WATER SUPPLY REPORT NUMBER SIX

STATE OF MICHIGAN
DEPARTMENT OF CONSERVATION
GERALD E. EDDY, DIRECTOR
GEOLOGICAL SURVEY DIVISION
WILLIAM L. DAOUST, STATE GEOLOGIST

SUMMARY OF GROUND-WATER CONDITIONS IN MICHIGAN 1961

BY

P. R. GIROUX
U. S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

1962

WATER SUPPLY REPORT NUMBER SIX

STATE OF MICHIGAN

DEPARTMENT OF CONSERVATION
Gerald E. Eddy, Director

GEOLOGICAL SURVEY DIVISION
William L. Daoust, State Geologist

SUMMARY OF GROUND-WATER CONDITIONS IN MICHIGAN

1961

By

P. R. Giroux

U. S. Geological Survey

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

1962

CONTENTS

CONTENTS (continued)

ILLUSTRATIONS AND TABLES

ILLUSTRATIONS AND TABLES (continued)

ILLUSTRATIONS AND TABLES (continued)

Tables

ILLUSTRATIONS AND TABLES

SUMMARY OF GROUND WATER CONDITIONS IN MICHIGAN

1961

By

P. R. Giroux

INTRODUCTION

This report is the sixth of a series covering ground-water levels 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 U. S. Geological Survey. The program is a part of the overall water-resources investigation carried out in cooperation with the Michigan Geological Survey. The following municipalities and industries supported the State Survey in its cooperative program.

Municipality or Industry	Official
City of Alma	J. D. McNaughton, City Manager
City of Battle Creek Water and Sewer Div., Dept. of Public Works	K. E. Garvey, Supt.
City of Cadillac	James Burch, City Manager
Fisher Body Div., GMC, at Grand Blanc	T. D. Welch, Works Engr. Dept.
City of Grand Ledge, Water Dept.	Harrison Millard, Supt.
City of Hastings, Public Services	K. P. Laberteaux, Director
City of Ironwood	Kenneth E. Long, City Manager

City of Jackson, Water Dept.	J. M. Rogeven, Supt.
City of Kalamazoo, Utilities	Albert Sabo, Mgr.
City of Lansing, Board of Water and Light	O. E. Eckert, General Mgr.
City of Lowell	Bernard Olson, City Mgr.
Michigan State University at Oakland	George Karas, Director, Physical Plant
Village of Ontonagon	Warren Millard, Village Supt.
City of Plymouth	Joseph Bida, Supt. Pub. Works
City of Pontiac	H. G. Parker, Supt. Water Dept.
Village of Rochester	Paul A. York, Village Mgr.
Township of Waterford	J. E. Seeterlin, Twp. Clerk
City of St. Louis	R. M. Henneberger, Jr., City Mgr.
City of Wyoming	P. T. Spelman, City Engr.
City of Ypsilanti	John Max, Supt., Water Purification Plant
Township of Ypsilanti	Robert Norris, Mgr., Water and Sewer Dept.

Cooperative ground-water investigations by the U.S. Geological Survey in Michigan are directed jointly by O.M. Hackett, Chief of the Ground Water Branch, U.S. Geological Survey, Washington, D.C., and W. L. Daoust, State Geologist, Michigan Geological Survey, Lansing, and are supervised by G. E. Hendrickson, District Geologist.

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 first of these series for the Northeastern States, which includes Michigan, has been published for the 2-year period 1956-57 as Water-Supply Paper No. 1537. The needs of the State, however, require more detailed and current ground-water information. As a result, publication of annual Water Supply Reports entitled "Summary of Ground-Water Conditions in Michigan" by the Michigan Geological Survey was started in 1956.

The first five reports of this series published, cover ground-water conditions in Michigan for the calendar years 1956 through 1960 as follows:

Water Supply Report	Year
1	1956
2	1957
3	1958
4	1959
5	1960

The State Water Supply Reports are designed to supplement data contained in the Federal reports and also provide interpretive text and illustrations. By means of these ground-water summaries, basic information concerning ground-water conditions in Michigan are readily available to the public.

Ground-Water Problems

Michigan has a bountiful supply of ground water. Since World War II, however, great demands have been placed on this resource by Michigan's dynamic, growing society, creating problems of supply, quality, and distribution. More and more ground water is being used for public supply, industry, agriculture, and recreation, despite the fact that during this same period the use of surface water has also increased. All estimates indicate that the demand for ground water during the next several decades will grow tremendously. With this certain prospect of increased demand many water problems will face the people of the State. Thus, our knowledge of the ground-water resources of every area of the State must be steadily and substantially improved. Intelligent water management requires a sound background of basic facts about the occurrence of water, its quantity and quality, and the manner in which it is used.

Michigan is surrounded by three of the largest bodies of fresh water in the world; it has more than 11,000 inland lakes, many thousands of miles of rivers and streams, and an enormous resource of ground water contained in numerous aquifers. The State is truly a "Water Wonderland!" Yet, the use of water creates problems, and water problems exist in many areas throughout the State. These problems are similar in many respects to those present throughout the Nation.

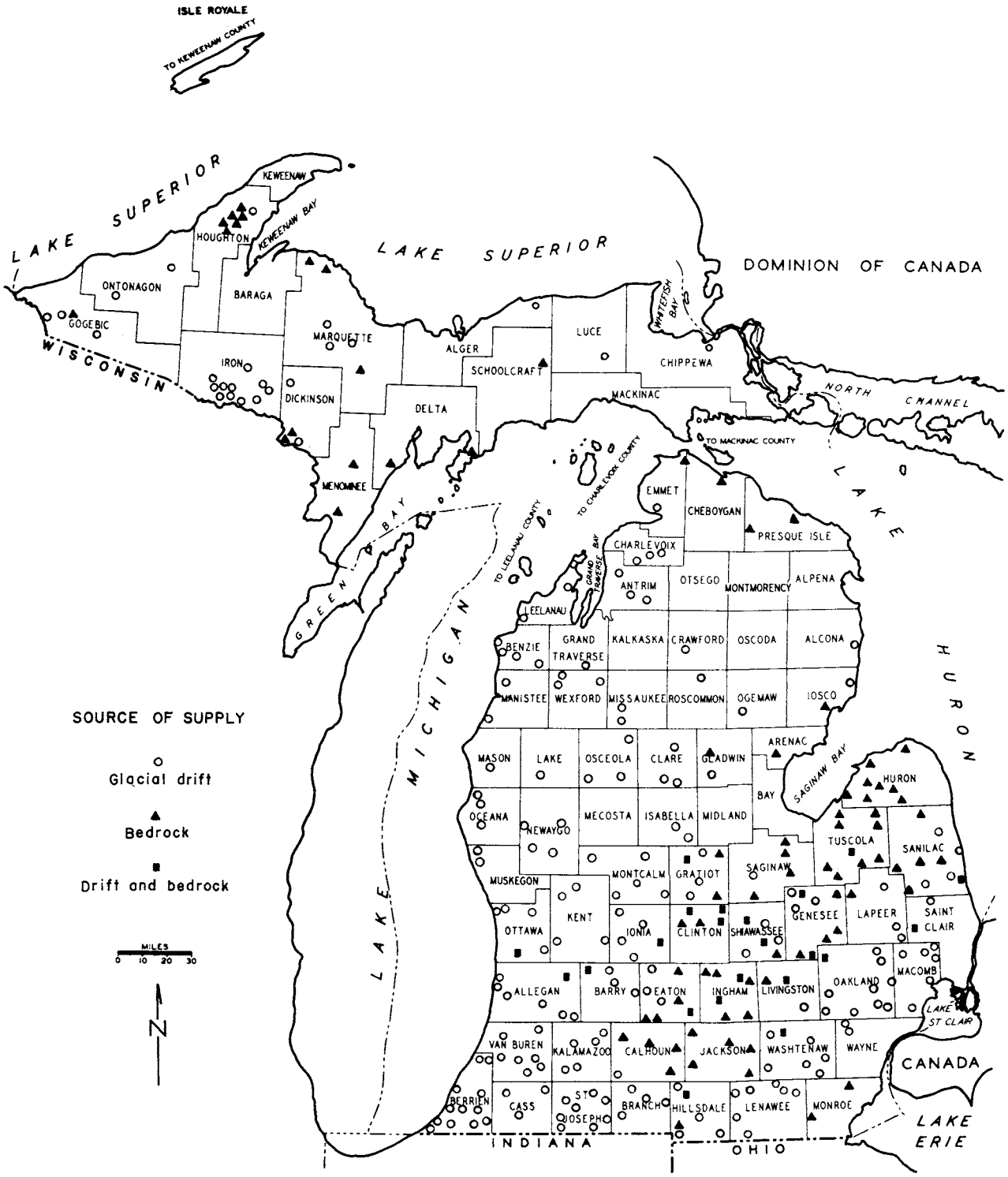


Figure I. Distribution and source of public water-supply systems using ground water.

The ever-increasing demand for water is a sure indication that existing problems will become more acute and widespread. These problems involve not only the adequacy of supply for various areas, but also considerations of quality, pollution, planning, and management.

The fact that the ground-water resources can be developed at relatively low cost in many areas of Michigan is demonstrated by water rates in the large cities. Statistics show that for Michigan cities of over 50,000 population, water rates generally are lower for cities using ground water than those using surface water. More than 250 of the municipal supplies in the State use ground water (fig. 1) and, if the Detroit metropolitan area is excluded, more than half of the water used for municipal supplies is ground water. Because use of the ground-water resource is commonly to the economic advantage of the user, and because much of this valuable resource is as yet undeveloped, a major step in meeting water problems is to make basic appraisals of the distribution and availability of ground water.

Without a broad background of basic facts concerning the quantity, quality, and distribution of all water resources available, new water developments obviously cannot be based on sound economic guidelines.

Objectives of the Observation Well Program

The observation-well program in Michigan is a part of a nationwide program, the purpose of which was summarized by Sayre (Water-Supply Paper 1404, p. 1, 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 1961 in 216 wells, of which 66 were equipped with continuous recording gages. The report summarizes water-level changes observed throughout the State, and analyzes these changes in selected areas.

During 1961 the cooperative program was continued with the addition of 10 ground-water recording stations. One objective of this cooperative program is to observe and analyze the effects of pumping on water levels in areas of heavy ground-water withdrawals.

The distribution of wells in which water levels were observed in 1961 is shown by figure 2.

Table 1 lists the basic information for each observation well, and the extremes of water-level fluctuations in 1961 and for the period of record. Fluctuations of water levels in representative wells are also shown by numerous hydrographs, and in many cases graphic interpretations of the changes in water level are made possible by including pertinent precipitation and (or) pumpage data. Several illustrations in this report include graphs showing the cumulative departures of annual precipitation from the long-term mean. These graphs were constructed by using the "zero" or "average" line to denote the average precipitation for the period of record preceding the period of the graph. Starting at this line the excess or deficiency of precipitation for each month or year is added algebraically to prepare the cumulative departure graph. Thus, for each time unit, a line sloping downward always indicates below-average precipitation and a line sloping upward, above-average precipitation. In cumulative graphs such as these, the slope of the line is the important part--that is, even where the graph is far below the zero line, if the slope is upward the period is one of above-average precipitation. The end point of the


ISLE ROYALE
TO KEWEENAW COUNTY
EXPLANATION
Observation well
Two or more observation wells
R.30W.
T. 49 N.
Diagram of geographical township
N
0 10 20 30 Miles
KEWEENAW
KEWEENAW BAY
HOUGHTON
ONTONAGON
BARAGA
GOGEBIC
IRON
MARQUETTE
DICKINSON
MENOMINEE
ALGER
SCHOOLCRAFT
DELTA
LUCE
CHIPPEWA
MACKINAC
WHITEFISH BAY
TO MACKINAC COUNTY
WISCONSIN
Menominee River
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
GREEN BAY

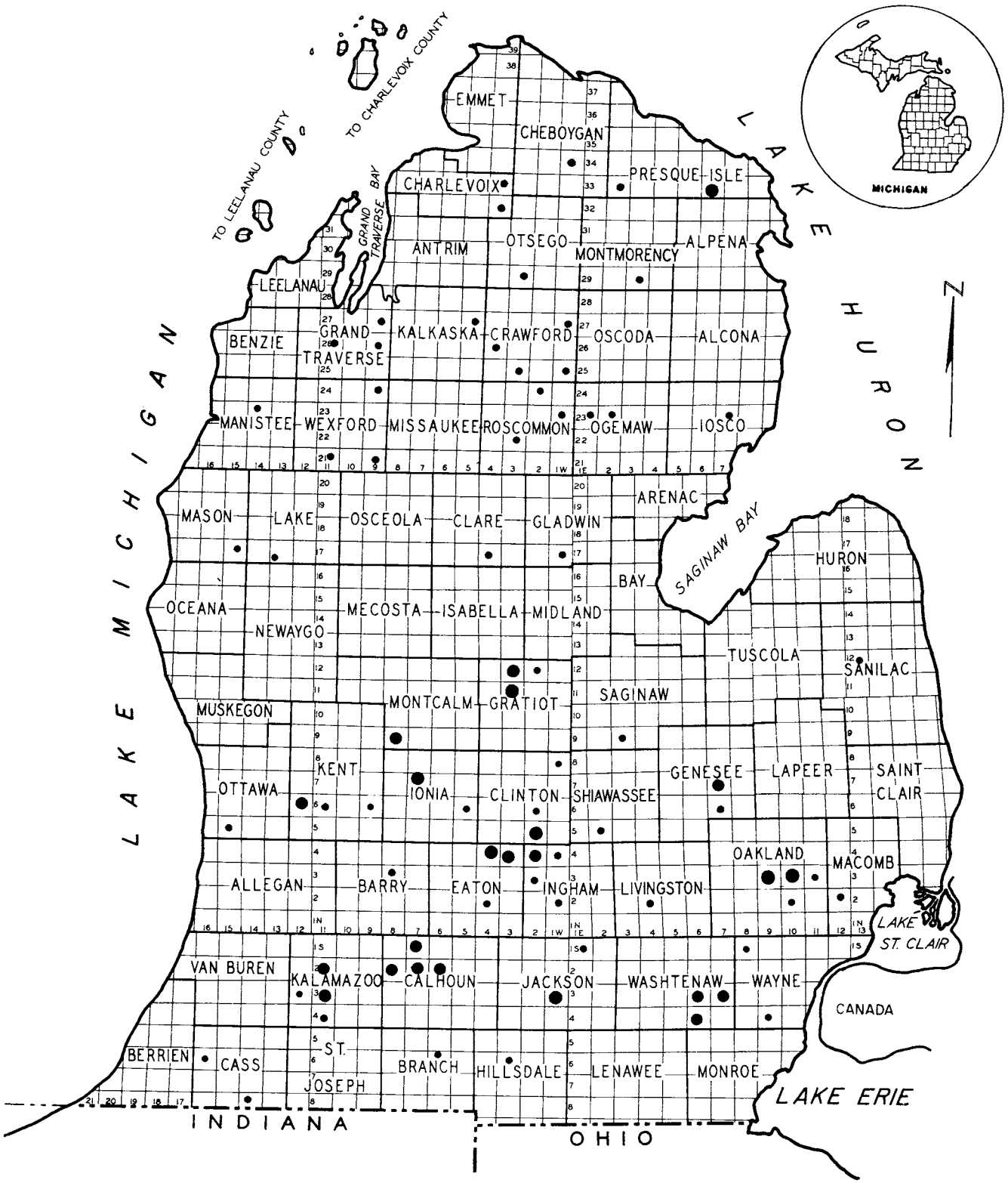


Figure 2. Location of observation wells in Michigan, 1961.

graph thus also gives the total rainfall above or below the average for the entire period of the graph.

Table 2 lists the reported monthly and annual ground-water pumpage for many municipalities, institutions, and some industries in the State.

Open-File and Published Records

Complete tabulations of water-level measurements and the 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 office of the Water Resources Section of the Michigan Geological Survey, Fourth Floor, Mason Building, Lansing or at the Michigan district office of the U. S. Geological Survey, Ground Water Branch, 407 Capitol Savings and Loan Building, Lansing. Records for the Northern Peninsula are also kept on file in the offices of the State and Federal 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.

Copies of annual "Summaries of Ground-Water Conditions in Michigan" are free on application while other 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 also published by the Michigan Geological Survey or the U. S. Geological Survey. These reports are also available for inspection at the offices listed above.

Well-Numbering System

The well-numbering system used by the State and Federal Surveys in Michigan indicates the location of wells within the rectangular subdivision of the land with reference to the Michigan meridian and base line (fig. 2). 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.

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 and A. E. Slaughter of the Michigan Geological Survey, for their assistance in the editing of this report series.

Ground Water and the Hydrologic Cycle (from McGuinness, 1962)

"Virtually all water available for useful purposes is moving in the hydrologic cycle (fig. 3), in which water evaporates from the oceans, precipitates on the continents, and is returned to the atmosphere by evaporation or to the oceans by overland or underground flow.

"Ground water is not an independent resource but simply a phase of the hydrologic cycle. Its withdrawal and use affect other phases of the cycle and must be considered in relation to them.

"Ground water is replenished wherever water from precipitation or runoff enters the soil and brings its moisture content above field capacity--the maximum moisture content at which water is held by capillary force against the pull of gravity. The excess water percolates downward to the capillary fringe, in which water is held above the water table by capillarity and may fill the pores completely but which is part of the zone of aeration, and through the fringe to the water table--the level at which the pressure is atmospheric.

"Once in the zone of saturation water moves in the direction of decreasing hydraulic head, through permeable rocks and over, under, or around less permeable ones to a point of discharge.

"Where there is a water table the water is "unconfined". Where water passes between impermeable beds and becomes confined under pressure it is "artesian". It will rise in a well above the bottom of the upper "confining bed" but may or may not flow, according to the relative elevations of the "piezometric surface" and the land surface.

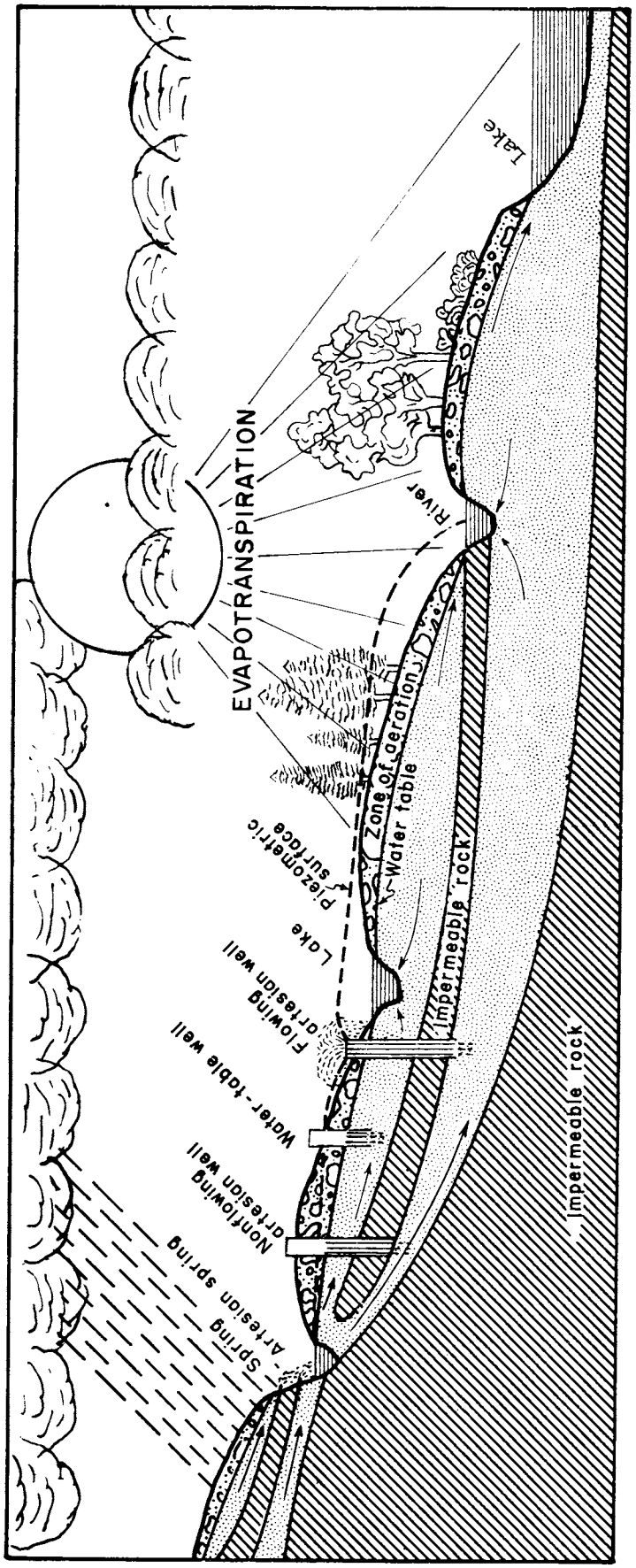


Figure 3. Diagrammatic section showing water table and artesian aquifers as part of the hydrologic cycle
(after Sayre, 1950)

"The ground water discharges by seepage or spring flow into streams, lakes or the ocean; or by evaporation and transpiration (evapotranspiration) where it lies near the land surface. It may travel only a few feet in a matter of minutes, as where a temporary zone of saturation is formed in the soil during a storm or snowmelt period, or tens or hundreds of miles over a long period, perhaps thousands of years.

"Ground-water reservoirs are the principal natural media for storage of water on the continents. The total ground-water storage exceeds that in natural and artificial surface-water bodies by perhaps more than a dozen times, even including the Great Lakes which contain many times more water than other surface bodies put together."

PRECIPITATION AND TEMPERATURE

Precipitation and temperature are the major climatic factors affecting the ground-water regimen in any area. Recharge to aquifers is supplied directly or indirectly by precipitation. Ground-water levels are affected by the quantity of precipitation, the season of its occurrence, its intensity, and nature.

As evidenced by hydrographs of natural fluctuations of water in wells (figs. 3 and 7), spring and fall are the seasons when most of the ground-water recharge occurs. In the spring before the growing season starts, snowmelt and rain normally result in large additions to the ground-water reservoirs. However, layers of ice, or frost in the ground, can impede infiltration when thaws occur. Under these conditions, water from snowmelt and early spring precipitation may be mostly lost to the aquifers by quick surface runoff. In the fall of the year, after the growing season ends and evapotranspiration demands are reduced by colder weather, substantial rises in water levels from rains usually occur.

According to the U. S. Weather Bureau, precipitation in 1961 was below average in the Northern Peninsula and also in the south-central and southwest parts of the Southern Peninsula. Elsewhere in the State the total annual precipitation ranged from about 0.3 to 3.0 inches in excess of average for the various climatological divisions of the State as designated by U. S. Weather Bureau publica-

tions. Locally, total annual precipitation ranged from a high of about 40 inches at Higgins Lake in the Southern Peninsula, to a low of 23 at Detour in the Northern Peninsula.

The winter season was one of the driest of record in the Southern Peninsula. Monthly deficiencies of precipitation were general throughout most of the State in March, May, June, and October through December. However, in September, record rainfall, with amounts of up to $12\frac{1}{2}$ inches locally, occurred at many stations, mostly as the result of the remnants of hurricane Carla. The principal results of the precipitation deficiencies in 1961 were the continuation from 1960 of low ground-water levels in the southern half of the Southern Peninsula. Locally, sharp rises occurred in late summer and early fall.

The annual temperature in 1961 was about average but varied considerably from normal, month by month. January was unusually cold whereas February and March were mild, with periods of above freezing temperatures allowing a little recharge to aquifers from thawing of light snow cover. Temperatures in April and May were much lower than usual, delaying the growing season and reducing evapotranspiration losses. Cool summer weather also reduced evapotranspiration losses, moderating the summer decline of water levels.

SUMMARIES OF GROUND-WATER CONDITIONS

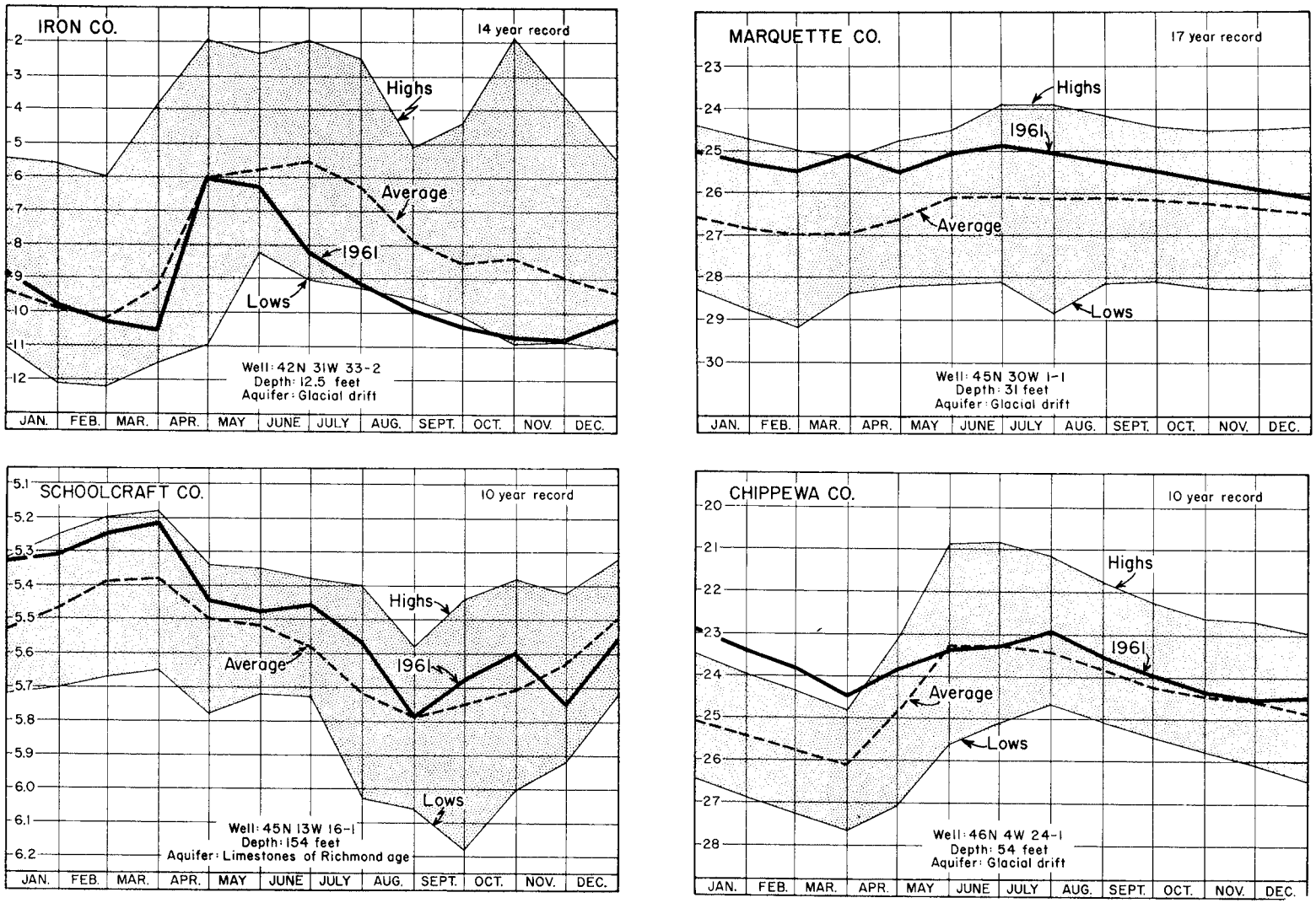
Statewide Changes in Storage from Natural Influences

Northern Peninsula

Water levels in four key wells (fig. 4) were lower in 1961 than in 1960 when record highs were observed. However, stages generally remained above average except in the Iron County well where water levels fell to record lows by late summer despite average spring recharge. This well is finished at shallow depth and levels fluctuate rapidly with changes in precipitation.

Water levels in two wells affected only by natural climatological conditions (fig. 5) show the correlation between ground-water levels and variations in precipitation over a period of 10 years. There is a fairly regular pattern of spring rises and summer declines. However, in the Chippewa County well, the summer decline generally continues until the following spring, while in the Schoolcraft County well the stages rise in the fall.

The effects of above-average precipitation, for example, from mid-1959 through 1960, resulted in several feet of rise of water levels in the Chippewa County well. However, in the Schoolcraft County well, water levels rose less than a foot in response to about 24 inches of above average precipitation during the mid-1959 through 1960 period. The smaller rise in the Schoolcraft County well may be the result of increased natural discharge through fractures in the limestone when water levels are high.



High, average, and low readings are for the period of record through 1960

Figure 4. Month-end water levels in key observation wells in the Northern Peninsula, 1961.

