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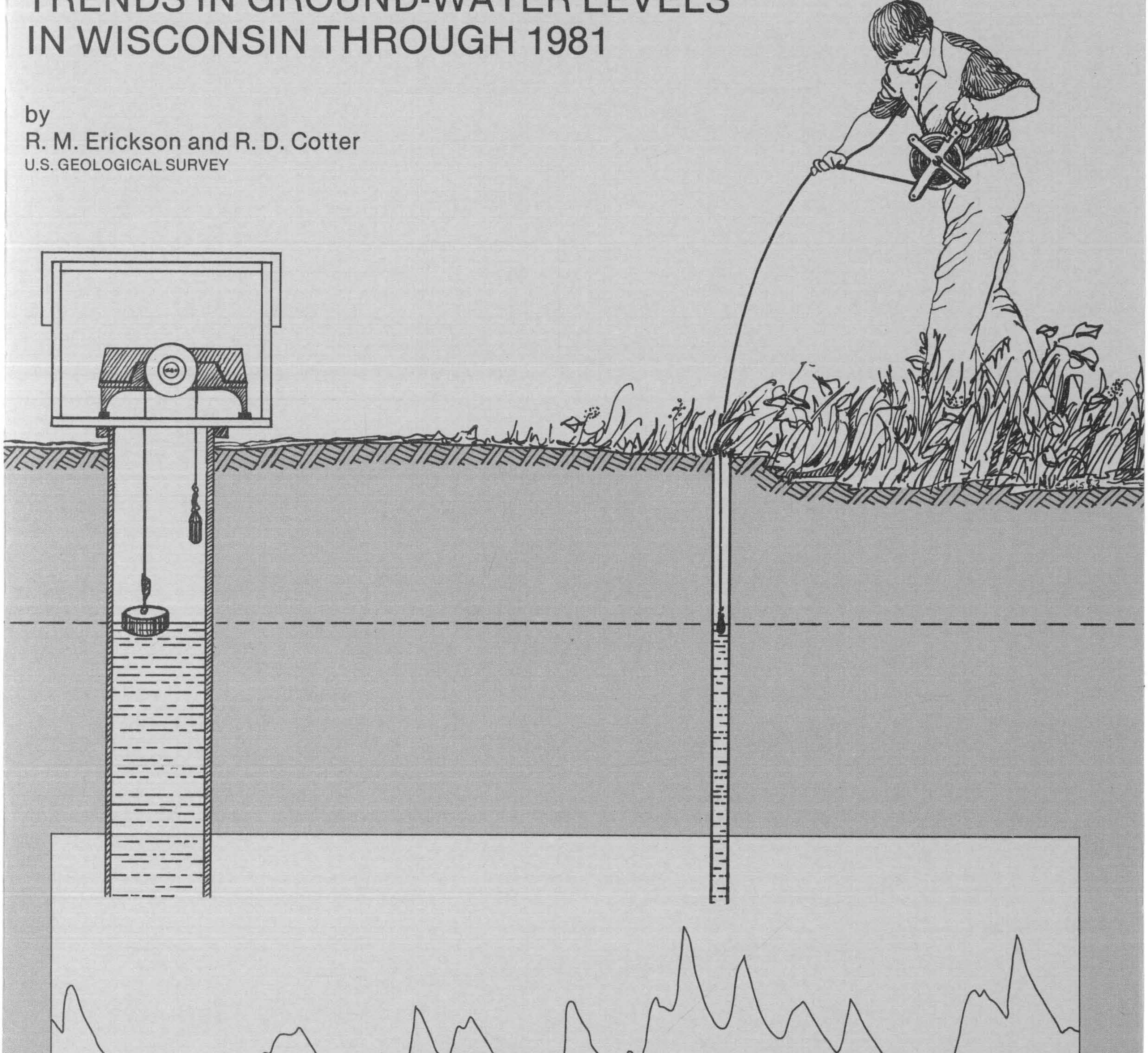
TRENDS IN GROUND-WATER LEVELS IN WISCONSIN THROUGH 1981

by
R. M. Erickson and R. D. Cotter
U.S. GEOLOGICAL SURVEY



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UNITED STATES DEPARTMENT OF THE INTERIOR
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This report is a product of the Geological and Natural History Survey Water Resources Program which includes: systematic collection, analysis, and cataloguing of basic water data; impartial research and investigation of Wisconsin's water resources and water problems; publication of technical and popular reports and maps; and public service and information.

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
and
UNIVERSITY OF WISCONSIN–EXTENSION
GEOLOGICAL AND NATURAL HISTORY SURVEY
M. E. Ostrom, Director and State Geologist
Madison, Wisconsin
January 1983

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For the convenience of readers who may want to use International System of Units (SI), the data may be converted by using the following factors:

Multiply	By	To obtain
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
degrees Fahrenheit (°F)	$\frac{(°F - 32)}{1.8}$	degrees Celsius (°C)

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INDEX OF HYDROGRAPHS OF WATER LEVELS--Continued

TRENDS IN GROUND-WATER LEVELS IN WISCONSIN THROUGH 1981

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ABSTRACT

Hydrographs of ground-water levels in Wisconsin display fluctuations in the potentiometric surface of confined and unconfined aquifers. The graphs are plotted from periodic (weekly or monthly) measurements and from continuous-recording gage records. Two hundred and ten hydrographs having periods of record of at least 5 years between 1934 and 1981 are included.

The water-level changes shown represent both natural fluctuations reflecting climatic control and declines or recovery brought about by pumping or cessation of pumping of ground water.

INTRODUCTION

The water supplies of Wisconsin are its most valuable natural resource. Although water supplies are abundant and sufficient to maintain the perennial flow of most streams and to sustain large increases in municipal, agricultural, and industrial use in many areas, the supply is not distributed equally throughout the State. Optimum development of water resources depends on knowledge of the occurrence, distribution, and movement of water; the quantity of discharge to and from a region; the relation of ground water to surface water; and the quantity and quality of the water available.

A fundamental part of the ground-water investigations in Wisconsin, begun in 1946 by the United States Geological Survey in cooperation with the Wisconsin Geological and Natural History Survey, is collecting water-level data, whose purpose is to determine short-term changes and long-term trends in ground-water levels and to relate these determinations to changes in storage in the ground-water reservoirs.

Purpose and Scope

The purpose of this report is to present data on ground-water levels through 1981 graphically and to relate water-level changes, by example, to natural recharge and discharge and to pumping effects in both confined and unconfined aquifers.

In 1934 and 1935, systematic measurements of ground-water levels were begun in a few wells in southwestern Wisconsin by the Soil Conservation Service, U.S. Department of Agriculture, and in central and northeastern Wisconsin by the Wisconsin Conservation Department. In 1946, the current observation-well network was established by the U.S. Geological Survey, in cooperation with the Wisconsin Geological and Natural History Survey.

This report summarizes water-level trends in Wisconsin through 1981. It includes hydrographs for the 187 current observation wells having a period of record of at least 5 years and for 23 wells discontinued or destroyed after 1970. Of these wells, 23 were equipped with continuous recording gages; of the remaining 173, 19 were measured weekly, and 154 were measured monthly. The locations of these wells are shown in figures 11 to 15. For hydrographs of discontinued or destroyed wells not included in this report, see Audini and others (1959), Devaul (1967), and Erickson (1972) as per table 1.

The observation-well network is constantly being reevaluated and revised as necessary. Some records are discontinued because the wells have been destroyed. Others may be discontinued that duplicate the record of another well in the region, and some are discontinued if the information is not considered useful. A committee made up of representatives of both surveys meets regularly to evaluate the network.

Well-Numbering System

A system of letters and numbers is used to designate a well (fig. 1). The county designation is derived from the county name (table 2); for example, the prefix AD indicates the well is in Adams County, the prefix MO indicates the well is in Monroe County, etc. The township designation within the county consists of the township, range, and section numbers. The letter W following the range number indicates that the well is located west of the principal meridian; the letter E indicates that the well is located east of the principal meridian (fig. 1). The last numerals (serial number) are assigned in the order that the wells were inventoried in the county. For example, well WI-17/16E/15-0048 is in Winnebago County; is in township 17 north, range 16 east, section 15; and was the 48th well inventoried in the county.

Only the serial numbers of the wells are shown on the location maps (figs. 11-15).

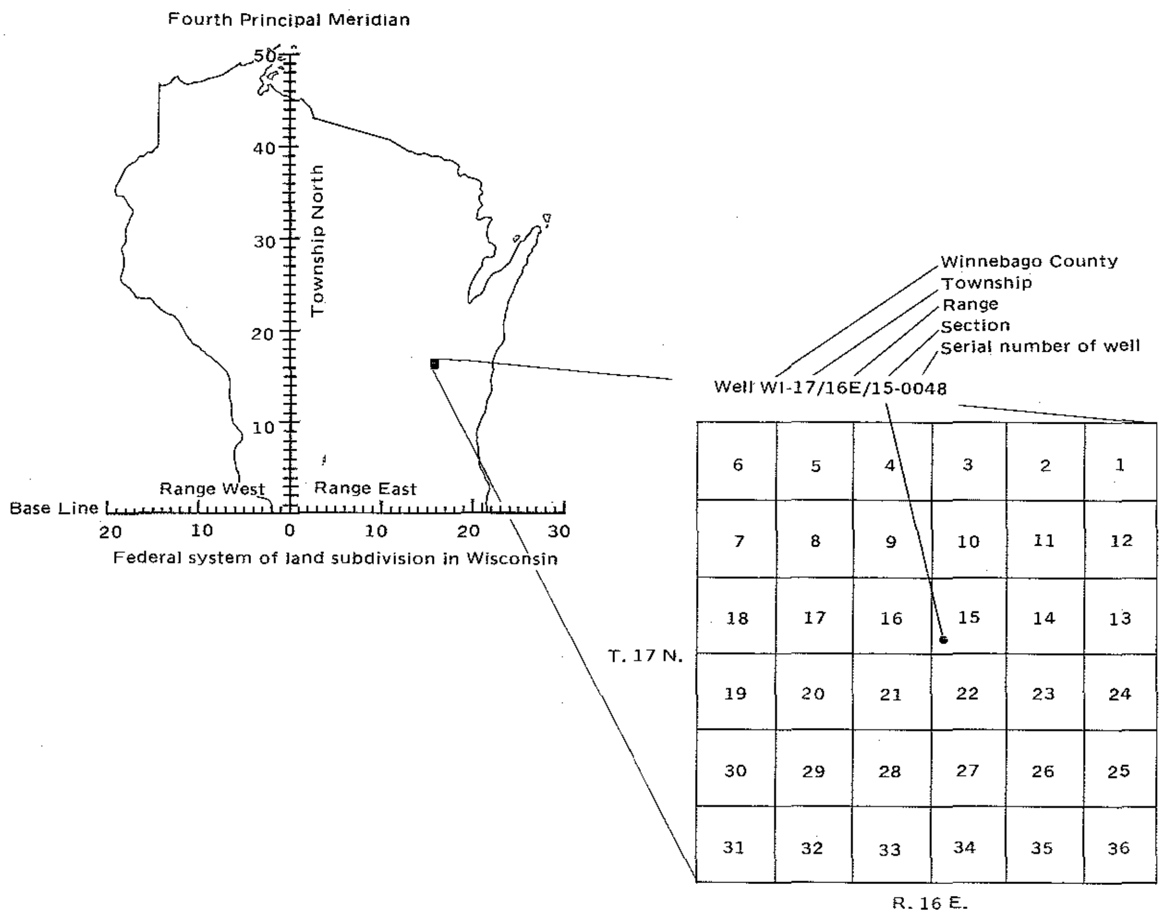


Figure 1. Well numbering system in Wisconsin.

Table 1. Discontinued or destroyed observation wells for which hydrographs have been published.

Well number	Report containing hydrograph: Audini and others (1959)	Devaul (1967)	Erickson (1972)	Period of record of hydrograph
AS-46/04W/06-0001	X	X		1943-55
AS-48/03W/36-0007		X	X	1958-73
BR-34/11W/25-0062		X		1956-64
BN-24/20E/25-0009		X		1947-64
BN-23/20E/22-0011	X	X		1946-67
BN-24/19E/35-0016	X	X		1947-60
BN-24/20E/02-0043	X	X		1948-65
BN-24/20E/29-0051	X	X	X	1935-71
BN-24/21E/13-0072	X	X		1949-65
BF-21/12W/29-0001	X	X		1947-61
CH-29/08W/18-0011	X	X		1953-64
CH-29/05W/31-0027		X		1958-68
CH-28/05W/01-0038		X	X	1956-71
CO-13/11E/29-0013	X	X		1949-64
CO-11/09E/36-0022	X	X	X	1949-71
CO-12/09E/05-0028	X	X		1949-70
CR-07/07E/36-0002	X	X	X	1953-72
CR-10/04W/22-0015		X	X	1957-75
DN-05/08E/32-0003	X	X		1946-63

Table 1. Discontinued or destroyed observation wells for which hydrographs have been published--Continued.

Well number	Report containing hydrograph: Audini and others (1959)	Devaul (1967)	Erickson (1972)	Period of record of hydrograph
DN-08/06E/08-0903		X		1963-68
DG-13/13E/15-0003	X	X		1946-66
DG-11/16E/05-0004	X	X	X	1947-72
DG-09/17E/30-0010	X	X		1946-64
DG-12/17E/10-0012	X	X		1946-64
DR-27/26E/08-0002			X	1964-74
DR-27/26E/08-0005	X	X		1946-61
DR-26/23E/22-0011	X	X	X	1950-72
EC-26/06W/32-0013	X	X	X	1951-74
EC-27/09W/27-0037		X	X	1956-75
FL-14/15E/32-0014	X	X		1953-67
FL-17/19E/30-0019	X	X		1948-67
FL-15/17E/03-0020	X	X	X	1950-76
FL-16/17E/33-0021	X	X		1950-64
IR-42/04E/12-0002		X		1957-64
IR-45/01E/02-0005		X		1957-62
JU-17/02E/21-0008	X	X		1950-67
KE-01/21E/08-0003	X	X		1946-62
LC-17/07W/07-0008	X	X		1953-64

Table 1. Discontinued or destroyed observation wells for which hydrographs have been published--Continued.

Well number	Report containing hydrograph: Audini and others (1959)	Devaul (1967)	Erickson (1972)	Period of record of hydrograph
LF-02/04E/33-0012	X	X	X	1947-72
LF-01/02E/34-0013	X	X		1951-64
LF-01/02E/34-0014	X	X		1951-58
LF-01/02E/22-0036	X	X		1951-59
LF-03/05E/08-0063	X	X		1952-66
LF-01/02E/17-0095	X	X		1953-70
LA-32/11E/32-0044	X	X		1948-63
MR-30/10E/25-0001	X	X		1948-70
MT-30/24E/06-0001	X	X		1946-61
MT-35/22E/18-0009	X	X		1950-64
MQ-16/10E/33-0007	X	X		1949-64
MQ-15/09E/17-0011	X	X		1950-64
ML-07/21E/12-0036	X	X		1946-64
ML-05/22E/24-0095	X	X	X	1946-71
ML-06/21E/11-0132	X	X		1946-59
ML-06/22E/20-0135	X	X		1946-63
ML-08/22E/04-0146	X	X		1946-68
ML-08/21E/03-0231	X	X		1949-68
ML-05/22E/24-0332		X		1956-64
MO-17/01W/01-0001	X	X		1947-66

Table 1. Discontinued or destroyed observation wells for which hydrographs have been published--Continued.

	Report containing hydrograph			
Well number	Audini and others (1959)	Devaul (1967)	Erickson (1972)	Period of record of hydrograph
MO-16/04W/32-0012	X	X		1934-64
MO-16/04W/03-0013		X		1934-56
OU-21/18E/24-0002	X	X		1947-69
OU-22/16E/20-0095	X	X		1952-70
OU-23/19E/30-0125	X	X		1953-70
OU-23/17E/08-0169	X	X		1953-70
OZ-11/21E/26-0023		X		1958-65
OZ-11/21E/26-0035		X		1958-65
PP-23/15W/21-0017		X	X	1957-73
PK-36/19W/25-0049		X		1951-66
PT-23/07E/34-0034	X	X		1950-68
PT-21/08E/25-0037			X	1950-74
PT-24/08E/02-0040	X	X		1950-65
PT-21/09E/29-0043	X	X		1950-68
RA-03/19E/32-0001	X	X		1946-64
RA-03/23E/09-0023	X	X		1952-67
RI-12/02E/12-0005	X	X		1953-64
SC-28/19W/31-0002	X	X		1947-70
SK-11/06E/01-0006	X	X		1946-67

Table 1. Discontinued or destroyed observation wells for which hydrographs have been published--Continued.

	Report containing hydrograph			
Well number	Audini and others (1959)	Devaul (1967)	Erickson (1972)	Period of record of hydrograph
SK-10/06E/15-0011	X	X	X	1948-70
SK-08/04E/07-0019		X		1957-67
SK-08/03E/01-0099		X		1963-68
SH-26/16E/02-0002	X	X		1947-64
SB-13/22E/01-0007		X	X	1958-71
TR-24/09W/09-0004	X	X		1953-59
VE-14/07W/14-0009	X	X		1934-61
WW-01/18E/35-0001	X	X		1946-64
WW-02/17E/04-0024	X	X	X	1952-72
WB-39/12W/31-0001	X	X	X	1948-71
WN-10/18E/20-0002	X	X		1947-64
WN-11/19E/11-0003	X	X		1946-64
WK-05/18E/23-0032	X	X		1947-60
WK-05/18E/19-0034	X	X		1947-64
WK-07/20E/03-0165			X	1966-71
WP-24/13E/34-0077		X		1958-67
WP-23/12E/25-0117		X		1958-67
WS-20/08E/10-0007	X	X		1950-69

Table 1. Discontinued or destroyed observation wells for which hydrographs have been published--Continued.

Well number	Report containing hydrograph: Audini and others (1959)	Devaul (1967)	Erickson (1972)	Period of record of hydrograph
WS-19/08E/15-0009	X	X		1951-66
WS-18/08E/14-0011		X		1954-63
WS-20/10E/23-0039		X		1954-64
WS-20/13E/34-0189		X		1957-64
WD-23/04E/02-0029	X	X		1944-64

Acknowledgments

Personnel of the University of Wisconsin Extension and the Wisconsin Department of Natural Resources are acknowledged for measuring water levels in 71 and 8 wells, respectively. Appreciation is given to private citizens who measured water levels and maintained recording gages on a few of the observation wells. Other citizens, industries, and local and State agencies are also acknowledged for making many of the observation wells available.

WISCONSIN'S AQUIFERS

In Wisconsin, all rocks below the water table contain some water. The water table is commonly within 50ft of the land surface. This zone of water-saturated rock constitutes the ground-water reservoir. The rocks making up this reservoir differ throughout the State.

Most of Wisconsin's water wells obtain water from one of four principal aquifers (water-yielding rocks). These aquifers include the sandstone, the Galena-Platteville, the Niagara, and the sand and gravel. The areal extent of each of these is shown on figure 2. The geology, lithology, thickness, and depth of the rocks making up these aquifers are shown on table 3. The units are listed from top (youngest) to bottom (oldest).

The sandstone aquifer is largely sandstone but includes beds of dolomite and siltstone. Well depths range from 50 ft to more than 2,000 ft in extreme southeast Wisconsin. The water in this aquifer is confined in eastern Wisconsin beneath the Maquoketa Shale (fig. 2). Water is also confined in other areas where this aquifer's upper rock units have a low permeability or where the aquifer is overlain by glacial drift of low permeability.

The Galena-Platteville aquifer is a dolomite that yields water to numerous wells where it is the uppermost bedrock unit. Where it is overlain by the Maquoketa Shale, it yields little water and is not a major aquifer (fig. 2). Well depths are as great as 475 ft but are commonly less than 250 ft. Water in this aquifer is commonly unconfined.

Table 2. County name abbreviations used as prefixes in well numbers.

