Ypsilanti State Hosp. (TW 20)	184	6	Qgd	-	1946-59		W	51.22	5-15-48	88.14	6-17-49	73.31	12-28	77.71	9-18	P, Meas. by owner.
	10-1	SW NW	Ypsilanti State Hosp. (TW 22)	173	6	Qgd	-	1946-59		W	61.48	6-12-53	88.27	7- 8-55	64.44	4-24	77.29	7-23	P, Do.
										Wayne County									
4S	9E 32-1	SW SE	Village of Waltz Improvement Assoc.	190	6	Ds	-	1959		R	-	-	-	-	7.46	12-12	9.22	10-2	Record started 10-2-59.
										Wexford County									
24N	9W 19-1	SW NW	MDC (38)	11	2	Qgd	944.16	1935-37, 41-44, 49-59		Q	0.94	4-10-51	3.74	8-19-36	0.49	4-6	2.49	7-8	
21N	11W 13-1	NW NE	USFS	62	6	Qgd	-	1948-59		M	46.28	6- 5-52	51.13	11- 1-58	48.24	7-13	51.04	4-6	
21N	9W 4-1	NW NE	City of Cadillac	277	6	Qgd	-	1949-59		Q	19.99	7- 6-53	23.83	10- 6-58	21.38	9-30	23.79	4-6	P

e - estimated

Table 2.--Reported ground-water pumpage by some Michigan municipalities, institutions, and industries (in million gallons).