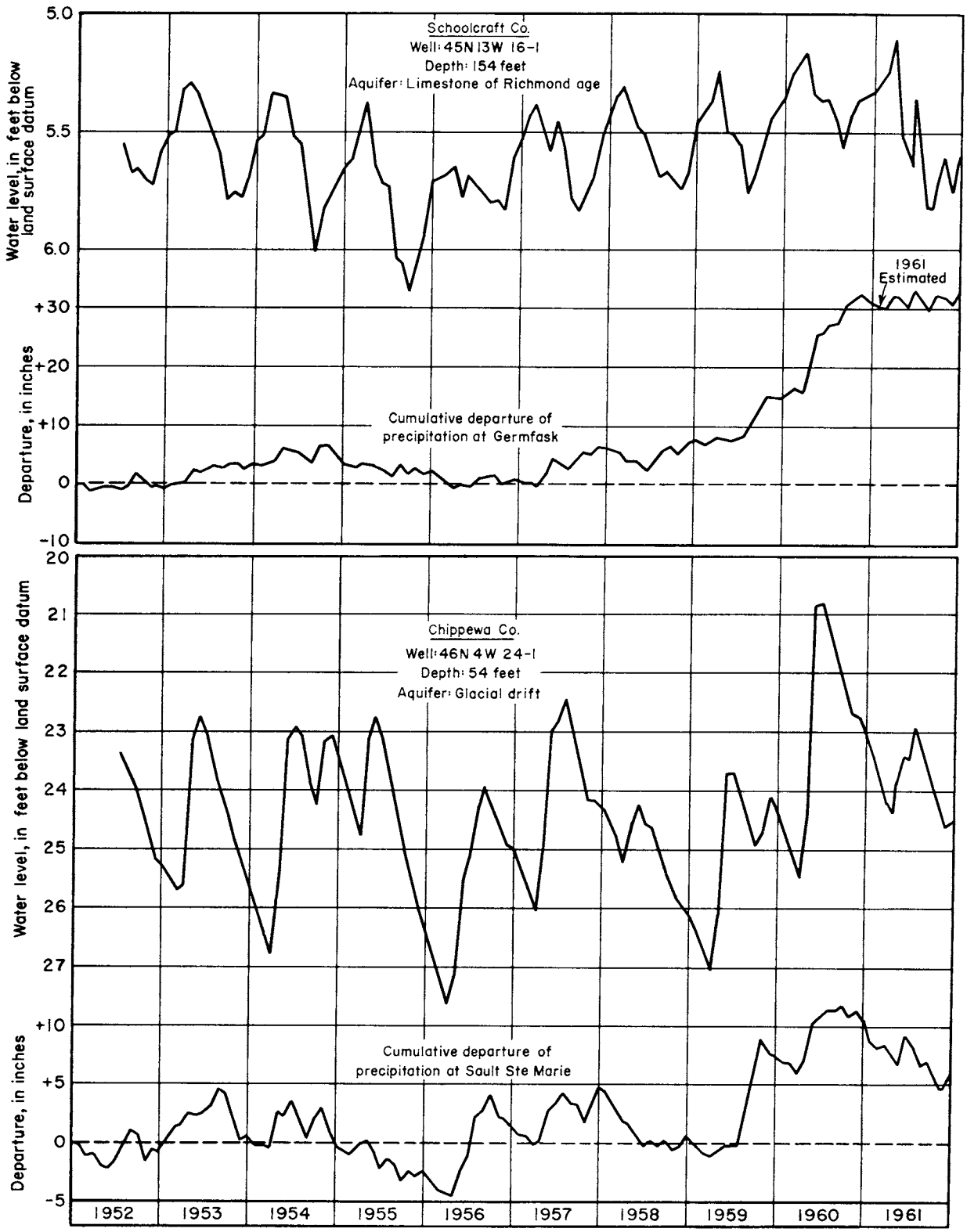


Figure 5. Hydrographs of two wells, and precipitation, in Chippewa and Schoolcraft Counties, 1952-61.

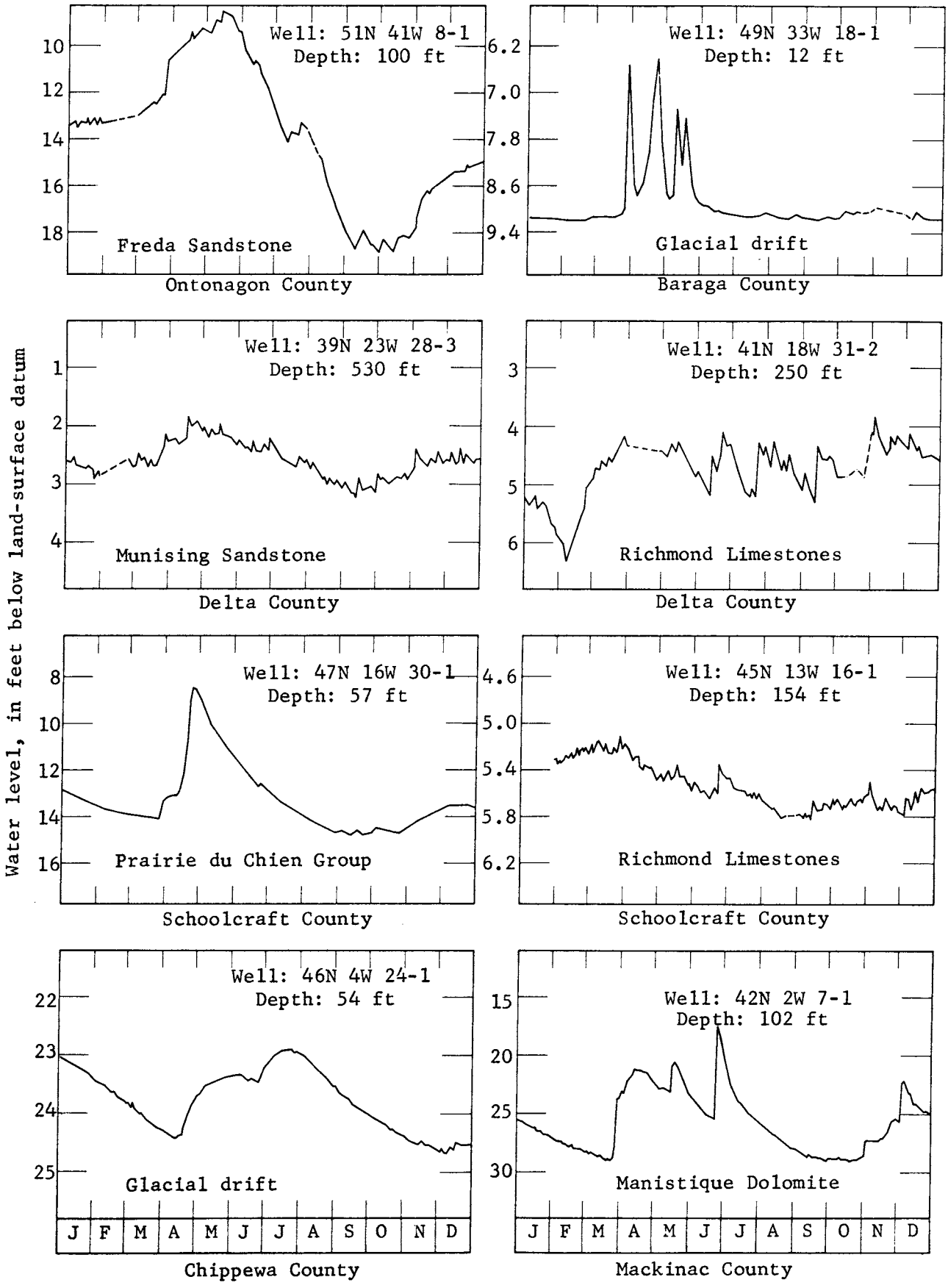


Figure 6. Hydrographs of eight selected wells in the Northern Peninsula, 1961.

Figure 6 shows annual hydrographs, based on records from continuous recording gages, of eight wells in the Upper Peninsula. These graphs illustrate seasonal fluctuations from natural climatological influences in wells finished in various formations and depths.

Most of the hydrographs show a winter low, a spring rise, and a summer decline, and some show a recovery in the fall. In some deep wells the seasonal effects are subdued. The high for the year may occur as early as March or as late as June or July. In the Mackinac County well heavy precipitation caused rapid rises of water level owing to immediate recharge through fractures in the limestone outcropping at the surface. The numerous cracks and crevices in the formation allow quick infiltration from storm waters. For example on June 22 and 23, more than four inches of rain fell in the area. This water quickly infiltrated, causing a sharp rise followed by a gradual decline. This same storm resulted in a peak in water levels in the Chippewa County well in late June and a small rise in well 16-1 in Schoolcraft County.

Many observation wells in the western half of the Northern Peninsula are maintained and observed by the Wisconsin-Michigan Power Company. They serve 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 and the levels reflect changes in natural storage in the shallow aquifers of that area. The Company issues monthly summaries of hydrologic condi-

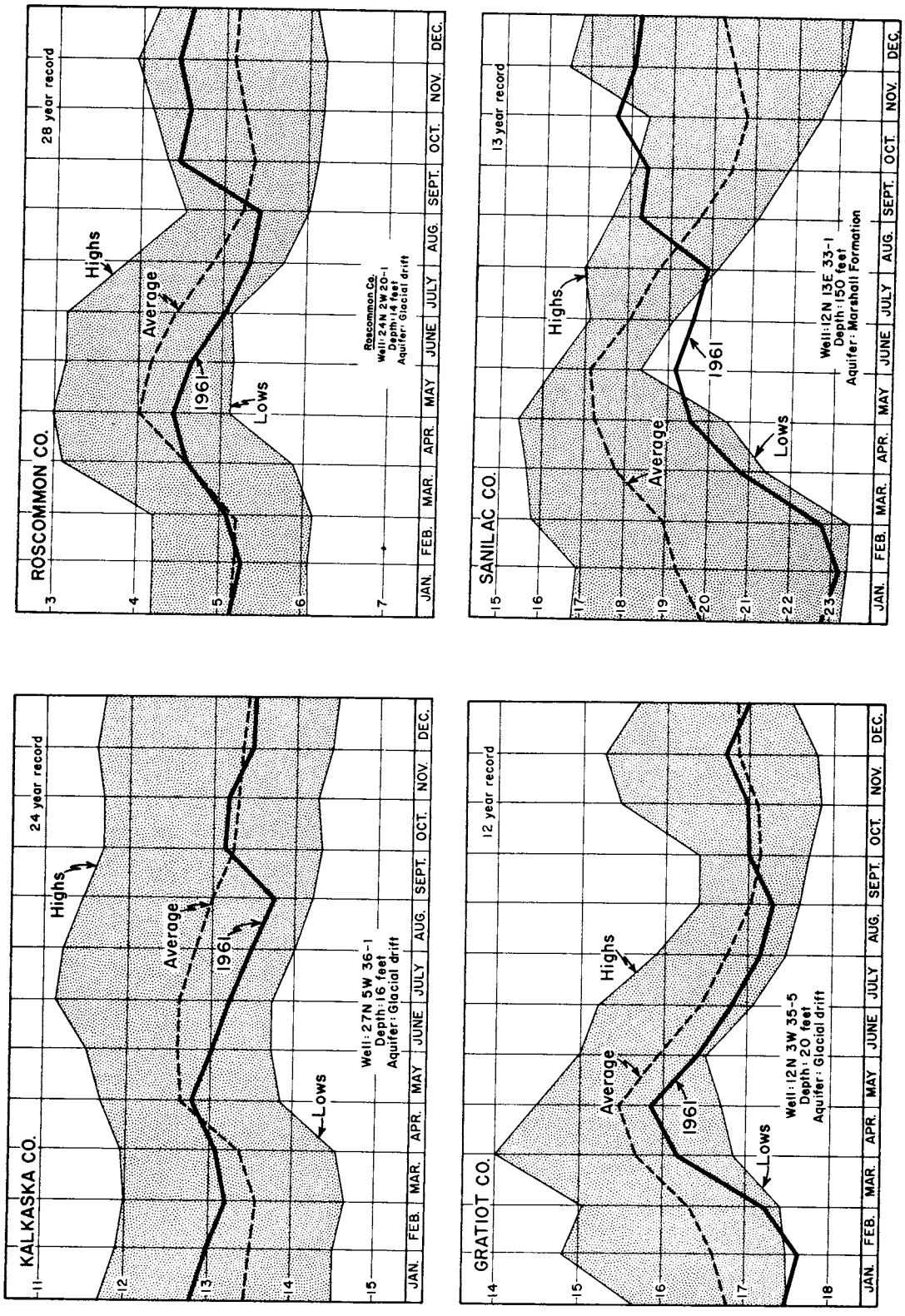
tions and annual reports (Kurtyka,1961) containing valuable information such as weather, evapotranspiration, and ground-water storage data. The 1961 annual Weather Bulletin (p.1) states "as the year ended, the average water table was at elevation 2.31 feet or 0.20 feet above normal." According to fig. 4, of their report, water table elevations were above average from January through June, below average July through November, and above average in December. Above-normal precipitation in the fall reversed the summer decline and levels rose from September to the end of the year.

Southern Peninsula

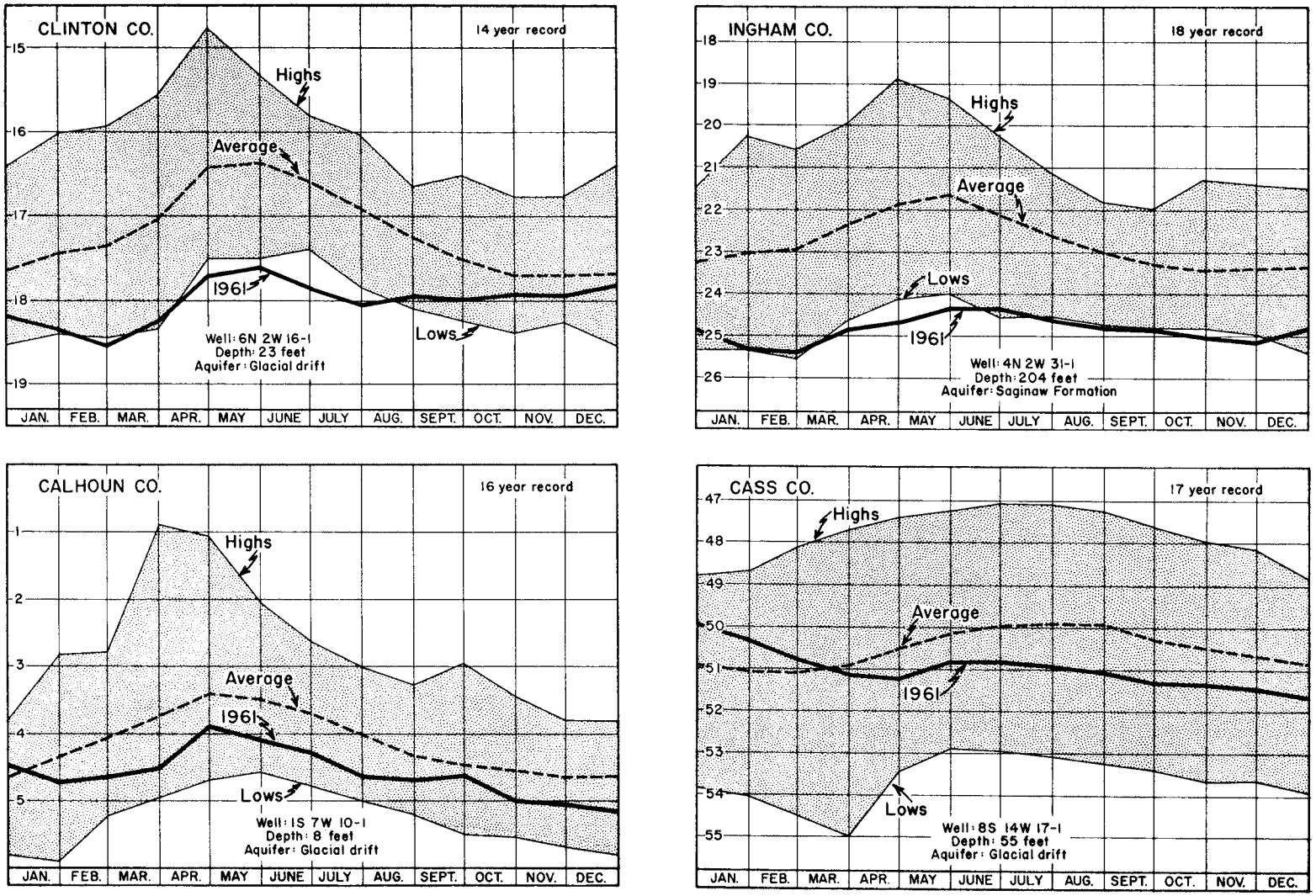
Figure 7 gives the month-end levels as compared with the extremes and average of record for eight key wells affected primarily by natural climatic conditions.

In the northern half of the Southern Peninsula the levels in key wells in Roscommon and Kalkaska Counties fell to below average stages during most of the summer as the result of less than usual spring recharge. However, heavy precipitation late in the summer caused sharp rises and stages were well above average in the Roscommon well.

Generally in the southern half of the Southern Peninsula levels were mostly at or near record lows at the beginning of the year. Although levels rose in the spring, stages generally remained below average the remainder of the year except in the Thumb area.



Water levels in feet below land-surface datum



High, average, and low readings are for the period of record through 1960

Figure 7. Month-end water levels in key observation wells in the Southern Peninsula, 1961.

In the Thumb area (Sanilac County) levels at the beginning of the year were low to record low, partly as a carryover from 1960. However, in late summer heavy precipitation resulted in very sharp rises,and levels reached record high stages in October.

In the Gratiot County key well, levels were low during most of the year but precipitation in August and September resulted in above average stages in the fall.

In the Clinton County well, levels were also low to record low until late summer when precipitation reversed the trend and water levels rose to about average by the end of the year.

In Ingham County, levels in the key well were at or near record low during the entire year, reflecting precipitation deficiencies in the winter and fall seasons, and some effects from areal pumping.

In Calhoun County, levels in the shallow key well remained below average principally because of lack of recharge in winter and spring.

In Cass County, levels fell and remained below average from early spring, mostly as a result of deficient winter and spring recharge.

Elsewhere in the southern half of the Southern Peninsula, water levels in wells at locations remote from pumping effects were generally low.

Statewide Changes in Storage From Pumping Influences

In areas where ground water is used for municipal or industrial supplies, water levels are observed to determine the relation between discharge from wells and natural, induced, and artificial recharge to aquifers. Declines,except as caused by precipitation deficiencies, would thus indicate depletion of the aquifers from the effects of pumpage. An effective method of determining the amount of water available from an aquifer is the analysis of long-term records of water levels and pumpage.

A recording station provides for the continuous collection of basic water-level data, which serves to indicate the day-to-day effects of pumping. The information obtained can be especially valuable to municipalities, industries, institutions, and their consultants in estimating the capacity of aquifers to meet present and future demands for water, the desirable separation between wells, and whether expansion of ground-water supply systems is feasible.

The following article appeared in the publication "Water Newsletter, Vol. 4, No. 9, May 7, 1962". It is reproduced here in its entirety by permission of the Editor. This is a particularly interesting and valuable treatment of well-field management problems.

"Well-Field Management"

"Competition for readily available surface-water supplies has become so intense in many parts of the U. S. that industrial plants and municipal water-supply systems requiring large quantities of water are turning in ever-increasing numbers to the development of underground water supplies. Ground water now constitutes almost one-third of the total withdrawn for public supply and almost one-sixth of the total used by self-supplied industries, exclusive of use for electric power generation. Almost 500,000 new water wells are drilled in the nation every year.

"Management of the expanding well fields that have come into existence in so many places calls for a level of technical knowledge and skill that was never required to any large degree for the old fashioned single water well. Some of the pitfalls that may arise in large ground-water developments are not readily apparent at the outset, and it is important to establish data-collection programs and monitoring facilities early in the work so that pumping can be continued with a minimum amount of trouble and expense.

"Management of a ground-water development logically begins during the exploratory stage, long before the water-supply facilities are constructed. In this preliminary phase, a very thorough geologic and hydrologic study, which may involve test drilling and test pumping, should be made. All records concerning each test well, such as

construction details, descriptions of materials penetrated, and the quality of the ground water should be carefully collected and filed. Particular attention should be given to the preparation of an accurate map of all test wells and the selection of a simple well-numbering system that will be adhered to over the years.

"Some of the most important data that should be compiled are those relating to fluctuations of ground-water levels. These will constitute a permanent record of ground-water conditions before the new water-supply facilities were constructed, and will not only aid in analyzing problems that may later develop, but will also serve as basic evidence in any litigation involving water supply. Such records can be extremely important in an application to public regulatory bodies for increased withdrawals and in disputes arising from water-level interference between wells.

"After the production wells are in operation, a regular program of observations should be started. Water levels should be measured periodically in all wells, whether pumping or idle, water samples should be collected for chemical analysis, detailed records of well performance should be prepared, and a running tabulation of pumpage should be maintained. The value of these records to the long-term operation of the well system cannot be overstated. Problems arising from excessive pumping, contamination, salt-water intrusion, declines of water levels, and unusual increases in temperatures can best be solved if adequate data are on hand regarding the performance history of the well field.

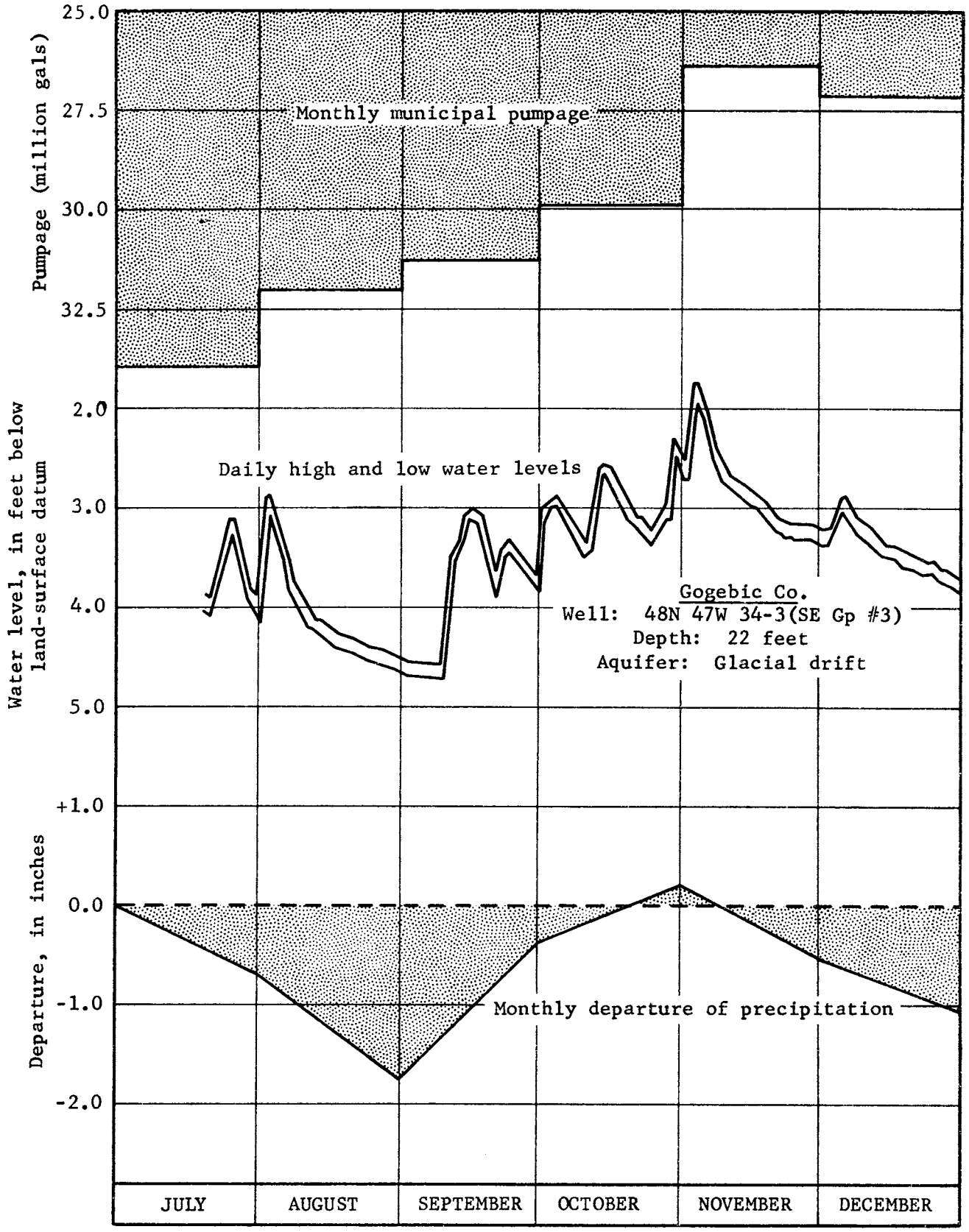


Figure 8. Hydrograph of well, pumpage, and precipitation, at Ironwood, 1961.

"Because ground water is a hidden resource, an extra effort must be made to keep track of its availability. Water can be the most important raw material used in an industrial plant, and a sound well-management program will not only pay large dividends by keeping operating expenses down, but will help to prevent problems from arising by giving adequate warning of unusual changes in ground-water conditions."

Northern Peninsula

Gogebic County

City of Ironwood.--The city obtains its municipal supply of water from wells finished at depths of from about 20 to 120 feet, in glacial drift aquifers.

In July of 1961 a continuous recorder was installed on an unused well owned by the City. In fig. 8, the daily high and low water levels from the record for this observation well show that a very small range in water level fluctuations results from the effects of municipal pumping. Departures of precipitation correlate closely with the trends of water level. This indicates that climatic effects are of greater influence on short-term fluctuations of the water levels than the present rate of municipal withdrawals of ground water.

Reported municipal withdrawals of ground water for public supply totaled 361 million gallons (mg) in 1961 (table 2), an increase of about 19 mg over 1960. The maximum pumpage day, for the City of Ironwood, in 1961 was 1.76 mg and the minimum 0.44 mg.

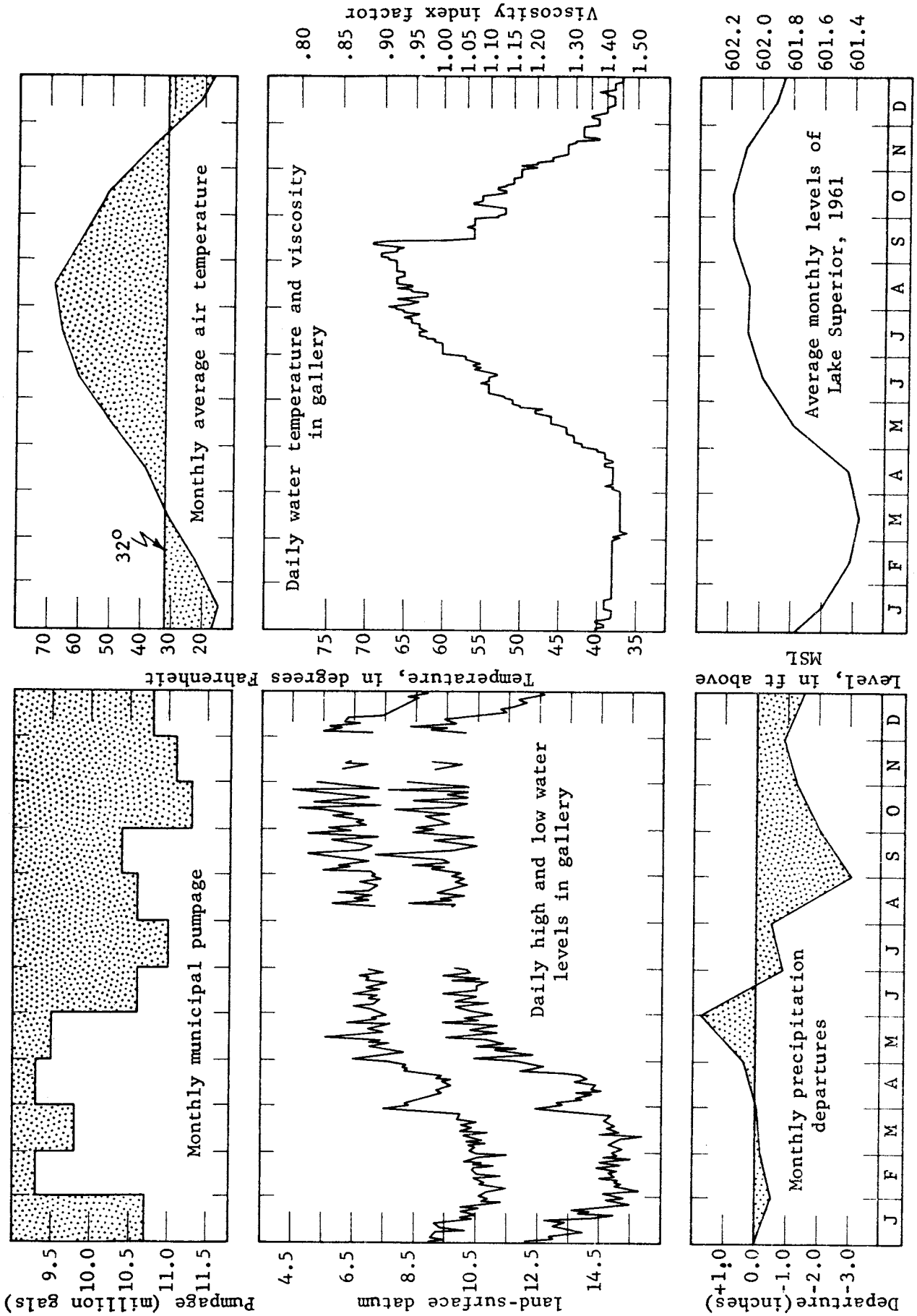


Figure 9. Hydrograph of gallery, pumpage, precipitation, and effects of changes in Lake Superior water temperature, at Ontonagon, 1961.

Ontonagon County

Village of Ontonagon.--The Village obtains water for public supply from a tile infiltration gallery parallel to and near the shore of Lake Superior. The gallery taps a deposit of beach sand. Under pumping conditions, lake water infiltrates through the sand into the gallery.

A continuous recording gage is maintained in the gallery. The water levels in the gallery do not show typical seasonal trends as in other observation wells in the Northern Peninsula (see fig. 6). As shown by figure 9, the water levels in the gallery are highest in the summer months and lowest in the winter months. No correlation is evident between the hydrograph and the graphs of pumping or departure of precipitation. Apparently, the water levels respond principally to changes in recharge by infiltration of water from Lake Superior.

During the summer months water from Lake Superior is warmer and of lower viscosity, and is able to infiltrate with less friction loss. Higher lake levels during the summer months also provide for a larger infiltration area and greater hydraulic head. In the winter months the water is colder and more viscous, the lake level is lower, and the infiltration area recedes from the gallery. In addition, sub-freezing temperatures cause ice to form along the shore, reducing the area of infiltration.

As a result of the poor recharge conditions during winter months, the maximum yield of the gallery is reduced considerably. As it has been observed that iron content of the water increases when the water level in the gallery drops below about 14 feet below land surface, pumping rates are controlled insofar as is practicable to prevent the water level in the gallery from falling below this point.

Municipal withdrawals of ground water by the Village totaled 124 million gallons (mg) in 1961 (table 2), or 17 mg less than in 1960. The maximum daily pumpage in 1961 was 0.64 mg and the minimum 0.22 mg.

Southern Peninsula

Barry County

City of Hastings.--The City obtains its water supply from wells finished in glacial drift at depths of from about 40 to 60 feet. In the latter part of 1961 a new well was drilled and cased through the drift and the Michigan Formation into the underlying Marshall Formation to a depth of 350 feet. This well is reported to produce large quantities of water of good quality. Attempts to use water from the Marshall Formation had previously been made and abandoned because water of poor quality from the Michigan Formation had not been cased out.