County	Prefix	County	Prefix
Adams	AD	Marathon	MR
Ashland	AS	Marinette	MT
Barron	BR	Marquette	MQ
Bayfield	BA	Milwaukee	ML
Brown	BN	Menominee	ME
Buffalo	BF	Monroe	MO
Burnett	BT	Oconto	OC
Calumet	CA	Oneida	ON
Chippewa	CH	Outagamie	OU
Clark	CK	Ozaukee	OZ
Columbia	CO	Pepin	PP
Crawford	CR	Pierce	PI
Dane	DN	Polk	PK
Dodge	DG	Portage	PT
Door	DR	Price	PR
Douglas	DS	Racine	RA
Dunn	DU	Richland	RI
Eau Claire	EC	Rock	RO
Florence	FC	Rusk	RU
Fond du Lac	FL	St. Croix	SC
Forest	FR	Sauk	SK
Grant	GR	Sawyer	SW
Green	GN	Shawano	SH
Green Lake	GL	Sheboygan	SB
Iowa	IW	Taylor	TA
Iron	IR	Trempealeau	TR
Jackson	JA	Vernon	VE
Jefferson	JE	Vilas	VI
Juneau	JU	Walworth	WW
Kenosha	KE	Washburn	WB
Kewaunee	KW	Washington	WN
La Crosse	LC	Waukesha	WK
Lafayette	LF	Waupaca	WP
Langlade	LA	Waushara	WS
Lincoln	LN	Winnebago	WI
Manitowoc	MN	Wood	WD

The Niagara aquifer is a dolomite. It is present only in eastern Wisconsin, where it is the uppermost bedrock unit. Well depths range from about 50 to 700 ft, but most are between 100 and 150 ft deep. Water in this aquifer is commonly unconfined, but may be confined in deep zones of the dolomite or where the aquifer is overlain by clayey drift.

The sand-and-gravel aquifer is not continuous but is made up of numerous layers, lenses, terraces, and valley fillings of sand and gravel that are part of the glacial and alluvial deposits covering most of Wisconsin (fig. 2). Wells in this aquifer are commonly less than 100 ft deep. The water in this aquifer is commonly unconfined.

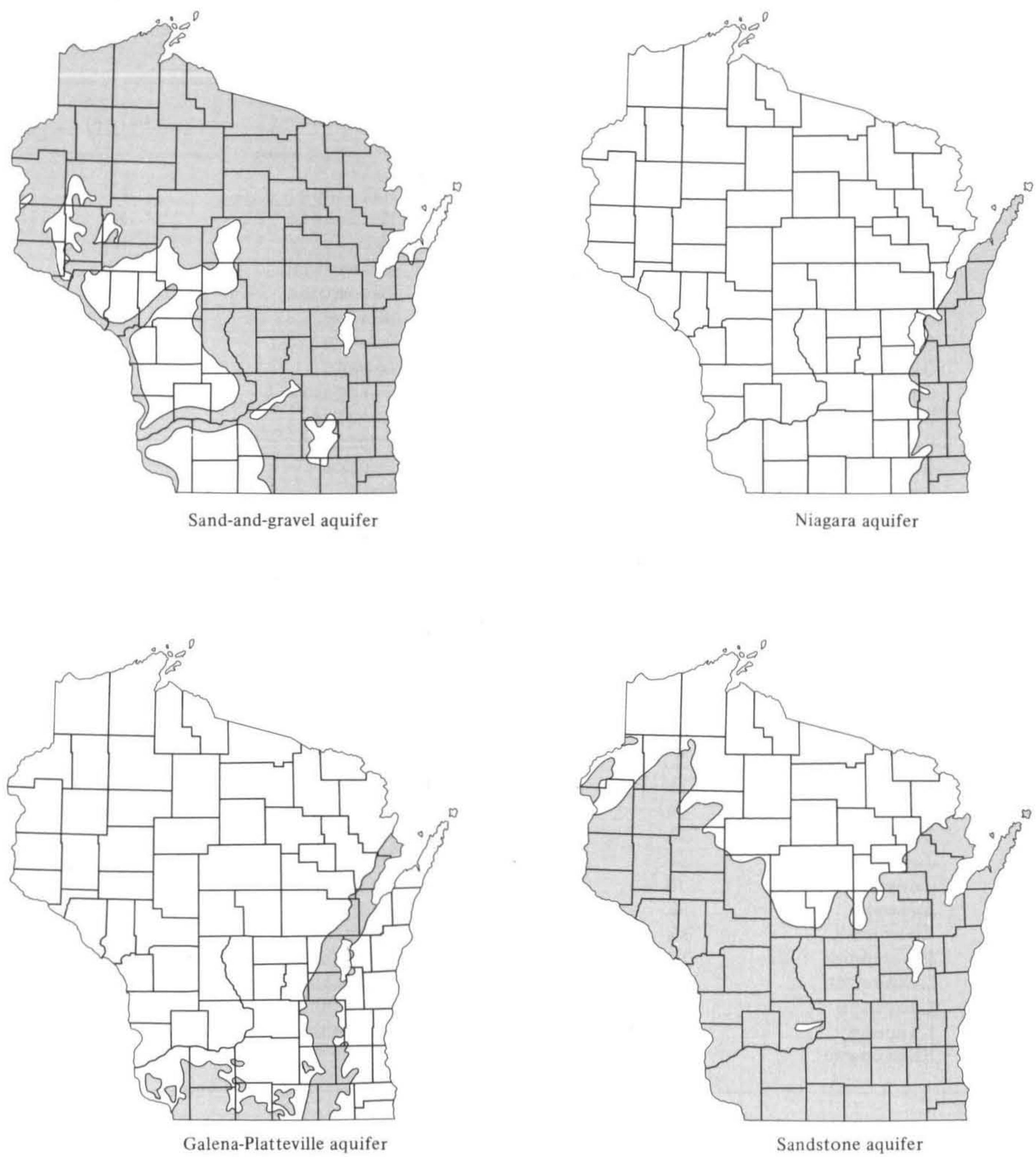


Figure 2. Principal aquifers of Wisconsin.

Table 3.--Geology of Wisconsin's major aquifers

Major aquifer	Geologic age	Stratigraphic unit	Dominant lithology	Thickness (ft)	Depth to top (ft)	Depth to water in wells open to this unit (ft)
Sand and gravel	Quaternary Period	Alluvium and glacial deposits	Unconsolidated clay, silt, sand, gravel, and boulders	As much as 600; between 50 and 200 in most areas	Surficial except where glacial deposits are covered by alluvium	Commonly between 10 and 70
Niagara	Devonian Period	Upper Series Middle Series	Dolomite	As much as 600	As much as 400; commonly 50 to 200	Commonly between 50 and 100
	Silurian Period	Cayugan Series Niagaran Series Alexandrian Series				
	Ordovician Period	Maquoketa Shale	Shale	As much as 600	As much as 800; commonly 200-400	Same as Niagara, very few wells open only to this unit
Galena-Platteville		Sinnipee Group	Dolomite	As much as 300	As much as 900; 10-100 where it is the uppermost bedrock unit	Commonly 50-100; as much as 400
Sandstone	Cambrian Period	St. Peter Sandstone Prairie du Chien Group Trempealeau Group Tunnel City Group Elk Mound Group	Sandstone Dolomite Sandstone Sandstone Sandstone	As much as 2,500	As much as 1,000	Commonly 50-100; as much as 400
	Precambrian Era		Granite Quartzite Basalt	Unknown, but in thousands of feet	From less than 100 to more than 2,000; varies greatly	From 10 to 400; varies greatly

[1]Stratigraphic nomenclature of the University of Wisconsin-Extension, Geological and Natural History Survey, which and does not necessarily follow the usage of the U.S. Geological Survey.

FACTORS AFFECTING GROUND-WATER LEVEL FLUCTUATIONS

Water levels fluctuate in response to changes in storage within the ground-water reservoir. Ground-water levels rise when recharge is more than discharge and decline when discharge is more than recharge. In Wisconsin, water levels in shallow wells usually rise in the spring and occasionally in the fall and decline through the summer and winter. They also fluctuate in response to long-range changes in precipitation. Levels in artesian wells (p. 26) also fluctuate briefly in response to earthquakes, loading by trains, and to changes in barometric pressure. Such fluctuations do not represent changes in ground-water storage, however.

Earthquakes cause brief but obvious changes in ground-water levels. Three wells in Wisconsin equipped with continuous recorders respond to 5 to 10 earthquake shocks per year. For example, the earthquake of November 29, 1978, with its epicenter in Oaxaca, Mexico, and a magnitude of 7.5 on the Richter scale, produced a sharp rise and fall of the water level in Milwaukee County well ML-0120 (fig. 3). The water level fluctuated over a range of 0.38 ft when the shock reached the well 35 minutes after it was recorded at the epicenter. Within 4 hours of the shock, its effect on the water level in this well was no longer evident. If the well had not been equipped with a continuous recorder, the effect would not have been noted.

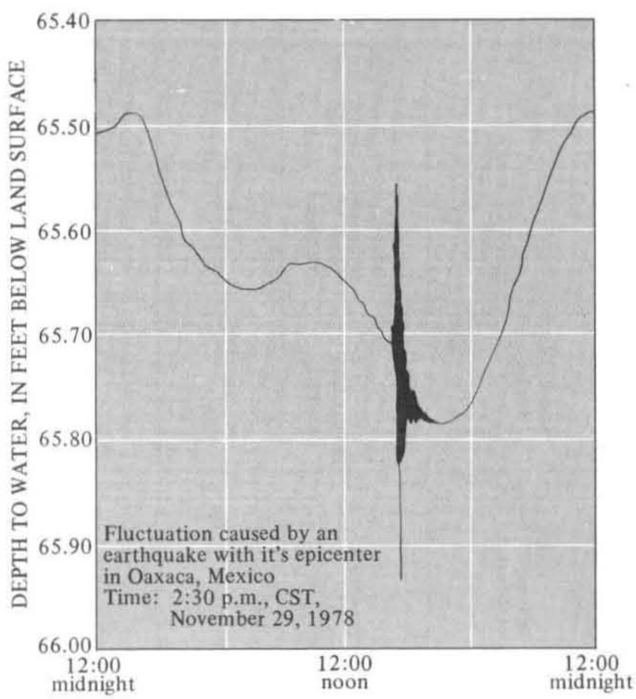


Figure 3. Effect of an earthquake on the water level in Milwaukee County well ML-0120.

Although ground-water levels fluctuate naturally, they remain fairly constant over long periods. However, when water is artificially removed by wells or drains, water levels decline until the hydraulic gradient around the well and the area drained is adequate to yield a constant quantity of water.

Water-Table and Artesian Conditions

The upper surface of the zone of saturation is known as the water table. The water table is generally a subdued replica of the surface topography: the water table is highest under the hills and lowest under the valleys. The depth to the water table is, however, greatest beneath the hills. Water moves in the direction of slope of the water table; in most areas, the movement is from areas of recharge toward areas of discharge.

The aquifer is termed artesian when its water is under greater than atmospheric pressure. The water level in a well finished in an artesian aquifer stands above the top of the aquifer. The imaginary surface that coincides with the height to which water in wells tapping artesian aquifers will rise is known as the potentiometric surface. Ground-water movement is downgradient in the direction of slope of the potentiometric surface.

Water levels in wells in artesian (confined) aquifers are many times more sensitive to changes in pumping or recharge than levels in wells in water-table (unconfined) aquifers. A change in level of many feet in an artesian well may represent the removal or addition of the same quantity of water as a change in water level of less than a foot in a water-table well.

Natural Recharge and Discharge

Recharge to the ground-water reservoir is the replacement of water that has been discharged or removed. Recharge occurs when rainfall and snowmelt percolate to the water table or when water moves from streams, ponds, or lakes into the ground. In Wisconsin, most of the ground-water recharge occurs during the spring from melting snow and rain, when evaporation and transpiration are low.

Water levels decline during the summer, when recharge from precipitation is scant and when natural discharge by evaporation, transpiration, and discharge to lakes, streams, and springs is substantial. Small quantities of precipitation cause little, if any, recharge until soil-moisture needs are met. Heavy rains on saturated soils may contribute significant recharge, with a resulting rise in water level. Water levels commonly rise in the fall after vegetation has been killed by the frost and soil-moisture needs have been satisfied. Water levels then decline until the following spring because natural discharge continues while recharge is retarded or prevented by frost in the soil, and water is stored on the land surface as snow or ice.

The water level in a well near Hancock in Waushara County shows these natural responses (fig. 4). The first water-level rise in March corresponds to a period of recharge of a week and a half, when the maximum daily temperatures remained above freezing, releasing snow and frost to recharge the ground-water reservoir. The rise in April and early May results from heavy precipitation in late April. Summer rains of less than 1in. did not recharge the ground-water reservoir, but the heavy rains in late August caused a sharp rise in the water table.

Water discharges naturally from a ground-water reservoir to springs, streams, and other surface-water bodies. It is also discharged to the atmosphere by evaporation and transpiration where the water table is at or near the land surface.

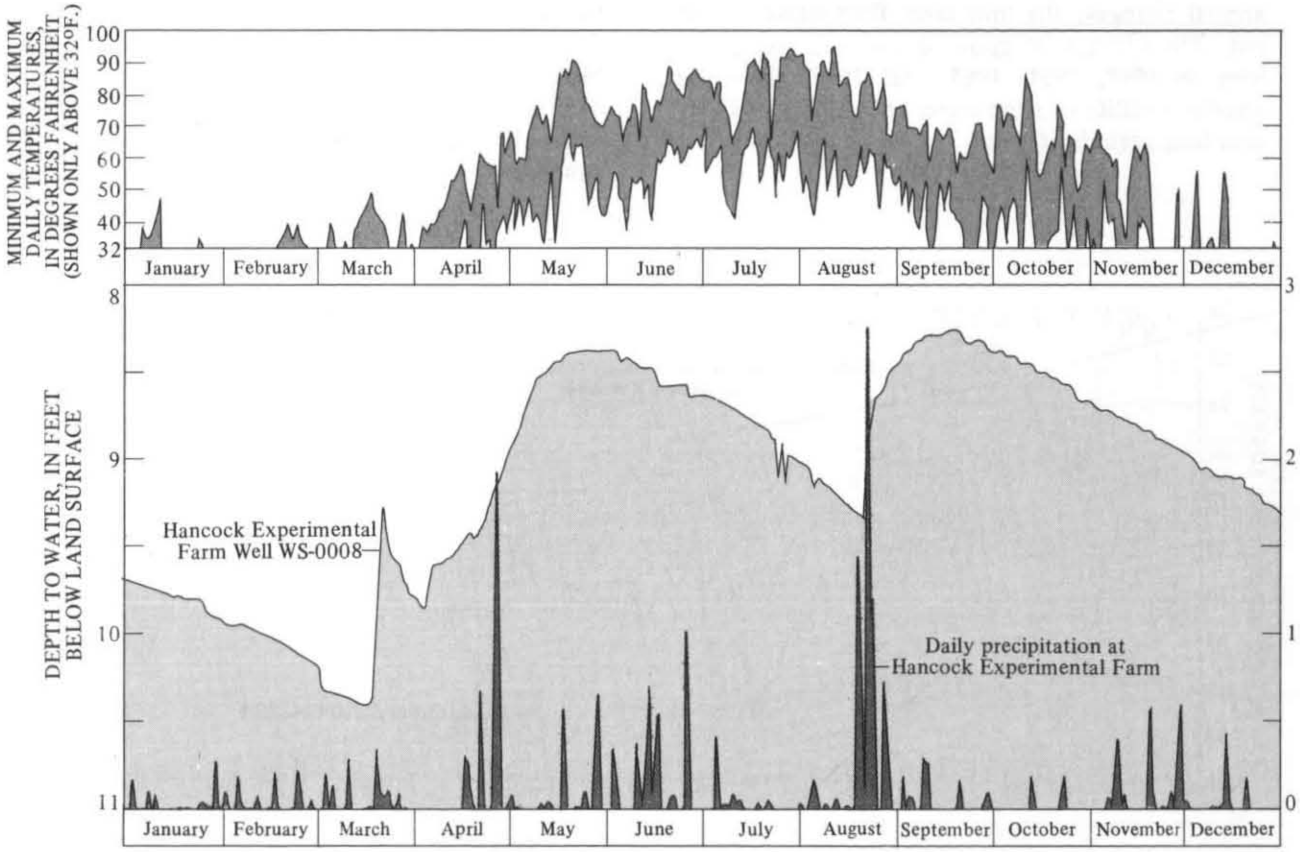


Figure 4. Effect of climate on natural fluctuations in the water table.

The ground-water reservoir holds tremendous quantities of slowly moving water, thereby damping the effects of natural recharge and discharge. The water table responds to climatic changes slowly and integrates small quantities of precipitation into slow rises in stage. Because of this response, the trend of fluctuations in the water table can be approximated from precipitation data at a nearby weather station. By using the same period of record for both precipitation and ground-water levels, a plot of cumulative departure from normal precipitation commonly shows similar trends to the hydrograph of ground-water levels. Graphs comparing 34 years of fluctuations between the water level in Oneida County well 23 and cumulative departure from normal precipitation at Willow Reservoir (10 mi to the west) are shown in figure 5. The peak ground-water levels lag behind peaks in the cumulative departure from normal precipitation by a few months.

Long-term climatic cycles can also be seen on well hydrographs (fig. 6). The graph of a well in Burnett County has a range of fluctuation of less than 6 ft for more than 40 years. With the slight annual changes, the long-term fluctuations stand out. These long-term cycles of about 13 years, with lows in 1938, 1951, 1965, and 1978, show the aquifer's ability to store water and release it slowly over long periods of time.

Pumping Effects

Pumping from wells causes an initial rapid decline (drawdown) in water level in the pumping well and in nearby wells. The greater the distance from the pumping well, the less the drawdown. Areally, the drawndown water surface has the shape of a cone (cone of depression) with its apex at the pumping well. As pumping continues, the water level continues to decline, but at a diminishing rate. When pumping stops, the water level at first rises rapidly and then at a diminishing rate until it is at or near prepumping levels. The hydrograph for a well in the city of Green Bay shows the effect of cessation of pumping in 1957 when the city transferred its supply source from wells to Lake Michigan (fig. 7). Since the initial recovery, however, water levels are again declining from pumping by other users.

In artesian aquifers, the cone of depression is larger than the cone created by a well pumping at an equal rate from a water-table aquifer. An example of the cone of depression created by pumping an artesian aquifer can be seen in figure 8. The contour map is based on water-level altitudes of several tens of wells, some pumping, some nonpumping. Here, pumping from numerous wells, each having a cone of depression covering several miles, creates an area of coalescing cones covering hundreds of square miles in southeast Wisconsin.

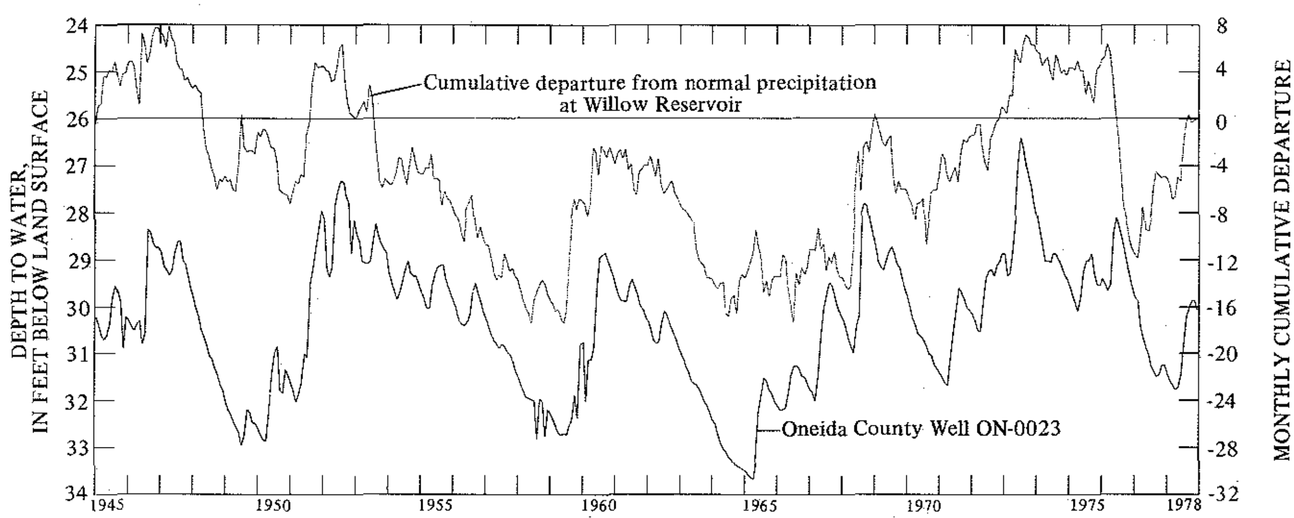


Figure 5. Water-table fluctuations compared to precipitation trends.