Water User	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1959 Total
ALGER COUNTY													
Burt Township	1.05	0.97	1.36	1.49	1.20	1.78	2.07	NA	NA	1.43	1.39	1.20	NA
ALLEGAN COUNTY													
City of Allegan	23.5	23.0	23.5	23.3	24.1	33.7	41.8	37.5	40.4	28.6	23.1	23.4	345.9
City of Otsego	17.6	15.2	16.8	17.2	19.5	20.7	19.8	23.4	20.3	16.0	18.3	17.5	222.3
BARRY COUNTY													
City of Hastings	20.7	19.9	21.8	21.5	25.2	31.5	32.5	28.8	29.4	28.7	27.2	27.6	314.8
BERRIEN COUNTY													
City of Buchanan	37.5	34.1	38.4	37.0	41.8	59.2	55.3	51.5	48.0	36.6	32.6	34.1	506.1
City of Niles	68.6	66.5	70.8	72.7	82.9	122.4	103.6	113.1	105.5	79.0	e65.1	72.1	1,022.3
BRANCH COUNTY													
City of Coldwater	35.6	34.6	39.5	43.4	46.9	81.9	69.5	62.3	51.9	46.1	40.3	39.7	591.7
Coldwater State Hospital	12.94	11.62	12.95	12.48	13.53	13.80	13.93	14.22	13.15	13.72	12.66	12.93	157.93
CALHOUN COUNTY													
City of Albion	115	112	123	119	122	133	128	126	125	124	113	116	1,456
City of Battle Creek	337	311	377	394	372	453	451	429	365	316	287	277	4,369
Battle Creek Township	19.0	17.7	21.1	21.0	31.9	64.4	59.9	39.3	33.5	18.1	16.4	16.3	358.6
City of Marshall	29.1	26.6	29.8	30.4	36.4	37.7	50.1	46.0	48.8	34.2	28.0	27.4	424.5
CASS COUNTY													
City of Dowagiac	18.1	18.6	16.8	18.2	18.0	24.9	27.4	20.7	27.7	17.4	17.4	14.9	240.1
CHARLEVOIX COUNTY													
City of East Jordan	10.34	9.81	10.89	11.41	13.17	17.09	21.70	19.66	12.95	14.14	11.49	12.34	164.99
CHEBOYGAN COUNTY													
City of Cheboygan	9.10	9.30	9.50	9.70	10.20	11.60	13.90	14.70	13.80	11.10	9.80	9.40	132.1
CLARE COUNTY													
City of Clare	14.8	14.3	15.4	16.3	16.9	23.0	24.7	24.9	23.3	17.6	14.7	14.9	220.8
CLINTON COUNTY													
City of St. Johns	21.1	19.5	22.0	23.2	22.2	27.0	26.8	26.2	23.2	22.3	21.8	18.8	274.1
EATON COUNTY													
City of Charlotte	23.8	27.1	31.9	30.7	36.0	42.5	37.4	36.7	35.6	31.8	28.6	28.8	390.9
City of Grand Ledge	14.0	13.0	13.6	12.8	15.4	18.6	20.3	20.4	16.7	16.1	13.7	11.7	186.3
GENESEE COUNTY													
Beecher Metro. Dist.	18.8	17.4	17.9	17.8	20.2	23.5	25.6	22.1	20.1	19.6	21.2	19.2	243.4
City of Davison	7.78	7.35	8.19	8.23	9.29	12.36	13.93	7.61	11.09	9.74	8.05	7.69	111.31
Village of Fenton	15.0	14.7	16.5	15.2	15.9	21.4	23.4	19.0	18.6	15.1	16.0	16.0	206.8
Village of Flushing	6.28	6.25	6.14	5.97	8.04	9.78	9.59	9.07	8.12	7.56	7.41	7.31	91.52
Fisher Body Div. (GMC) at Grand Blanc	5.03	4.59	5.40	5.13	6.03	6.12	5.97	6.38	6.89	6.52	5.87	7.88	71.81
City of Mt. Morris	6.13	6.27	6.47	5.82	6.47	6.81	6.80	6.50	6.47	6.26	5.93	6.33	76.26
Village of Otisville	0.82	0.72	0.80	0.77	0.87	1.30	1.59	1.34	0.89	0.82	0.83	0.75	11.50
GLADWIN COUNTY													
City of Beaverton	1.74	2.32	2.48	2.04	1.87	1.99	2.24	2.48	1.98	1.35	1.57	1.57	23.63
GOGEBIC COUNTY													
City of Bessemer	12.5	12.4	12.7	11.4	11.6	12.3	12.2	12.0	11.9	11.8	11.4	12.2	144.4
City of Ironwood	e25.5	e29.2	31.8	30.5	28.6	31.0	32.0	29.2	27.3	26.0	26.8	28.0	e345.9
City of Wakefield	1.74	1.57	1.60	1.95	1.99	2.15	1.91	1.66	1.84	1.74	1.53	1.90	21.58
GRATIOT COUNTY													
City of Alma	41.3	38.1	47.2	46.2	61.3	64.8	69.3	62.9	56.8	58.0	49.6	48.3	643.8
City of St. Louis	22.6	21.1	20.6	21.0	23.5	24.6	21.4	21.8	20.2	19.0	19.3	19.6	254.7
INGHAM COUNTY													
City of East Lansing	31.3	28.9	31.6	35.0	43.4	54.1	55.8	41.1	38.5	37.7	33.6	29.6	460.6
City of Lansing	526	475	513	512	566	659	663	564	558	509	390	489	6,424
Lansing Township	32.5	33.7	37.6	36.3	46.3	40.5	41.2	39.2	38.4	28.0	19.9	38.7	432.3
City of Mason	10.20	8.00	9.21	9.78	12.17	14.27	16.44	14.83	12.17	11.43	9.85	10.22	138.37
Meridian Township	7.24	7.52	7.30	7.16	8.78	11.61	11.82	12.50	9.12	7.77	7.51	7.56	105.89
Michigan State Univ.	71.4	59.5	58.7	74.6	65.7	57.7	88.5	71.9	66.6	74.8	62.3	62.0	813.7
IONIA COUNTY													
City of Ionia	27.4	24.4	28.8	24.6	28.7	36.0	40.9	34.2	30.6	26.6	18.5	20.4	341.1
Ionia State Hospital	10.49	9.33	9.52	9.57	10.47	11.54	12.10	11.50	10.88	10.60	10.00	10.13	126.13
Ionia State Prison	1.30	0.87	1.12	1.21	1.03	2.61	2.81	2.80	1.21	1.33	1.61	1.60	19.50
City of Portland	8.28	7.97	9.09	7.78	10.02	13.52	15.13	12.11	10.09	8.79	7.71	8.12	118.61
IRON COUNTY													
City of Stambaugh	7.82	7.64	8.82	9.00	8.95	9.34	8.45	7.50	7.09	6.64	7.08	6.78	95.11
ISABELLA COUNTY													
City of Mt. Pleasant	56.9	51.5	57.2	60.2	65.1	73.3	73.3	61.2	56.3	54.5	51.8	57.4	718.7

Table 2.--Reported ground-water pumpage by some Michigan municipalities, institutions, and industries (in million gallons).--Continued