Observation well 3N 8W 18-1 at the Fair Grounds reflects withdrawal of ground water from the drift by municipal and industrial wells. In fig. 10 the effects of precipitation, municipal pumpage

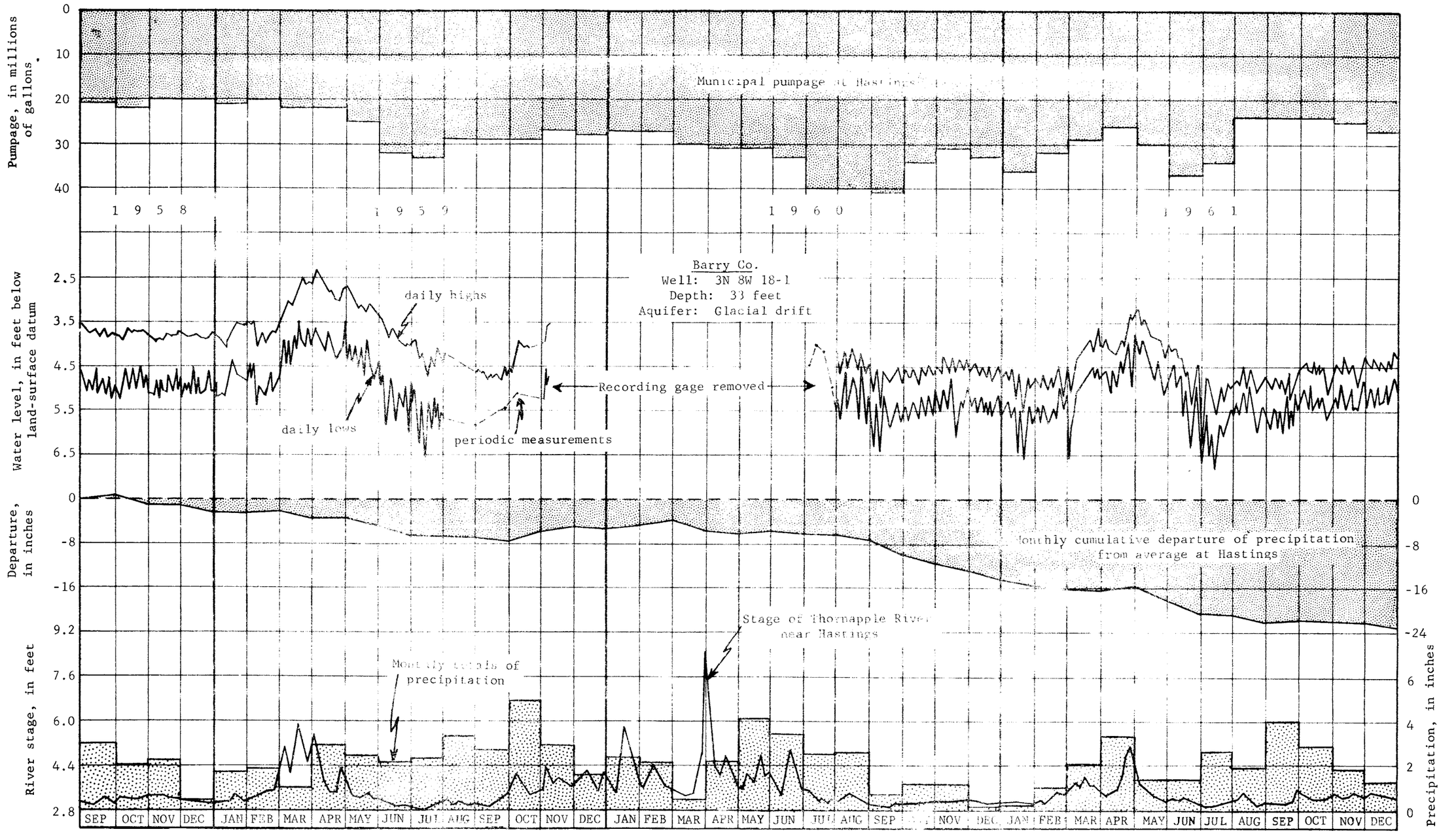


Figure 10. Hydrographs of range in a well, river stages, pumpage and precipitation, at Hastings, 1958-61.

and river stages are shown. As shown by the precipitation departure graph, a precipitation deficiency of about 22 inches was recorded during the period illustrated. The peaks in river stages coincide with the highs in ground-water levels.

Water levels fluctuate sharply in response to pumping but there is no long-range decline apparent in the hydrograph that can be attributed directly to the pumping withdrawals. Rather it appears that any decline for the period has resulted from overall long-range climatological effects.

Precipitation in the spring and especially in late summer and fall of 1961 resulted in a rise in water levels in the observation well despite the overall deficiency of precipitation for the year of nearly nine inches. This rise indicates the effect of rainfall at times favorable to ground water recharge.

Municipal withdrawals of ground water by the City of Hastings were reported to be 348 million gallons (table 2) for the year, whereas 398 and 315 million gallons were pumped in 1960 and 1959 respectively. In 1961 pumpage was less than in 1960 mainly as the result of the discontinuance of use of municipal water by a large local industry.

Calhoun County

Battle Creek Metropolitan area.--Most municipal and industrial wells in the area obtain water from the Marshall Formation. Some domestic wells are finished in the overlying glacial drift.

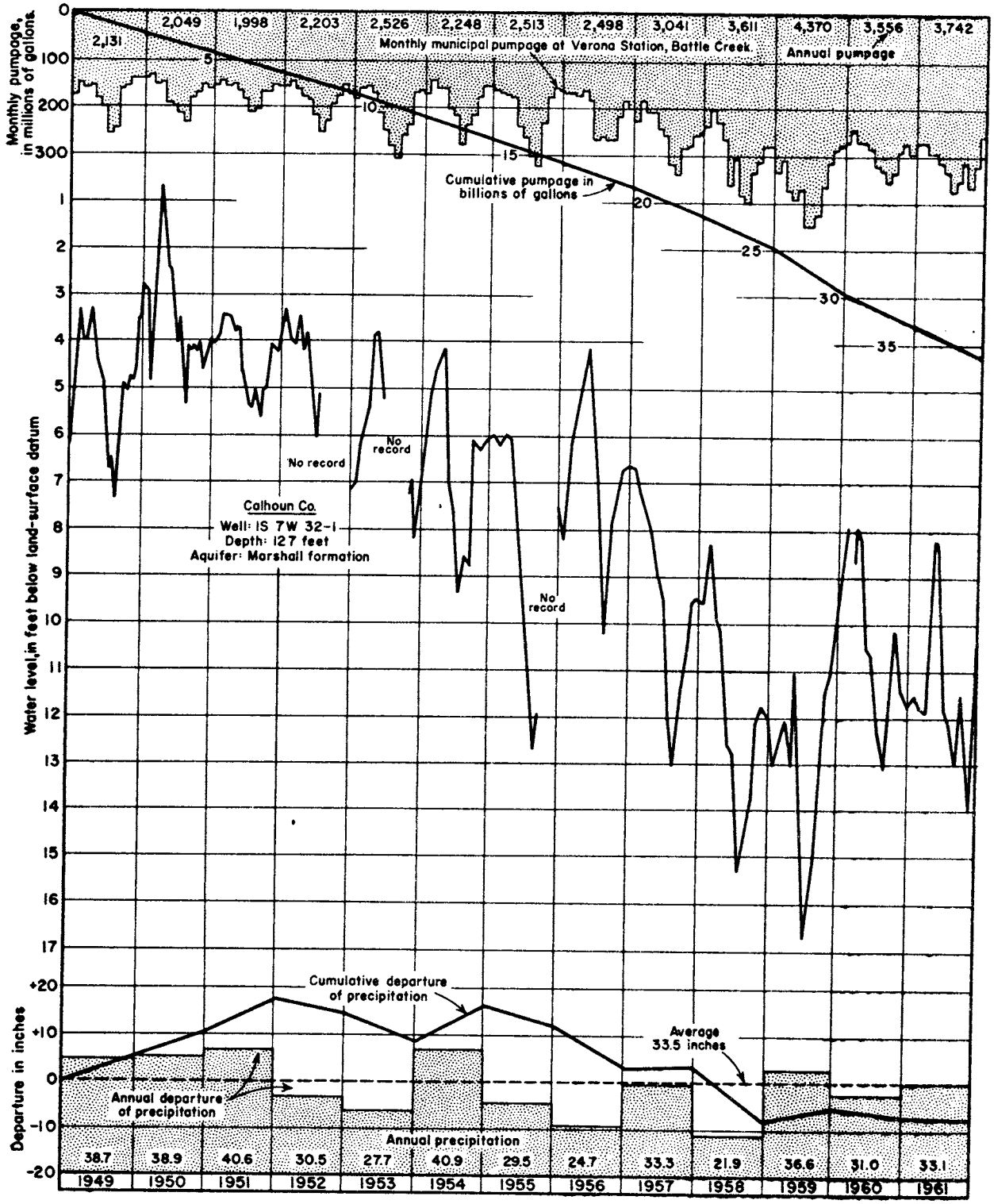


Figure 11. Hydrograph of well at Verona Station, pumpage, and precipitation, at Battle Creek, 1949-61.

At Battle Creek's Verona well field about 27 wells are finished at depths of 120 to 160 feet in the Marshall Formation. The Goguac pumping station, with wells in drift, is on a standby basis and was not used in 1961. Although more than 82 billion gallons of water have been pumped since the start of operation of the Verona well field in June 1914, water levels remain relatively high and near land surface (fig. 11).

Figure 11 shows the effects of pumping and precipitation variations on levels in the Verona Station observation well for the 13-year period, 1949-1961. A combination of increasing pumpage and a total deficiency of precipitation of about 26 inches in the 1952-58 period resulted in a declining trend in water levels. With record pumpage in 1959 water levels fell to the lowest stages observed. Water levels quickly recover from the effects of periods of heavy pumping, and when precipitation is average, as in the 1959-61 period, and pumping is reduced, levels remain relatively stable.

In mid-1958, the base level of the Kalamazoo River was lowered downstream from its confluence with the Battle Creek River. The effect of this lowering on water levels in four wells is shown in fig. 12. A new base level for ground-water discharge was created, causing declines in water levels which were largest in wells nearest the Kalamazoo River. The declines occurred in the glacial drift and in the underlying Marshall Formation.

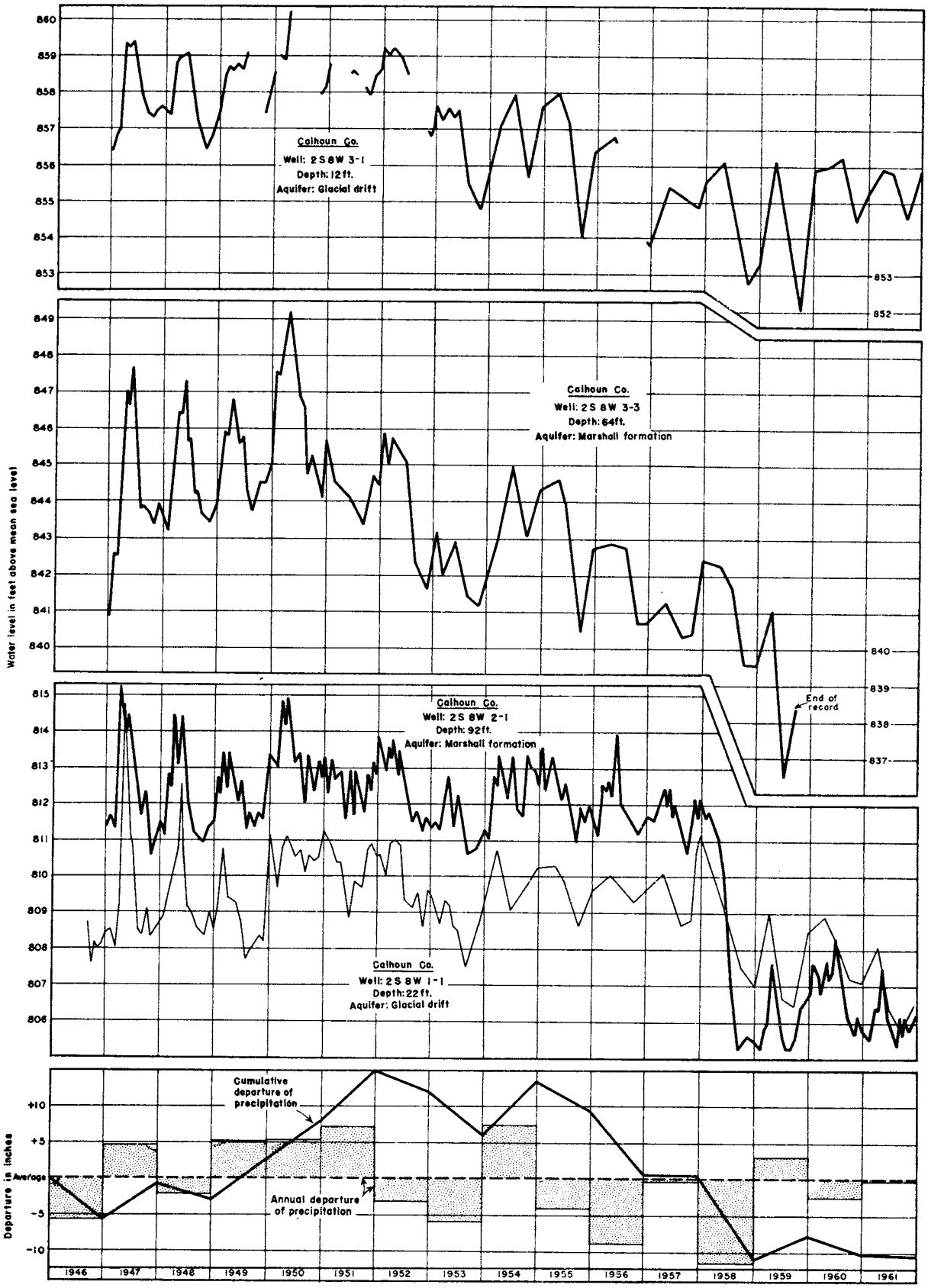


Figure 12. Hydrographs of four wells showing effect of lowering of the base level of the Kalamazoo River, at Battle Creek, 1946-61.

Dryness in the winter reduced the normal springtime rise of ground-water levels. By the end of the year levels in the drift aquifers had fallen about half a foot. However, year-end levels in Marshall Formation wells were higher, with net rises averaging from ½ foot to as much as 1¼ feet at the Verona Station observation well.

Total municipal pumpage by the City of Battle Creek was reported as 3,742 million gallons (mg) (table 2). The maximum day in 1961 was 17.1 mg on July 12 and the minimum day 5.77 mg on December 25.

In addition the Township of Battle Creek pumped 354 mg from the Marshall Formation in 1961 (table 2) with a maximum day of 3.3 mg.

Eaton County

City of Grand Ledge.--The three municipal wells and the two observation wells in Grand Ledge are finished in the Saginaw Formation at depths of 190 to 400 feet.

Figure 13 shows comparative water levels in the two observation wells and their relation to municipal pumpage and precipitation. The scale for well 11-1 was amplified for comparative purposes.

The artesian head at municipal well No. 2 is above land surface but pumping this well results in large drawdowns and these are quickly reflected in the park observation well (2-1) located about one-third of a mile northwest. At observation well 11-1 about a mile away these effects, although discernible, are less owing to the greater distance.

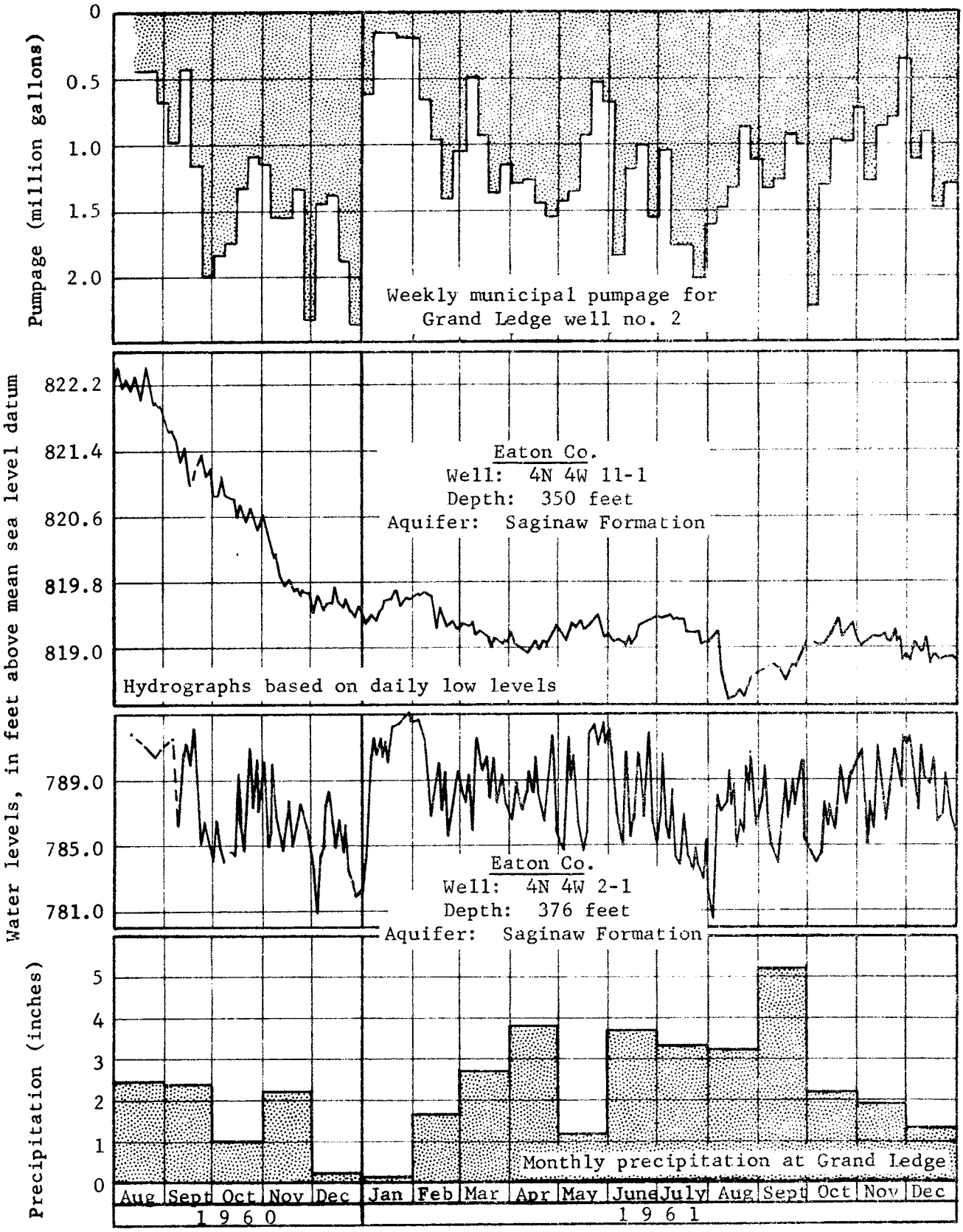


Figure 13. Hydrographs of two wells, pumpage, and precipitation, at Grand Ledge, 1960-61.

As water from the Saginaw Formation discharges into the Grand River nearby, the stage of the river as well as precipitation also has an effect on the height of ground-water levels. However, no data is available on river levels at Grand Ledge for comparison. The large amount of precipitation that fell in August and September of 1961 resulted in recharge to the aquifer and water levels in the two observation wells rose, reversing the summer decline.

Reported municipal pumpage (table 2) totaled 156 million gallons (mg), 6 mg more than in 1960. The maximum day occurred on June 30 when 0.8 mg were pumped.

Genesee County

Flint Metropolitan area.--The City of Flint obtains its municipal supply from the Flint River. However, Burton Township to the south, Beecher Metropolitan Water District to the north, and many industries in the area obtain water from the Saginaw Formation or from the overlying glacial drift.

Most observation wells in the area reflect changes in water levels caused by pumping from the drift and bedrock. Water levels in two shallow observation wells finished in the glacial drift respond principally to natural climatic conditions (table 1). In both of these wells water levels rose about $1\frac{1}{2}$ feet for the year principally as the result of recharge from the large amount of rainfall in August and September. In well 7N 7E 20-2, which is finished in the deeper drift aquifer but at some distance from pumping effects, water levels

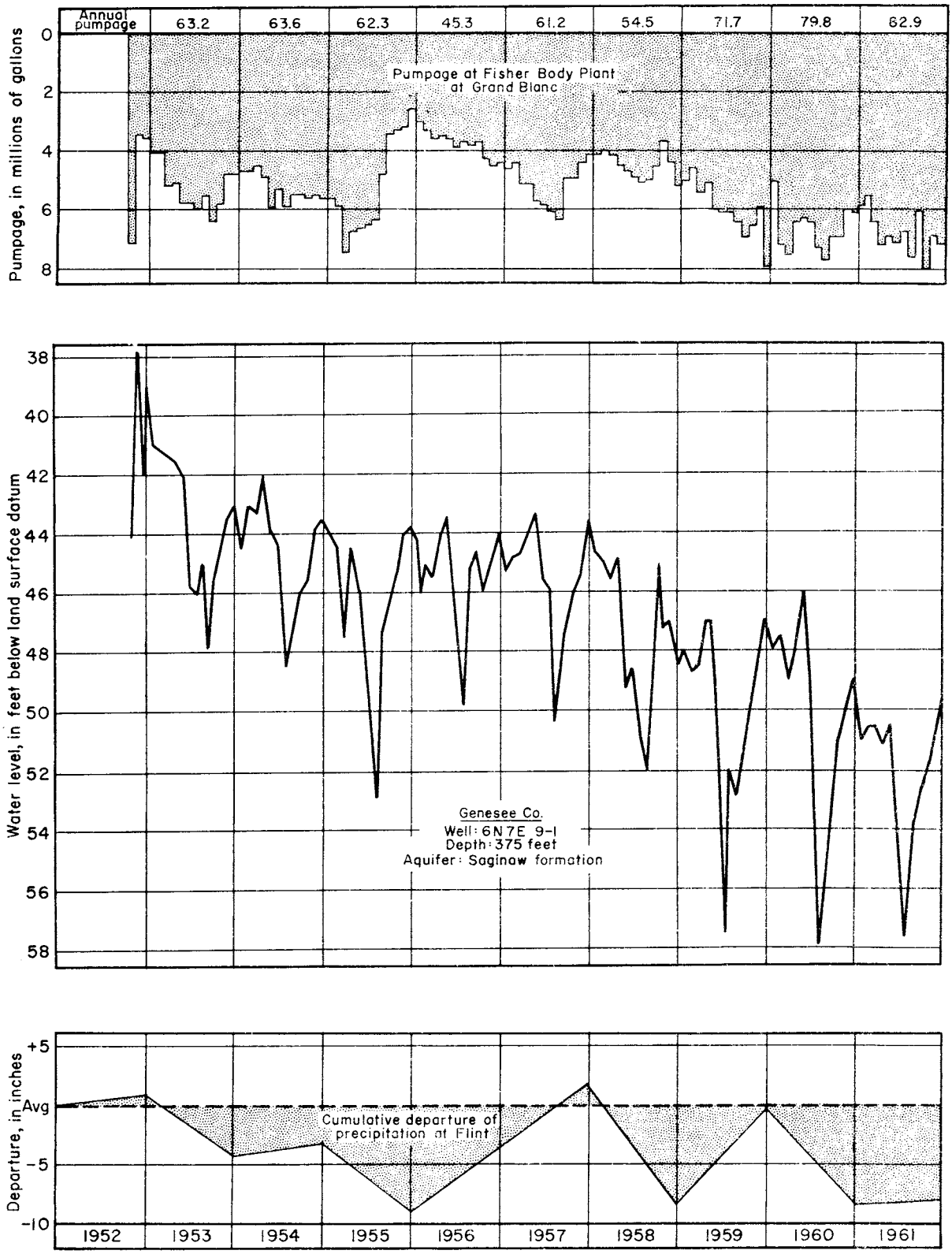


Figure 14. Hydrograph of well, pumpage, and precipitation, at Fisher Body Plant near Grand Blanc, 1952-61.

also rose in the fall and stages were nearly two feet higher at the end of the year. Observation well 7N 7E 32-1 (table 1), is also finished in the deeper drift aquifer but its levels reflect municipal pumping by Burton Township from the drift. In this well a long-term decline continued in 1961, and observed stages were about one foot lower at the end of the year from the effects of the pumpage.

Water levels in observation wells tapping the Saginaw Formation (table 1) rose about half a foot, continuing the rising trend of the past four years.

An observation well is maintained at the Fisher Body Plant of General Motors Corporation, at Grand Blanc. The water levels in this well reflect pumpage by three production wells finished at depths of 230 to 275 feet in the Saginaw Formation at the plant's well field. Increased pumpage has resulted in some lowering of water levels (fig. 14). Precipitation trends also affected water stages. For example, in 1956 and 1957 above-average precipitation appears to have countered the effects of an increase in pumpage. For the entire period illustrated, the precipitation was about eight inches below average, so that part of the long-term water-level decline can be attributed to this overall deficiency of rainfall. In 1961, recharge to the aquifer in the spring was small owing to a relatively dry winter, but in late summer and early fall heavy precipitation resulted in substantial recharge to the aquifer and year-end levels were about the same as at the end of 1960, despite the increased plant pumpage.

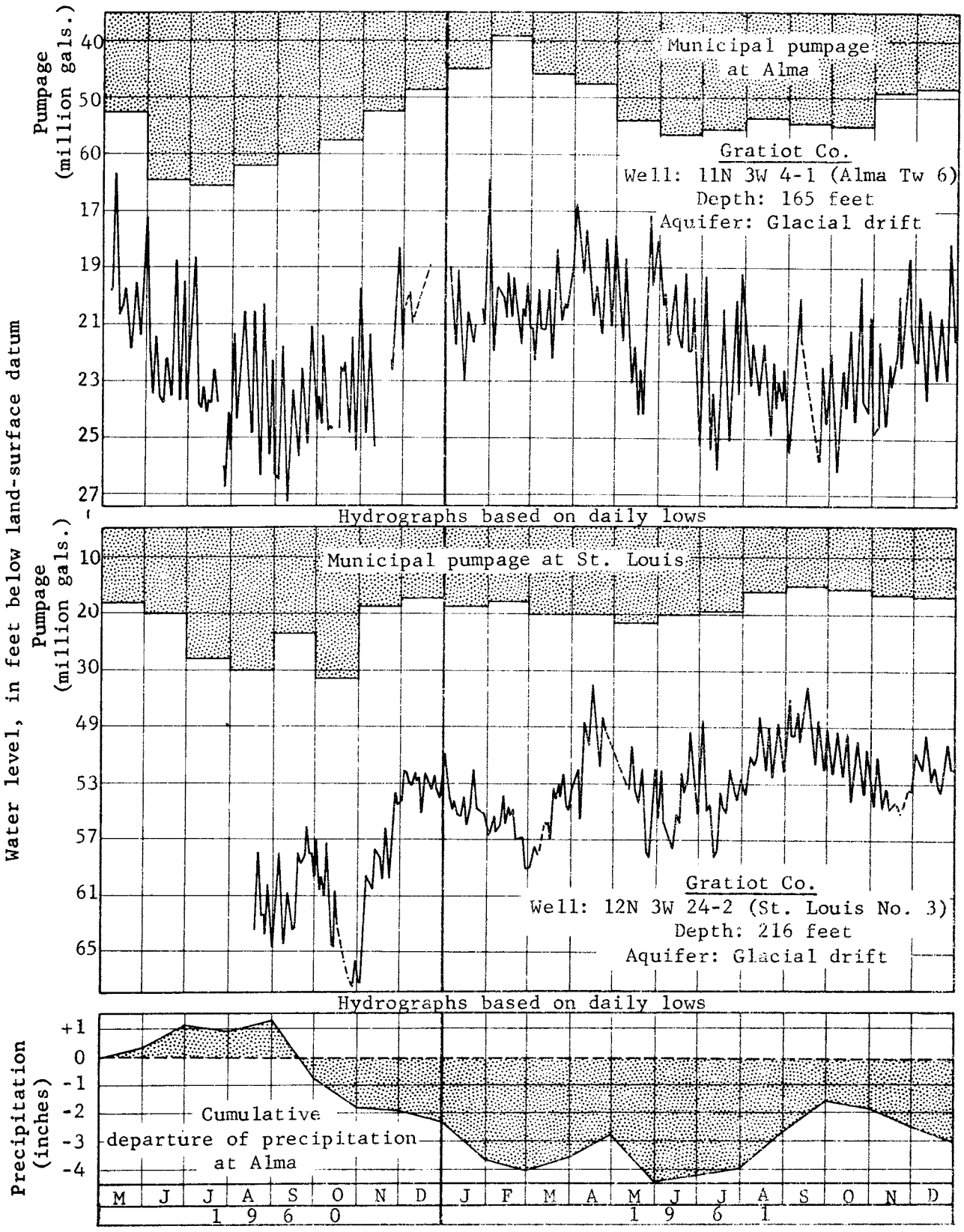


Figure 15. Hydrographs of wells, municipal pumpage, and precipitation, at Alma and St. Louis, 1960-61.

Total reported pumpage of 82.9 million gallons (table 2) was the highest of record for the Fisher Body Plant with a maximum day of 0.36 mg on September 27 and a minimum day of 0.05 mg on January 2.

Gratiot County

City of Alma--Five municipal wells, 82 to 164 feet deep, and industrial wells in the area obtain water from the buried outwash. A sixth municipal well, 550 feet deep, taps the underlying Saginaw Formation but is seldom used, as the water is of poor quality. Observation wells in the area are finished in shallow drift and in deeply buried gravel outwash. Water levels in the shallow drift primarily reflect variations in precipitation and temperature, whereas artesian pressures in the buried outwash are principally affected by municipal and industrial pumping.

Well 12N 3W 35-5 (fig. 7) is finished in shallow drift and reflects variations in natural recharge conditions. Its levels were low until fall when heavy precipitation resulted in rises to average stages.

From the hydrograph of well TW 6 (fig. 15) it is evident that water levels in this well fluctuate in response to changes in rate of municipal pumpage. Although masked by the pumping, and not too readily discernible, periods of above average or below average precipitation, as shown by the departure graph, also affect the water

levels--dampening rises or accenting falls in levels from the pumpage effects. For example, heavy precipitation in August and September of 1961 offset any further general decline for the year.