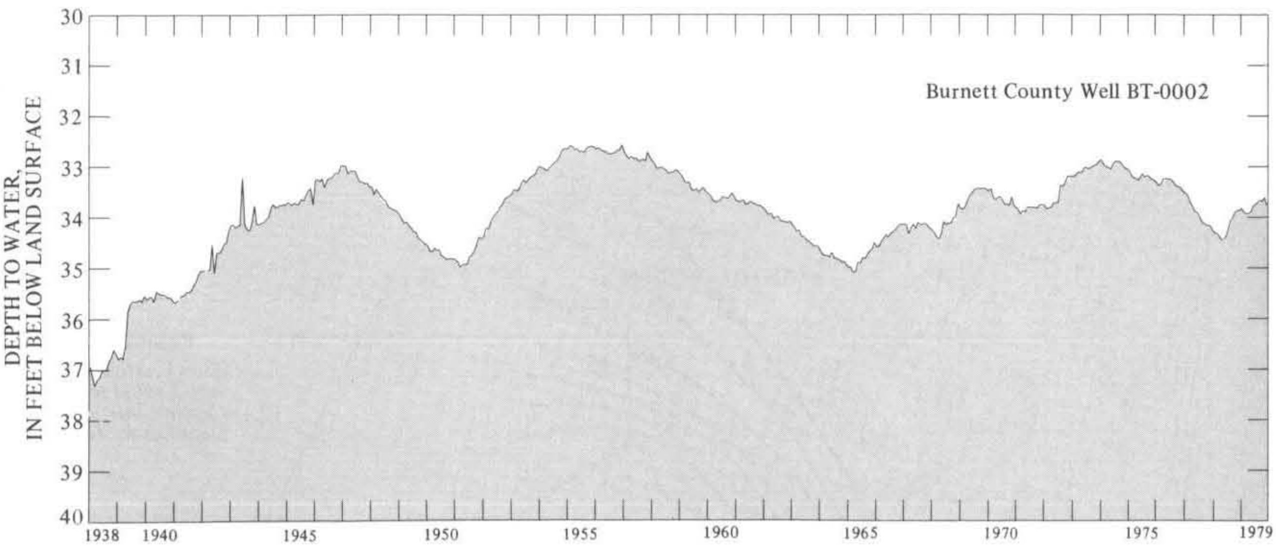


Figure 6. Long-term fluctuations in the water table.

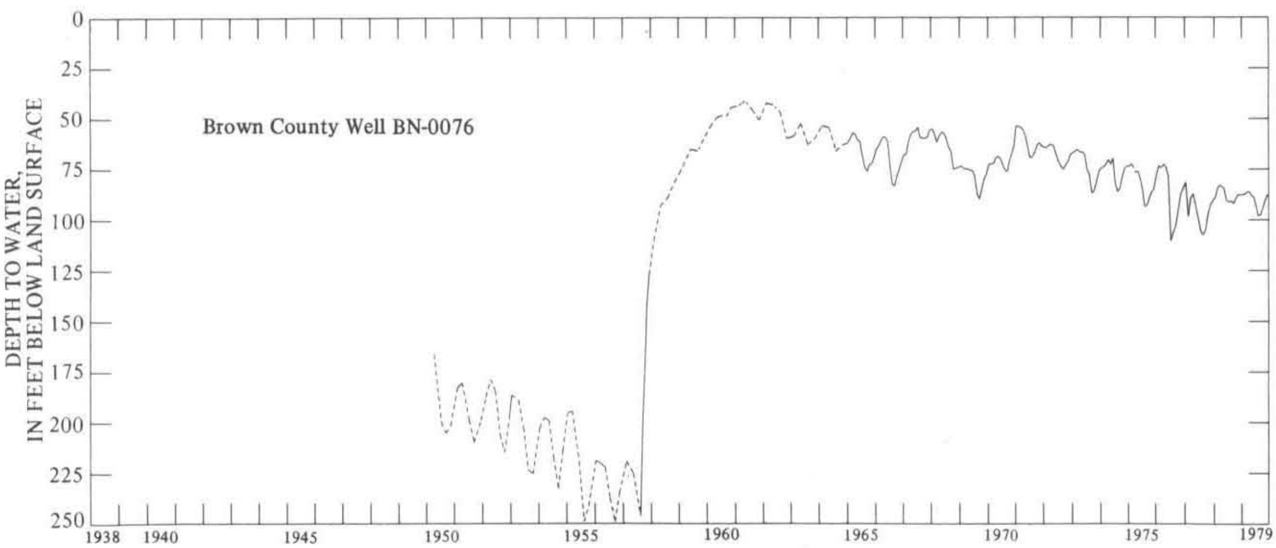
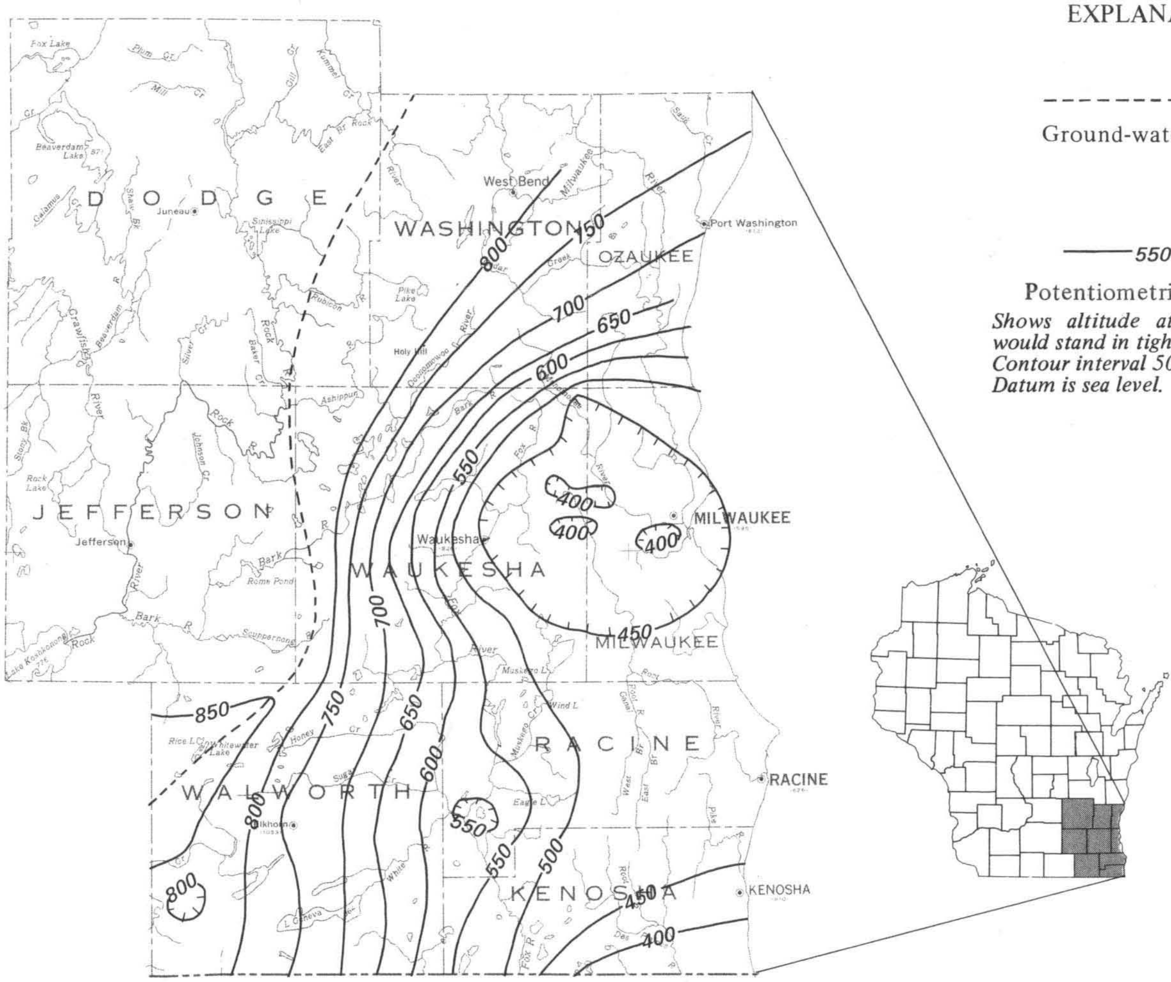


Figure 7. Ground-water level recovery in the City of Green Bay.



EXPLANATION

Ground-water divide

550

Potentiometric contour

Shows altitude at which water would stand in tightly-cased wells. Contour interval 50 feet. Datum is sea level.

Potentiometric surface by
H.L. Young, written communication, 1981.

SCALE 1:1 000 000

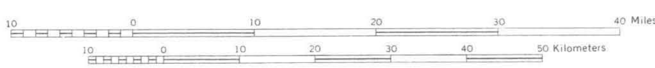


Figure 8. Potentiometric surface of the sandstone aquifer in southeastern Wisconsin, fall 1980.

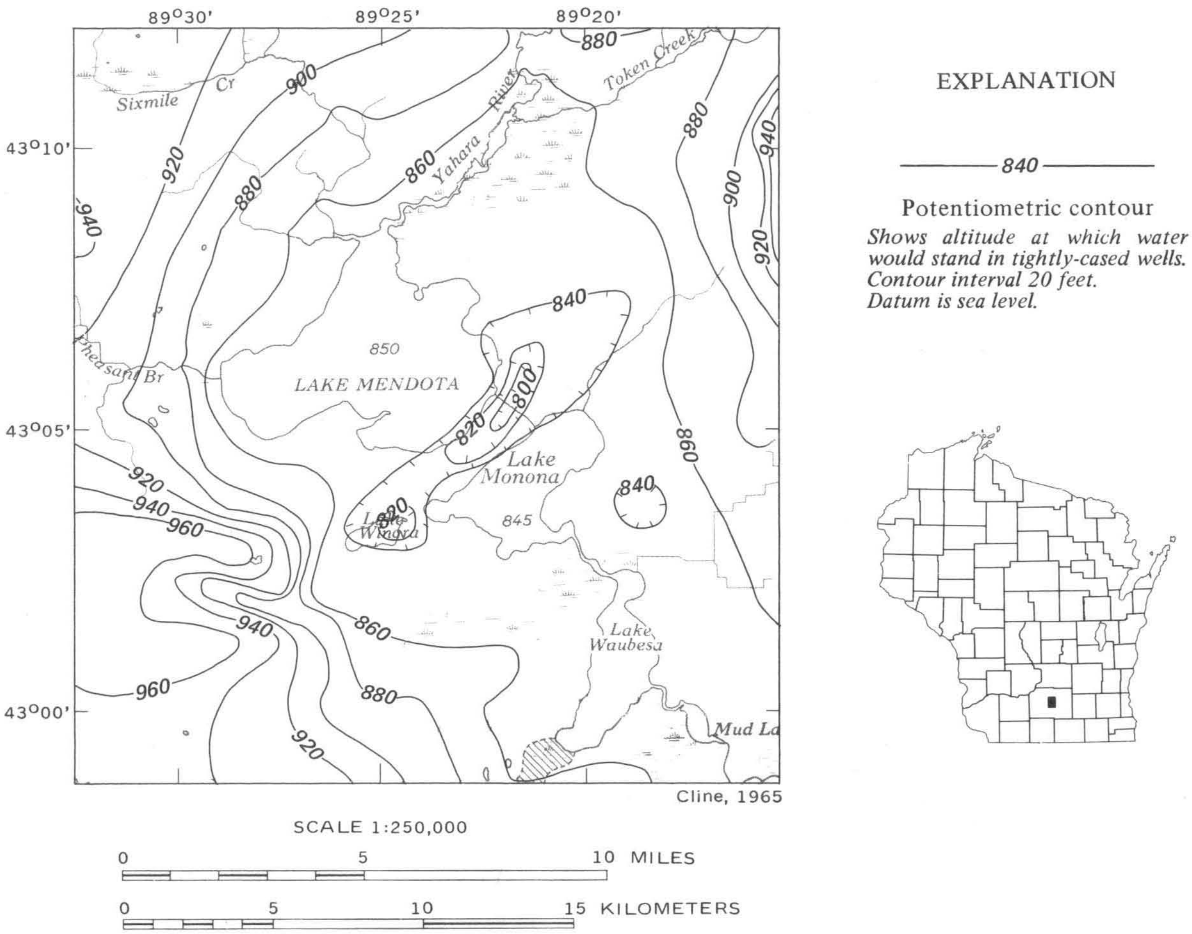


Figure 9. Potentiometric surface of the sandstone aquifer near Madison, Wisconsin, fall 1980.

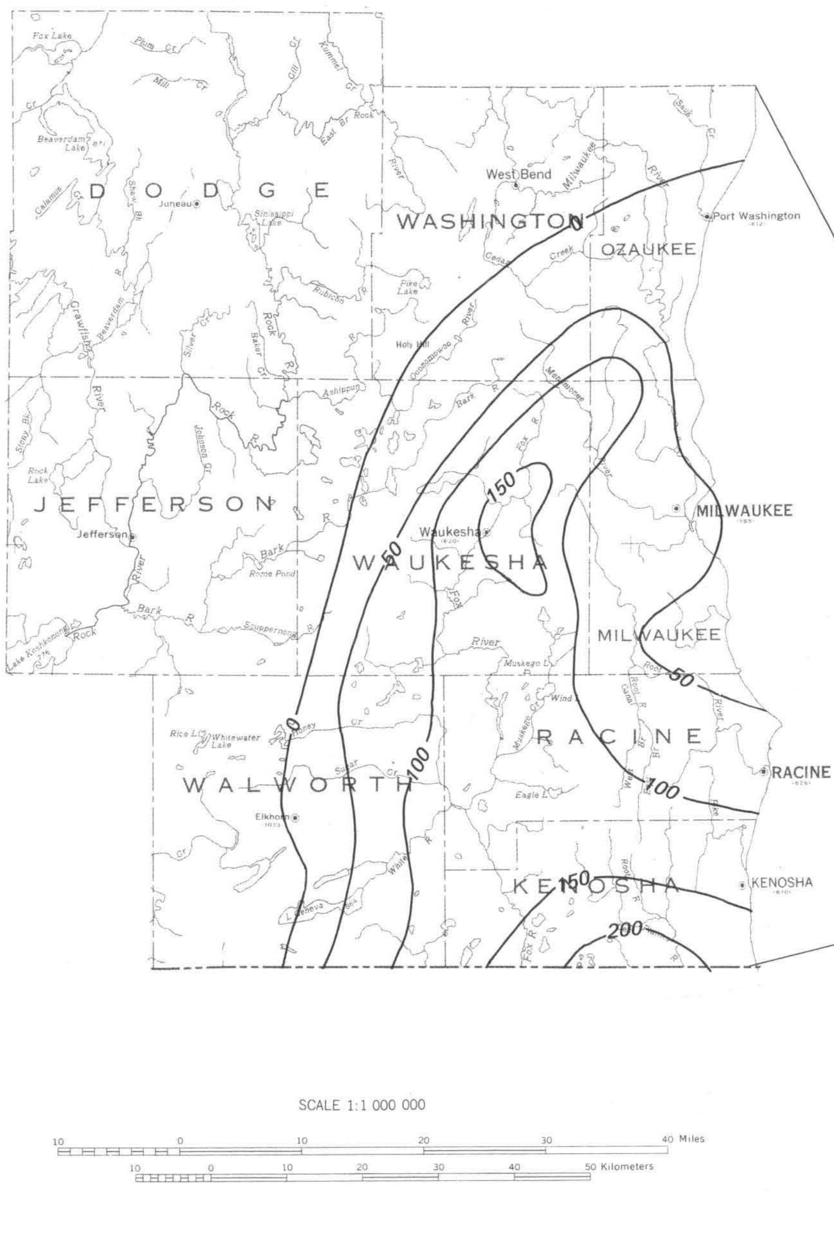
By contrast, the cones of depression in the Madison area are shallow and relatively small depressions in the water table (fig. 9).

In areas of long-term concentrated pumping, the drawdown effects can be illustrated by water-level-change maps. Figure 10 was constructed from figure 8 and a map of the potentiometric surface in 1961 and shows how much the potentiometric surface declined during this 19-year period.

WATER-LEVEL HYDROGRAPHS

The following hydrographs of 210 wells represent the entire period of record of each well through December 1981. They are arranged alphabetically by county and consecutively by serial number within each county. The horizontal scale is the same for all wells (20 years per frame), but the vertical scale differs, depending on the range of fluctuations. Minus values represent water levels above land surface. When a flowing well is reported without a measured head, in feet above land surface, it is arbitrarily plotted as 1 ft above land surface. All hydrographs are plots of the lowest monthly measured water level, regardless of the measuring frequency. The current measuring frequency is listed. Dashed portions of the hydrograph represent periods of incomplete record.

Five regional maps show the location and county serial number of each well (figs. 11-15).



EXPLANATION

——— 50 ———

Line of equal head decline

Shows decline in head of water level in the sandstone aquifer between 1961 and 1980. Contour interval 50 feet.

Figure 10. Decline in the potentiometric surface of the sandstone aquifer in southeastern Wisconsin between 1961 and 1980.