Water User	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1959 Total
JACKSON COUNTY													
City of Jackson	343	322	356	358	396	475	496	440	386	342	290	332	4,536
Jackson State Prison	38.0	34.6	38.8	40.5	41.6	56.4	57.4	55.3	45.5	41.8	38.8	41.1	529.8
KALAMAZOO COUNTY													
City of Kalamazoo	351.	363	344	363	443	547	593	509	500	382	348	373	5,116
Kalamazoo State Hosp.	19.9	19.5	20.5	22.0	20.7	17.7	22.1	22.8	20.1	22.8	22.1	21.2	251.4
City of Parchment	14.05	12.25	13.20	13.36	15.71	19.46	21.29	9.72	9.58	10.07	7.05	6.75	152.49
KENT COUNTY													
City of Grandville	9.64	10.64	9.57	10.72	11.24	14.58	33.08	24.34	24.47	9.85	8.36	8.97	175.46
Jervis Corp. at Grandville	10.17	10.51	9.84	7.84	7.71	10.46	7.12	6.27	4.45	9.75	6.06	8.19	98.37
City of Lowell	6.88	6.48	7.34	7.50	8.77	13.31	14.35	12.10	9.93	9.11	9.20	9.92	114.89
Village of Sparta	10.8	11.2	11.3	11.6	14.2	17.3	17.3	14.4	15.4	14.9	10.4	10.9	159.7
City of Wyoming	100.3	88.1	110.1	112.0	137.2	257.5	231.3	173.1	174.3	111.4	93.3	96.3	1,684.9
LAPEER COUNTY													
City of Lapeer	13.9	13.1	15.7	14.8	16.5	16.9	16.5	17.9	13.9	12.5	11.9	13.9	177.5
LENAWEE COUNTY													
City of Tecumseh	48.8	42.3	46.6	52.2	57.7	69.5	68.7	61.0	56.0	54.3	52.7	55.0	664.8
LIVINGSTON COUNTY													
Village of Fowlerville	3.10	2.85	3.69	3.17	3.61	5.95	6.90	5.72	3.51	2.89	3.64	3.03	48.06
City of Howell	20.6	18.7	22.3	21.4	21.0	21.8	24.5	23.5	21.8	19.7	17.7	19.4	252.4
State Sanitarium at Howell	3.37	2.75	2.89	2.77	2.92	6.35	8.02	4.44	3.20	2.75	2.80	2.94	45.2
MACOMB COUNTY													
City of Centerline	22.2	19.3	20.1	18.3	8.3	Detroit water used effective May 13, 1959							
City of Fraser	9.68	8.48	10.24	10.64	13.11	23.31	25.20	17.82	15.43	11.79	10.98	10.59	167.27
MANISTEE COUNTY													
City of Manistee	26.9	25.2	27.4	27.4	32.0	51.3	50.4	40.2	36.3	31.7	34.1	36.3	419.2
MONROE COUNTY													
Village of Carleton	2.79	2.67	2.11	2.14	2.52	2.52	2.88	2.98	2.70	2.53	2.49	2.99	31.32
MONTCALM COUNTY													
City of Greenville	35.6	29.4	31.6	32.1	38.0	58.1	38.9	38.3	37.3	29.2	23.5	28.5	420.5
OAKLAND COUNTY													
City of Birmingham 1/	5.57	5.22	5.47	6.16	6.36	14.26	20.61	12.92	7.69	6.12	6.42	5.98	1/102.78
City of Pontiac	296	265	301	298	335	417	468	334	335	326	246	304	3,925
Village of Rochester	29.9	27.6	31.6	31.4	24.4	43.4	44.6	39.0	37.0	33.8	29.5	32.5	404.7
City of Troy	24.6	21.9	23.6	24.8	26.8	40.4	42.5	40.5	31.5	27.5	24.1	26.2	354.4
ONTONAGON COUNTY													
Village of Ontonagon	7.74	8.26	9.28	6.33	6.71	7.02	7.31	6.87	6.55	7.68	9.51	9.00	92.26
SANILAC COUNTY													
City of Croswell	9.45	7.11	7.53	7.48	8.56	11.67	17.99	23.34	14.11	10.76	12.44	14.57	145.01
ST. JOSEPH COUNTY													
City of Sturgis	42.8	41.7	45.4	45.9	51.7	66.2	66.7	68.4	57.9	e45.4	44.1	44.6	e620.8
City of Three Rivers	23.1	21.5	25.1	26.4	30.4	39.3	38.6	37.6	32.5	24.0	22.6	22.3	343.4
SHIAWASSEE COUNTY													
City of Corunna	4.55	4.32	4.72	4.80	4.99	7.36	7.94	6.28	5.43	5.11	4.94	5.63	66.07
City of Durand	9.11	8.68	9.85	9.32	10.00	12.29	12.73	10.66	9.97	9.81	9.42	9.65	121.49
City of Owosso	68.7	65.9	70.9	65.7	74.0	99.9	95.2	87.3	78.8	80.3	66.7	69.3	922.7
Village of Perry	1.39	1.80	1.84	0.54	1.15	2.15	2.68	2.04	1.46	1.64	1.42	1.50	19.61
TUSCOLA COUNTY													
Village of Cass City	9.07	8.00	9.06	9.59	10.60	12.10	11.88	9.08	9.12	8.30	7.36	8.37	112.53
WASHTENAW COUNTY													
City of Ann Arbor 2/	43.5	46.8	62.4	40.9	68.0	113.6	125.1	105.3	104.8	94.0	63.5	45.5	913.4
City of Ypsilanti	89.7	79.7	78.7	89.0	100.5	121.8	134.5	108.3	109.1	103.7	91.6	98.8	1,205.4
Ypsilanti Township	157	139	155	159	179	200	213	193	178	155	112	164	2,004
Ypsilanti State Hosp.	16.2	18.4	19.1	16.5	19.7	20.2	26.9	19.3	19.7	17.8	16.2	17.1	227.1
WAYNE COUNTY													
City of Plymouth	51.4	43.0	48.0	45.8	45.9	66.8	66.7	66.2	57.4	45.8	42.6	45.4	1,205.4

NA - Not available
e - Estimated
1/ - Detroit surface-water supply also used
2/ - Also use surface-water supply from Huron River