Water levels in the spring of the year were the highest since 1958 in some observation wells finished in the deeper drift aquifer. However, year-end levels were from half a foot to as much as three feet lower than at the end of 1960, despite the decreased pumpage.

Total reported municipal pumpage in 1961 (table 2) was 604 million gallons as compared to 645 mg in 1960. The maximum day reported in 1961 was 2.45 mg on July 12.

City of St. Louis.--The City obtains water from six municipal wells tapping the deeply buried sand and gravel outwash deposits at depths of from 213 to 223 feet. Industrial supplies are also obtained from wells in this aquifer.

The water levels in observation well St. Louis No. 3 fluctuate sharply in response to changes in municipal pumping rates and less rapidly to variations in precipitation (fig. 15). Levels were at their lowest for the period of record in late October, 1960, as a result of a total deficiency of three inches of precipitation in September and October combined with heavy municipal pumping. Reduced pumping and near-normal precipitation in November and December of 1960 resulted in a substantial rise by the end of the year.

In 1961 heavy precipitation in the spring and again in August and September when conditions are favorable to ground-water recharge, resulted in higher levels. Thus, year-end levels were about two feet higher in 1961 than in 1960.

Total reported municipal pumpage for 1961 was 218 million gallons (table 2) compared to 262 mg in 1960. In 1961 a maximum day of 0.94 mg was reported.

Ingham County

Lansing Metropolitan area.--The Saginaw Formation is the principal source of water for wells in the area. A few domestic wells in the area obtain small supplies of water from the overlying glacial drift.

Lansing obtains water from 115 wells. Thirty-six are pumped by airlift, a few by submersible pumps, and the remainder by turbine pumps. Wells are 14-inch diameter and average 425 feet in depth. In East Lansing there are five municipal wells, Michigan State University has nine, Lansing Township has five, and Meridian Township eight. Depths of these wells range from 300 to about 500 feet. All these wells obtain water from the Saginaw Formation.

Observation wells in the Lansing area are finished in the Saginaw Formation except for one finished in the overlying glacial drift (table 1, Ingham Co.).

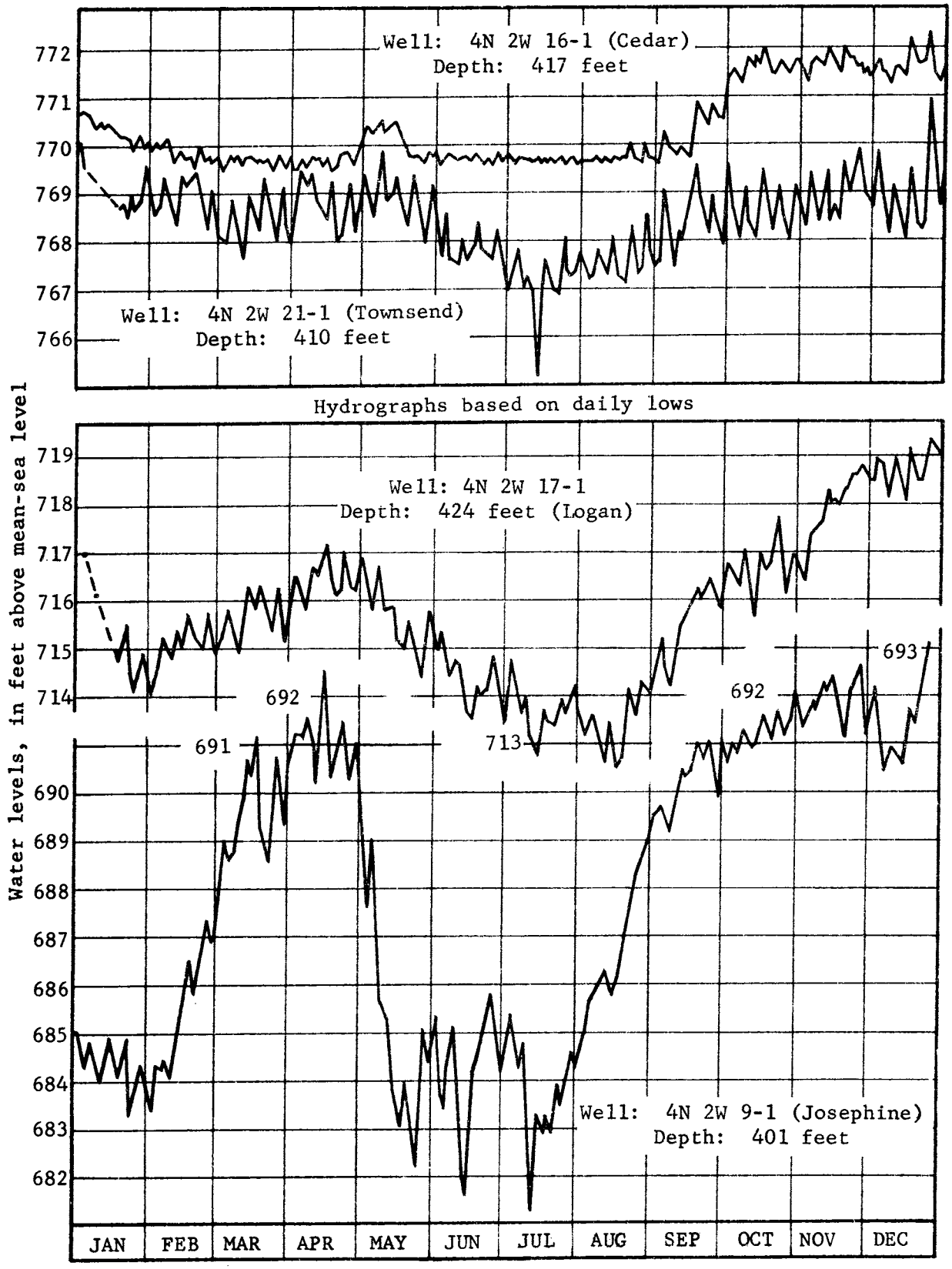
Water levels in observation wells finished in the Saginaw Formation reacted to changes in patterns of pumping, and also to total withdrawals of ground water in the area. Levels in some wells fell to new lows of record in the area (table 1, Clinton, Eaton, and Ingham Counties).

In the northeastern part of the Lansing area levels in wells 5N 2W 31-1 and 32-1 fell about 8 and 2½ feet respectively to new lows of record (table 1, Clinton Co.). Record lows were also observed in Eaton County wells 4N 3W 10-1 and 12-1 in the western part of the area (table 1, Eaton Co.).

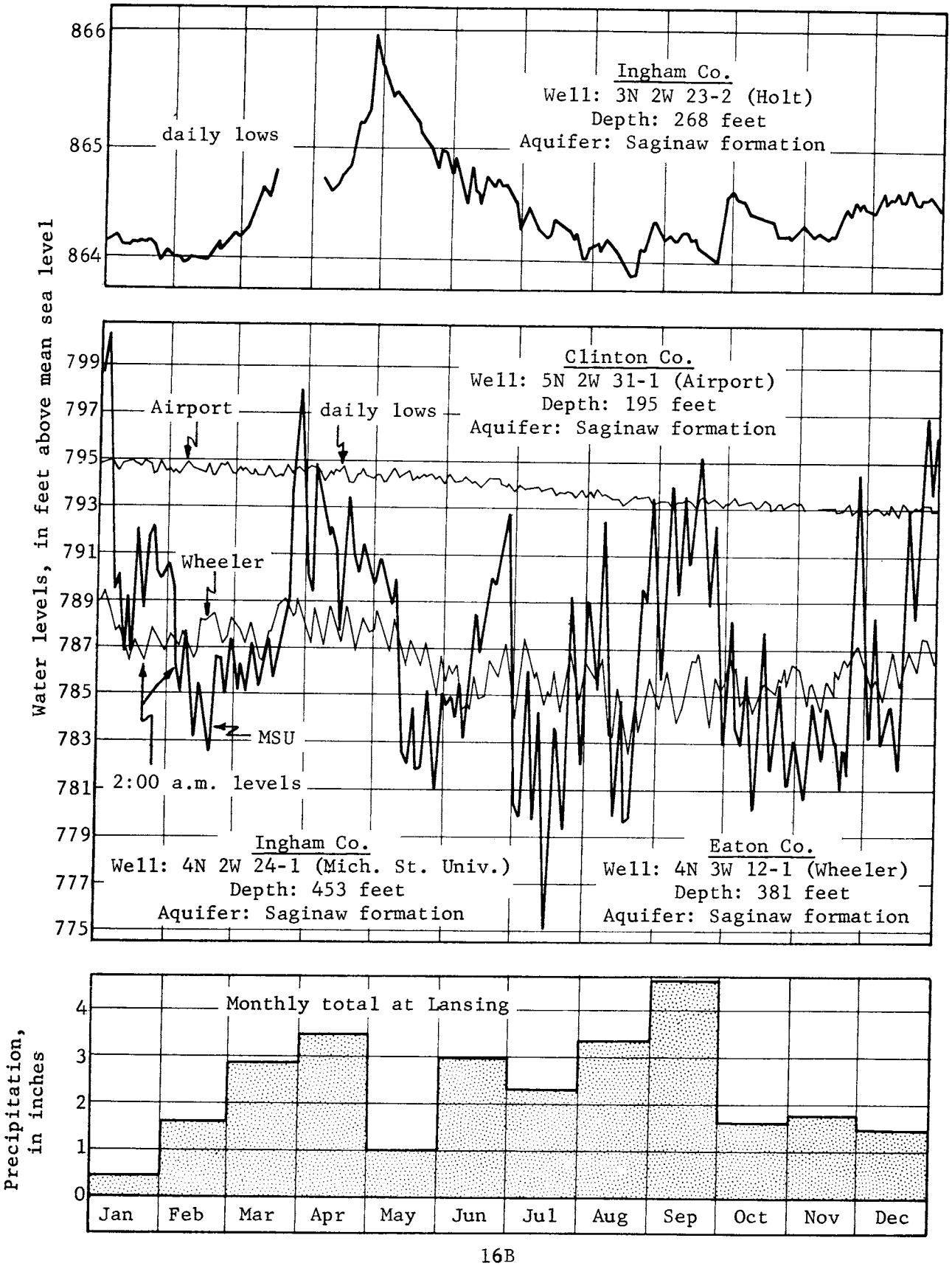
In addition two wells in Lansing in the western and southwestern section fell to record lows.

Elsewhere in the Lansing area water levels were not as low owing to local reduction of pumpage.

In figure 16, the 1961 hydrographs of eight wells based on records from continuous recording gages are shown. Sea level datum is used to allow for comparison of water levels. The lowest stages at the Josephine well (fig. 16A) were nearly 200 feet lower than at the Holt well to the south, and about 100 feet lower than at the Michigan State University on the east side and the Wheeler well (fig. 16B) on the west side of Lansing. Although a deep cone of depression is created by pumping in this area, the areal extent of the cone is still not large. Precipitation effects are generally


Well: 4N 2W 16-1 (Cedar)
Depth: 417 feet
Well: 4N 2W 21-1 (Townsend)
Depth: 410 feet
Hydrographs based on daily lows
Well: 4N 2W 17-1
Depth: 424 feet (Logan)
Well: 4N 2W 9-1 (Josephine)
Depth: 401 feet
Water levels, in feet above mean-sea level
772
771
770
769
768
767
766
719
718
717
716
715
714
692
691
713
693
692
690
689
688
687
686
685
684
683
682
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

16A



16B

Figure 16. Hydrographs of eight wells in the Greater Lansing area, and precipitation, 1961.

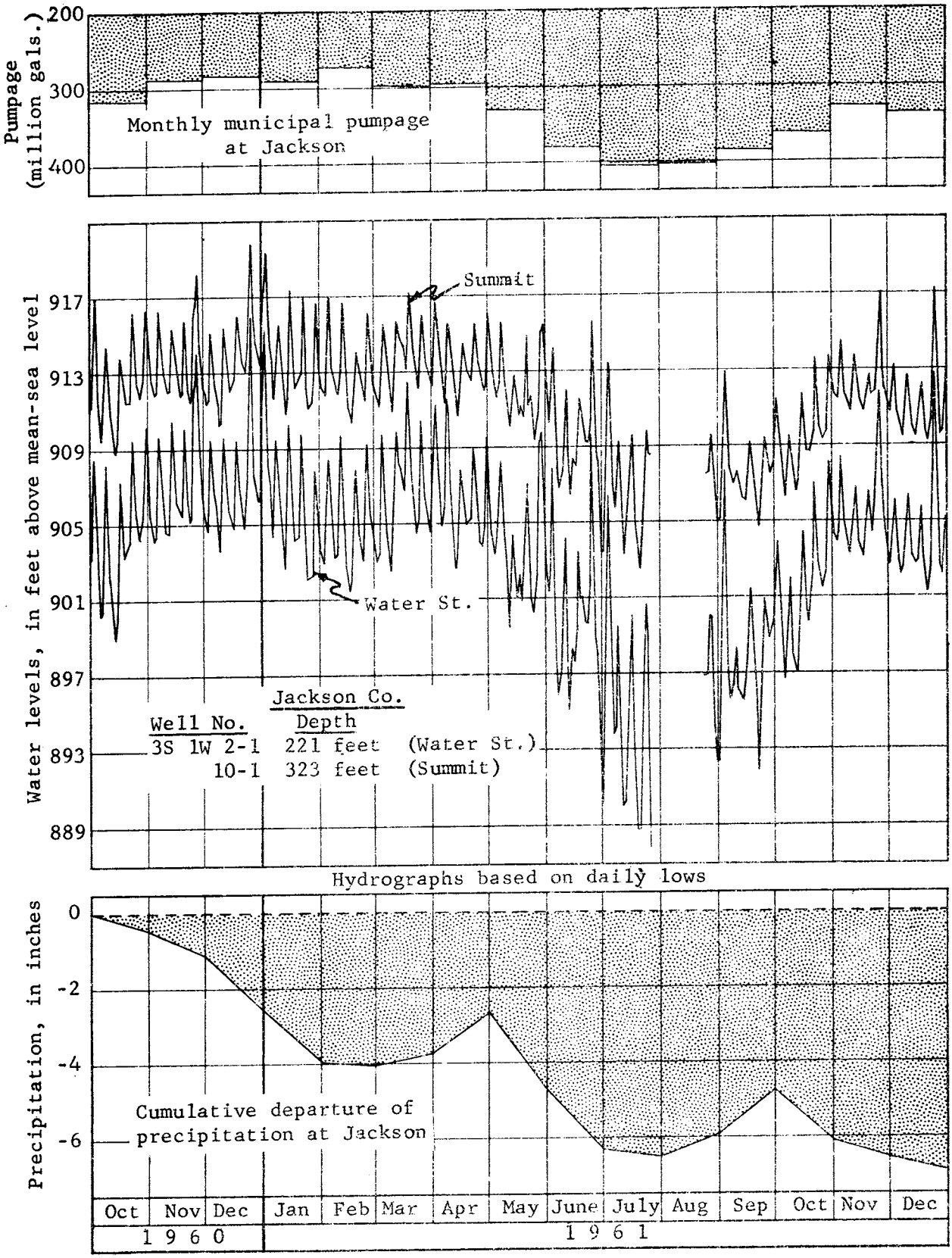


Figure 17. Hydrographs of two wells, pumpage, and precipitation, at Jackson, 1960-61.

masked by the heavy pumping. Despite a total precipitation deficiency for the year, heavy precipitation in early spring, and in August and September resulted in some recharge. Levels in some wells were higher at the end of 1961 than at the end of 1960, as a result of the recharge from precipitation and a decrease of 300 million gallons in total municipal and institutional withdrawals of ground water.

Total reported withdrawals of ground water in 1961 for municipal, institutional, and industrial use in the Lansing area (table 2) was 8.1 billion gallons with an average of about 22.3 million gallons per day. The total was less than the 8.2 in 1959 and the 8.4 billion gallons in 1960.

Jackson County

City of Jackson.--Most municipal, industrial, and institutional wells in the area obtain water from sandstone strata in the Saginaw, Parma, and Marshall Formations. The city obtains water from 14 wells, 380 to 400 feet deep, tapping these sandstone strata. Eleven of these wells are at the Belden Road well field.

Water levels in three observation wells in the area reflect withdrawals of ground water principally from the municipal well field at Belden Road.

The hydrographs of two wells in Jackson (fig. 17) do not indicate a continuing downward trend of water levels, despite

large withdrawals of water by the municipal wells. The precipitation deficiency of about seven inches for the period illustrated apparently has not had much effect on water levels. The Water Street observation well is 1.1 miles, and the Summit well 1.7 miles from the Belden field. Although water levels in these wells fall sharply from the effects of heavy city pumping the stages quickly recover when pumping was decreased, for example on weekends.

At the Belden Road observation well (table 1) sharp drawdowns of water levels, as much as 40 feet in a few hours, occur in response to pumping of nearby wells. Levels quickly recover however, when pumping is decreased.

Reported municipal withdrawals of ground water by the City of Jackson totaled 4.1 billion gallons in 1961 (bg) (table 2) as compared to 4.0 in 1960 and 4.5 in 1959. Pumpage by the State Prison at Jackson was 0.5 bg (table 2).

Kalamazoo County

City of Kalamazoo.--Wells in the Kalamazoo area obtain water from glacial drift. About 75 municipal wells are finished in the drift at depths of 120 to 220 feet. Large supplies of ground water for municipal and industrial use have been obtained with no significant dewatering except as caused by deficiencies in precipitation. The maintenance of high water levels is accomplished by using induced recharge from surface ponds and locally controlling

withdrawal rates. As the drift aquifers are underlain by the Coldwater Shale which produces only small amounts of poor quality water, wells are not generally drilled below the drift.

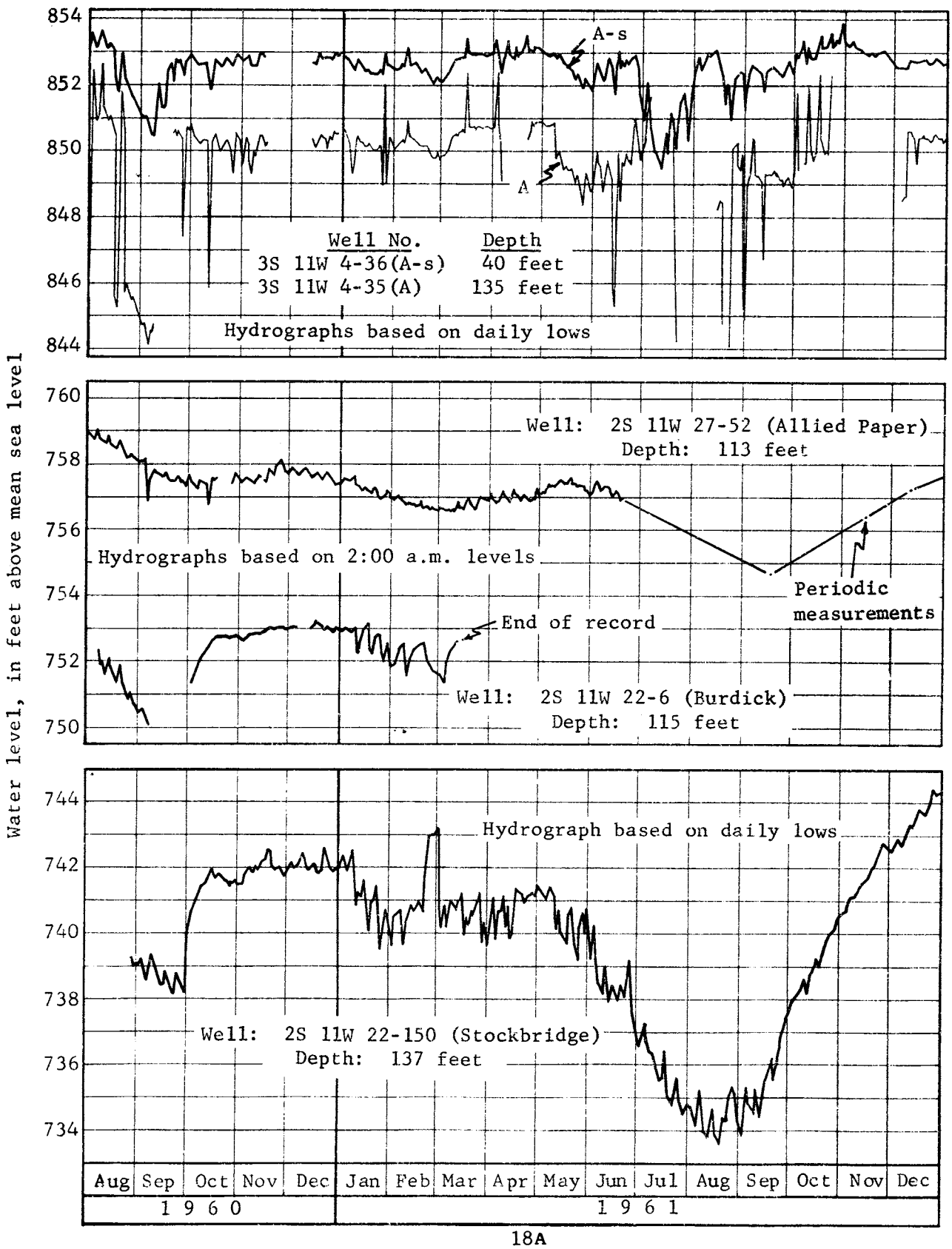
Figure 18 shows fluctuations of water levels in six wells. It also shows the location of all observation wells in the area.

The Atwater well hydrograph (fig. 18B) reflects natural conditions as no wells are pumped in the immediate vicinity. The decline in water levels for the period of record is the result of precipitation deficiencies for the year.

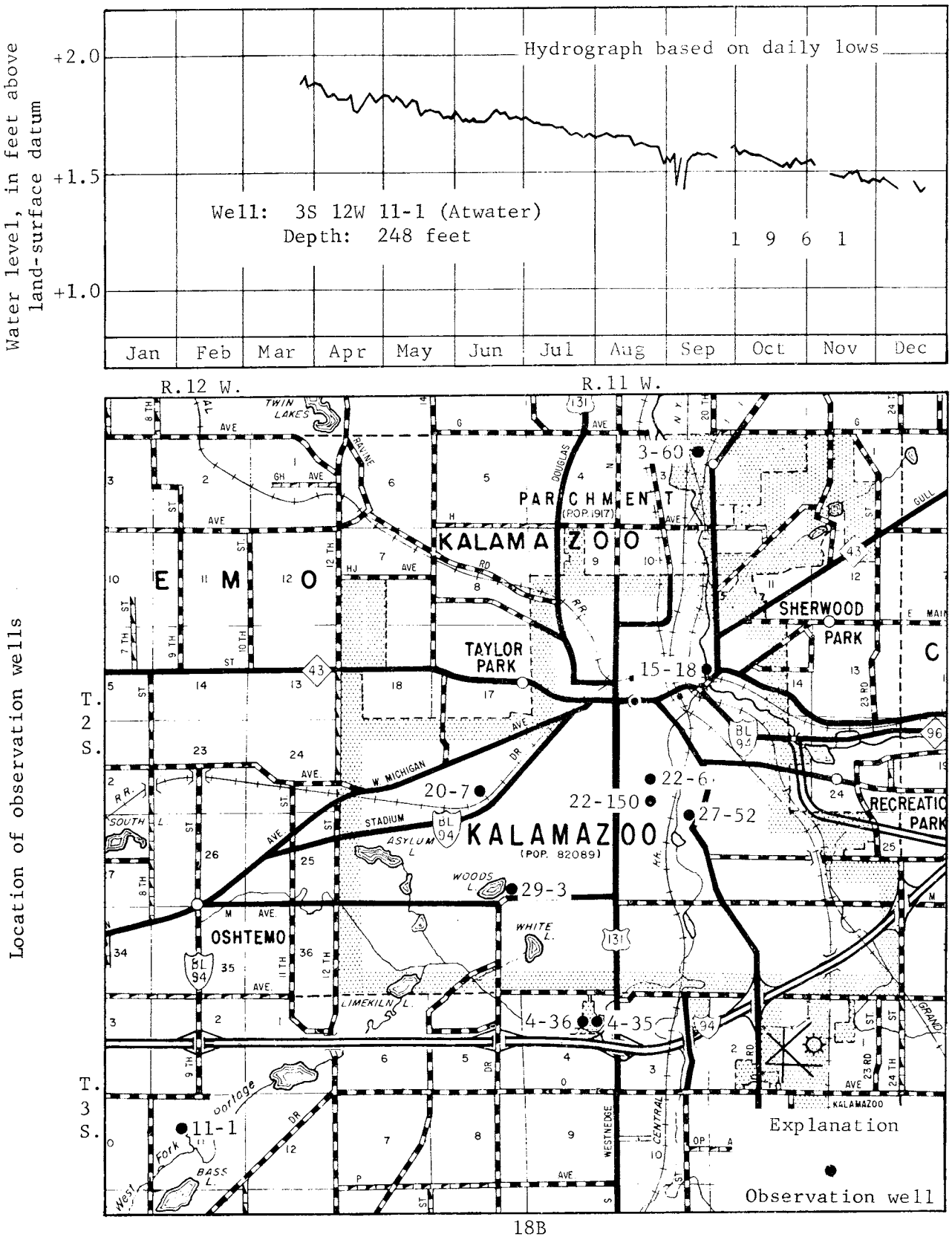
The Stockbridge well (fig. 18A)(replacing the destroyed Burdick observation well) provides a continuation of the record for the heavily pumped Axtell Creek area. Levels were higher at the end of the year because of reduced withdrawals of ground water from the field in the fall.

Levels in wells A and A-s (fig. 18A) reflect pumping withdrawals from the Station 9 well field. When pumps are turned on levels are drawn down in both the deep artesian aquifer and the shallow aquifer. As the result of the effects of the recharge from the ponded water, years of heavy pumpage at this field have not caused any appreciable lowering of water levels.

In the general area lower ground-water levels in recent years (table 1) are mostly the result of long-term deficiencies in


Water level, in feet above mean sea level
854
852
850
848
846
844
A-s
A
Well No. Depth
3S 11W 4-36(A-s) 40 feet
3S 11W 4-35(A) 135 feet
Hydrographs based on daily lows
760
758
756
754
752
750
Well: 2S 11W 27-52 (Allied Paper)
Depth: 113 feet
Hydrographs based on 2:00 a.m. levels
Periodic measurements
End of record
Well: 2S 11W 22-6 (Burdick)
Depth: 115 feet
744
742
740
738
736
734
Hydrograph based on daily lows
Well: 2S 11W 22-150 (Stockbridge)
Depth: 137 feet
Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1960
1961

18A



18B

Figure 18. Hydrographs of six wells, and location map, at Kalamazoo, 1960-61.

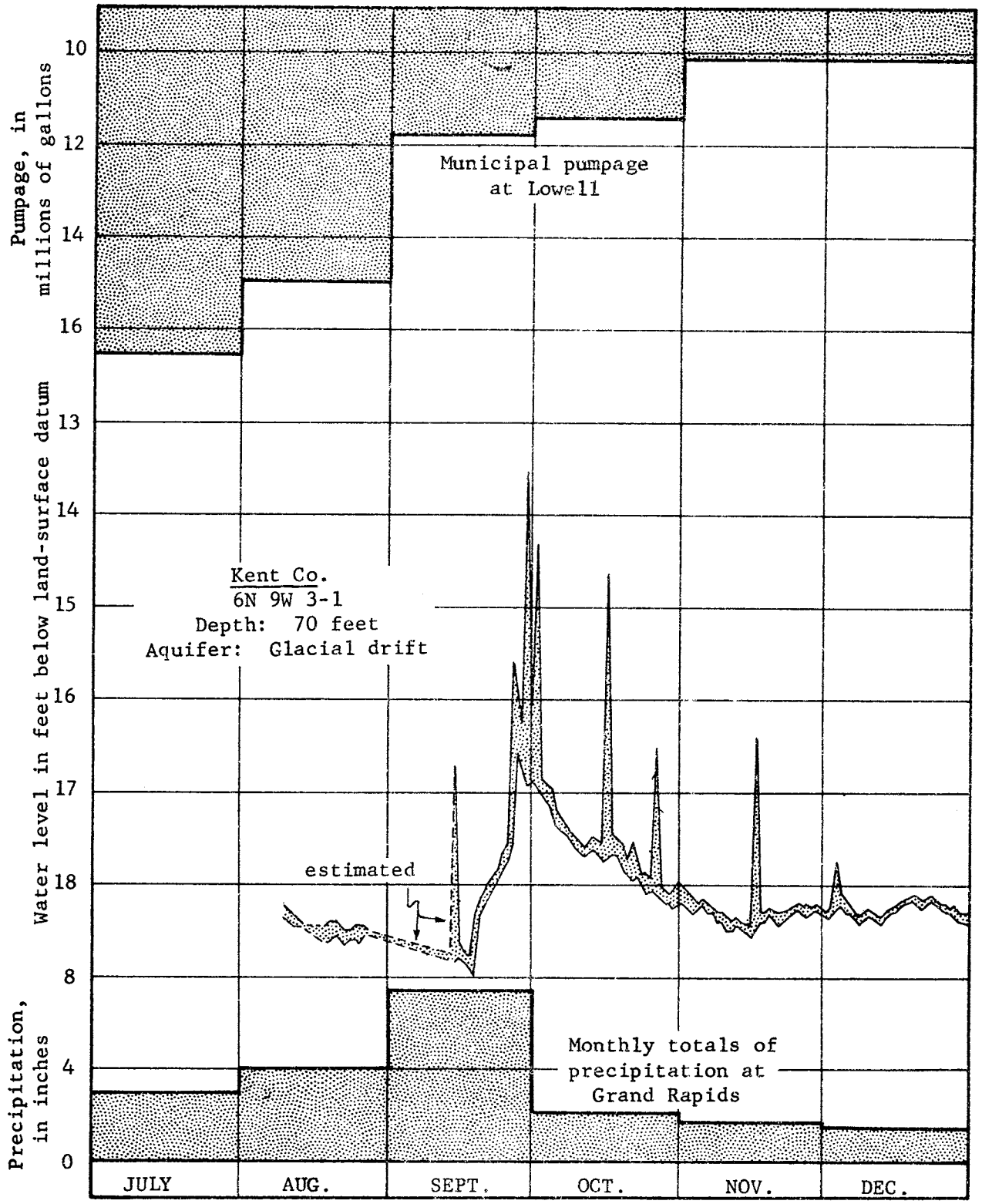


Figure 19. Hydrograph of range in a well, pumpage, and precipitation, at Lowell, 1961.

precipitation. Since 1952 the deficiency has amounted to about 30 inches of rainfall.