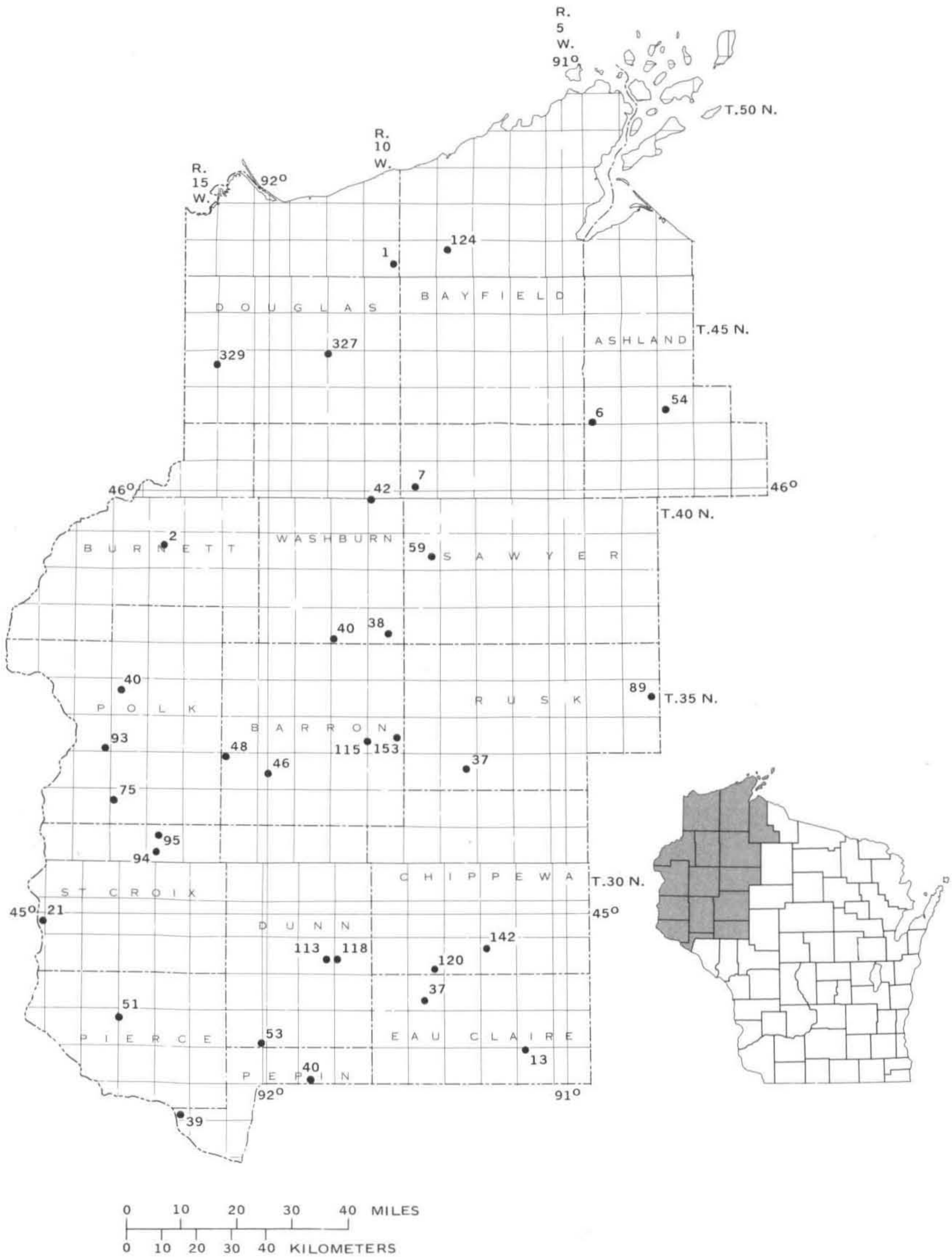


Figure 11. Location of observation wells in northwestern Wisconsin.

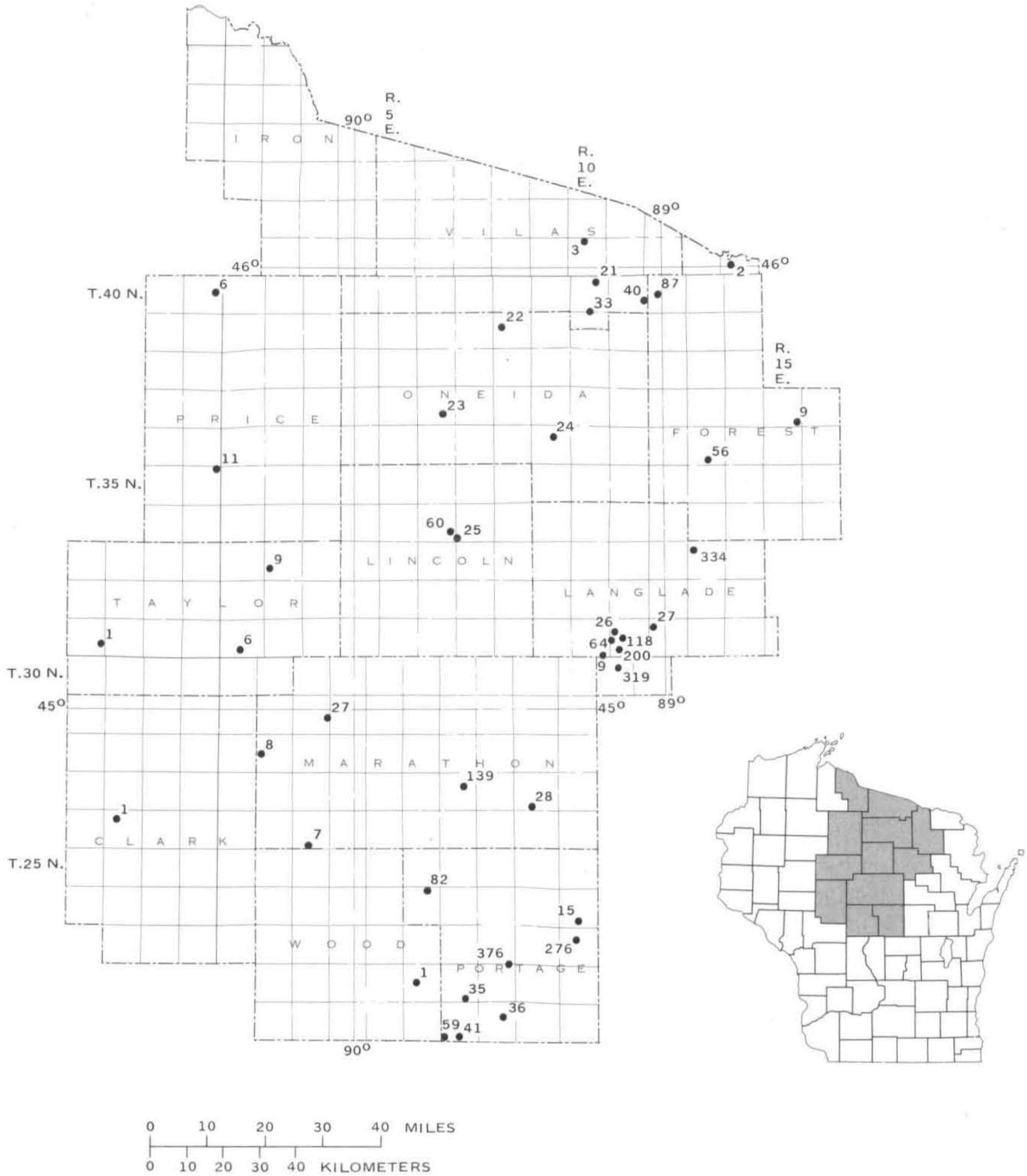


Figure 12. Location of observation wells in northcentral Wisconsin.

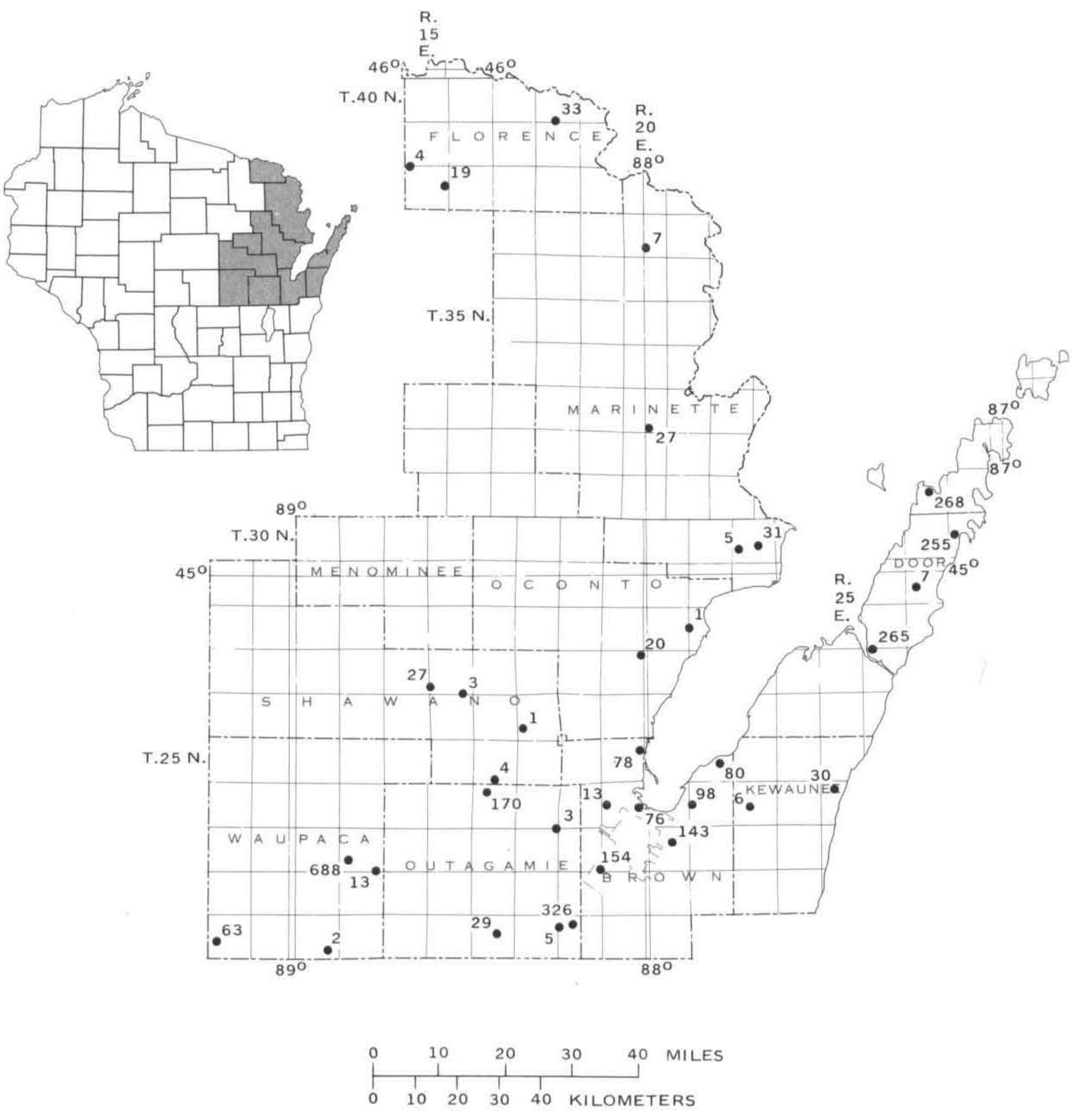


Figure 13. Location of observation wells in northeastern Wisconsin.

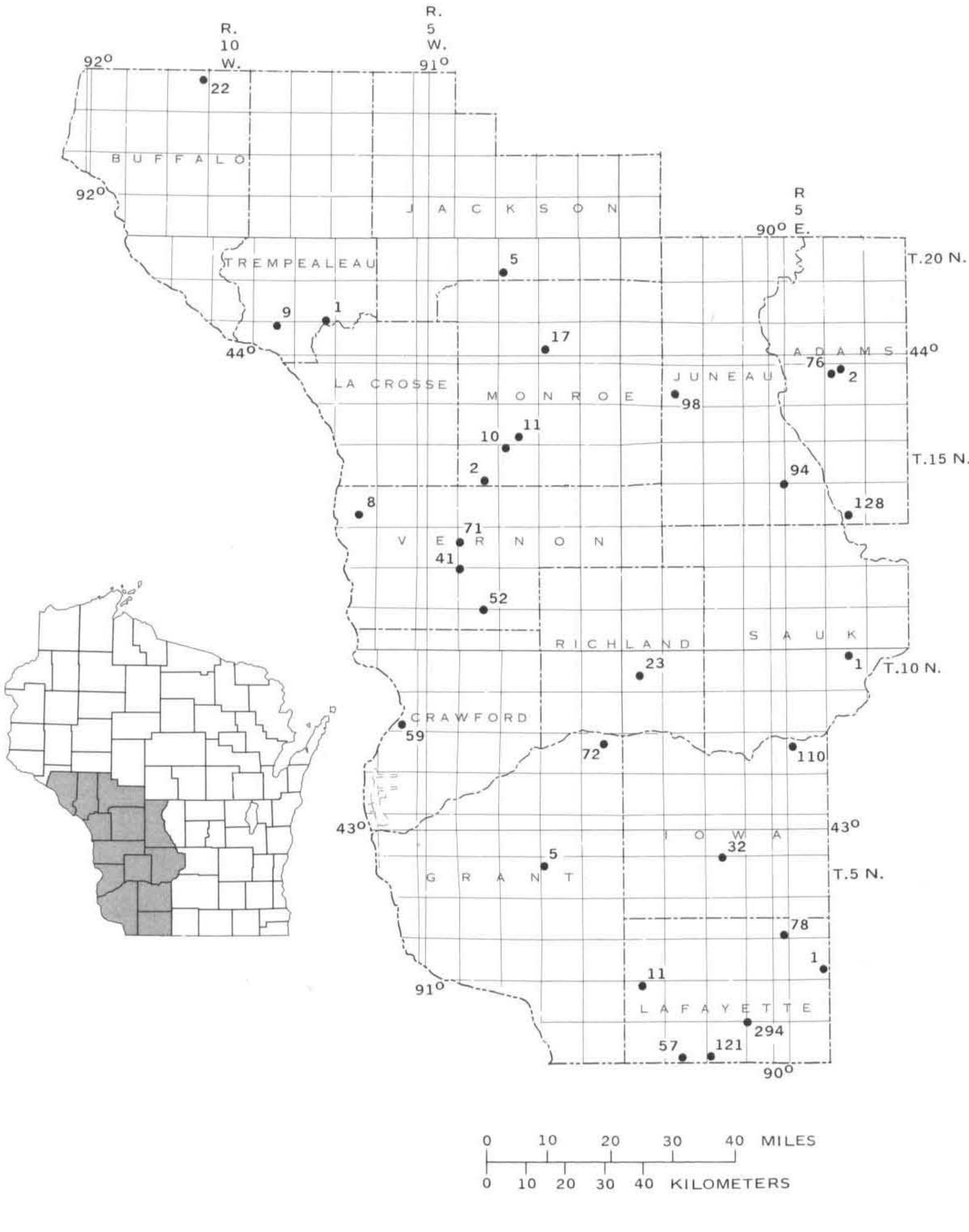


Figure 14. Location of observation wells in southwestern Wisconsin.

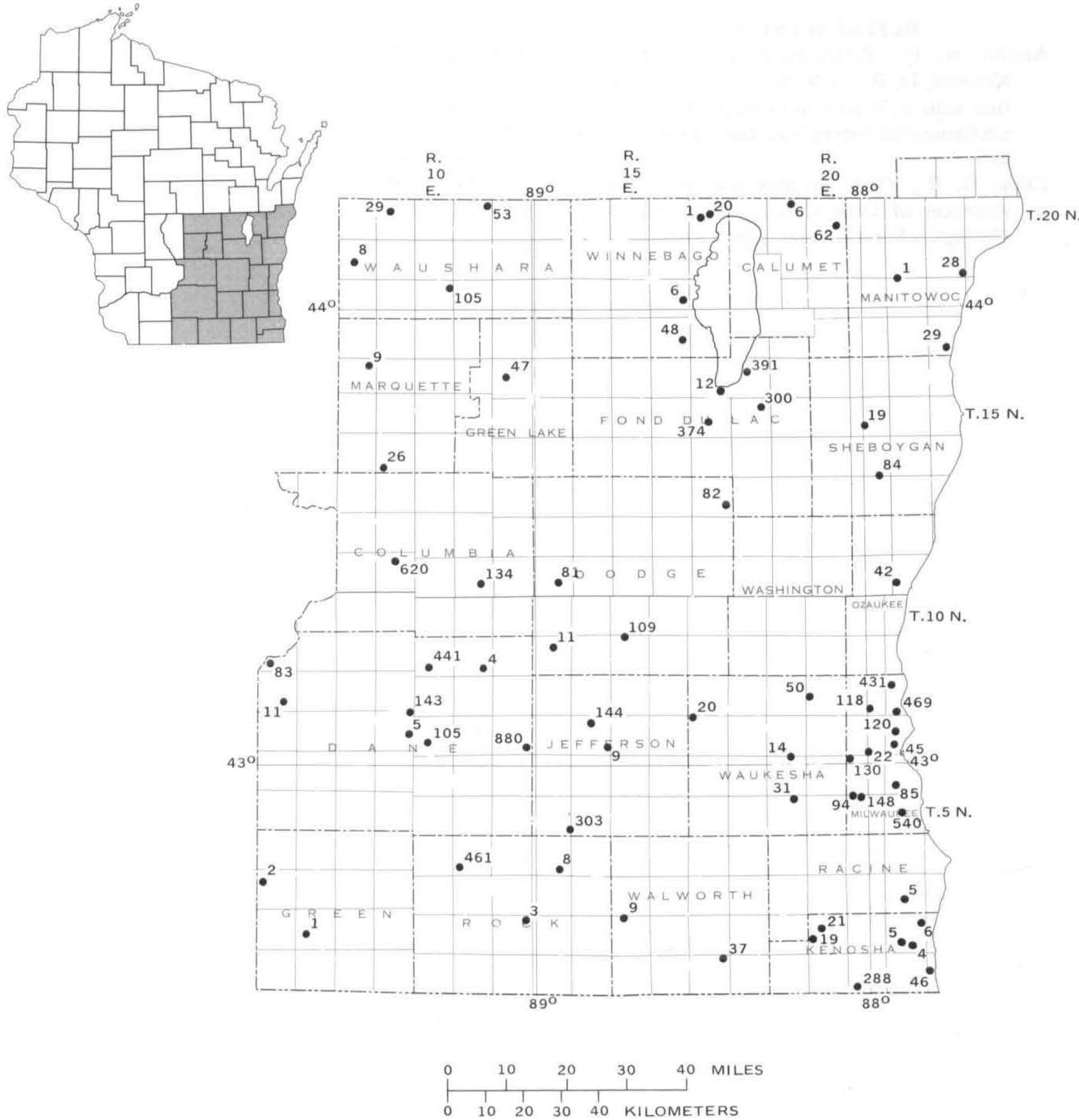


Figure 15. Location of observation wells in southeastern Wisconsin.