Reported municipal withdrawal of ground water was 4,930 million gallons (mg) (table 2) as compared to the record 5,116 (mg) in 1959. The maximum day in 1961 was 29.5 mg July 12, and the minimum 6.4 mg December 31.

Kent County

City of Lowell.--The City obtains its water from four wells finished in glacial drift at depths of from 50 to 70 feet.

On August 8, 1961, a recording gage was installed on an unused well in Lowell. The water levels in the well reflect withdrawals of ground water by three municipal wells from which most of the City's supply is obtained. The fourth well is used only during peak periods and is at some distance from the observation well.

The short period of record (fig. 19) indicates that both precipitation and pumping of nearby city wells affect the water levels in the observation well. The daily range in water levels generally is very small. Most of the sharp peaks of short duration probably are the result of shutdown of nearby wells for short periods. Some of the peaks may be caused by recharge from storms.

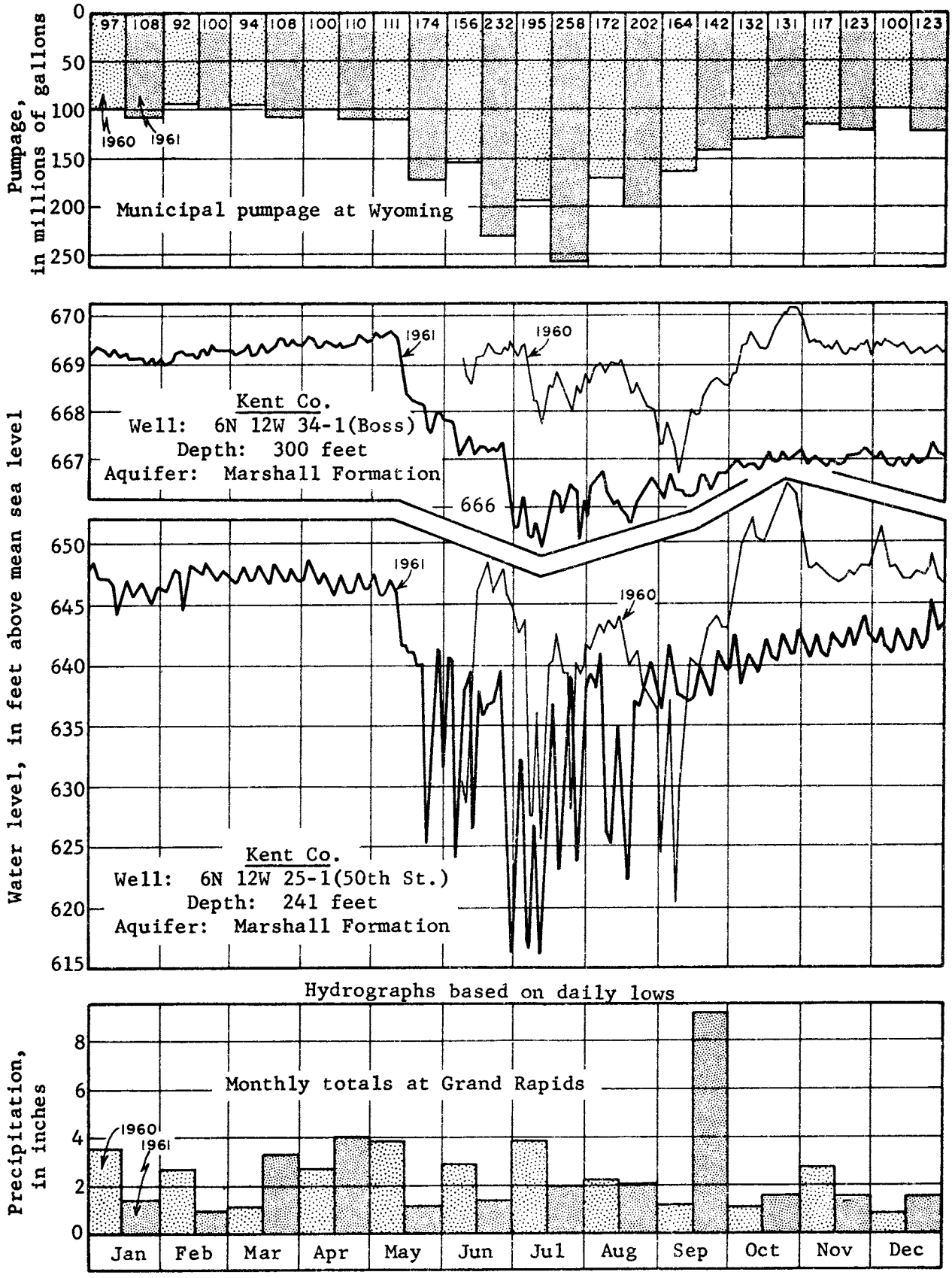


Figure 20. Comparative hydrographs of two wells, pumpage, and precipitation, at Wyoming, 1960-61.

Reported municipal pumpage for the year (table 2) was 143 million gallons (mg) or 13 mg less than in 1960. In 1961 the maximum day was 0.83 mg and the minimum day 0.22 mg.

City of Wyoming.--The City obtains its municipal supply from about 28 wells tapping the glacial drift or Marshall Formation at depths of from 50 to 300 feet.

This City's water supply system has been expanded in recent years and a study has been made by a consulting firm to determine the water potential of the area. Supplies sufficient for many years have reportedly been located.

Recording gages on observation wells reflect withdrawals of ground water from the Marshall Formation. No observations were being made on wells in the glacial drift in 1961.

Figure 20 illustrates comparative data for the years 1960 and 1961. The lower water levels in 1961 were the result of an increase in municipal withdrawals and a deficiency of precipitation of more than 10 inches in the period September 1960 to September 1961. Although more than nine inches of precipitation fell in September 1961, the rains were mostly the results of remnants of hurricane Carla and fell in intense storms which resulted in quick runoff and little evident recharge to the ground water aquifers.

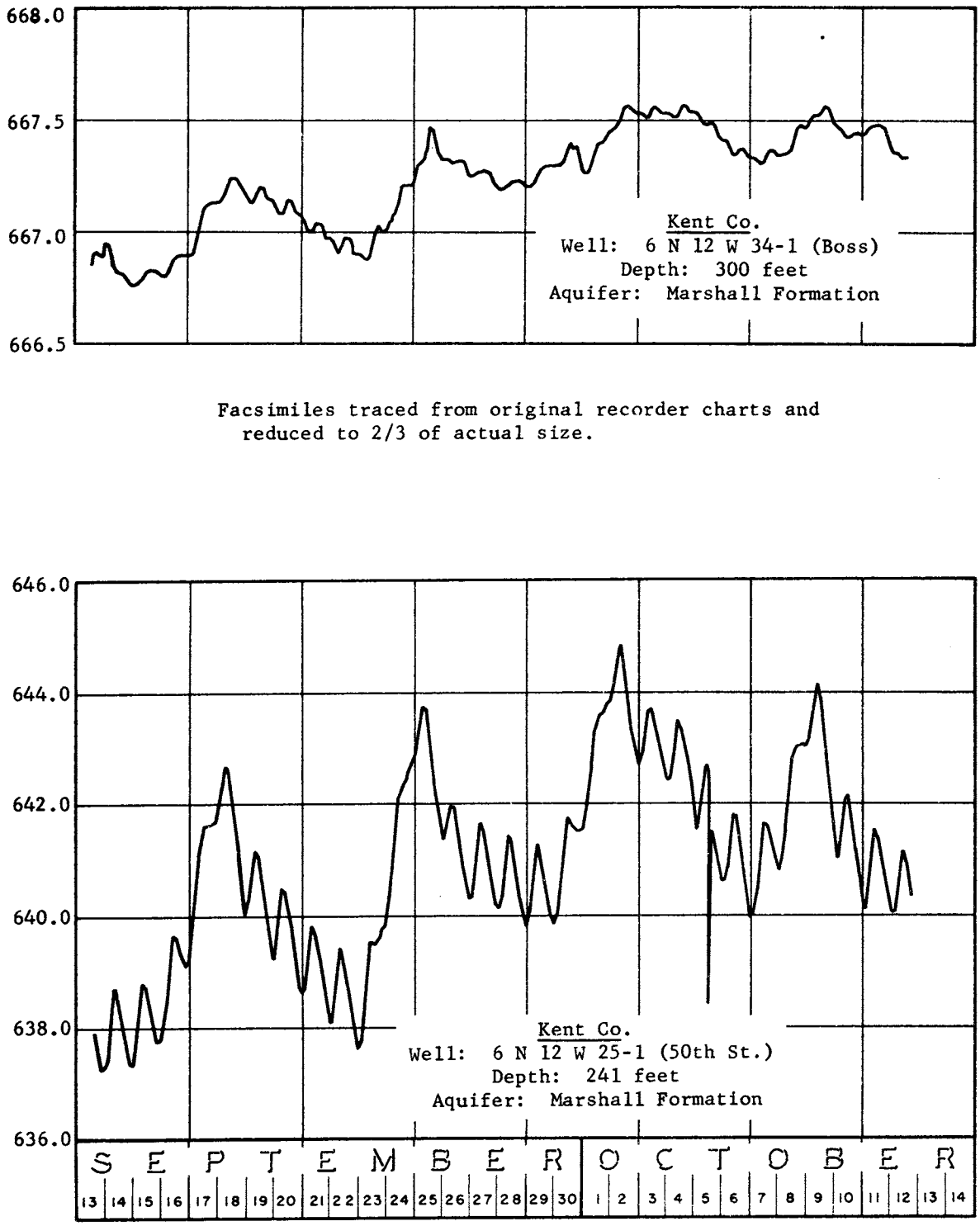


Figure 21. Monthly recorder charts from two wells in Wyoming. September 13-October 12, 1961.

Facsimiles of monthly recorder charts from two wells are shown on Figure 21. The vertical scale for the Boss well is one-fourth of that for the 50th Street well. Water levels in both wells rise and fall at about the same times, but the flucuations are much greater in the 50th Street well than in the Boss well which is further from areas of heavy pumping.

Reported municipal withdrawals of ground water totaled 1,811 million gallons (mg) for the year (table 2) with a maximum daily pumpage of 14.9 mg. The total pumpage was 19 percent more than in 1960.

Oakland County

Michigan State University at Oakland.--The supply of water for the campus in 1961 was obtained from a six-inch well finished at about 150 feet in the glacial drift aquifer. An additional production well and an observation well were drilled in 1961. The water levels in the observation well (fig. 22) reflect the heavier pumping during the school season and also the effects of deficiencies of precipitation. Any recovery of water levels from snowmelt and spring rains, and in the fall from recharge after the end of the growing season, appears to have been masked by the relatively heavy pumping during those periods. Thus, the summer decline continued until year's end. A drop of about $1\frac{1}{2}$ feet was registered for the year.

University pumpage was reported as 11.7 million gallons (mg) for the year with a maximum day of 0.50 mg.

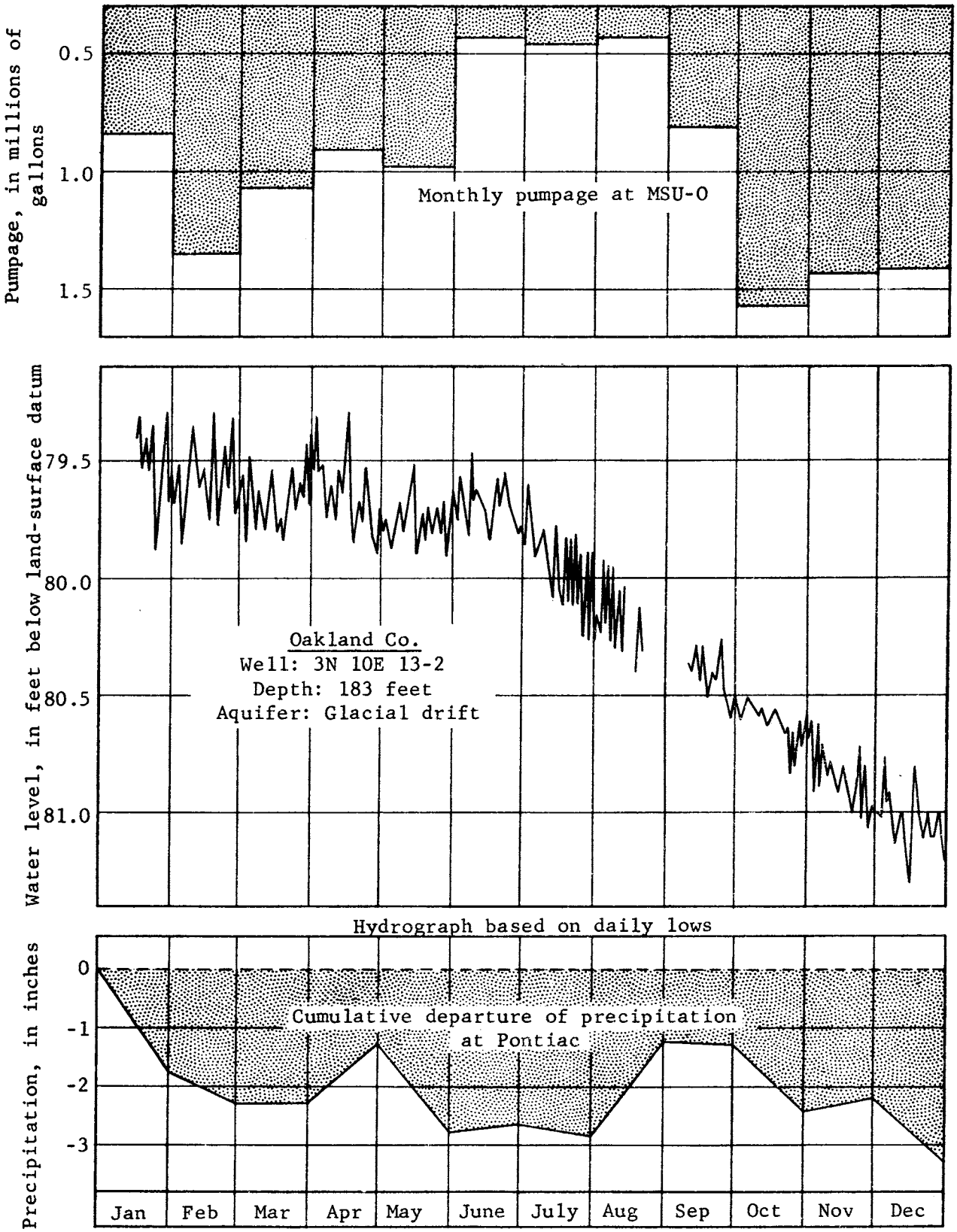


Figure 22. Hydrograph of well, pumpage, and precipitation, at Michigan State University - Oakland, near Rochester, 1961.

City of Pontiac.--Municipal and industrial supplies of water are obtained from wells finished in glacial drift aquifers. The City obtains water from 23 wells that are finished in the drift at depths of 100 to 280 feet.

The levels in the Walnut Street observation well (fig. 23) reflect changes in municipal pumping in that area and also the effects of variations in precipitation. Most of the precipitation deficiency of 14 inches in the 1960-61 period occurred in 1960. As a result levels were quite low at the beginning of 1961. Spring recharge to the aquifers caused a moderate rise in water levels, but heavy summer pumpage that followed and deficiencies of precipitation in the fall resulted in slightly lower year-end levels. However, the low levels in July 1961 were still seven feet higher than the lowest of record in 1955 (table 1). Reported municipal pumpage by the City of Pontiac totaled 3,529 million gallons (mg) (table 2) for 1961 or 269 mg less than in 1960. In 1961 the maximum day was 19.2 mg and the minimum 5.6 mg.

Waterford Township.--The Township supply is derived from wells finished in glacial drift at depths of about 200 to 300 feet. Ten housing subdivisions in the Township also obtain water from wells finished in the drift at depths of from 40 to 179 feet.

Water levels in the observation well (fig. 23) reflected increased pumpage in 1961. However the net decline for the period illustrated was only about a foot and evidently was also influenced

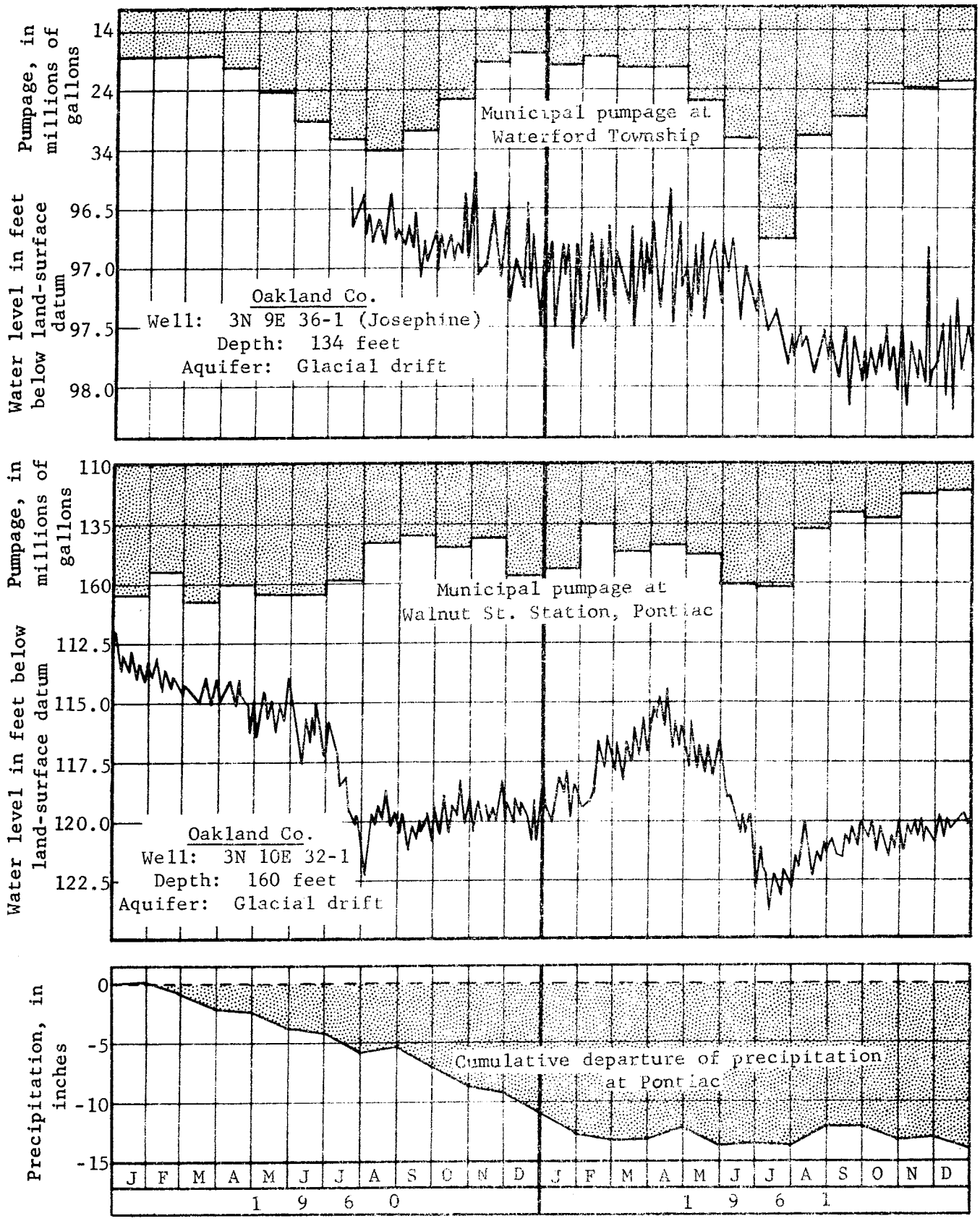


Figure 23. Hydrographs of two wells, pumpage, and precipitation, at Pontiac, and Waterford Township, 1960-61.

by 14 inches of deficiency of precipitation in the 1960-61 period.

In September of 1961 a recording gage was installed on a second observation well at Garfield Estates (table 1). This well is located more than a mile from public supply wells. The water levels are above land surface and reflect pumping in the area and also variations in precipitation.

Reported municipal pumpage by the Township was 314 million gallons (mg) (table 2) an increase of about 30 mg over estimated pumpage in 1960. In addition about 10 subdivisions have their own public water supplies in the Township.

Village of Rochester.--The Village obtains water from several wells, finished in glacial drift, at depths of from 65 to 120 feet.

In August of 1961, a recording gage was installed on an unused well at the municipal well field. The levels in the well fluctuated 4 to 6 feet in response to the pumping of nearby municipal wells in the field but recovered quickly when pumps were shut off. The hydrograph (fig. 24) shows the daily lows in the observation well. The stages and trend in water levels follow closely the pattern of daily pumping operations. The effects of precipitation are not readily discernible.

Reported municipal pumpage of ground water by the Village in 1961 was 486 million gallons (mg) (table 2) with a maximum day of 2.45 mg. The 1961 total was about 36 mg less than in 1960.

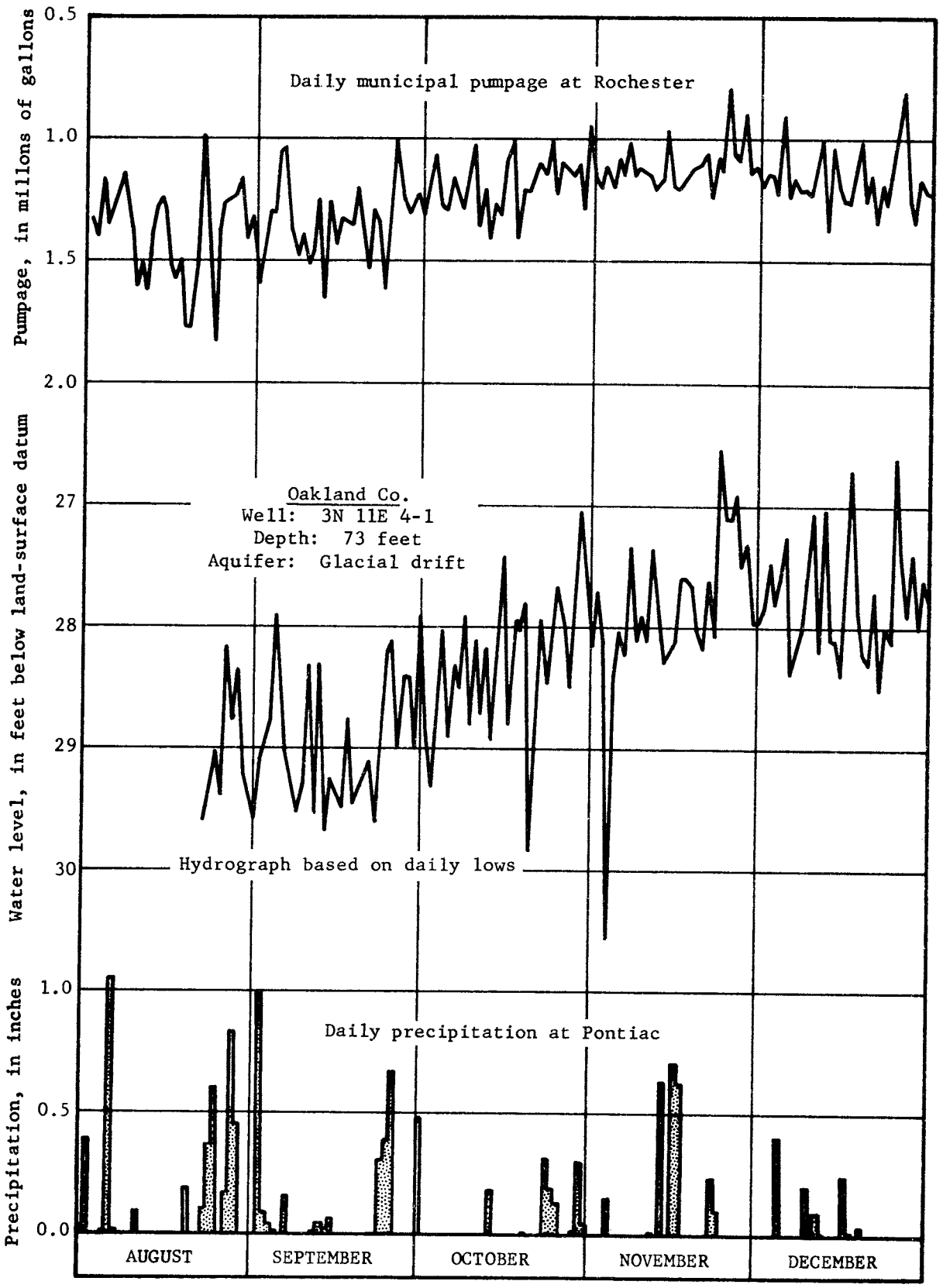


Figure 24. Hydrograph of well, pumpage, and precipitation, at Rochester, 1961.

Washtenaw County

City of Ypsilanti.--The City obtains water for municipal supply from wells finished in glacial drift at depths of 87 to 102 feet.

Water levels in the observation well at Gilbert Park (fig. 25) were a few feet higher in 1961 than in comparable months of record in 1960. Water levels fluctuated with pumpage variations. Water levels were highest in early May of 1961 as the result of decreased winter pumpage and spring recharge from snowmelt and above-average rainfall. The summer decline in water levels was reversed in August and September when 11 inches of rain fell and pumpage was reduced. Both pumpage and precipitation departures correlate well with the hydrograph.

Reported withdrawals of ground water for municipal supply totaled 1,030 million gallons (mg) for the year, with a maximum day of 5.08 mg, and a minimum day of 1.16 mg. For 1961 the total was 156 mg less than in 1960 and 175 mg less than in 1959.

Ypsilanti Township.--The four public supply wells and the observation wells, at the Township well field at Bridge Road and the Huron River, are finished in glacial drift at depths of from 50 to 90 feet. Levels in two of the six observation wells fell to record low stages early in the year (table 1) but rose several feet later in the year.

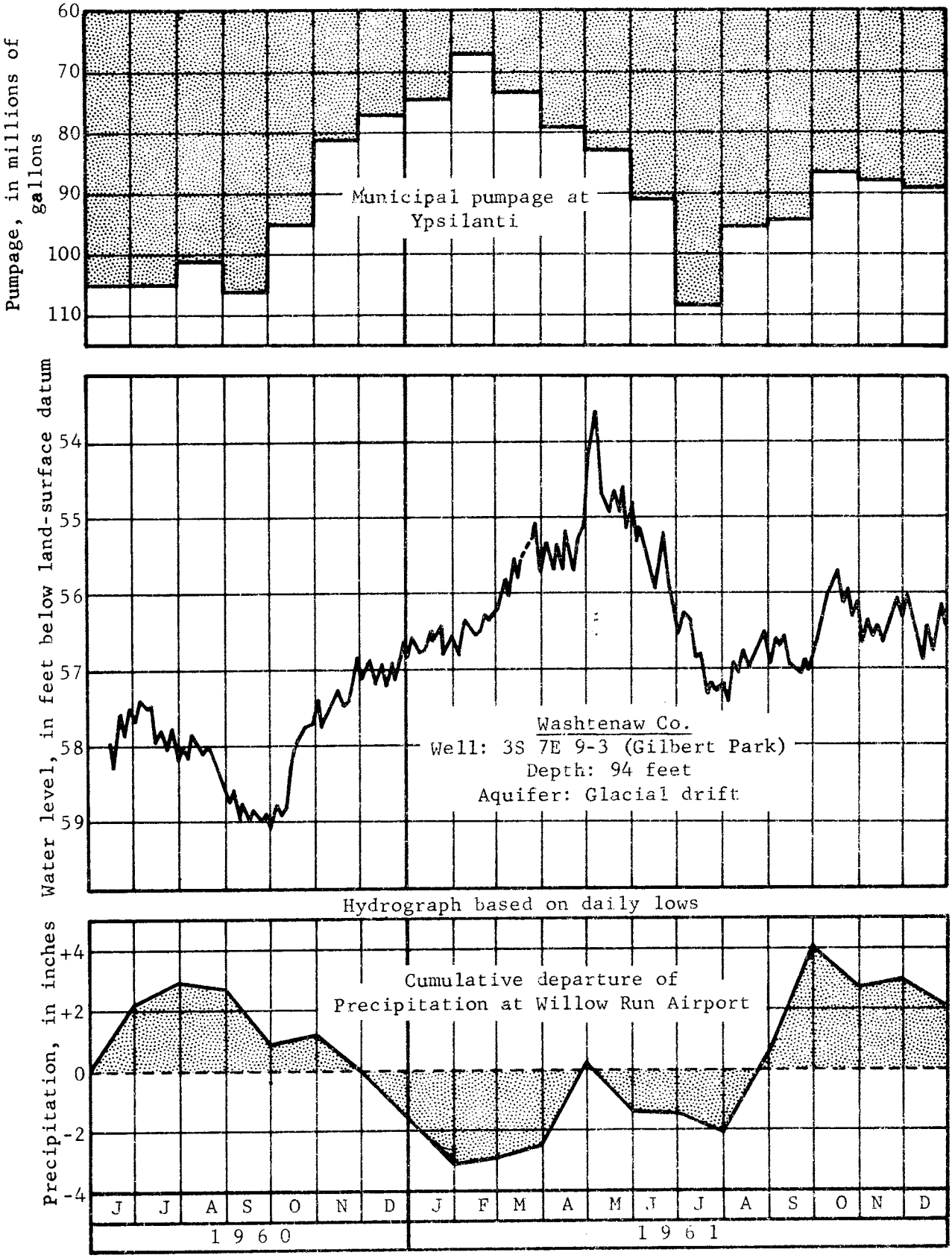


Figure 25. Hydrograph of well at Gilbert Park, pumpage, and precipitation, at Ypsilanti, 1960-61.

Comparison of records of water levels in the observation well equipped with a continuous recording gage (fig. 26) show that stages were higher in 1961 than for comparable periods in 1960 when levels fell to lows of record in early August. As pumpage was about the same in both years it is apparent that the higher levels in 1961 were the result of increased rainfall. The departure graph indicates that rainfall in 1960 was about 4 inches below average and in 1961 was above average by the same amount. Thus 1961 had 8 inches more of precipitation than 1960. In addition, rainfall in 1961 was above average in the spring and early fall when conditions are most favorable for ground water recharge.

Reported municipal withdrawals of ground water for public supply totaled 2,175 million gallons (mg), with a maximum day of 8.03 mg and a minimum day of 3.00 mg. The 1961 total was 16 mg less than was pumped in 1960.

Wayne County

City of Plymouth.--The City obtains its municipal water supply from wells finished in glacial drift at depths of from 20 to 100 feet at three well fields.

A continuous recording gage was installed in September on an unused well in the Beck Road well field. Levels in this well reflect pumping withdrawals by the nearby wells and also the influence of precipitation. The pumping in this field is reportedly held at a relatively steady continuous rate. When pumps are shut off sharp rises occur in the observation well. More than 11 inches of rain

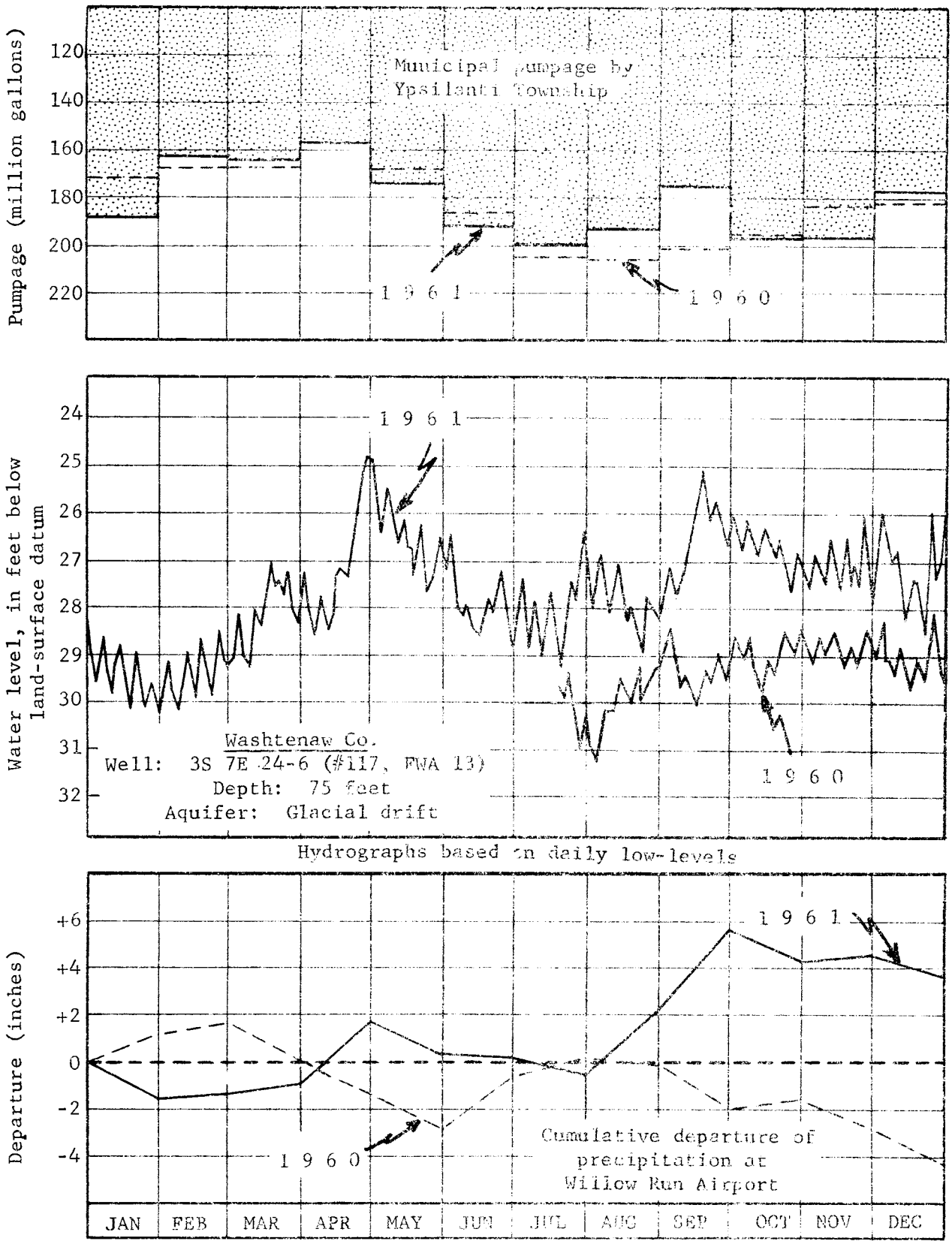


Figure 26. Comparative hydrographs, pumpage, and precipitation, at Ypsilanti Township well field, 1960-61.

fell in August and September and water levels were high at the beginning of the record (fig. 27). In the last three months of the year water levels fell, owing to the deficient precipitation.

The Beck Road well field yields about one million gallons a day. A well in another well field at 6-Mile and Beck Roads is pumped as needed. This well has a reported yield of 2600 gallons per minute. A large diameter well in the third well field on Mill Street is also used when needed.

Reported municipal pumpage by the City of Plymouth totaled 685 million gallons (mg) (table 2) in 1961 with a maximum day of 2.40 mg and a minimum of 1.62 mg. The total pumpage was 41 mg less in 1961 than in 1960.

Wexford County

City of Cadillac.--Pumping of municipal supplies of water from Lake Cadillac was discontinued October 26, 1961, and the City began pumping ground water from six new wells having a reported capacity of 10.5 million gallons per day. These municipal wells are finished in buried sands and gravels at depths of about 300 feet. A million gallon elevated tank provides adequate pressures throughout the distribution system.

From 1949 to mid-1953 a recording gage was maintained on observation well 21N 9W 4-1 after which only periodic measurements were made. On July 14, 1961 a continuous recording gage was reinstalled to observe changes in ground-water levels in response to the

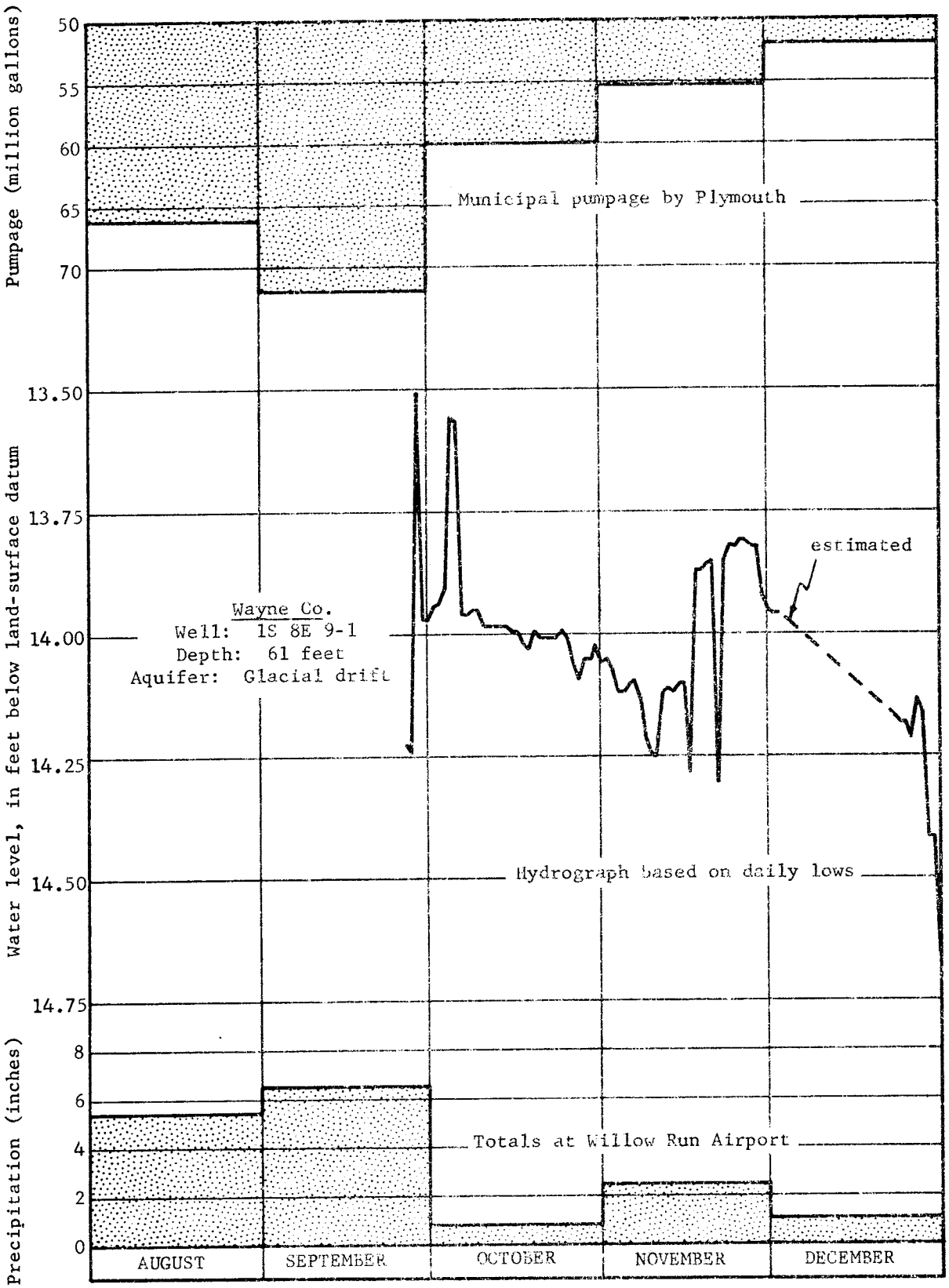


Figure 27. Hydrograph of well at Beck Road Field, pumpage, and precipitation, at Plymouth, 1961.

pumping in the new well field. The observation well is 277 feet deep and finished in the same aquifer as the City wells. The observation well is about one mile from the City well field.

The long-range hydrograph for the well (fig. 28) shows that the fluctuations in water levels follow closely the precipitation departure. The upper part of the figure shows the short term hydrograph from the recording gage record for a few months prior to and after City pumping began. In late October the start of ground-water pumpage is indicated by a small but abrupt drop in water level.

Total reported municipal pumpage for 1961 was 304 million gallons (mg) (table 2) of which about 34 mg was pumped from wells beginning October 26. The maximum day in 1961 was reported as 4.00 mg and the minimum as 0.60 mg.

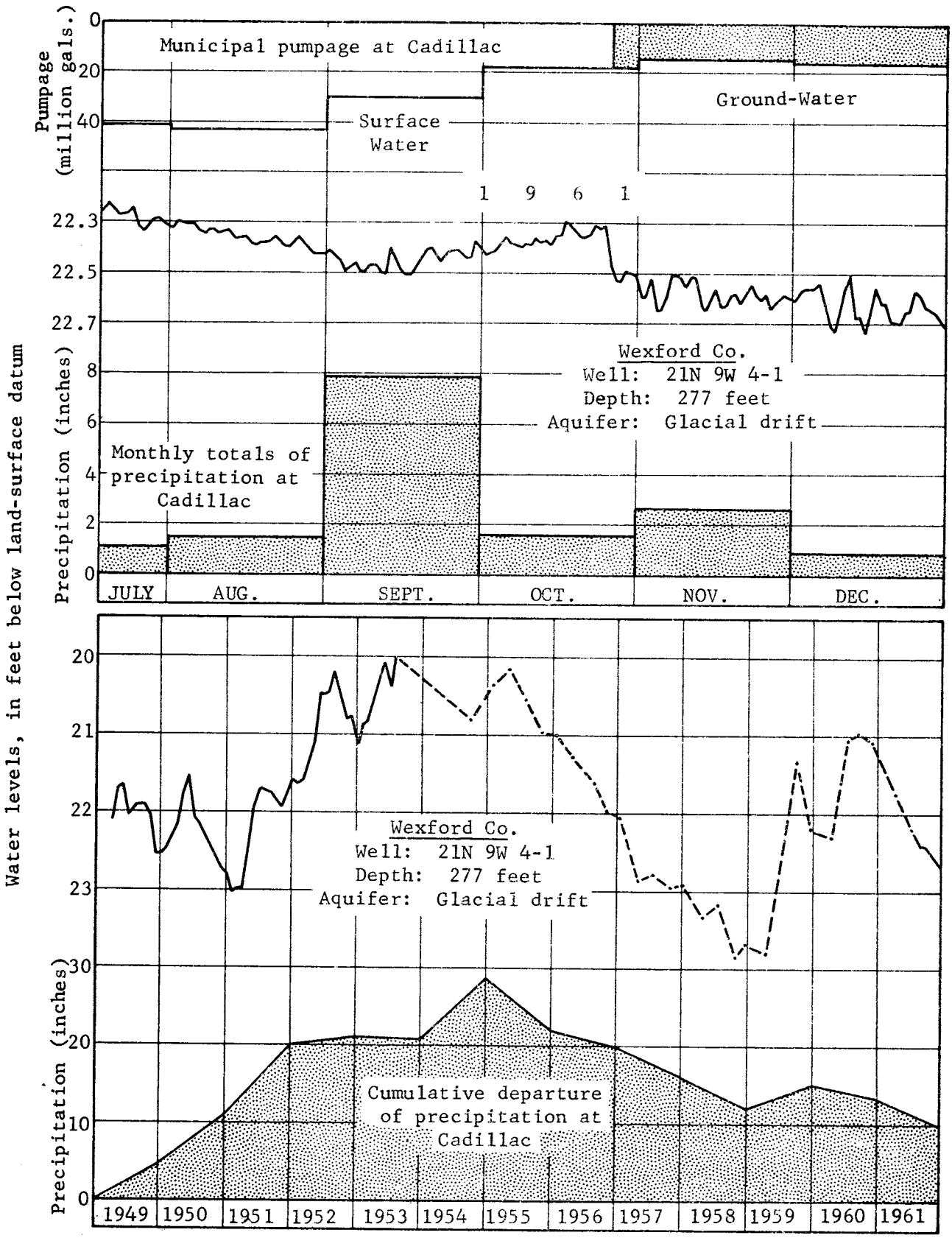


Figure 28. Hydrographs of well, pumpage, and precipitation, at Cadillac, 1949-61.

REFERENCES

Giroux, P. R., 1957, Summary of Ground-Water Conditions in Michigan, 1956: Michigan Geol. Survey Water Supply Rept. 1, 49 p., 21 figs.

_____, 1958, Summary of Ground-Water Conditions in Michigan, 1957: Michigan Geol. Survey Water Supply Rept. 2, 79 p., 22 figs.

Giroux, P. R., and Thompson, Ted, 1960, Summary of Ground-Water Conditions in Michigan, 1958: Michigan Geol. Survey Water Supply Rept. 3, 77 p., 23 figs.

_____, 1960, Summary of Ground-Water Conditions in Michigan, 1959: Michigan Geol. Survey Water Supply Rept. 4, 69 p., 21 figs.

_____, 1961, Summary of Ground-Water Conditions in Michigan, 1960: Michigan Geol. Survey Water Supply Rept. 5, 74 p., 24 figs.

Kurtyka, J. C., and others, 1961 Monthly and Annual Weather Bulletins and Menominee River Data Summaries in 1961, Wisconsin - Michigan Power Co.

McGuinness, C. L., 1962, the Ground-Water Situation in the United States, Outline of a talk, Training Program; U. S. Public Health Service, Cincinnati, Ohio, February 26, 1962.

Water Newsletter, Vol. 4, No. 9, May 7, 1962. Water Information Center, Inc.

Table 1.--Records of Michigan observation wells and extremes in water levels observed in 1961 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
IPs - Saginaw Formation of Pennsylvanian age
Mb - Bayport Limestone of Mississippian age
Mm - Marshall Formation of Mississippian age
Dt - Traverse Group of Middle and Late Devonian age
Dtb - Thunder Bay Limestone of Middle Devonian age
Ds - Sylvania Sandstone of Middle and Late (?) 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 - 61: Frequency of measurement in 1961. R - Continucus recorder; D - Daily; W - Weekly; M - Monthly; Q - Quarterly; S - Semiannual; A - Annual.

Observed water-level extremes: 1961 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 61	Observed water level extremes: Through 1960 Highest	Date	Lowest	Date	In 1961 Highest	Date	Lowest	Date	Remarks
							NORTHERN PENINSULA										
							Alger County										
45N 19W 25-1	SW NE	USFS	66	6	Qgd		1959-61	M	6.35	6-29-60	12.66	8-26-59	9.93	4-27	11.38	11-22	
							Baraga County										
49N 33W 18-1	NE SW	Mich. College of Mining and Tech.	12	16	Qgd		1958-61	R	e4.90	4-25-60	9.40	2- 9-59	6.38	4-22	9.20	2-13	Meas. by owner.
48N 32W 12-1	SE SE	MSHD (WMP 14)	10	1¼	Qgd		1948-61	M	4.19	5- 3-51	6.72	3-15-49	5.01	5- 1	6.44	12-28	Meas. by WMP.
							Chippewa County										
46N 4W 24-1	NE SE	USFS (Raco CCC Camp)	54	6	Qgd		1952-61	R	20.70	7- 3-60	27.77	4-12-56	22.90	7-24	24.69	12-8,9	
							Delta County										
43N 19W 24-3	NW NW	Harry Clarage	405	4	Otb		1958-61	M	77.02	7-29-60	80.06	4- 9-59	78.62	2-23	79.40	11-22	
42N 19W 20-3	NE NE	USFS	134	6	Or		1958-61	M	23.76	6-27-60	25.86	3-31-59	25.06	4-26	25.59	9-29	
42N 18W 17-2	SW NE	USFS	60	6	Qgd		1958-61	M	21.20	5-25-60	24.97	3-31-59	23.37	5-31	24.86	10-27	
41N 19W 17-1	NE SW	USFS	58	6	Or	635±	1958-61	M	0.50	4-29-60	3.82	8-26-59	0.91	4-26	4.01	9-29	
41N 18W 31-2	SE SW	Charles Thompson	250	4	Or		1958-61	R	3.77	5- 7-60	5.91	8- 3-59	3.82	11- 3	6.31	2- 7	
40N 22W 4-2	NE NW	USFS	40	5	Qgd		1958-61	M	20.28	10-13-60	23.50	4-28-59	20.81	2-23	21.67	11-22	
4-4	NE NW	USFS	34	5	Qgd		1959-61	M	14.87	7-29-60	17.10	4-29-60	15.49	1-31	16.42	11-22	
39N 23W 28-3	SW NE	Marshall and Sherman Blake	530	5	Cm	680±	1958-61	R	1.52	5- 6-60	3.86	9-28-58	1.73	4-16	3.25	9-12	

38N 22W 24-1	NW SE	USFS (3)	36	6	Or	585±	1958-61	M	1.10	4-29-60	5.53	10-27-58	1.45	4-26	4.86	2-23	
							Dickinson County											
43N 29W 32-1	NW NE	Dickinson Co. (WMP 11)	12	1¼	Qgd		1948-61	M	5.12	4-18-51	dry	10-12-48	7.46	5- 1	dry	10- 2	Meas. by WMP.
42N 27W 33-1	NE NW	E. W. La Freniere (WMP 10)	12	36	Qgd		1945-46,58-61	M	2.74	5- 3-60	10.75	10- 3-55	4.66	5- 1	9.78	3-29	Do.
41N 30W 25-1	NE SW	Dickinson Co. (WMP 1)	20	1¼	Qgd		1948-61	M	2.66	5- 3-60	dry	10- 3-55	7.82	6- 1	dry	1-30	Do.
25-2	NW SE	Wm. Carrola (WMP 2)	16	36	Qgd		1945-46, 48-61	M	1.69	5- 3-60	dry	1-30-59	4.74	6- 1	9.60	10- 3	Do.
25-3	SE NE	Oscar Martinson (WMP 3)	12	48	Qgd		1945-46,48-61	M	1.57	5- 3-60	dry	11- -48	4.55	5- 1	8.78	3-29	Do.
							Gogebic County											
48N 47W 34-3	NE SE	City of Ironwood (SE well, Gp 3)	22	6	Qgd		1961	R					1.73	11-4	4.71	9- 9	P, Record started 7-19-61
							Iron County											
46N 34W 14-1	NE NW	Oliver Iron Mining Co. (WMP 18)	12	1¼	Qgd		1945-61	M	3.65	6- 2-54	8.60	3-15-49	5.88	6- 2	7.95	3- 1	Meas. by WMP.
46N 33W 18-1	SW NW	MSHD (WMP 17)	12	1¼	Qgd		1948-61	M	2.80	4-18-49	dry	2-28-56	5.91	6- 2	8.19	9- 1	Do.
45N 37W 23-1	SW NE	USFS (WMP 28)	8	1¼	Qgd		1948-61	M	0.75	8-31-51	4.72	9-11-48	1.23	5- 2	4.18	8-31	Do.
45N 35W 33-1	SE NW	MSHD (WMP 34)	12	1¼	Qgd		1948-61	M	1.93	7- 6-53	8.44	3-15-49	3.61	6- 1	5.69	12-28	Do.
45N 33W 8-1	SW SW	Basilio Prandi (WMP 20)	33	36	Qgd		1945-61	M	22.71	5- 3-60	32.16	3-15-49	24.69	6- 2	26.96	11-30	Do.
44N 37W 14-1	NW NW	USFS (Former James Lake CCC Camp)	102	6	Qgd		1959-61	R	93.8	11-29-60	95.75	10-22-59	94.11	12- 4	94.90	5-17	
44N 35W 6-1	SW SW	USFS (Paint River Profile 1)	6	1¼	Qgd	1468.15	1948-61	M	+0.10	5- 2-51	2.26	11-15-48	0.73	5- 2	2.32	8-31	Meas. by WMP.
6-2	SW SW	USFS (Paint River Profile 2)	13	1¼	Qgd	1475.14	1948-61	M	5.08	7- 6-53	8.92	11-15-48	6.77	5- 2	8.72	8-31	Do.
6-3	NW SW	USFS (Paint River Profile 3)	12	1¼	Qgd	1476.35	1948-61	M	4.03	7- 6-53	9.20	11-15-48	6.38	6- 1	8.96	10- 2	Do.
7-1	NW NW	USFS (Paint River Profile 4)	4	1¼	Qgd	1469.28	1948-61	M	1.12	5- 2-51	3.73	8- 1-47	1.94	5- 2	3.55	8-31	Do.
44N 35W 7-2	NW NW	USFS (Paint River Profile 5)	13	1¼	Qgd	1471.25	1948-61	M	2.50	7- 6-53	9.44	10-26-48	3.77	5- 2	5.34	8-31	Do.
7-3	NW NW	USFS (Paint River Profile 6)	17	1¼	Qgd	1475.83	1948-61	M	8.48	5- 2-51	13.40	10-26-48	11.02	5- 2	12.78	10- 2	Do.
44N 33W 10-1	SW SW	Iron Co. (WMP 21)	8	1¼	Qgd		1948-61	M	1.95	4-29-54	7.94	1-12-51	2.88	5- 1	7.89	3-29	Do.
43N 36W 1-1	SW NE	Iron Co. (WMP 27)	9	1¼	Qgd		1948-61	M	6.48	5- 2-60	9.02	6-30-52	7.67	5- 2	8.50	1-30	P, Meas. by WMP
43N 35W 11-1	SE NE	J. J. Javoroski (WMP 23)	47	36	Qgd		1945-61	M	38.61	9- 1-60	47.08	8-15-49	39.89	1-30	41.56	12-29	Do.
13-1	SW SE	F. V. Gendzwill (5)	65	36	pe		1945-61	S	47.90	9-11-46	63.68	11-30-46	52.17	5- 9	52.28	10- 5	Mine drainage study
13-2	SW SE	Boyington (hole 4-44)	?	?	?		1945,47-61	S	66.39	1-14-52	71.56	3-24-49	67.87	10- 5	68.46	5- 9	Do.
20-1	SW SE	Mrs. B. Hendrikson (WMP 25)	48	1¼	Qgd		1945-61	M	41.66	6-20-53	48.29	8-15-49	41.81	6-29	44.46	7-31	Meas. by WMP.
24-1	SE NE	Spies-Johnson No. 73 (7)	?	3	Qgd?		1945-61	A	67.57	12-15-60	86.05	1-19-49	67.20	10- 5			Mine drainage study
26-1	SW NE	City of Iron River (1)	150	2	Qgd		1945-61	S	18.64	5-2 -60	44.58	3-24-50	18.52	5- 9	20.68	10- 5	P
43N 34W 19-1	NW SW	Spies-Johnson No. 3004 (8)	?	3	Qgd?		1945-61	S	60.25	12-15-60	89.5	10-20-45	59.87	10- 3	60.52	5- 9	Mine drainage study
19-2	NE SW	Spies-Johnson No. 3c (9)	?	3	Qgd?		1945-61	S	66.50	12-15-60	84.10	12-21-48	66.23	10- 5	66.72	5- 9	Do.
29-1	SW NE	Rogers Mine (11)	?	48	Qgd		1947-53,56-61	S	10.31	8-15-53	20.69	3-24-50	14.19	5- 9	14.74	10- 5	Do.
43N 32W 28-2	NE SW	Caya Mine (17)	?	?	Qgd?		1952-61	M	0.68	5-24-60	86.03	3-18-53	2.63	5-26	10.80	2-24	Do.
26-3	SW NE	Caya Mine	200+	4	?		1959-61	M	29.79	5- 2-60	36.26	10-27-60	31.02	5-26	37.50	2-24	
42N 36W 15-1	NE SW	MSHD (Brule River Profile No. 1)	6	1¼	Qgd	1543.92	1948-61	M	0.81	4-29-54	3.17	10-26-48	1.73	5- 2	2.70	8-31	Meas. by WMP.
15-2	NE SW	MSHD (Brule River Profile No. 2)	7	1¼	Qgd	1545.60	1948-61	M	0.46	7- 6-53	3.10	10-26-48	1.20	5- 2	2.69	1-31	Do.

Table 1.--Records of Michigan observation wells and extremes in water levels observed in 1961 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 61	Observed water level extremes								Remarks
									Through 1960				In 1961				
									Highest	Date	Lowest	Date	Highest	Date	Lowest	Date	
							Iron County (Continued)										
42N 36W 15-3	NW SW	W. Young Estate (Brule Riv. Profile No. 3)	14	1¼	Qgd	1554.36	1948-61	M	3.67	4-29-54	8.29	10-26-48	5.52	6- 1	7.55	3- 2	Meas. by WMP.
42N 34W 7-1	SW NE	Zimmerman No. 1 (13)	171	12	Qgd	1165.32	1945-61	S	129.02	12-15-60	153.27	4-21-50	128.22	10- 5	128.96	5- 9	P, Mine drainage study.
42N 31W 33-1	NW SE	Iron Co. (WMP 7)	11	1¼	Qgd		1948-61	M	+0.20	5- 2-60	6.28	10-13-48	0.30	5- 1	4.00	1-30	Meas. by WMP.
33-2	NW SE	Joseph Giachino (WMP 8)	12	15	Qgd		1945-61	M	1.89	10-30-51	12.22	2-25-53	6.05	5- 1	10.83	11-29	Do.
41N 31W 10-1	SW NE	Iron Co. (WMP 5)	17	1¼	Qgd		1948-61	M	8.47	1- 3-52	dry	12-15-48	11.90	6-29	15.28	3-29	Do.
							Luce County										
49N 11W 2-5	NW NE	State (5)	7	1¼	Qgd		1959-61	M	+0.40	5-26-60	6.34	7-30-59	0.20	4-27	4.48	12-15	Lake Hydr. study.
49N 10W 6-6	SW SW	State (6)	8	1¼	Qgd		1959-61	M	1.98	5-31-60	8.02	8-26-59	2.69	5-24	6.50	10-30	Do.
46N 10W 25-20	NW NW	John Barrett Estate	20	48	Qgd		1958-61	M	0.11	5- 3-60	0.86	6-29-60	0.69	4-27	0.89	10-31	Freezes in winter.
							Mackinac County										
42N 2W 7-1	NE NE	USFS (Pontchartrain)	102	6	Sm		1956-61	R	13.1	5-11-60	29.35	11- 5-57	17.53	6-25	28.99	3-20 9-29	
9-1	NE NW	Kenneth Kerr	84	2	Sm		1956,59-61	M	+1.0	*	3.87	2-26-59	*		4.52	9-28	* Often flows. Not meas. in winter.
41N 5W 23-1	SW NW	MDC (Round Lake)	47	6	Ss		1956-61	M	4.30	5- 7-59	17.48	3-19-59	5.38	6-29	15.12	2-28	
							Marquette County										
49N 30W 22-1	SW NE	Marquette Co. (WMP 13)	17	1¼	Qgd		1948-61	M	0.64	5- 3-51	13.32	9- 2-48	8.62	5- 1	11.59	9- 1	Meas. by WMP.
47N 28W 1-1	NW SE	Inland Steel Co. (Morris Mine No. 1)	216	38	Qgd		1961	R					e62.5	12-31	70.99	10-26	P-recovery.
3-1	SW SW	Ely Township	75	8	Qgd		1961	R					13.60	8-22	14.87	12- 2	Record started 7-6-61.
4-1	NE NE	Inland Steel Co. (Blueberry Mine 8B)	68	8	Qgd	1577	1961	R					17.27	10-17	18.03	12-31	Record started 10-13-61.
10-1	NW NW	Clarance Carlson	17	6	Qgd		1961	M					8.35	9-27	10.18	12-22	Record started 7-6-61.
46N 28W 1-1	SE NW	Clarance Carlson	96	6	Qgd		1961	M					35.59	8-22	37.05	11-14	Record started Aug. 1961.
45N 30W 1-1	SW NW	Arnold Janofski (WMP 4)	31	36	Qgd		1945-61	R	23.82	7-18-60	29.28	3-15-49	23.90	3-26	26.12	12-31	Fed. key well.
45N 25W 28-1	NE NW	MDC (Gwinn CCC)	18	6	Qgd?		1958-61	M	0.67	4-26-60	4.82	3-31-59	2.05	4-20	4.10	8-30	
28-2	NW NE	Forsyth Twp.	100	240	Qgd		1961	R					8.2	8- 7	42.2	7-10	Record started 7-3-61.