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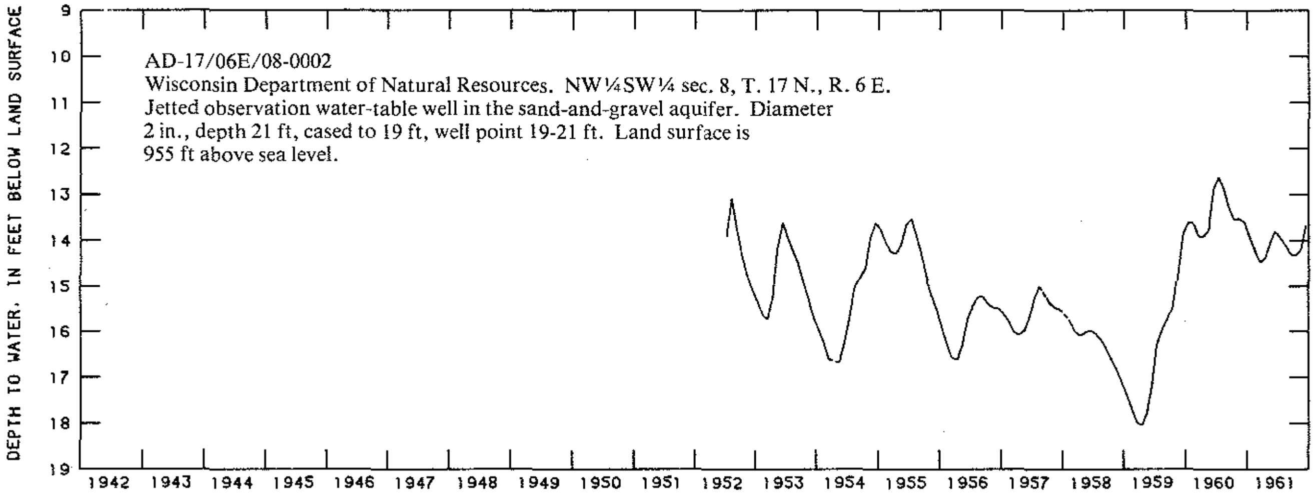

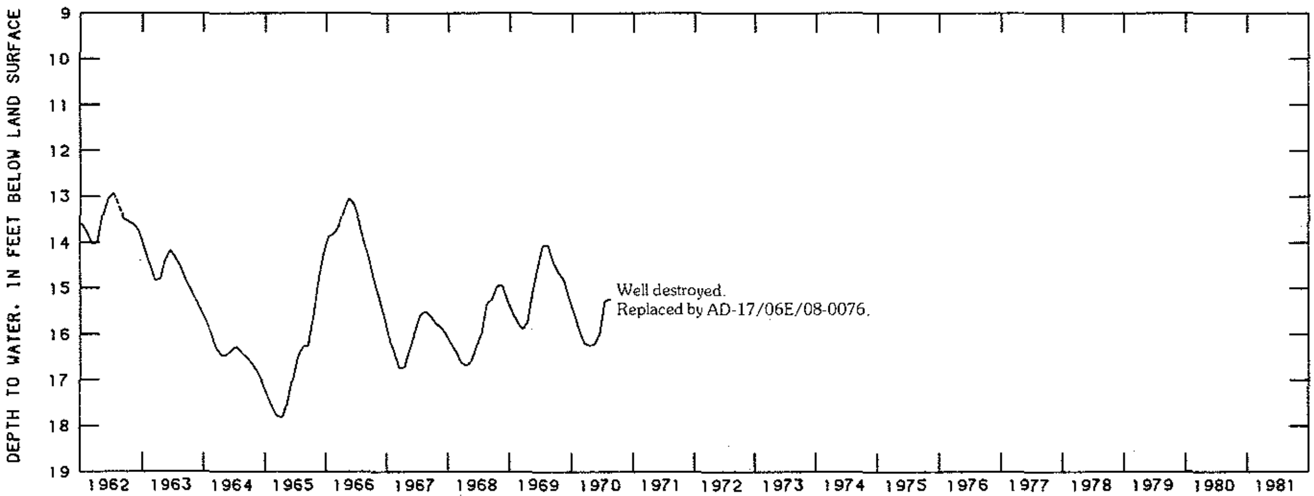

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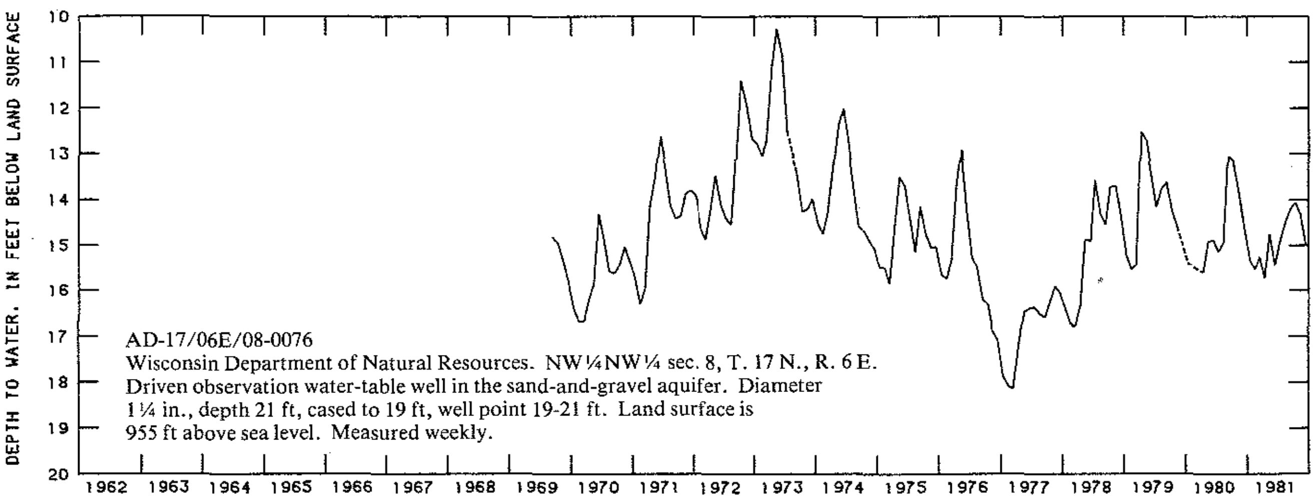

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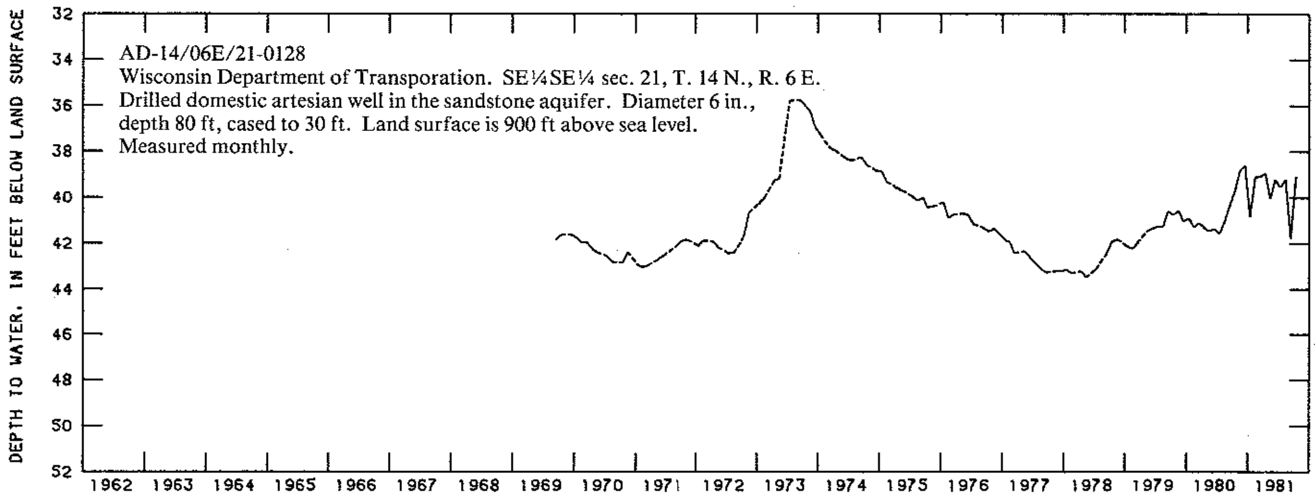

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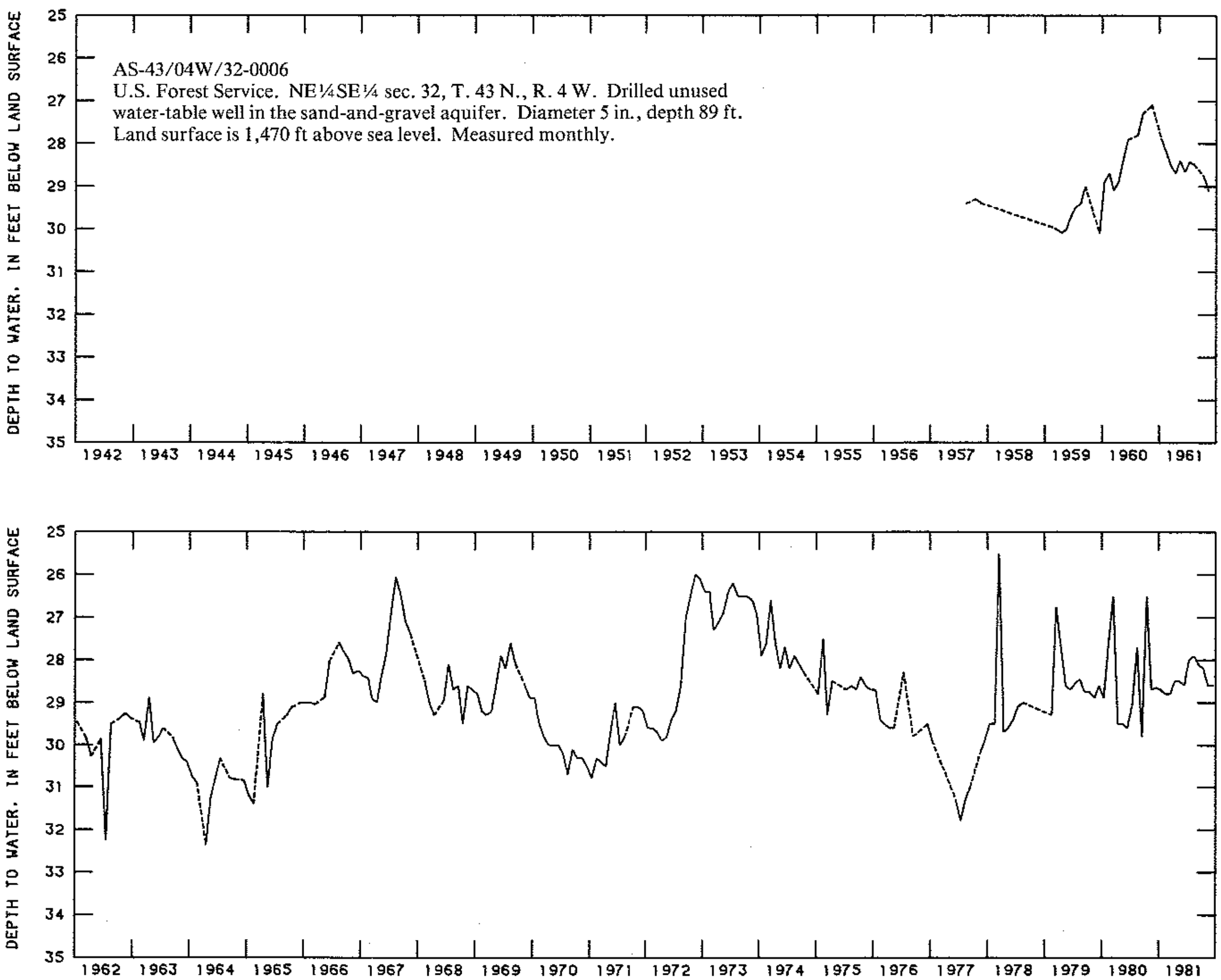

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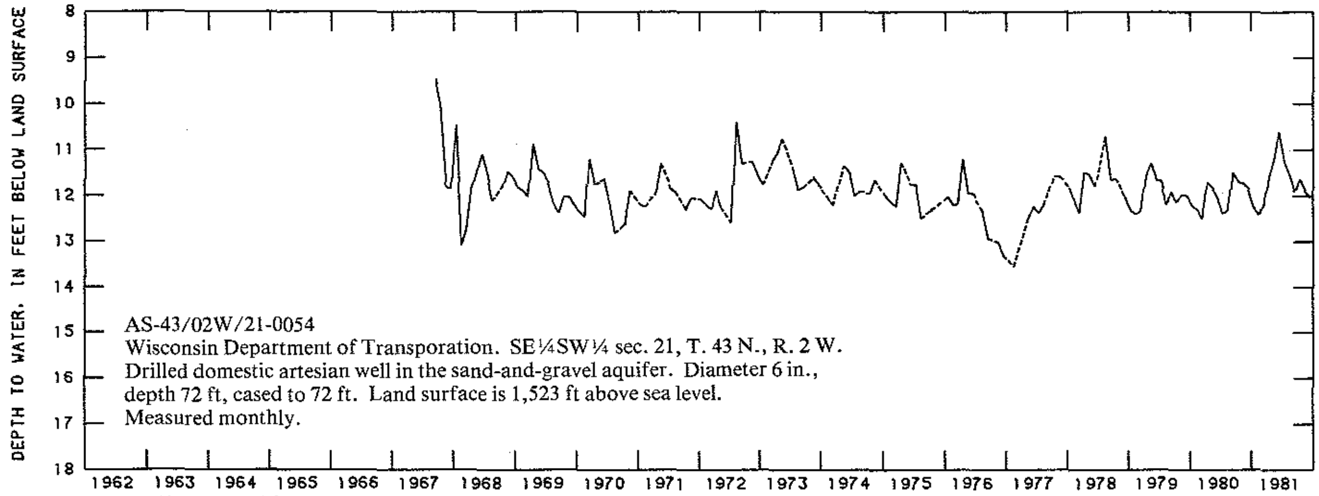

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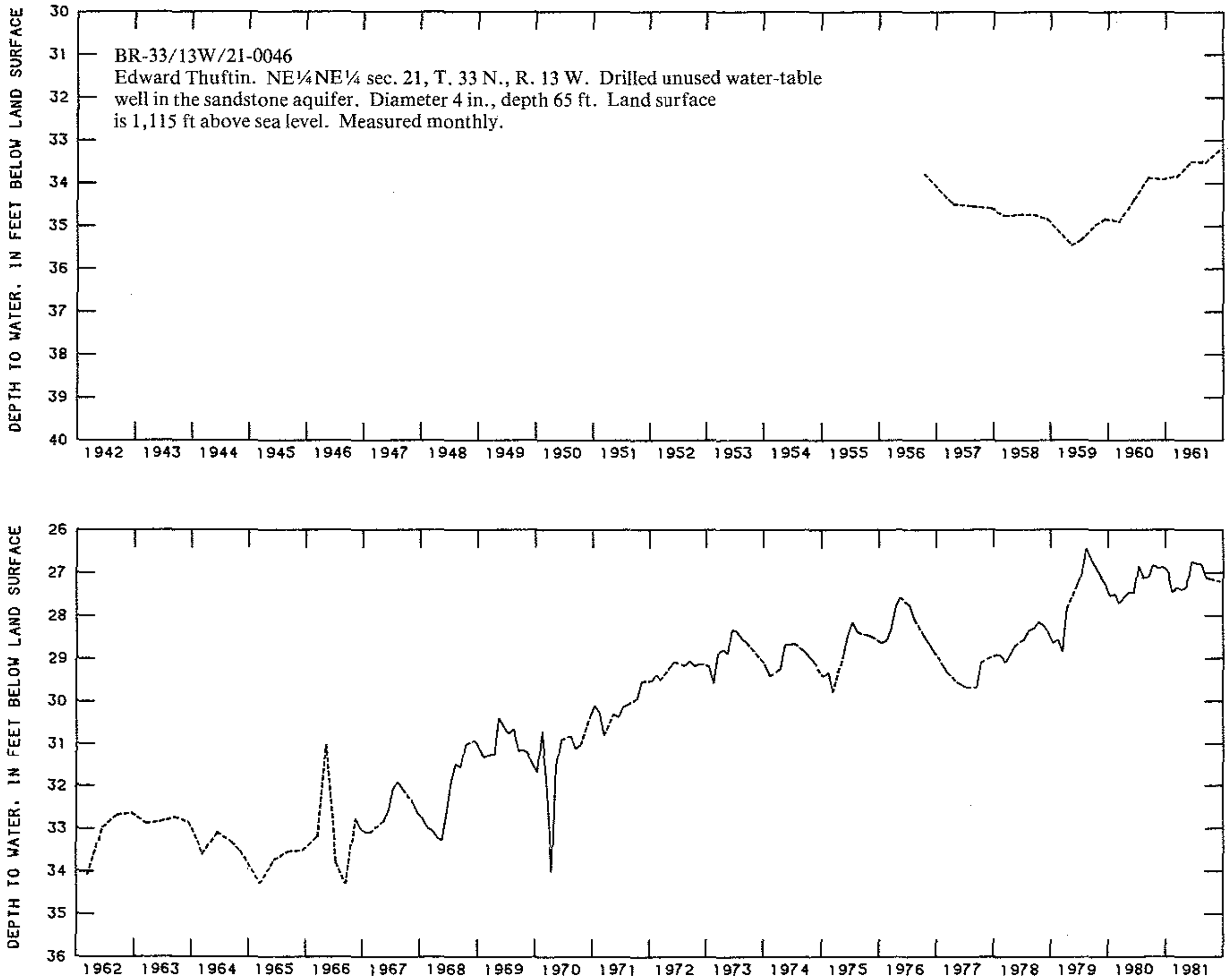

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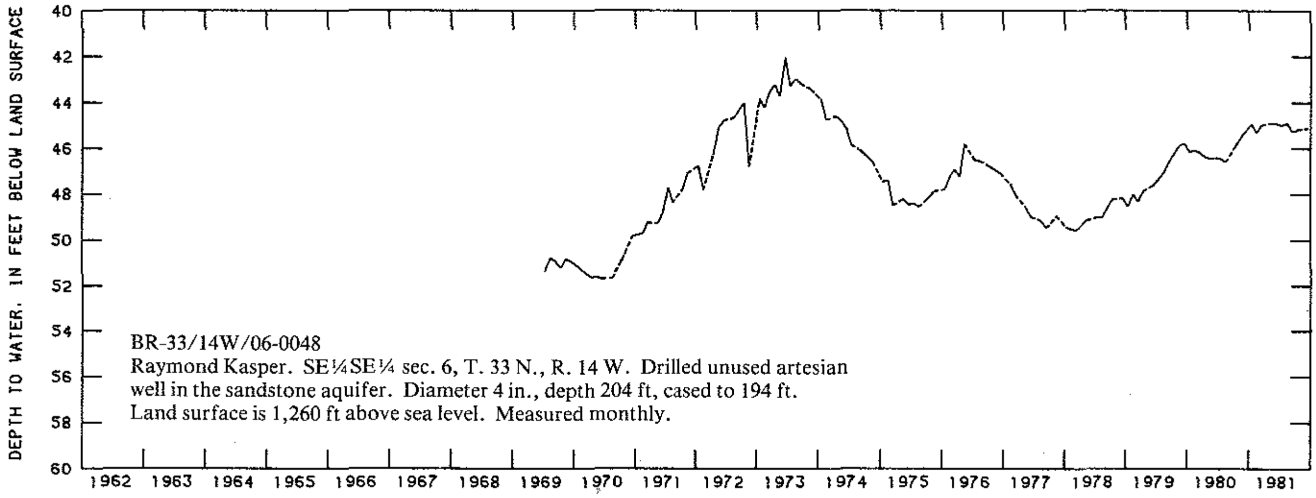

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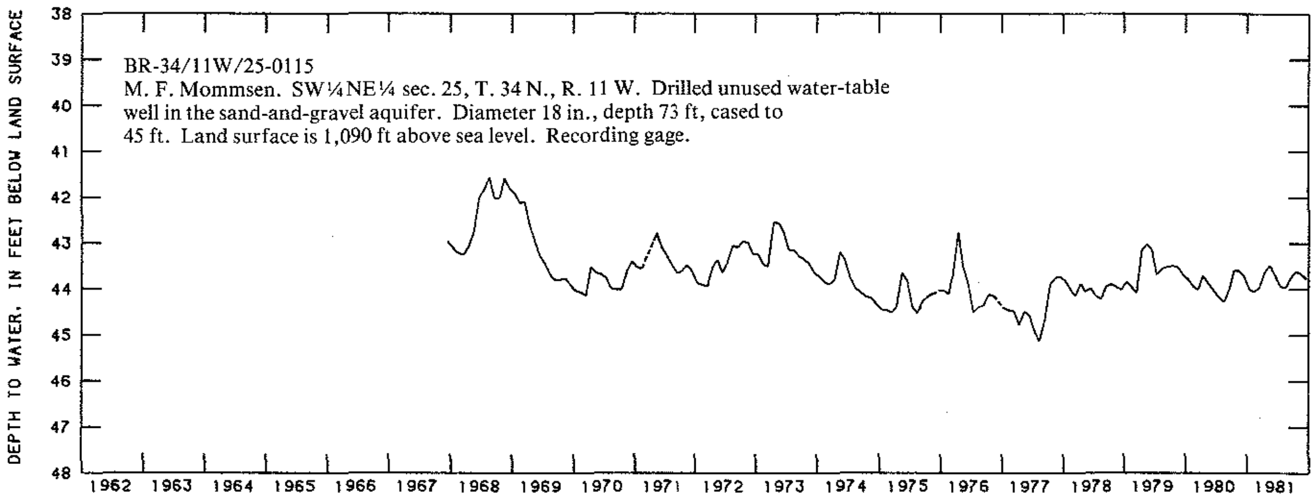