	28-3	NW NE	Forsyth Twp.	39	1¼	Qgd		1961		W					14.74	7-24	16.63	8-30	Record Start. 5-16-61., P.
44N 26W	28-1	NE SE	MDC (Esc. Riv. CCC)	31	6	Qgd		1953-61		M	1.90	5-17-60	2.83	8-30-57	2.03	5-17	2.50	9-26	Meas. by MDC.
									Menominee County										
37N 26W	19-1	NE SE	MSHD	16+	4	Otb		1959-61		M	3.70	5- 2-60	5.13	10-27-60	4.24	4-25	6.77	2-24	
									Ontonagon County										
51N 41W	8-1	SE NW	Mich. Corrections Dept.	100	6	pCf		1958-61		R	8.18	4-15-59	18.12	10-13-60	8.4	5-14	18.8	9-30 10-10	
52N 39W	30-1	NW NW	Village of Ontonagon	22	20	Qgd		1960-61		R	6.3	12- 6-60	13.1	12- 9-60	2.0	10-26	13.4	3-11	P
									Schoolcraft County										
47N 16W	30-1	NW NW	MDC (Cusino CCC Camp)	57	6	Op		1957-61		R	5.7	5-10-60	15.51	11- 7-57	8.5	4-26	14.8	9-12	
45N 18W	31-1	NE SW	USFS	229	5	Otb		1958-61		M	13.71	6-29-60	16.69	1-27-59	14.51	4-27	15.66	9-29	
45N 13W	16-1	SW SW	U.S. Fish and Wildlife Service	154	4	Or		1952-61		R	4.80	5- 8-60	6.28	9-26-55	5.11	3-28	5.84	9-13	
									SOUTHERN PENINSULA										
									Barry County										
3N	8W 18-1	SE NE	City of Hastings	33	6	Qgd		1958-61		R	2.32	4- 5-59	6.71	7-16-59	3.16	4-30	6.81	7-12	P
									Branch County										
6S	6W 22-1	NE SW	City of Coldwater (3)	130	6	Qgd		1949-61		W	10.08	4- 8-50	16.67	1-15-54	11.00	5-12	15.94	2-10	P, Meas. by owner.
									Calhoun County										
1S	7W 10-1	NW NW	K. N. Sabin	8	15	Qgd	907.99	1946-61		W	0.89	3-28-50	5.98	2-11-59	3.35	7- 5	5.15	12-27	
	32-1	NE SE	City of Battle Creek (Verona 22)	127	8	Mm	830.79	1939-61		D	0.7	4-26-50	16.75	7-16-59	9.25	5- 8	13.50	8-16	P, Meas. by owner.
	32-2	NE NW	Mrs. Harriett Rice	43	2	Mm	842.88	1946-61		Q	8.98	4-25-50	18.93	9-23-59	15.93	4- 4	17.50	9-18	P
2S	8W 1-1	SW SE	Sherman Mfg. Co.	22	2	Qgd	825.19	1946-61		Q	10.49	4-11-47	18.82	9-23-59	17.10	4- 4	19.47	9-18	
	2-1	NW SE	Oliver Elec. Mfg. Co.	92	10	Mm	819.99	1946-61		R	4.75	4- 9-47	14.95	9-11-59	12.60	5- 3	14.77	8-25	P
	3-1	SE SE	Dominic Conto	12	2	Qgd	862.02	1946-61		Q	1.75	4-28-50	9.89	9-23-59	6.10	4- 4	7.46	9-18	
	3-2	SE NE	Eaton Mfg. Co.	80	10	Mm	833.39	1946-61		Q	13.43	4-25-50	25.41	9-23-59	21.43	12-19	22.53	4- 4	P
	14-1	NE SE	City of Battle Creek	62	2	Qgd	916.05	1939-61		Q	9.10	5-31-52	32.76	3-26-41	11.53	6-21	12.28	12-19	
2S	8W 14-2	SE SE	City of Battle Creek (TW 1)	89	26	Qgd	914.97	1945-61		Q	6.22	5-29-50	12.86	10-18-46	8.36	6-21	9.19	12-19	
2S	7W 7-1	SW NE	Oliver Farm Implement Co.	74	6	Mm	834.30	1945-61		Q	15.00	4-11-47	24.68	9-23-59	19.30	4- 4	22.75	9-18	P
	17-1	NW SW	City of Battle Creek	87	2	Mm	841.78	1945-61		Q	6.57	4-25-50	11.38	9-23-59	9.85	12-19	10.60	9-18	P
	18-1	SW SW	Do.	87	2	Mm	832.49	1945-61		Q	+0.50	4-25-50	3.24	9-21-49	1.07	12-19	2.00	9-18	P
2S	6W 25-1	NE NE	City of Marshall (Ferguson)	59	6	Mm	904.85	1950-61		M	5.46	5- 9-50	9.59	10- 6-58	7.95	4-30	8.86	7-28	P, Meas. by owner.
	25-2	SE NW	City of Marshall (Egeler)	67	6	Mm	901.15	1950-51, 56-61		Q	6.50	9-14-50	9.00	8-14-57	7.94	4- 4	8.30	6-21	P, Meas. stopped 6-61.
	25-3	SW SE	City of Marshall (Filkin)	82	4	Mm	914.15	1950-61		Q	19.71	5- 3-50	26.32	12-19-56	23.47	4- 4	24.14	6-21	P, Meas. stopped 6-61.

Table 1.--Records of Michigan observation wells and extremes in water levels observed in 1961 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 61	Observed water level extremes: Through 1960 Highest	Date	Lowest	Date	In 1961 Highest	Date	Lowest	Date	Remarks
Cass County																	
6S 16W 1-1	SW NE	City of Dowagiac	159	10	Qgd	750.19	1949-61	W	+5.20	2-20-60	5.97	7-24-53	+2.37	4-21	3.88	8- 4	P, Meas. by owner.
8S 14W 17-1	NE NW	Ted Little	55	28	Qgd		1945-61	W	46.20	7-16-50	55.03	3-10-57	50.14	1- 1	51.65	12-31	
Charlevoix County																	
33N 4W 2-1	SW NE	MDC	94	6	Qgd		1948-61	Q	69.49	7-14-60	75.85	4-16-56	72.20	7-12	73.49	4-12	
32N 4W 10-1	NE SE	MDC (33)	17	2	Qgd		1934-41, 48-61	M	1.19	3-30-58	7.42	2-12-59	3.64	4-21	5.34	9-11	
Cheboygan County																	
34N 1W 1-1	NW SW	MDC (7)	11	2	Qgd		1938-41, 48-52, 55-61	Q	2.75	3-28-38	5.55	10-13-55	3.88	12-11	4.81	9-11	
Clare County																	
17N 4W 33-1	NW NW	Watervliet Paper Co.	15	1¼	Qgd		1958-61	M	8.52	5- 2-60	10.56	2-27-59	8.89	5- 1	10.28	8-25	
Clinton County																	
8N 1W 13-1	SW NW	Village of Elsie	298	12	Ps	699.68	1947-61	M	+3.78	6- 3-50	37.55	10-15-57	0.01	2-27	3.68	1-27	P, Meas. stopped 6-61.
6N 2W 16-1	SE SE	MSHD	23	14	Qgd	803.32	1948-61	M	14.59	4-19-52	18.53	12-29-53	17.62	5-26	18.55	2-27	Fed. key well
5N 2W 31-1	NW SW	Mich. Dept. of Aeronautics	195	6	Ps	e850	1949, 55, 60-61	R	45.0	3-21-49	53.00	9- 2-55	54.86	1- 7	57.33	12-15	P
32-1	SW SE	Mich. Health Dept.	135	4	Ps	849.21	1944-61	M	42.02	9-14-44	82.94	12- 1-60	81.49	5-29	90.80	11-27	P
Crawford County																	
27N 1W 20-1	SW SW	MDC (22)	15	2	Qgd		1934-57, 60-61	Q	1.55	7-11-43	5.92	10-12-55	4.11	4-14	4.79	7-19	
26N 4W 11-1	NW SW	MDC	12	15	Qgd	1147.59	1942-61	R	4.03	6- 1-43	9.85	9- 3-58	6.64	10- 2	8.56	8-30	
25N 3W 28-1	SW SW	MDC (8)	13	1¼	Qgd	1175.14	1934-37, 39-61	Q	8.60	7-28-60	11.28	10-22-58	9.93	4-21	10.51	9-30	
25N 1W 15-1	SE SE	USFS	56	6	Qgd		1948-61	R	29.36	7-27-60	35.97	4- 4-51	31.07	1- 7	32.13	9-18	
Eaton County																	
4N 4W 2-1	SW SW	City of Grand Ledge	376	12	Ps	846.59	1948-61	R	21.34	5- 5-50	29.72	9-14-59	26.77	2- 7	28.23	8-13	P
11-1	NW NE	Do.	350	8	Ps	788.9	1960-61	R	+3.8	9-19-60	8.3	12- 4-60	+3.8	8-28	6.2	7-29	P
4N 3W 10-1	SE NE	John Schneeberger	121	3	Ps	855.99	1944-61	M	31.28	5-27-48	38.59	10-28-59	38.21	1-31	39.36	11-27	P
12-1	SE SW	F. A. Wheeler	381	6	Ps	861.91	1953-61	R	67.51	11-23-53	79.4	7-16-59	72.3	1- 2	79.8	8-19	P
2N 4W 19-1	NW SW	City of Charlotte	25	240	Qgd	889.44	1947-61	Q	8.04	4- 7-47	16.48	9-23-59	15.45	6-15	15.95	9-18	P
Genessee County																	
7N 7E 9-1	SE SW	Consumers Power Co.	288	12	Ps	761.83	1946-61	Q	17.50	4-11-48	45.48	7-20-57	24.07	3-30	25.98	6-14	P, Meas. stopped 6-61.
17-1	SE NE	Do.	222	12	Ps	757.83	1946-61	R	24.23	2-12-50	37.99	8-24-55	25.14	12- 4	31.53	7-27	P
20-2	SW SW	City of Flint	169	2	Qgd	749.48	1947-61	Q	1.09	4-26-50	9.07	9-15-55	4.74	12-18	6.82	6-14	

	29-1	SE SW	C. F. Crain	14	1¼	Qgd	776.63	1946-61	Q	1.69	12-22-49	10.66	10-10-60	7.55	3-30	9.56	9-29	
	29-2	SW SE	Jack Palmer	8	18	Qgd	779.86	1946-61	Q	+0.20	6-29-48	dry	10-10-60	5.63	6-14	7.55	9-29	
	32-1	SW SW	A. W. Arndt	140	2	Qgd	792.27	1946-61	Q	18.51	6- 2-47	35.36	9- 2-59	32.73	3-30	34.99	9-29	P
6N 7E	9-1	SW SE	Fisher Body Div., GMC	375	6	Ps	841.71	1952-61	R	37.79	11-24-52	59.9	8- 9-60	47.3	1- 3	57.9	7-12	P
								Gladwin County											
17N 1W	7-1	SW NW	City of Beaverton	93	12	Qgd	721.50	1950-61	D,W	27.94	4- 6-59	49.35	6-26-50	30.33	4-25	46.98	3-27	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, 55-61	M	0.74	5-19-60	2.54	7-26-35	0.91	8- 4	1.62	9-12	
26N 11W	27-1	NW SW	MDC (2)	14	2	Qgd	914.25	1935-37, 41-44, 48-61	Q	1.20	4-14-59	4.02	8-18-36	1.70	12-11	2.91	9-12	
26N 9W	13-1	SW SW	MDC (2)	14	2	Qgd	961.78	1934-37, 41-44 48-61	M	4.66	5-19-61	7.87	10-11-49	4.92	10- 5	7.00	9-12	
								Gratiot County											
12N 3W	24-2	NE SE	City of St. Louis (3)	216	16	Qgd		1960-61	R	50.00	12-12-60	67.6	10-28-60	44.6	4-17	59.1	2-28	P
	34-1	SW SE	S. J. Brown	55	2	Qgd	727.12	1947-61	M	6.08	4-26-48	40.87	6-28-50	16.45	2-27	22.29	8-25	P
	35-3	NW SW	Walter Stone	26	2	Qgd	732.62	1947-61	M	10.07	5- 3-48	24.30	8-27-58	17.67	3-31	19.92	8-25	P
	35-5	SW NW	Reed Excavating Co.	20	36	Qgd	738.78	1950-61	M	13.74	4- 7-50	17.91	11-12-53	15.87	4-28	17.63	1-27	
12N 2W	18-1	NE NW	Mich. Chemical Co.	1350	5½	Mm		1957-61	R	212.3	12-31-60	267.7	8-30-57	195.71	12-31	212.26	1- 1	
11N 3W	3-6	NW NW	E. H. Waber	49	2	Qgd	733.20	1946-61	M	4.99	2-27-59	32.98	12-16-55	24.08	2-27	29.04	7-24	P
	4-1	SW NE	City of Alma (TW 6)	165	8	Qgd	732.31	1955-58, 60-61	R	12.06	6-14-55	27.3	9- 9-60	14.3	4-10	26.2	10-6	P
	36-1	SE SE	Village of Ithaca	785	8	Ps	804.50	1947-61	M	78.25	1-22-52	83.96	9- 4-49	80.10	4-28	80.73	2-27	Meas. stopped 8-61.
								Hillsdale County											
6S 3W	23-2	NW NW	City of Hillsdale (TW 6)	26	6	Qgd		1957-61	W	1.62	6-27-60	12.96	9-18-57	1.75	5- 8	8.75	8-14	P
								Ingham County											
4N 2W	4-1	NW SW	C & O R.R. (East 1)	38	12	Qgd	842.19	1953-61	M	25.98	3- 3-53	34.38	12-28-59	32.29	1-31	34.05	11-27	P
	9-1	SE NW	City of Lansing (Seymour 1)	401	14	Ps	828.81	1929-61	R	15.63	3-26-31	154.77	4-10-56	135.5	12-28	145.7	7-13	P
	16-1	NE SE	City of Lansing (Cedar)	417	12	Ps	829.11	1945-61	R	42.01	3-11-46	67.0	8-22-49	56.28	12-26	59.64	4-17	P
	17-1	NW NE	City of Lansing (Logan)	424	20	Ps	858.72	1929, 31, 33-61	R	34.34	12- ?-29	149.64	4-11-56	139.1	12-26	146.2	8-17	P
	17-2	NW NW	Olds Drop Forge (4)	417	12	Ps	872.55	1946-61	Q	104.86	12-10-46	148.47	4-10-56	143.75	12-28	149.47	9-26	P
	19-1	SW SW	Waverly Hills Assoc.	87	2	Ps	833.94	1947-61	Q	0.00	3-29-50	8.74	12-29-60	6.31	9-26	7.38	12-28	P
	21-1	NE NW	City of Lansing (Townsend)	410	14	Ps	834.10	1906, 19, 29-61	R	2.0	5- 9-06	74.33	8-21-59	62.34	12-26	68.93	7-13	P
	22-1	SW NW	City of Lansing (P-5)	338	12	Ps	823.64	1930-61	M	7.1	7- ?-32	58.68	10-16-59	50.78	11-27	54.60	3-29	P
	23-1	NE NW	City of Lansing(RS-7)	467	12	Ps	824.86	1930-32, 36-61	M	7.55	11-17-30	116.28	7-23-59	73.61	12-26	82.61	1-27	P, Meas. by owner.
	24-1	NE SW	Mich. State Univ.	453	10	Ps	853.45	1945-61	R	25.47	3-25-46	e80.0	7-17-59	53.1	1- 2	78.6	7-14	P
	28-1	NE NW	Atlas Drop Forge (2)	425	8	Ps	849.20	1944-45, 48-61	Q	30.28	4-23-48	54.40	8-19-48	51.60	3-29	54.57	6-27	P
	31-1	SW SW	C. A. Weber	204	3	Ps	880.15	1944-61	M	18.92	4-26-52	25.57	2-27-59	24.16	6-27	25.42	2-27	P
4N 1W	18-1	SE NE	Marble School	175	3	Ps	847.85	1952-61	M	20.09	4-27-53	34.05	7-31-59	32.96	3-29	36.63	7-27	P
3N 2W	23-2	SE NE	Delhi Twp.	268	8	Ps	e880	1959-61	R	2.07	3-31-60	5.84	12-27-60	3.89	4-27	6.09	8-17	P
2N 1W	5-1	SE SE	City of Mason (old 2)	150	6	Ps		1948-61	W	0.08	6-29-49	8.96	9-10-60	2.58	8-26	8.07	8- 5	P, Meas. by owner.
								Ionia County											
7N 7W	23-1	NW NW	Michigan Tng. Unit at Ionia	127	6	Qgd	741.65	1960-61	R	28.65	11-12-60	30.53	12-14-60	28.36	4-28	34.12	10-13	P

Table 1.--Records of Michigan observation wells and extremes of water levels observed in 1961 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 61	Observed water level extremes: Through 1960 Highest	Date	Lowest	Date	In 1961 Highest	Date	Lowest	Date	Remarks
Ionia County (Continued)																	
7N 7W 25-1	SW NE	Ionia State Hospital	23	6	Qgd	635.76	1960-61	R	12.51	8-25-60	13.74	10-19-60	9.34	4-28	17.42	10-28	P
6N 5W 33-1	- NE	Barley-Earhart Co.	15	180	Qgd		1957-61	M,R	4.35	4- 1-60	10.25	7-17-59	7.40	4-28	10.07	8-17	Recorder removed 7-61.
Iosco County																	
23N 7E 7-1	NE SE	USFS	341	6	Qgd		1948-61	Q	25.13	8- 3-52	28.10	4-27-59	25.99	4-17	26.70	12- 1	
Jackson County																	
1S 1E 36-9	SE SE	MDC (9)	9	1¼	Qgd	920.28	1956-61	W	0.42	5-10-56	6.80	12-30-58	1.00	5- 6	6.37	8- 4	Meas. by MDC.
3S 1W 11-2	NE NE	City of Jackson (4a)	360	6	Ps, Mm		1957-61	D	19.2	11-27-60	93.0	8-26-59	18.6	1- 2	90.0	7-16	P, Meas. by owner.
10-1	SW SE	Summit Township	323	12	Ps,Mm	e935	1960-61	R	14.7	12-26-60	24.66	12- 9-60	14.3	1- 2	32.4	7-20	P
3S 1W 2-1	SE NW	City of Jackson	221	8	Ps, Mm	e935	1960-61	R	17.5	11-28-60	36.0	10-14-60	17.7	1- 3	46.0	7-27	P
Kalamazoo County																	
2S 11W 3-60	NE NE	KVP Co. (61)	36	6	Qgd	763.18	1956-61	W	9.61	4- 4-60	12.82	9-18-59	10.15	5- 1	12.90	7-17	P
15-18	NE SE	Consumers Power Co.	64	12	Qgd	766.17	1946-61	Q,M	9.20	3-28-50	17.29	12-17-58	15.49	6-15	18.20	9-15	P
20-7	SW SE	Western Mich. Univ.	78	8	Qgd	868.68	1946-61	Q,M	33.44	6-19-50	38.15	9-17-59	35.86	3-23	37.53	10-16	
22-6	NE SW	City of Kalamazoo (Burdick)	115	6	Qgd	777.45	1946-61	R	11.22	3-11-52	31.48	9-11-59	24.25	1-17	26.10	3- 3	P, Record stopped 3-61.
22-150	SE SW	Do.(Stockbridge)	137	4	Qgd	764.7	1960-61	R	20.15	12-17-60	26.53	9-24-60	18.97	12-26	31.08	8-19	P
27-52	NE NE	Allied Paper Co. (7)	113	12	Qgd	802.59	1946-61	R,M	34.46	5- 5-50	64.37	9- 1-46	44.97	5-14	47.88	9-15	P, Recorder removed 6-61.
29-3	SW SE	Oakwood, Inc.	47	2	Qgd	880.72	1946-61	Q,M	26.12	8- 1-52	30.58	12-30-59	29.99	3-23	30.59	11-13	
3S 12W 11-1	SE NW	City of Kalamazoo (Atwater)	248	3	Qgd		1961	R					+1.96	3-27	+1.41	9- 8	Record started 3-61.
3S 11W 4-35	SE NE	City of Kalamazoo (A-D)	135	3	Qgd	854.03	1959-61	R	1.50	10- 3-60	12.89	11- 3-59	1.34	10-30	9.93	8-22	P
4-36	SE NE	Do. (A-S)	40	3	Qgd	854.01	1959-61	R	0.21	8-10-60	9.12	11- 4-59	0.04	10-30	4.55	7-12	P
4S 11W 21-2	NW SW	Willis Chamberlain	19	1¼	Qgd		1957-61	W	10.77	7-20-60	15.12	2- 8-59	12.00	5-24	14.09	12-27	
Kalkaska County																	
27 W 36-1	SE NW	MDC (100)	16	1¼	Qgd		1939-61	W	11.12	7-11-43	13.43	3-25-60	12.30	3-24	13.80	9- 8	
Kent County																	
6N 12W 17-1	SE NE	Jervis Corp. (1)	30	12	Qgd		1950-61	M	6.88	6- 8-56	16.45	2-12-54	9.60	5- 9	12.02	2-28	P, Meas. by owner.
17-2	SE NE	Do.	26	6	Qgd	606.05	1950-61	M	7.34	6- 1-56	16.32	2-12-54	9.50	5- 9	11.96	1-31	P, Do.
25-1	SW SW	City of Wyoming	241	12	Mm	e666	1960-61	R	10.0	10-24-60	45.8	9- 8-60	15.6	4- 3	50.4	7-12	P
34-1	SE NE	Do.	300	8	Mm	e735	1960-61	R	64.82	10-26-60	68.29	9- 9-60	65.29	5- 8	69.85	7-12	P

6N 11W 19-1		SE	Lear Mfg. Co.	301	8	Mm		1960-61	R	34.3	12- 5-60	68.5	9- 8-60	38.0	2-20	e75.2	7-1	P
6N 9W 3-1		SW NE	City of Lowell	70	12	Qgd		1961	R					13.52	9-29	18.98	9-18	Records started 8-61.
Lake County																			
17N 13W 4-1		SE NE	C & O R.R. (West Well)	83	8	Qgd		1957-61	Q	17.17	7- 6-60	20.36	5-23-58	18.23	4-11	19.08	9-12	
Livingston County																			
2N 4E 3-1		NW SW	Howell State Sanitarium.	148	8	Ps	916.13	1958-61	R	10.2	4-30-59	27.8	12-13-58	10.58	5- 8	26.77	6-30	P, Meas. by owner.
Macomb County																			
2N 12E 1-1		SE NE	B. H. Tolley	29	48	Qgd		1959-61	R	0.50	1-13-60	7.45	10-31-60	0.93	4-25	6.52	8-19	
Manistee County																			
23N 14W 21-1		NE SW	Village of Kaleva	70	8	Qgd		1959-61	R	8.49	5-15-60	10.90	10-23-60	9.63	3-13	11.19	8-25	P
Mason County																			
17N 15W 3-1		SE SW	USFS	32	6	Qgd	737.37	1948-61	M	13.90	6-30-60	19.45	8-24-58	15.21	4- 2	16.25	12- 2	
Montcalm County																			
9N 8W 10-1		SW NW	City of Greenville (1)	29	12	Qgd		1957-61	R	3.35	11-17-57	7.90	8- 6-59	4.39	1-16	6.38	6-15	Record stopped 6-61.
	15-1	SW NW	City of Greenville (9)	65	12	Qgd		1950-61	M	11.40	4- 1-50	17.40	8- 1-58	13.40	5- 1	15.75	2- 1	P, Meas. by owner.
Montmorency County																			
29N 3E 21-1		NW NE	MDC (32)	14	2	Qgd		1945-61	Q	2.54	7- 6-60	5.91	1-27-56	4.12	12- 4	4.36	7- 5	
Oakland County																			
3N 9E 7-1		NE SW	Garfield Estates	77	6	Qgd		1961	R					40.05	8-5	0.55	11- 4	Record started 7-61.
3N 9E 36-1		NW NE	Waterford Twp. (Josephine St.)	134	12	Qgd		1960-61	R	96.03	11-16-60	97.49	12-28-60	95.92	4-16	98.26	12-16	P
3N 10E 13-2		SW NE	Mich. State Univ. at Oakland	183	6	Qgd		1961	R					78.84	2-25	81.3	12-15	P, Record started 1-61.
3N 10E 31-1		NE SW	City of Pontiac (Orchard Lake Rd.)	173	12	Qgd	926.4	1952-61	R	107.7	2-16-59	128.0	8-16-55	113.5	4-10	124.3	7-12	P
	32-1	SE NW	City of Pontiac (6)	160	8	Qgd	921.88	1939-61	R	99.55	4-22-40	129.5	8- 5-55	115.4	4-10	123.9	7-13	P
3N 11E 4-1		SE NW	Village of Rochester	73	6	Qgd		1961	R					23.2	12-25	30.6	11-3	Record started 8-61.
2N 10E 22-1		NE NW	Cranbrook School (3)	65	6	Qgd		1950-61	W	11.00	4-30-56	17.60	9-26-55	12.60	5- 1	17.10	10-23	P, Meas. by owner.
Ogemaw County																			
23N 1E 4-1		SE NE	MDC (15)	21	4	Qgd		1934, 55-61	Q	1.14	4-27-60	4.26	10-10-55	2.09	4-14	2.77	9- 7	
25N 2E 2-1		NE NW	Charles Hudson	7	36	Qgd		1951-61	R	0.37	5- 5-52	4.30	3- 5-59	1.84	5-25	3.91	2-17	

Table 1.--Records of Michigan observation wells and extremes of water levels observed in 1961 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	?	61	Observed water level extremes: Through 1960 Highest	Date	Lowest	Date	In 1961 Highest	Date	Lowest	Date	Remarks
Otsego County																		
29N 3W 29-1	SW SE	MDC (106)	15	2	Qgd		1933-61		Q	5.56	5-14-47	9.74	10- 7-58	7.29	4-12	8.27	9-11	
Ottawa County																		
5N 15W 28-71	SE SE	City of Holland	108	1¼	Qgd		1946-55, 57-61		M	56.44	8- 8-46	dry	9-14-54	69.29	12- 2	74.06	3- 1	Meas. by owner.
Presque Isle County																		
33N 2E 30-1	NE SE	MDC (19)	14	2	Qgd		1934-44, 48-61		Q	0.61	7-12-60	5.69	1-27-56	1.40	4- 4	3.78	9-11	
33N 6E 8-1	NW NW	Albert Styma	61	6	Dt		1959-61		M	5.66	4- 4-60	15.92	12- 1-60	7.88	4- 4	14.89	2- 2	
15-1	NW NW	Harley Ennest	31	5	Dt		1959-61		R	2.8	5-10-60	11.6	8-26-60	4.40	3-27	10.50	2-14	P
21-1	NE NE	Mike Ardycan	43	5	Dt		1959-61		M	5.06	12-14-59	7.20	8- 6-59	4.27	4- 4	6.87	2- 2	
Roscommon County																		
24N 2W 20-1	NE NW	MDC (1)	14	8	Qgd	1145.30	1934-61		R	2.78	5- 3-51	6.23	12- 6-49	3.39	9- 1	5.48	8-31	Fed. key well.
23N 1W 3-1	SE SE	MDC (50)	12	2	Qgd	1188.95	1939-61		Q	1.62	6-15-43	7.31	12-14-49	4.17	4-14	5.76	9- 7	
22N 3W 22-1	SE NE	MDC (7)	14	2	Qgd	1170.58	1934-61		Q	2.56	4-27-60	4.85	12- 8-60	4.87	4- 6	5.70	12-20	
Saginaw County																		
9N 3E 16-2	SE NW	Ray Ellis	129	3	Ps		1958-61		W	35.41	1-27-59	53.84	9- 8-59	37.14	12-19	53.79	7-11	P
Sanilac County																		
12N 13E 33-1	SE SE	MSHD	150	3	Mn		1948-61		W	15.45	4-25-51	23.60	2-11-59	17.07	11-29	23.28	2-15	
Shiawassee County																		
5N 2E 16-1	NE SE	A. B. Cobb	26	1½	Qgd	896.00	1948-61		Q	17.28	5- 3-50	22.18	2-27-59	20.87	6-14	21.54	3-30	
Washtenaw County																		
3S 6E 16-1	SW NW	City of Ann Arbor	23	2	Qgd	817.43	1920-61		W	e+2.5	2- ?-30	e10.0	11- ?-27	0.0	11-22	5.75	9-20	P, Meas. by owner.
16-2	SE NW	Do.	23	192	Qgd		1948-61		W	+2.00	6-30-51	15.50	8-21-57	0.0	10-23	10.24	9- 6	P, Do.
3S 7E 9-2	SW NE	City of Ypsilanti (NR)	50	6	Qgd		1944-46, 48-53, 60-61		M	29.12	11- 5-45	40.8	7- 2-59	32.05	5-13	38.50	1- 7	P
9-3	SE NE	City of Ypsilanti (GP)	94	6	Qgd		1944-46, 48-53, 60-61		R	29.12	11- 5-45	59.15	10- 1-60	53.22	5- 8	57.45	8-4	P
24-1	NE SW	Ford Motor Co. (104)	87	4	Qgd	665.56	1943-45, 49-61		M	5.79	1- 5-50	16.43	10-16-56	13.80	9-23	15.21	12-16	P
24-2	NE SW	Do. (106)	53	4	Qgd	664.51	1943-45, 49-61		M	11.81	7-13-43	35.11	8- 5-60	31.54	9-23	36.33	1-21	P
24-4	NE SW	Do. (107)	53	4	Qgd	664.05	1943-45, 49-61		M	11.55	1- 5-50	36.93	8- 5-60	32.49	9-23	36.79	1-21	P
24-5	NW SW	Do. (109)	77	4	Qgd	665.56	1943-45, 49-61		M	15.15	6- 6-45	40.04	12-20-60	38.47	8-30	40.70	2-18	P
24-6	SW SW	Federal Works Agency (117)	75	6	Qgd	657.83	1944-45, 49-61		R	5.69	2-15-50	e31.25	8- 5-60	23.72	4-30	30.31	2- 1	P
3S 7E 24-7	- SW	Ford Motor Co. (124)	90	24	Qgd	686.5	1955-61		M	23.47	12-29-55	36.05	10-16-56	31.99	5-13	33.95	4-15	P, Meas. stopped 7-61.