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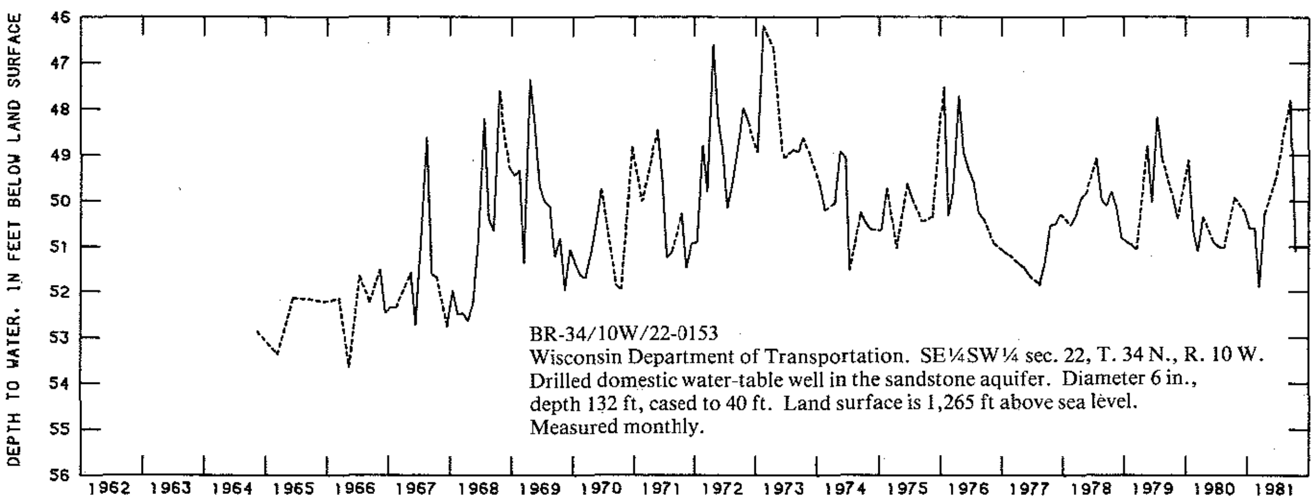

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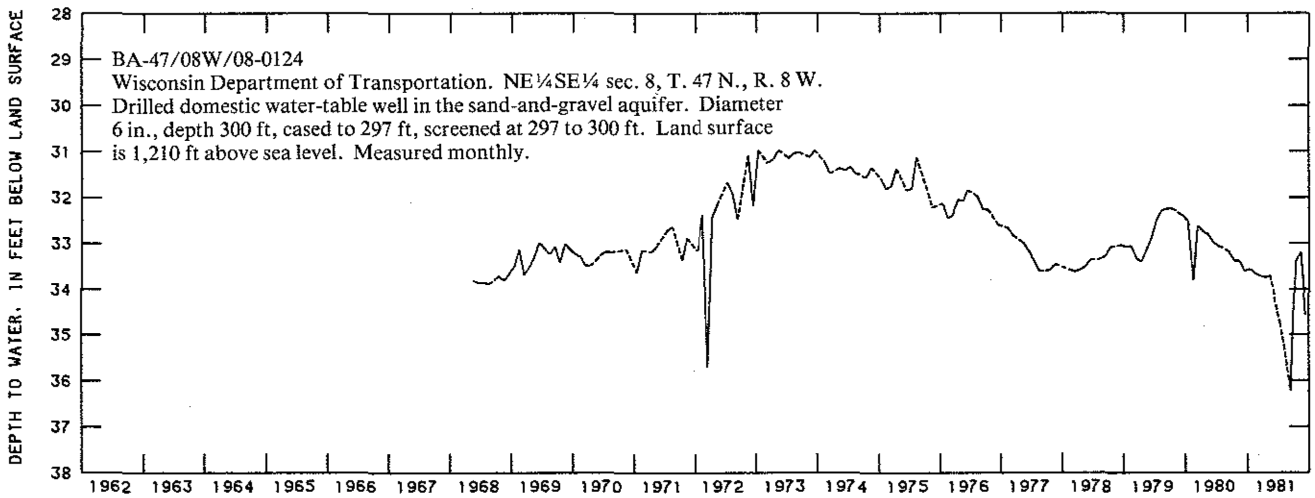

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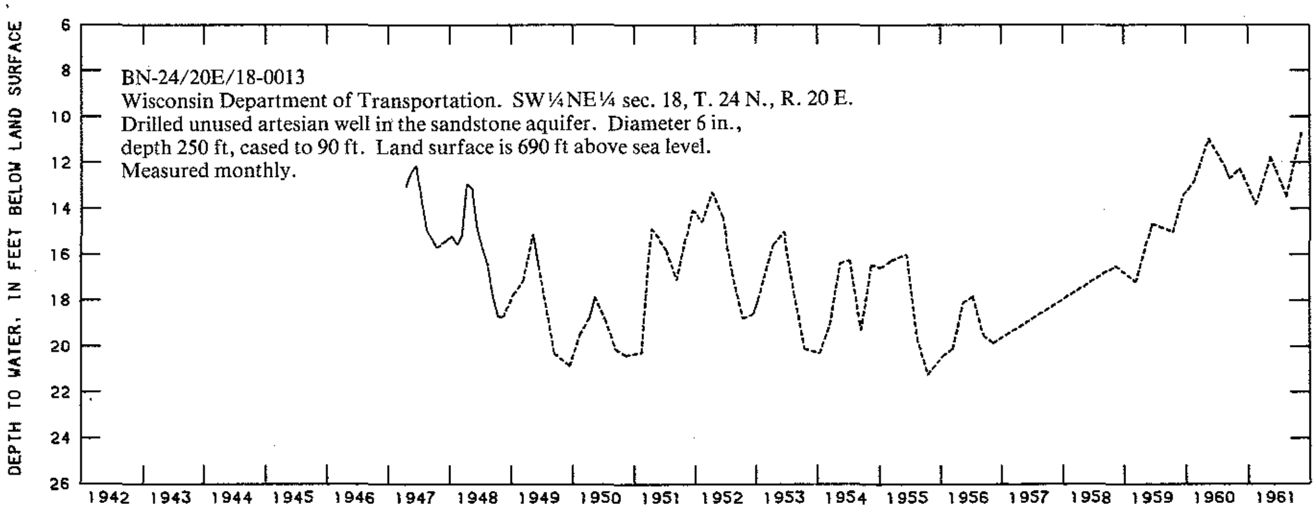

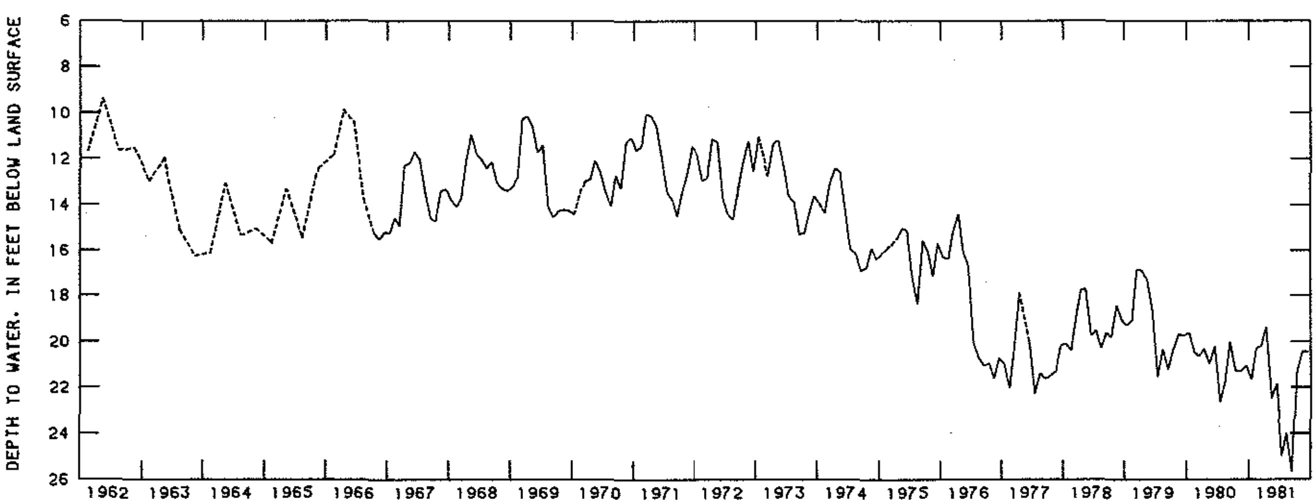

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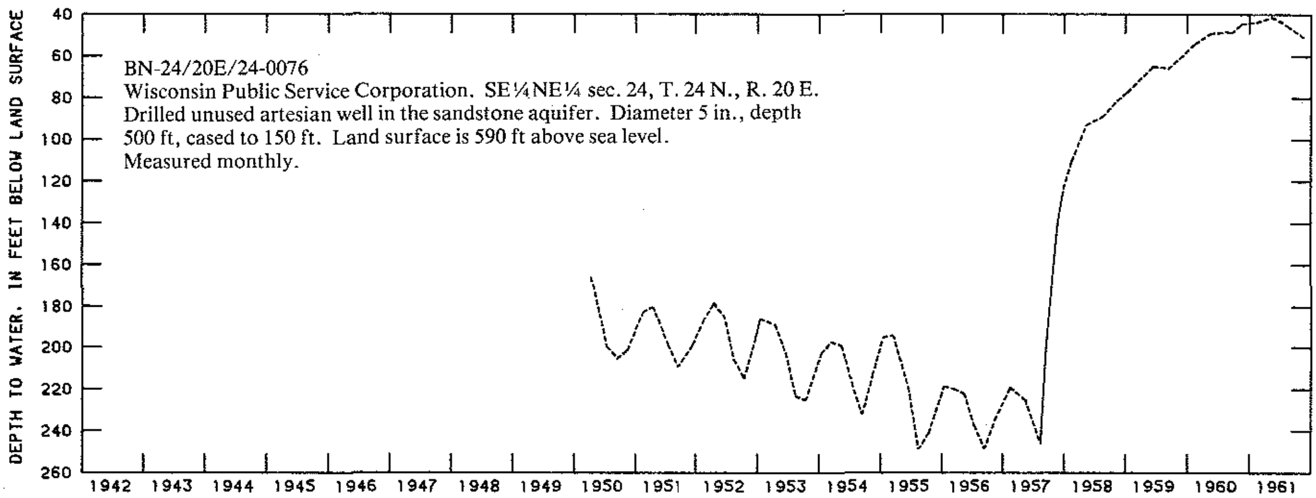

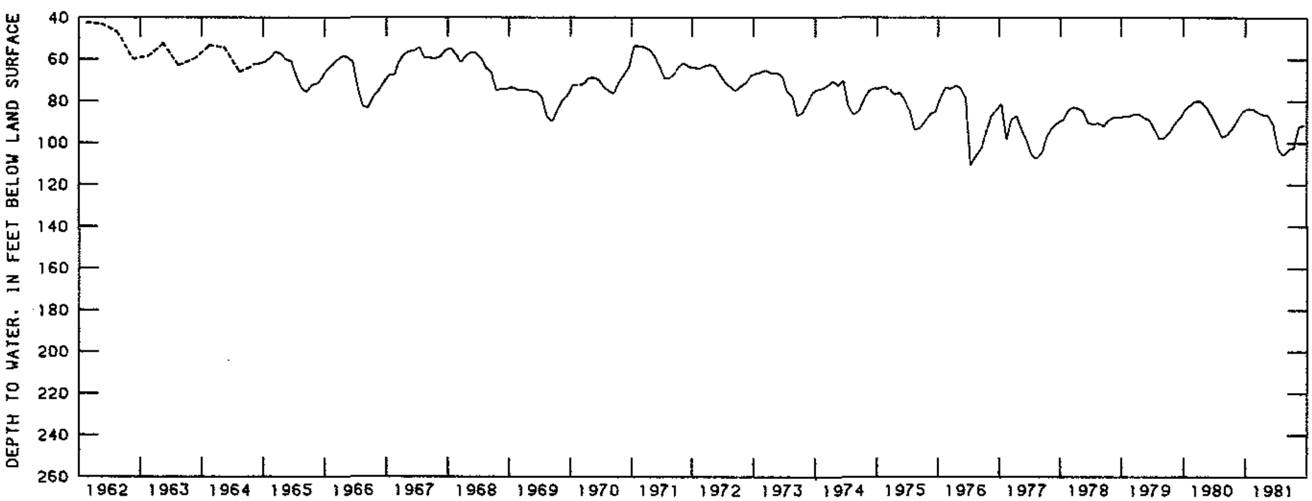

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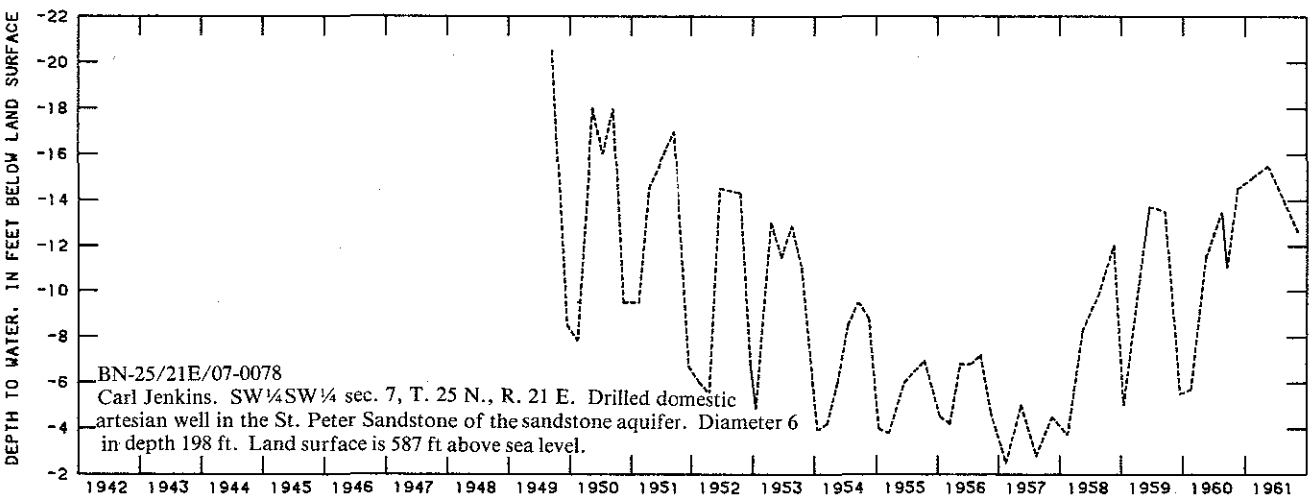

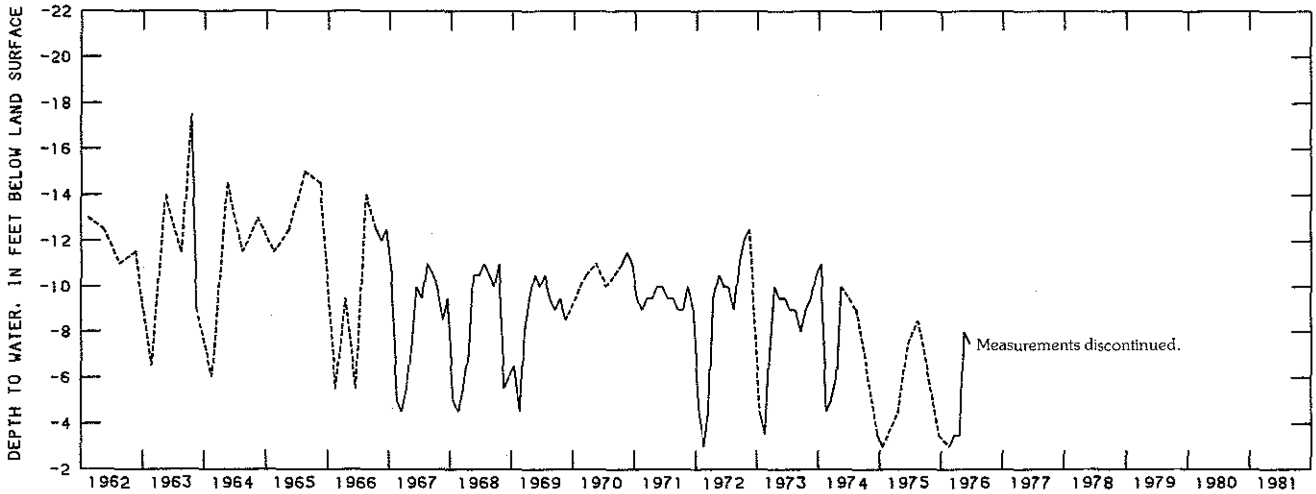

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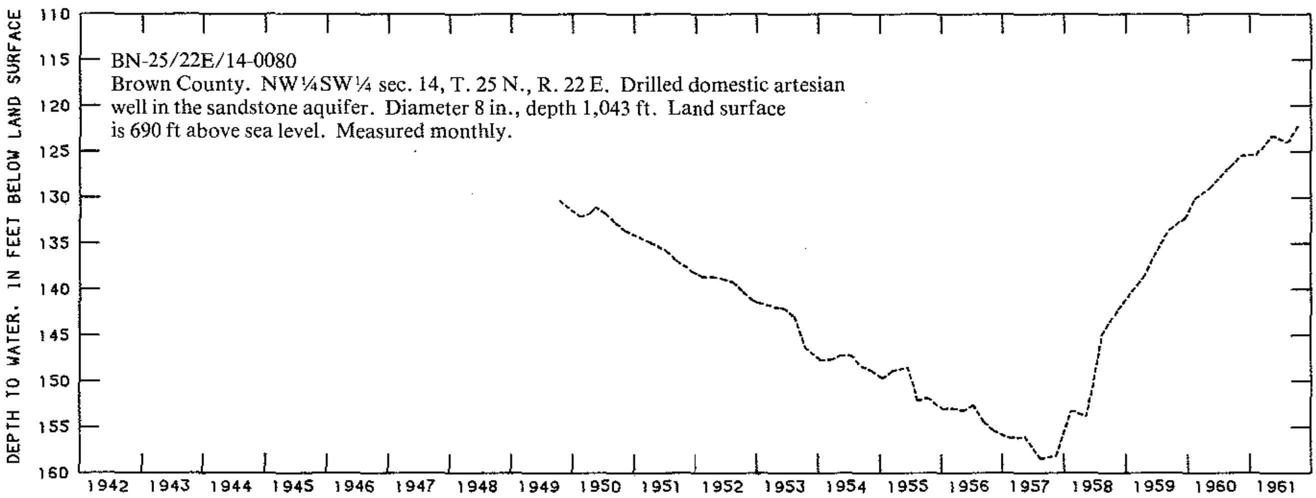