										Washtenaw County (Continued)										
4S	6E	9-1	NW NW	Ypsilanti State Hosp. (TW 20)	184	6	Qgd		1946-61		W	51.22	5-15-48	88.14	6-17-49	55.66	11-14	73.17	1-4	P, Meas. by owner
		10-1	SW NW	Ypsilanti State Hosp. (TW 22)	173	6	Qgd		1946-61		W	61.48	6-12-53	88.27	7- 8-55	56.77	10- 9	73.85	8-11	P, Do
										Wayne County										
1S	8E	9-1	SW NW	City of Plymouth	61	6	Qgd		1961		R					e11.0	9-28	e16.9	9-11	P
4S	9E	32-1	SW SE	Village of Waltz Improvement Assoc.	190	6	Ds		1959-61		R	6.75	2-10-60	13.44	8- 3-60	7.94	5-15	13.94	7-19	P
										Wexford County										
24N	9W	19-1	SW NW	MDC (38)	11	2	Qgd	944.16	1935-37, 49-61	41-44	Q	0.49	4- 6-59	3.74	8-19-36	1.21	4-10	2.42	9-12	
21N	11W	13-1	NW NE	USFS	62	6	Qgd		1948-61		M	46.28	6- 5-52	51.13	11- 1-58	48.39	1-10	49.57	11- 6	
21N	9W	4-1	NW NE	City of Cadillac	277	6	Qgd		1949-61		Q,R	19.99	7- 6-53	23.83	10- 6-58	21.63	4-10	22.74	12-15	P, recorder installed 7-61.

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.	1961 Total
NORTHERN PENINSULA													
ALGER COUNTY													
Burt Township	2.31	1.59	1.82	1.88	2.00	2.37	3.13	2.47	1.74	1.66	1.40	1.26	23.63
CHIPPEWA COUNTY													
Kincheloe Air Force Base near Kinross	11.0	9.9	11.2	11.1	14.0	15.8	23.8	25.6	17.4	16.3	14.2	15.2	185.5
GOGEBIC COUNTY													
City of Bessemer	11.7	11.3	12.8	11.8	12.2	12.3	13.3	11.9	13.4	10.4	9.6	11.7	142.4
City of Ironwood	29.9	27.4	31.1	30.7	30.1	32.2	32.8	32.4	31.3	29.9	26.4	27.2	361.4
Marenisco Township	3.84	3.47	4.14	3.87	4.53	4.64	4.39	4.15	3.61	3.22	2.98	3.28	46.12
City of Wakefield	6.60	6.20	6.49	6.49	6.42	6.54	7.43	7.00	5.79	6.38	5.95	5.68	76.97
HOUGHTON COUNTY													
City of Hancock	14.7	13.3	14.7	15.1	14.4	16.9	17.1	17.5	14.8	14.7	13.6	13.9	180.7
City of Houghton	27.6	26.8	28.5	27.6	27.6	27.5	28.2	26.8	24.9	30.0	26.5	24.8	326.8
IRON COUNTY													
City of Caspian	6.82	5.88	6.23	6.45	6.97	7.20	7.33	6.54	6.48	6.55	5.90	5.24	77.59
City of Gaastra	--	--	--	--	--	--	--	--	--	--	--	--	e3.42
City of Iron River	14.0	10.9	12.9	11.7	12.2	11.8	13.3	11.9	10.1	9.5	9.2	10.0	137.5
City of Stambaugh	6.94	6.74	7.31	7.10	7.57	8.24	8.13	8.83	8.13	8.28	7.08	7.27	91.62
Stambaugh Township	--	--	a2.22	--	--	a2.71	--	--	a3.53	--	--	a2.12	10.57
LUCE COUNTY													
City of Newberry	10.9	10.3	11.2	9.6	10.1	10.5	11.5	e10.5	e9.4	e9.4	e8.9	e8.8	e121.1
State Hospital at Newberry	9.14	9.29	11.88	9.61	10.87	13.34	11.73	15.37	10.63	10.00	12.22	9.69	133.77
MARQUETTE COUNTY													
State House of Corr. and Br. Prison at Marquette	8.50	7.03	7.50	6.97	7.11	7.19	7.05	8.92	9.17	7.87	7.80	7.72	92.83
ONTONAGON COUNTY													
Village of Ontonagon	10.7	9.3	9.8	9.3	9.5	10.6	11.0	10.6	10.4	11.3	11.1	10.8	124.4
SOUTHERN PENINSULA													
ALCONA COUNTY													
City of Harrisville	.82	.84	.74	.79	1.04	1.26	1.78	2.05	1.63	1.34	.97	.86	14.12
ALLEGAN COUNTY													
City of Allegan	26.8	23.9	24.8	21.2	33.7	41.3	30.8	31.1	24.2	23.3	21.6	22.9	325.6
City of Plainwell	8.74	8.17	9.11	9.56	13.13	15.78	17.35	13.04	10.90	9.78	11.13	9.22	135.91
City of Otsego	11.4	10.5	12.4	12.2	14.3	19.0	20.2	18.0	15.3	14.7	13.7	14.7	176.4
ANTRIM COUNTY													
Village of Mancelona	8.98	7.87	9.34	8.71	10.33	11.69	10.53	11.15	10.53	10.40	9.84	10.18	119.55
BARRY COUNTY													
City of Hastings	36.4	32.1	28.8	25.9	29.8	36.5	33.8	24.3	24.3	24.0	25.4	26.5	347.8
Village of Middleville	15.9	14.9	17.8	18.8	19.9	21.8	e17.3	19.4	18.5	19.9	9.6	15.0	e208.8
BENZIE COUNTY													
City of Frankfort	6.33	5.54	5.80	5.87	6.21	7.10	9.51	8.40	5.64	5.77	4.94	5.34	76.45
BERRIEN COUNTY													
Village of Berrien Springs	6.35	5.79	7.12	7.01	7.22	6.48	10.91	8.13	7.94	7.77	6.62	6.27	87.61
City of Buchanan	38.1	33.3	38.6	33.4	37.1	41.0	47.0	42.8	38.7	35.5	36.7	35.2	457.4
City of Coloma	e4.40	e3.94	e4.41	e4.62	e4.88	e5.04	e5.35	e5.51	e5.20	e4.88	e4.41	e4.88	e57.52
City of Niles	74.0	66.7	69.9	69.3	82.4	93.7	88.2	94.0	82.6	75.5	69.8	75.5	941.6
City of Watervliet	e6.2	e5.8	e6.2	e6.0	e6.2	e12.0	e12.4	e12.4	e12.0	e6.2	e6.0	e6.2	e97.6
BRANCH COUNTY													
City of Bronson	18.9	14.8	16.6	17.0	16.1	19.1	21.4	23.9	21.3	25.0	19.6	16.2	229.9
City of Coldwater	36.2	35.5	39.4	41.4	49.5	59.6	68.2	52.0	50.0	48.3	44.8	37.7	562.6
State Home and Tng. School at Coldwater	13.4	11.8	13.0	13.1	14.2	14.1	14.5	14.0	13.8	13.6	12.9	12.9	161.3
CALHOUN COUNTY													
City of Albion	113	101	111	112	123	105	105	127	120	125	116	106	1,364
Three new wells													35.1
American Legion Hosp. at Battle Creek	.547	.491	.414	.506	.619	.497	.453	.560	.415	.404	.456	.501	5.863
Village of Athens	e1.59	e1.59	e1.59	e2.61	e2.61	e2.61	e2.61	e2.61	e2.61	e2.61	e2.61	e2.61	e28.26
City of Battle Creek	268	269	293	292	313	333	373	350	312	364	321	254	3,742
Battle Creek Twp.	23.1	23.0	23.3	21.4	33.9	42.3	53.5	38.4	25.7	24.9	22.7	21.9	354.1
City of Marshall	25.2	25.2	27.6	26.2	31.4	37.4	45.2	40.0	34.1	30.5	26.6	27.6	377.0

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.	1961 Total
CASS COUNTY													
City of Dowagiac	24.0	22.8	21.0	23.4	20.7	26.1	38.2	30.6	35.5	28.6	24.8	24.8	320.5
Village of Marcellus	1.67	1.63	2.61	2.00	2.25	2.44	4.93	2.35	1.92	1.89	1.69	1.61	26.99
CHARLEVOIX COUNTY													
City of East Jordan	8.00	9.73	7.92	6.43	9.10	14.19	12.51	17.37	9.05	7.80	7.10	7.31	116.51
CHEBOYGAN COUNTY													
City of Cheboygan	9.7	10.3	10.0	11.1	12.0	12.9	13.6	14.0	12.4	10.4	10.2	9.0	135.6
Village of Mackinac City	3.04	4.46	5.25	5.16	5.44	5.90	6.99	8.57	5.36	5.03	2.97	2.92	61.09
CLARE COUNTY													
City of Clare	12.2	12.7	15.3	16.4	20.8	39.0	24.1	36.7	33.4	18.5	12.1	11.7	252.9
City of Harrison	2.41	3.59	3.89	3.16	3.97	4.50	4.92	4.02	3.50	3.35	3.22	3.19	43.72
CLINTON COUNTY													
Village of Ovid	1.96	2.29	2.24	2.31	2.25	2.50	4.78	2.81	1.81	2.09	1.82	2.95	29.81
City of St. Johns	30.5	26.7	24.1	24.4	27.6	28.8	30.7	32.1	30.5	30.0	27.6	24.2	337.2
EATON COUNTY													
Village of Bellevue	--	--	--	--	--	--	--	--	--	--	--	--	e24.0
City of Olivet	--	--	--	--	--	--	--	--	--	--	--	--	e18.0
City of Charlotte	27.5	29.1	32.1	33.0	36.4	37.7	38.5	38.7	36.8	34.8	29.0	31.8	405.4
City of Eaton Rapids	25.9	24.9	40.7	34.8	30.8	31.7	38.2	39.2	35.7	27.1	25.9	27.3	382.2
City of Grand Ledge	11.9	11.2	11.9	11.5	13.3	14.2	15.8	15.9	14.5	13.3	11.0	11.3	155.8
EMMET COUNTY													
City of Harbor Springs	8.13	7.26	7.46	8.65	8.23	15.92	15.45	23.10	20.83	9.60	7.65	6.99	139.27
GENESEE COUNTY													
Beecher Metr. Dist.	21.9	19.8	20.2	20.6	22.1	27.0	28.3	28.4	27.9	25.7	24.5	26.3	292.7
City of Davison	7.66	7.02	8.45	8.44	9.05	10.62	13.72	10.39	13.41	9.47	8.71	8.65	115.59
Village of Fenton	15.1	17.3	16.4	14.6	16.1	17.7	21.9	18.2	17.1	16.4	15.2	14.2	200.2
Fisher Body Div., at Grand Blanc	5.95	5.66	6.42	7.22	6.91	7.09	6.75	7.61	6.02	8.01	6.87	7.17	81.68
Village of Flushing	6.41	5.94	6.82	6.58	7.92	8.68	9.70	7.60	7.37	7.23	7.38	6.41	88.04
Village of Linden	1.53	1.43	1.50	1.66	1.53	1.69	1.71	1.77	1.68	1.69	1.43	1.27	18.89
Village of Montrose	2.11	1.71	1.85	1.68	2.32	2.71	3.06	2.79	2.46	2.08	1.17	1.97	26.11
City of Mt. Morris	6.53	5.93	6.40	6.32	6.73	7.06	7.35	6.86	6.42	6.51	5.52	5.81	77.44
Village of Otisville	.99	1.36	1.33	1.13	1.19	1.13	1.29	1.03	1.08	1.00	.92	.94	13.39
GLADWIN COUNTY													
City of Beaverton	3.61	3.30	3.04	2.43	3.49	2.63	3.54	2.40	2.94	2.93	2.14	2.72	35.17
GRAND TRAVERSE COUNTY													
State Hosp. at Traverse City	13.7	12.4	13.9	13.8	14.0	15.0	14.9	14.4	13.7	12.8	12.0	12.2	162.8
GRATIOT COUNTY													
City of Alma	44.8	39.1	45.9	47.6	53.9	56.4	55.5	53.6	54.6	55.0	49.1	48.2	603.7
Village of Breckenridge	2.60	2.70	2.70	2.50	2.90	3.00	3.70	3.30	3.30	3.20	2.90	2.70	35.50
City of Ithaca	e3.75	3.75	4.30	e4.00	e4.50	e4.65	4.80	5.23	5.52	5.19	6.08	5.61	e57.36
City of St. Louis	18.7	17.7	20.0	20.1	21.6	20.1	19.5	16.1	15.0	15.4	16.6	16.7	217.5
HILLSDALE COUNTY													
Village of Jonesville	5.55	6.78	7.09	9.05	8.62	9.26	11.04	8.51	7.64	6.80	6.27	6.14	92.75
City of Hillsdale	--	--	--	--	--	--	21.90	1.84	--	--	--	--	b23.74
City of Reading	--	--	--	--	--	--	--	--	--	--	--	--	1.29
HURON COUNTY													
Village of Pigeon	e3.0	e2.7	e3.0	e3.3	e3.7	e3.9	e6.8	e7.4	e4.5	e4.3	e3.9	e3.4	e49.9
Village of Sebewaing	7.13	9.34	6.79	7.87	6.94	9.84	13.82	9.88	11.54	10.10	9.68	6.29	109.22
INGHAM COUNTY													
City of East Lansing	32.9	29.2	30.6	32.0	39.9	46.0	57.3	39.7	37.7	38.3	34.5	31.6	449.7
City of Lansing	509	444	473	455	519	539	589	566	506	523	483	494	6,100
Lansing Twp.	42.1	31.7	27.7	41.8	41.8	36.0	30.8	42.4	33.3	46.1	31.5	30.5	435.7
Village of Leslie	7.14	4.70	4.91	4.87	5.71	7.08	9.45	7.12	6.31	5.21	4.96	5.13	72.59
City of Mason	11.1	9.9	12.7	12.3	13.8	15.0	17.7	25.9	19.3	14.1	12.9	12.2	176.9
Meridian Twp.	9.07	8.25	8.75	8.72	11.76	12.38	13.91	10.84	11.01	10.79	9.46	9.70	124.04
Mich. State Univ. at East Lansing	83.9	84.7	85.3	85.8	93.7	88.6	84.4	76.6	77.6	98.7	86.9	70.9	1,017.1
Oldsmobile Forge Plant at Lansing	13.3	12.3	11.2	13.4	13.8	15.1	14.1	12.7	13.6	13.8	14.1	13.1	160.5
Village of Stockbridge	2.10	1.64	1.72	1.37	1.96	2.14	2.36	2.71	2.01	1.75	1.57	2.19	23.52

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.	1961 Total
IONIA COUNTY													
City of Ionia	30.7	31.1	34.1	32.1	34.7	34.5	35.5	34.7	34.5	35.2	35.4	34.4	406.9
State Hosp. at Ionia	10.3	9.4	10.3	10.1	10.5	10.5	11.8	11.9	11.3	10.9	10.4	10.6	127.9
Mich. Reform. at Ionia	22.7	20.4	23.9	22.5	26.0	25.4	29.5	28.2	22.0	26.4	24.3	24.2	295.5
Mich. Tng. Unit at Ionia	2.15	2.20	1.16	1.35	1.74	1.71	3.03	2.02	1.45	1.72	2.35	1.14	22.02
Village of Portland	9.51	8.23	9.05	7.98	10.71	11.53	14.07	11.30	11.31	11.47	9.25	13.87	128.28
Village of Saranac	8.16	7.44	8.81	8.43	9.30	9.48	14.19	7.73	6.71	7.33	7.20	7.13	101.92
ISABELLA COUNTY													
City of Mt. Pleasant	51.5	46.1	51.7	49.2	38.3	55.6	59.0	44.0	48.0	47.6	46.1	41.0	598.0
JACKSON COUNTY													
Village of Concord	2.25	1.47	1.74	1.56	2.29	1.98	3.28	1.85	1.91	1.58	1.40	1.65	22.96
Village of Grass Lake	1.22	1.19	1.20	1.24	1.21	1.31	2.01	1.62	1.21	1.20	1.22	1.22	15.85
City of Jackson	291	273	298	297	330	380	404	403	384	362	328	337	4,087
State Prison of S. Mich., at Jackson	37.4	33.9	37.7	34.3	43.8	45.4	51.5	49.6	46.3	46.1	40.5	42.2	508.7
KALAMAZOO COUNTY													
Village of Augusta	1.00	1.11	1.64	1.75	2.08	2.58	3.41	2.47	2.01	1.92	1.60	1.54	23.11
City of Galesburg	2.19	1.99	2.61	2.52	3.55	4.73	4.56	4.56	3.47	2.74	2.50	2.11	37.53
City of Kalamazoo	375	341	384	366	425	502	636	519	447	353	294	288	4,930
State Hosp. at Kalamazoo	17.7	17.2	17.8	17.2	17.4	13.8	17.7	17.1	18.7	18.5	16.4	21.1	210.6
Village of Vicksburg	5.20	4.88	5.44	5.27	6.23	6.90	7.23	7.27	7.17	6.27	6.30	6.61	74.77
KALKASKA COUNTY													
Village of Kalkaska	3.65	4.54	3.53	3.89	3.88	4.37	4.81	4.19	3.40	3.08	3.10	3.36	45.80
KENT COUNTY													
City of Cedar Springs	7.40	7.40	7.40	7.45	7.50	7.75	7.86	7.87	7.69	7.69	7.50	7.50	91.01
City of Grandville	10.9	14.3	13.3	13.3	23.0	34.1	46.4	32.2	16.6	14.2	15.3	14.6	248.2
Jervis Corp. at Grandville	5.99	4.59	5.84	5.53	10.69	9.92	9.62	10.25	6.55	7.49	11.34	14.31	102.12
City of Lowell	12.2	8.1	9.9	11.4	11.1	14.9	16.6	15.0	11.8	11.5	10.2	10.2	142.9
Paris Twp.	25.8	21.9	25.8	26.5	42.5	62.8	66.3	46.7	35.1	31.3	28.4	27.0	439.9
Village of Sparta	13.2	12.0	11.2	14.3	16.5	14.6	16.3	12.0	14.0	13.2	12.8	e16.2	e166.3
City of Wyoming	108	100	108	110	174	232	258	202	142	131	123	123	1,811
LAPEER COUNTY													
Village of Imlay City	5.03	5.45	6.61	6.39	8.02	9.19	11.29	6.85	10.20	7.82	5.52	8.25	90.62
City of Lapeer	12.9	12.1	13.5	12.1	13.1	17.1	18.0	17.7	17.6	15.9	15.5	15.3	180.8
State Home and Tng. School at Lapeer	20.3	20.5	22.5	20.9	22.5	20.7	22.3	18.8	18.9	20.4	19.7	21.6	249.1
LENAWEE COUNTY													
Village of Clinton	--	--	a13.8	--	--	a18.0	--	--	a18.0	--	--	a30.0	79.8
City of Hudson	8.24	7.81	8.40	8.01	7.46	7.33	8.27	9.34	8.47	7.19	7.10	5.81	93.43
City of Morenci	5.36	4.71	5.74	5.82	5.81	6.48	6.88	5.02	4.89	4.62	4.90	4.56	64.81
City of Tecumseh	68.9	67.3	71.1	72.5	64.3	71.1	74.5	69.6	74.6	68.3	62.1	74.3	838.5
LIVINGSTON COUNTY													
City of Brighton	5.85	5.12	5.61	5.29	6.96	9.75	17.75	13.51	9.05	14.93	8.45	6.32	108.59
City of Howell	19.8	17.4	20.4	21.0	21.4	20.4	20.6	21.0	20.3	20.3	18.9	19.8	241.3
State Hosp. at Howell	2.85	2.67	3.07	2.39	2.43	4.04	8.03	3.13	2.50	2.41	2.70	2.59	38.81
MACOMB COUNTY													
City of Fraser	12.6	11.4	12.6	12.4	16.0	20.2	23.8	17.9	16.2	16.4	13.7	13.4	186.6
Village of Richmond	6.13	6.18	6.85	6.70	e7.20	e7.90	8.30	7.48	7.79	7.34	6.79	6.50	e85.16
Village of Romeo	10.6	10.0	10.3	10.2	10.4	12.2	14.2	14.3	11.2	10.6	10.4	10.1	134.50
MANISTEE COUNTY													
City of Manistee	41.8	37.7	42.6	38.6	45.4	50.3	61.0	55.1	40.3	40.6	39.7	34.4	527.5
MASON COUNTY													
City of Scottville	4.11	4.30	5.22	4.96	6.94	7.51	10.05	9.10	6.92	4.61	5.50	4.35	73.57
MONROE COUNTY													
Village of Carleton	2.65	2.77	2.64	2.63	2.71	2.84	3.12	3.03	3.00	2.81	2.40	2.28	32.88
MONTCALM COUNTY													
City of Carson City	8.90	7.90	8.04	8.15	9.55	10.88	10.90	10.77	10.46	10.50	9.82	9.92	115.79
City of Greenville	30.9	27.2	25.1	23.8	27.0	32.2	31.9	e24.5	e23.5	22.5	19.8	20.7	e309.1
Village of Howard City	.66	.76	.85	1.02	1.00	1.14	1.50	1.22	.99	.81	.84	.80	11.59
Village of Lakeview	--	--	a4.46	--	--	a5.56	--	--	a4.73	--	--	a4.80	19.55
Village of Sheridan	1.13	.95	1.09	.96	1.82	2.07	3.26	1.85	1.70	1.28	1.06	1.14	18.31

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.	1961 Total
MUSKEGON COUNTY													
City of Montague	3.87	6.38	4.35	3.78	6.53	8.12	8.30	10.31	5.68	5.70	6.20	5.86	75.06
City of Whitehall	9.03	8.48	9.26	9.67	13.14	15.48	20.83	18.05	12.16	10.94	9.54	9.97	146.55
NEWAYGO COUNTY													
City of Fremont	11.2	12.9	11.7	12.6	13.2	17.3	28.4	29.4	29.4	25.7	24.2	30.8	246.8
OAKLAND COUNTY													
City of Birmingham	.066	.069	.077	.072	.062	.075	.068	.071	.070	.061	.066	.069	e.826
Cranbrook School	8.2	3.8	7.3	8.9	12.4	13.6	13.1	11.1	13.9	16.1	10.9	8.5	127.8
Mich. State Univ. at Oakland	.840	1.352	1.067	.906	.976	.427	.459	.427	.812	1.566	1.429	1.412	11.673
Village of Oxford	4.69	4.65	4.33	4.26	6.13	5.83	7.00	5.54	4.82	7.34	4.80	3.67	63.06
City of Pontiac	288	244	267	267	305	348	343	321	278	303	288	277	3,529
State Hosp. at Pontiac	14.1	12.6	14.3	13.9	15.2	15.3	14.5	13.6	14.9	8.0	.5	3.1	140.0
Village of Rochester	37.3	34.9	41.2	40.9	43.7	47.8	53.2	42.7	39.8	36.5	33.2	34.9	486.1
City of South Lyon	33.6	35.7	41.8	39.3	41.7	43.5	29.1	43.6	38.7	40.6	37.0	43.6	468.2
City of Sylvan Lake	3.53	3.63	3.04	3.42	3.84	4.69	6.48	5.43	4.42	3.42	4.17	3.65	49.72
City of Troy	21.2	20.4	22.9	23.7	29.9	33.1	26.6	30.7	32.1	29.0	25.4	21.8	316.8
Waterford Twp.	19.6	18.3	20.0	e20.0	25.7	31.9	49.1	31.6	28.5	22.9	23.6	22.5	e313.7
OCEANA COUNTY													
City of Hart	10.3	10.4	10.5	9.4	12.0	14.6	36.1	27.0	19.2	24.7	20.3	11.0	205.5
Village of Pentwater	.157	.156	.156	.161	.163	.168	4.321	4.576	.181	.170	.160	.158	10.527
OGEMAW COUNTY													
City of West Branch	5.83	6.56	7.26	5.82	7.32	8.61	8.37	8.71	6.86	6.81	6.29	5.79	84.23
OSCEOLA COUNTY													
City of Evart	e30.0	e30.0	e30.0	e25.0	e25.0	e25.0	e26.0	e26.0	e26.0	e35.0	e35.0	e35.0	e348.0
OTSEGO COUNTY													
City of Gaylord	8.58	9.75	10.99	10.40	10.68	11.17	11.69	11.17	15.45	8.84	8.49	8.82	126.03
N. Mich. T B San. at Gaylord	e1.43	e1.29	e1.43	e1.38	e1.43	e1.38	e1.43	e1.43	e1.38	e1.43	1.29	1.35	e16.65
OTTAWA COUNTY													
City of Grand Haven													
Lake Infil. Wells	54.7	50.3	53.1	46.3	72.4	100.2	117.0	106.1	75.9	58.9	54.1	50.0	839.0
Drift Wells	18.5	16.7	15.8	17.7	16.6	17.7	17.4	17.7	11.9	17.7	16.9	16.7	201.3
City of Hudsonville	--	--	a10.1	--	--	a15.8	--	--	a30.5	--	--	a13.3	69.7
Village of Spring Lake	9.89	7.99	8.91	9.34	13.27	20.22	23.50	17.96	10.65	9.11	8.79	8.77	148.4
City of Zeeland	19.2	18.2	21.3	22.1	25.6	32.1	28.5	32.2	36.2	35.4	30.9	26.3	328.0
SAGINAW COUNTY													
Bridgeport Twp.	5.69	5.01	5.18	5.42	6.10	7.72	8.42	7.81	7.24	6.35	5.80	6.44	77.18
Village of St. Charles	3.54	3.57	3.36	3.30	3.94	3.92	4.28	3.48	3.64	3.57	3.26	2.89	42.75
Thomas Twp.	3.18	4.34	3.23	2.94	3.60	2.95	3.17	3.53	3.86	4.10	3.59	4.12	42.61
ST. CLAIR COUNTY													
Village of Capac	3.91	3.32	4.03	3.62	4.29	4.19	6.89	5.50	4.94	4.04	4.57	3.76	53.06
City of Yale	3.62	3.61	4.40	4.79	5.25	5.43	6.87	5.92	5.80	4.21	4.12	4.96	58.98
ST. JOSEPH COUNTY													
Village of Constantine	--	--	a6.97	--	--	a8.13	--	--	a8.33	--	--	a6.54	29.97
City of Sturgis	44.1	38.6	44.2	42.2	48.4	55.2	61.1	57.1	54.5	51.2	50.6	46.9	594.1
City of Three Rivers	25.2	25.3	27.0	27.2	32.7	33.3	38.1	32.2	30.6	26.1	24.9	26.0	348.6
SANILAC COUNTY													
City of Croswell	8.68	8.38	8.51	10.78	14.73	12.87	17.94	28.44	21.41	20.13	17.58	13.25	182.7
Village of Deckerville	3.25	3.18	3.70	3.56	4.17	3.81	4.70	9.29	5.68	4.27	4.37	4.79	54.77
City of Sandusky	13.8	14.0	14.1	12.5	14.8	15.5	13.9	14.2	13.8	12.7	11.8	12.5	163.6
SHIAWASSEE COUNTY													
City of Corunna	6.32	5.23	5.69	5.41	5.90	6.59	6.71	6.45	6.14	5.88	5.51	5.72	71.55
City of Durand	10.5	9.8	11.6	11.1	11.4	10.7	12.5	10.3	11.1	10.7	10.2	10.1	130.0
City of Owosso	69.3	66.9	74.1	68.2	75.7	82.4	91.1	79.9	79.4	77.4	71.7	73.2	909.3
Village of Perry	1.86	1.59	1.76	1.68	1.96	2.16	2.74	1.95	1.71	1.81	1.59	1.65	22.46
TUSCOLA COUNTY													
State Hosp. at Caro	9.84	8.94	9.40	9.76	10.48	10.38	13.90	9.95	10.00	9.54	8.61	9.27	120.07
Village of Cass City	6.08	6.38	7.05	6.52	7.56	7.71	7.84	6.79	6.85	6.41	6.00	6.07	81.26
City of Vassar	11.6	15.2	13.1	10.8	12.3	16.6	22.1	15.9	14.5	13.1	13.1	11.4	169.7
VAN BUREN COUNTY													
Village of Bangor	13.0	12.9	15.3	14.1	16.0	18.8	22.1	21.2	19.7	20.3	19.4	18.2	211.0
Village of Hartford	5.17	4.91	5.08	5.27	8.42	9.19	12.36	8.34	7.36	6.59	5.34	5.59	83.62
Village of Lawton	25.9	23.6	15.3	19.9	16.3	17.8	20.2	15.7	20.7	40.5	16.6	17.1	249.6

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.	1961 Total
WASHTENAW COUNTY													
City of Ann Arbor	65.1	55.6	74.8	76.2	83.0	94.0	119.4	113.9	104.0	64.1	59.7	75.0	c984.8
Boys Tng. School at Whitmore Lake	.638	.511	.594	.549	.626	.677	.806	.848	.887	.802	.849	.738	8.525
Cassidy Lake Tech. School	1.3	1.2	1.3	1.4	1.4	1.5	e1.5	e1.5	e1.4	e1.3	e1.2	e1.2	e16.2
Village of Dexter	3.89	3.82	3.90	3.14	4.29	3.62	6.15	4.82	5.66	4.96	4.27	3.59	52.11
City of Saline	4.24	3.71	4.81	4.74	6.30	7.12	9.45	7.38	7.03	6.29	6.07	7.21	74.35
City of Ypsilanti	74.5	66.9	73.9	79.3	82.9	90.9	108.4	95.5	94.4	86.5	87.8	89.3	1,030.1
Ypsilanti Twp.	187	163	164	157	174	192	199	193	175	197	197	177	2,175
State Hosp. at Ypsilanti	15.7	14.4	14.1	15.7	15.7	17.7	20.7	20.8	16.1	14.7	13.2	13.2	192.0
Village of Manchester	3.67	3.56	4.00	4.09	4.12	4.75	4.88	5.40	5.60	3.88	4.08	4.41	52.44
WAYNE COUNTY													
City of Belleville	--	--	a15.4	--	--	a15.9	--	--	a13.1	--	--	a13.4	57.8
State Hosp. at Northville	21.6	19.4	21.6	21.4	21.0	20.6	21.8	21.0	20.0	21.2	21.2	21.6	252.4
City of Plymouth	51.2	46.2	50.1	50.2	54.4	59.7	67.0	66.3	72.1	60.1	55.3	52.0	684.6
State Home and Tng. School at Northville	2.20	1.86	1.93	1.70	1.74	2.05	1.83	2.59	1.76	1.47	2.19	2.41	23.73
WEXFORD COUNTY													
City of Cadillac	16.0	15.7	15.9	13.6	34.5	45.2	41.0	43.1	30.5	18.5	14.8	15.7	d304.5
City of Manton	.49	1.23	1.13	1.16	1.35	2.32	3.49	1.17	1.21	.72	.52	.83	15.62

a) Meters read quarterly
b) Pumped in summer months only
c) Also use surface water
d) Surface water used until Oct. 26
e) Estimated