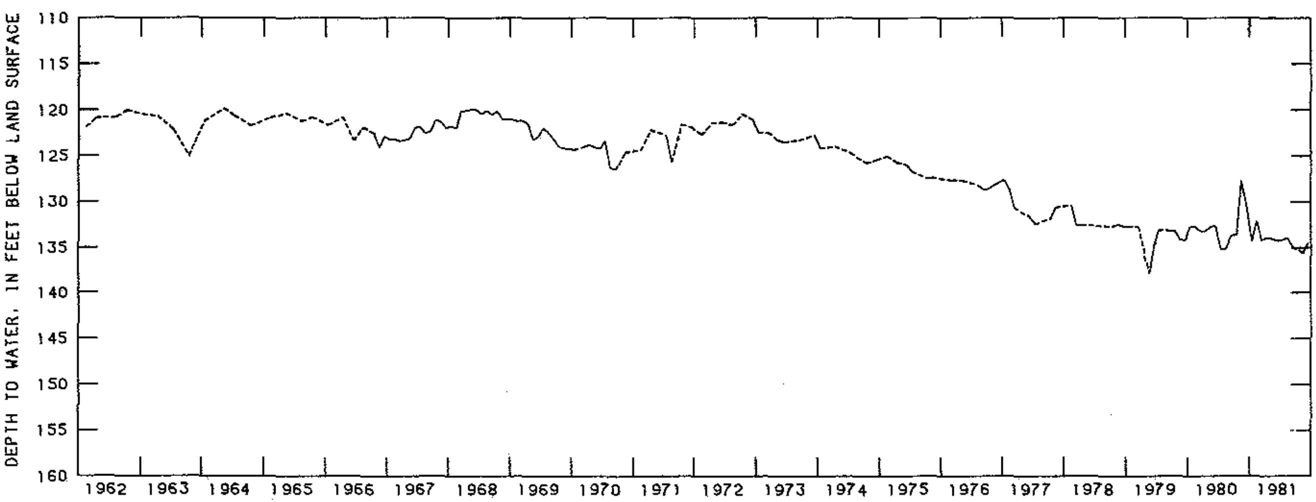

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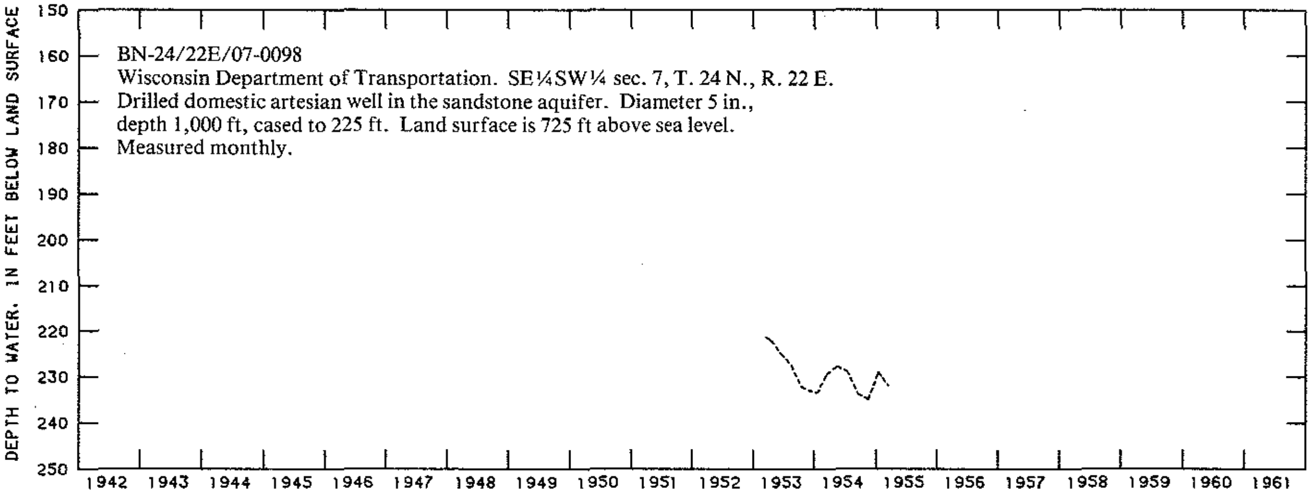

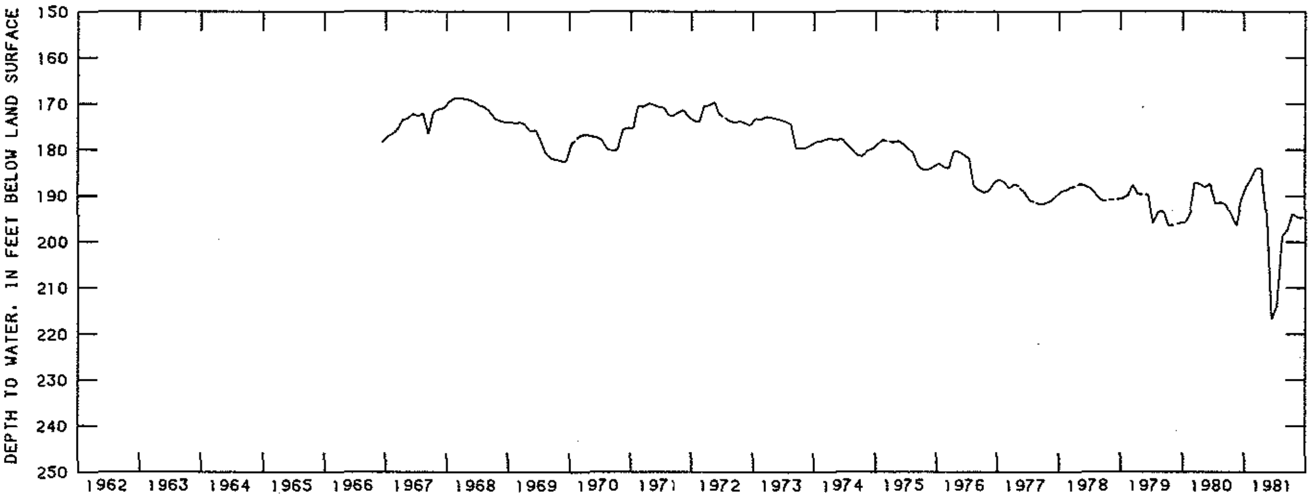

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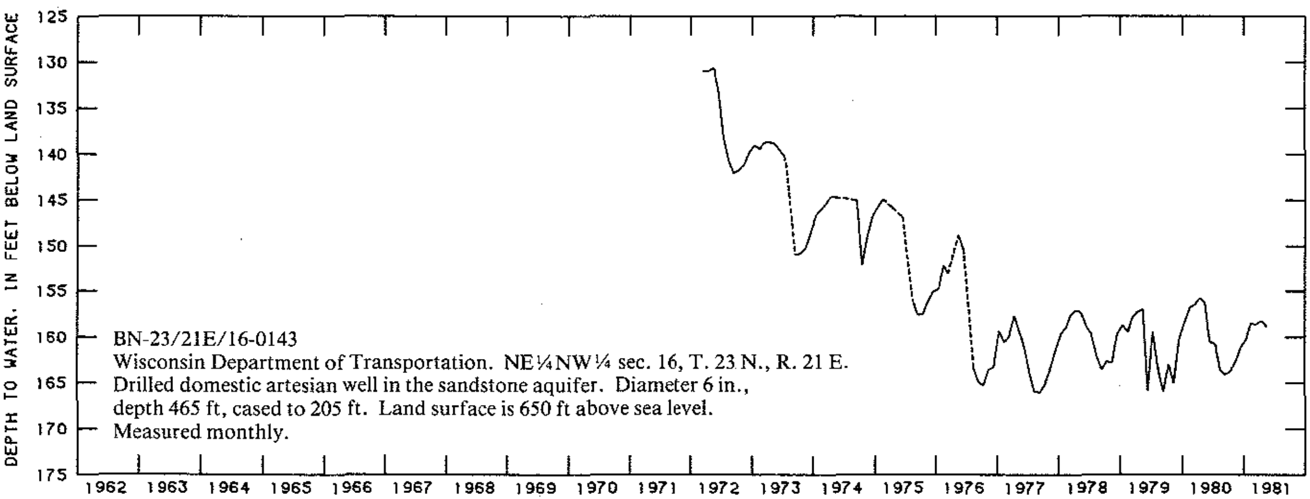

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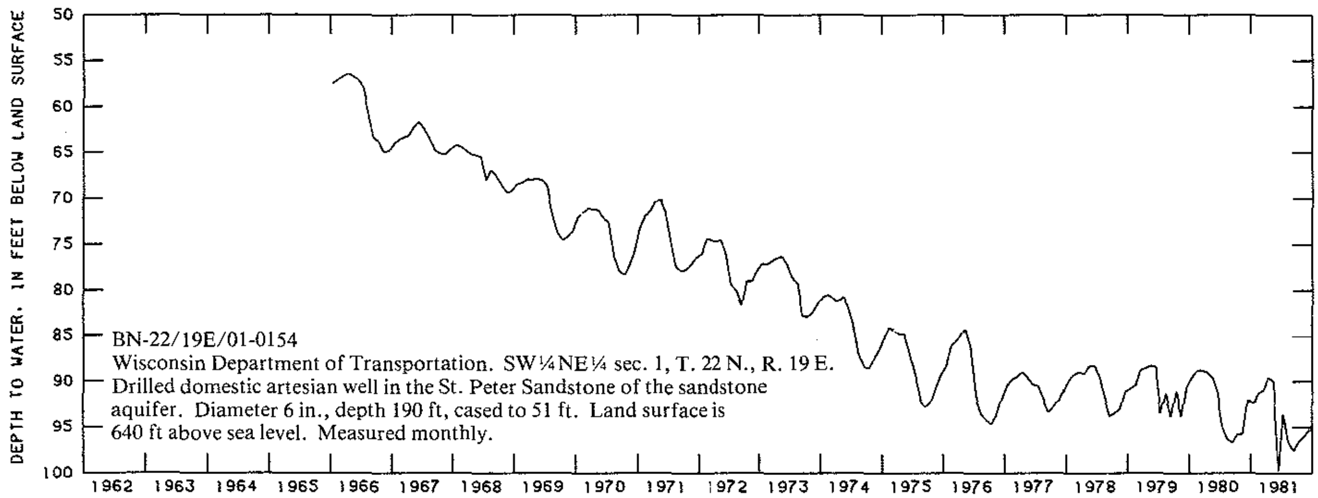

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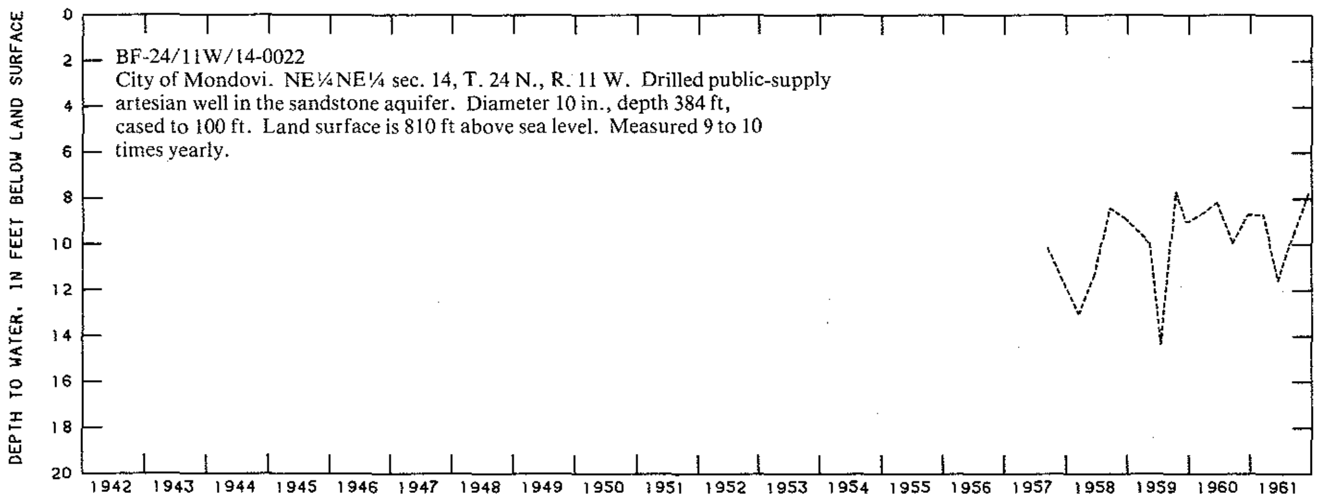

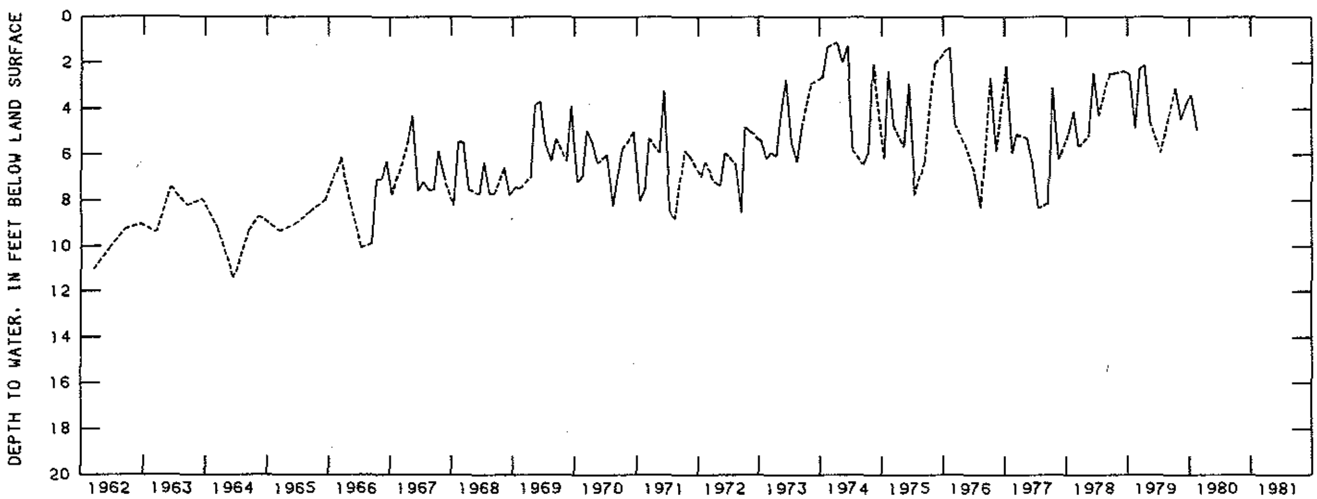

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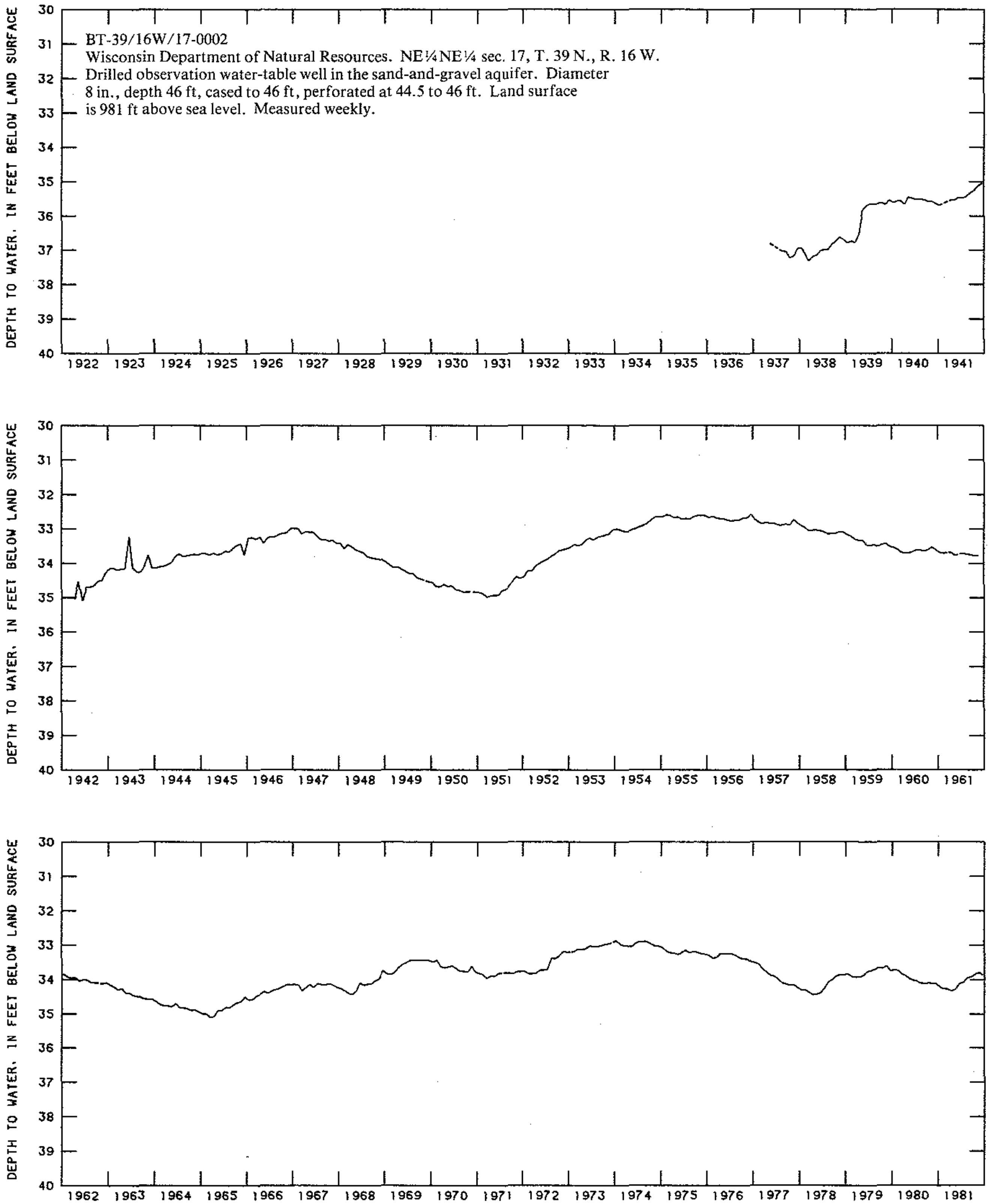

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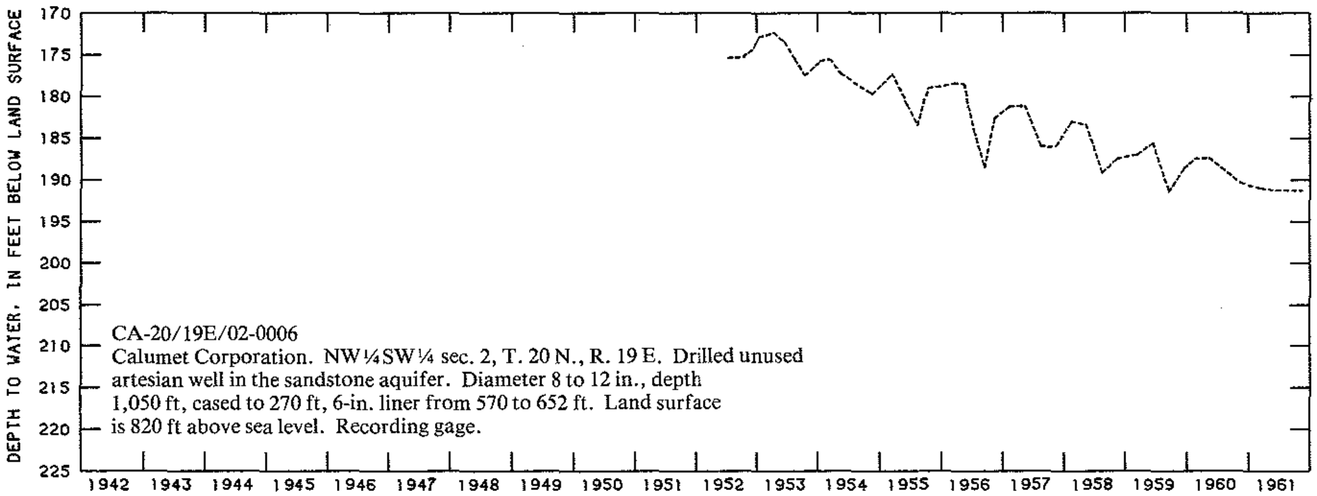

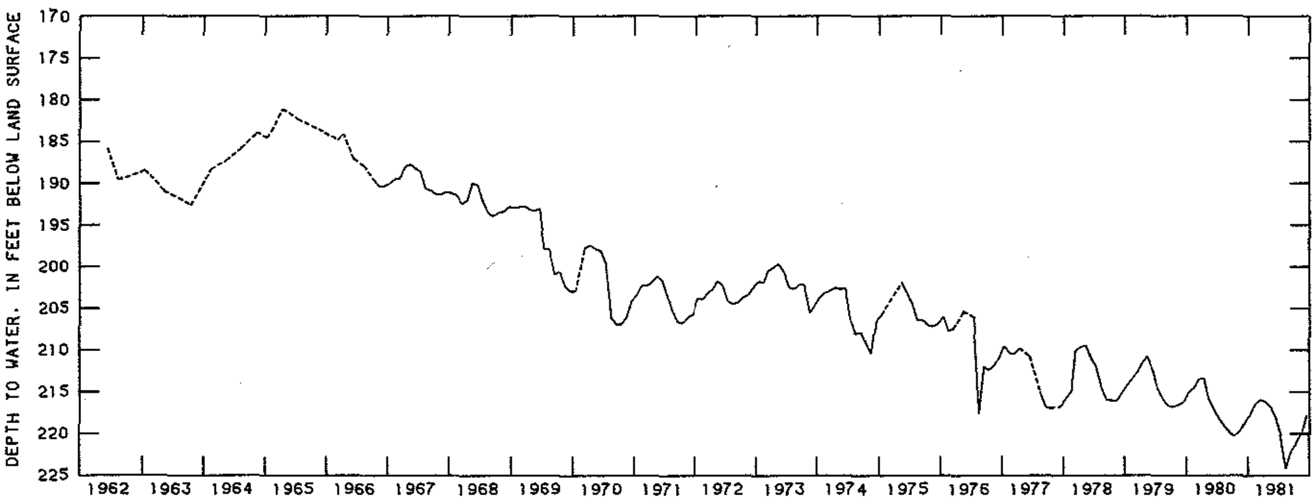

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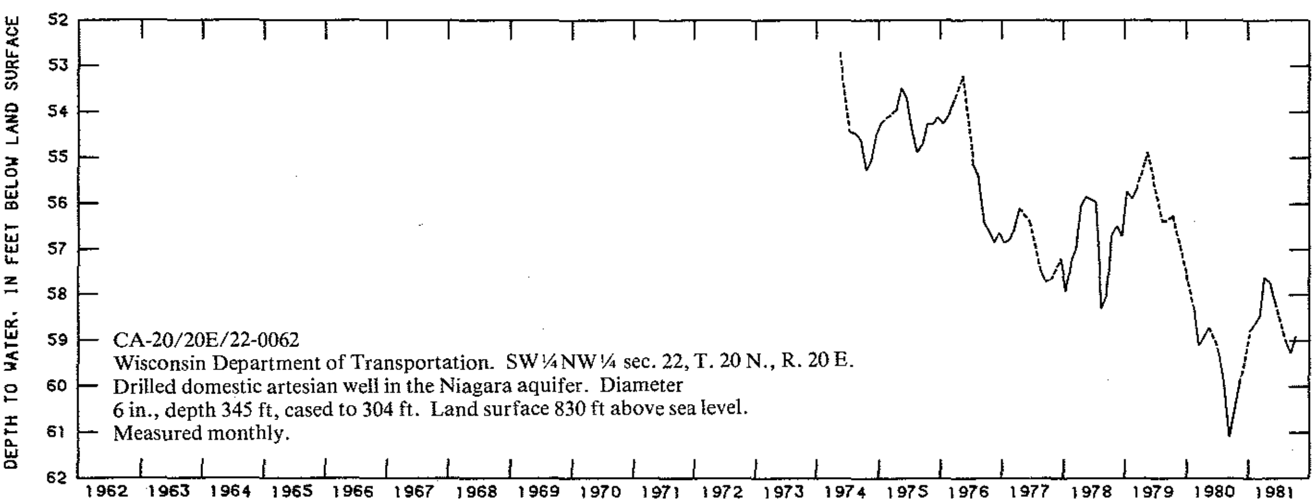

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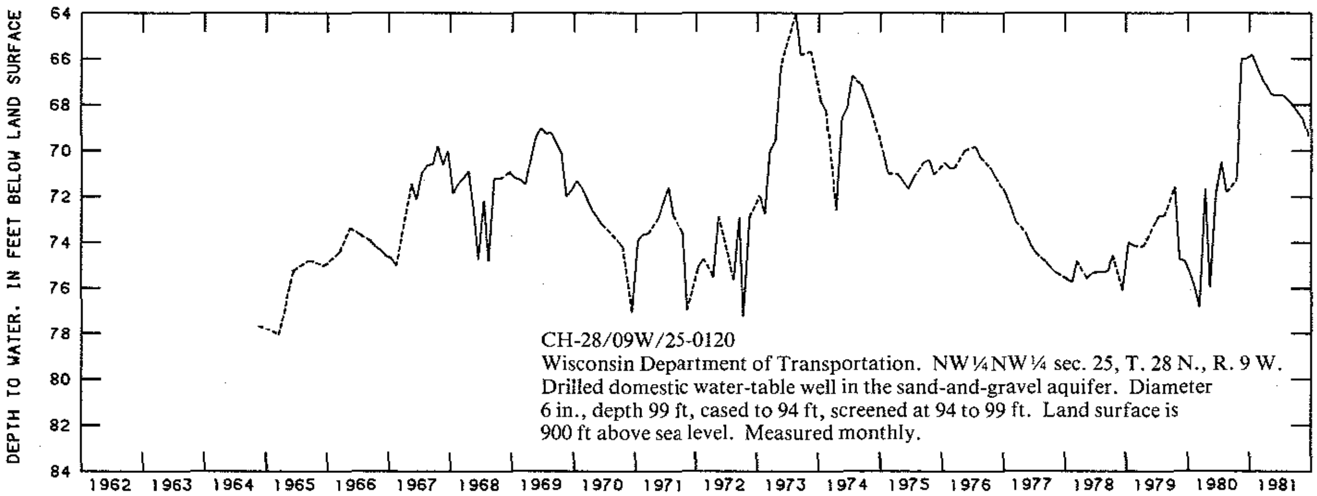

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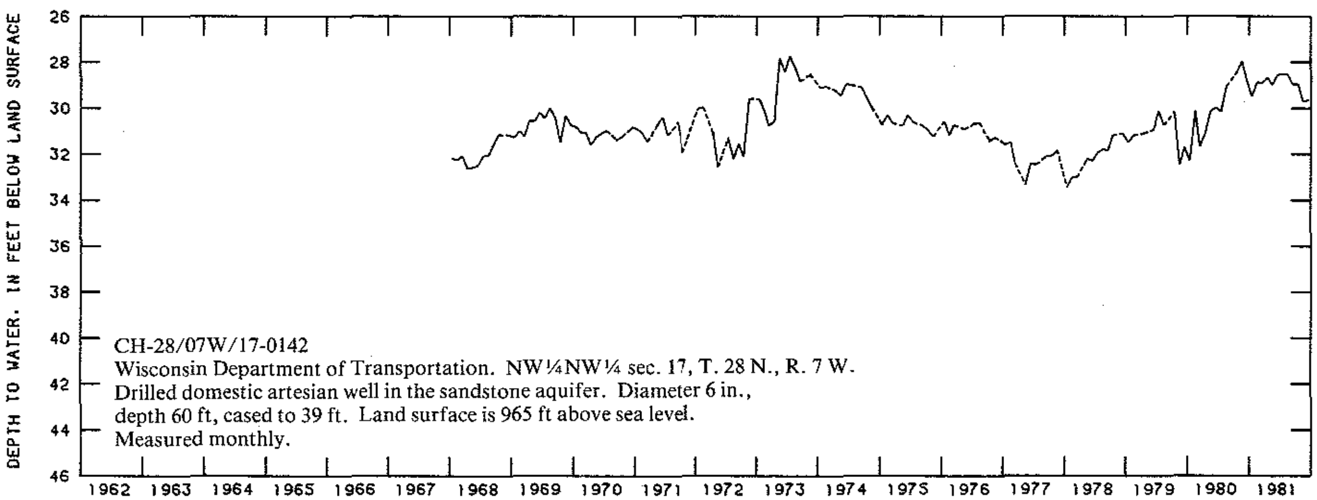

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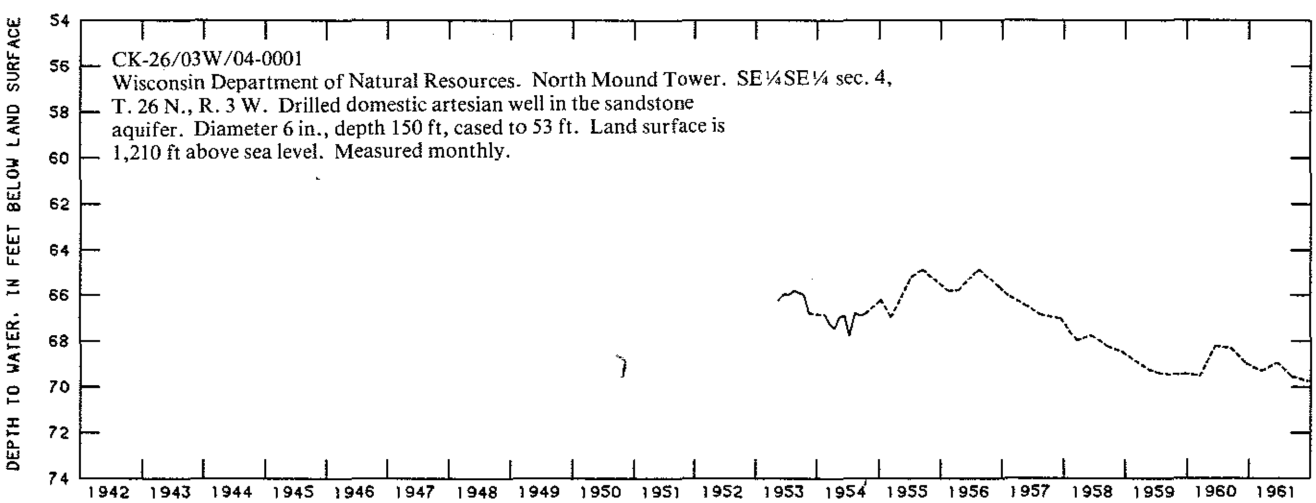

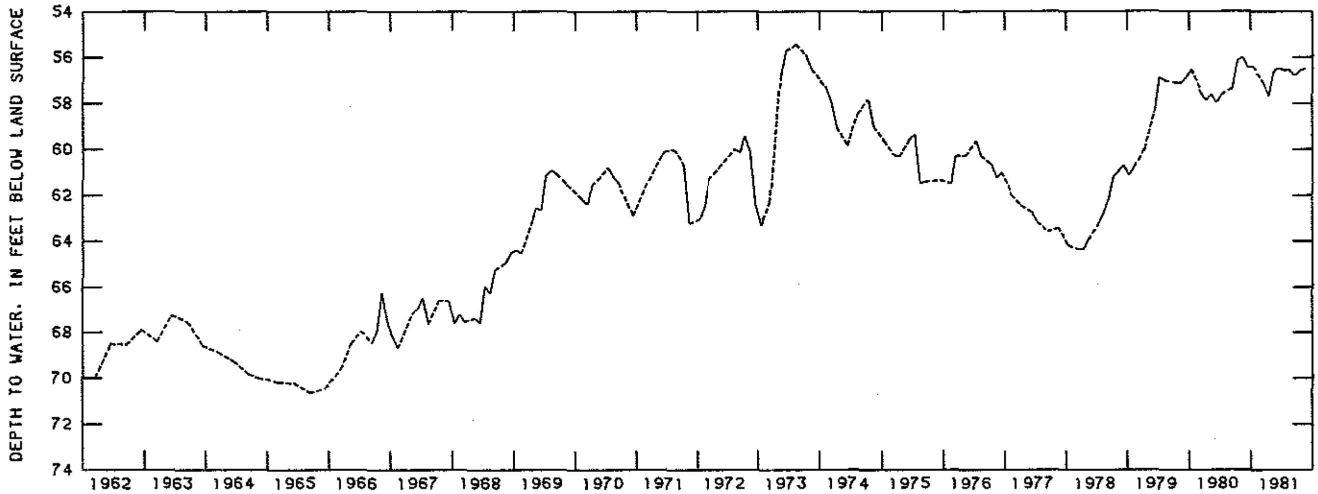

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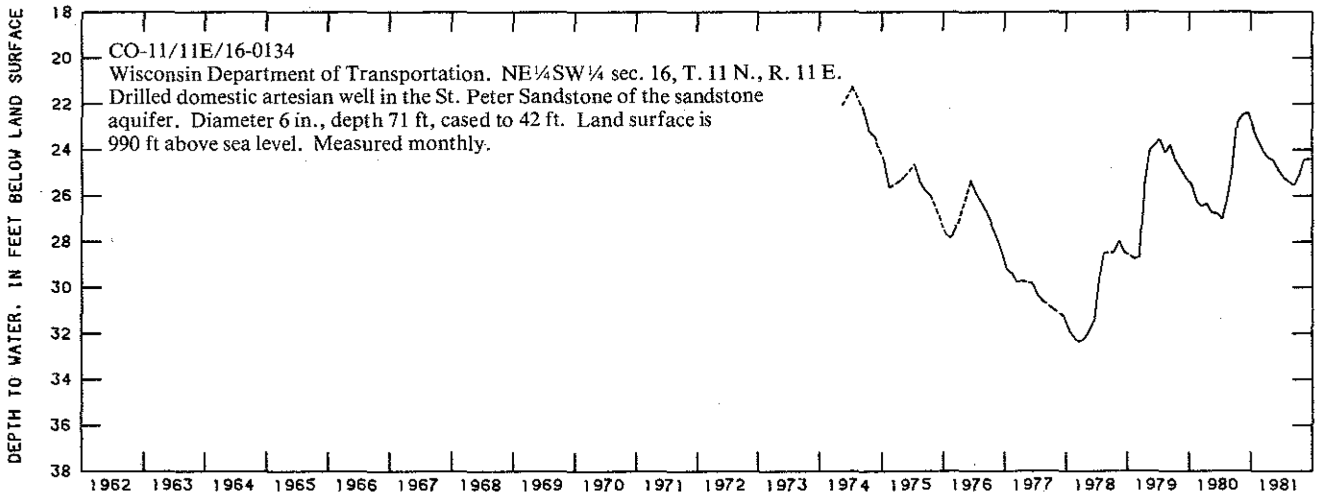

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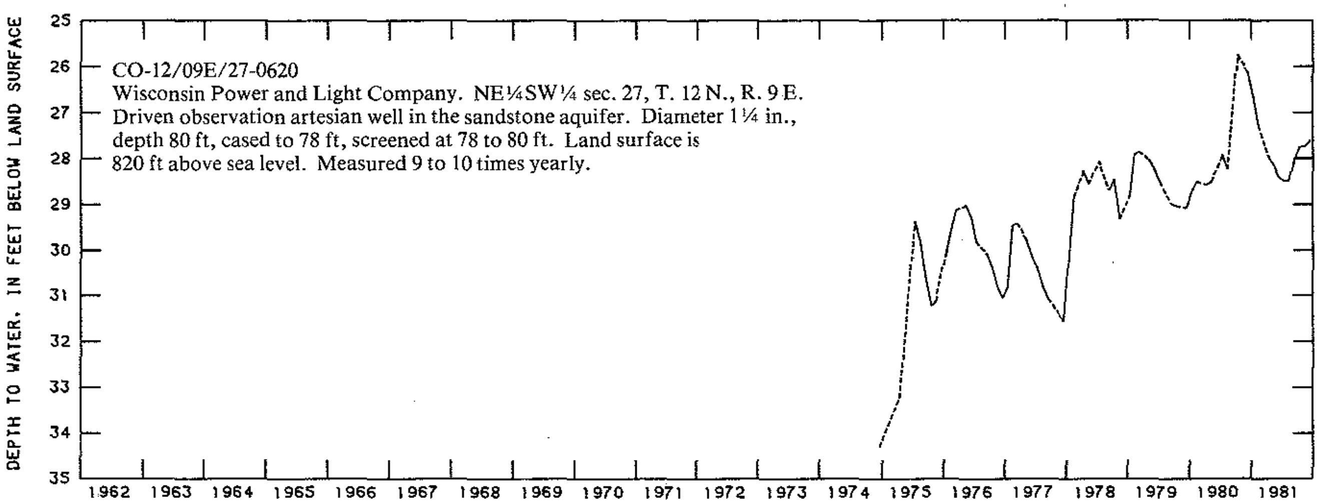

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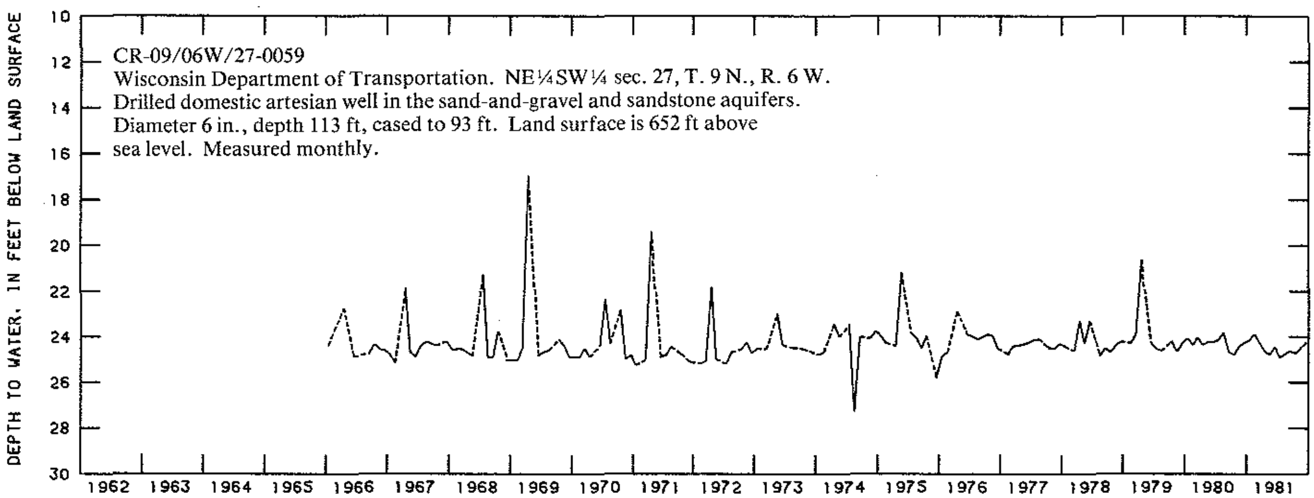

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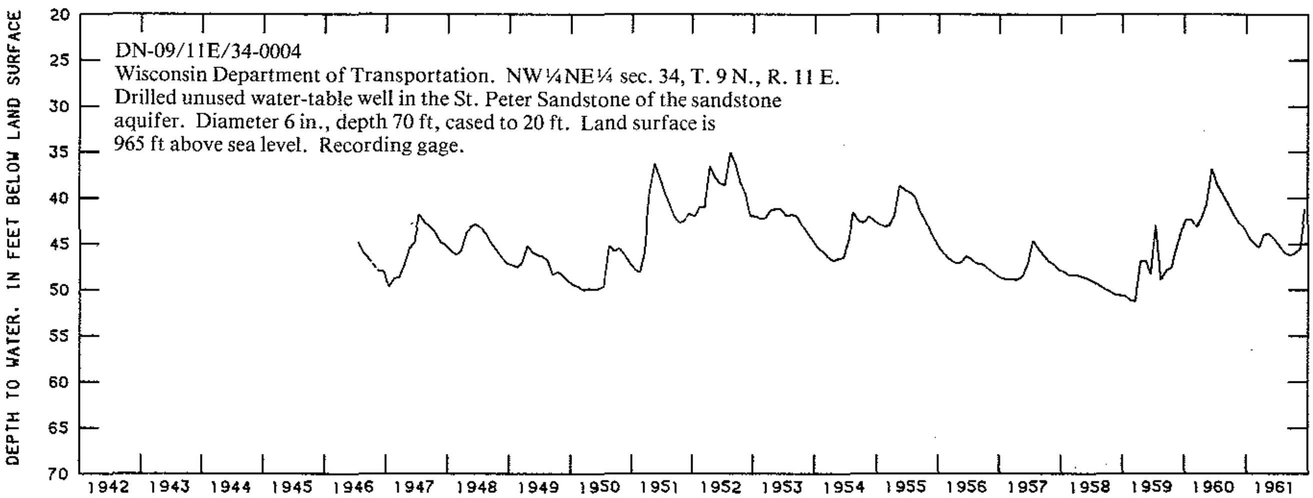

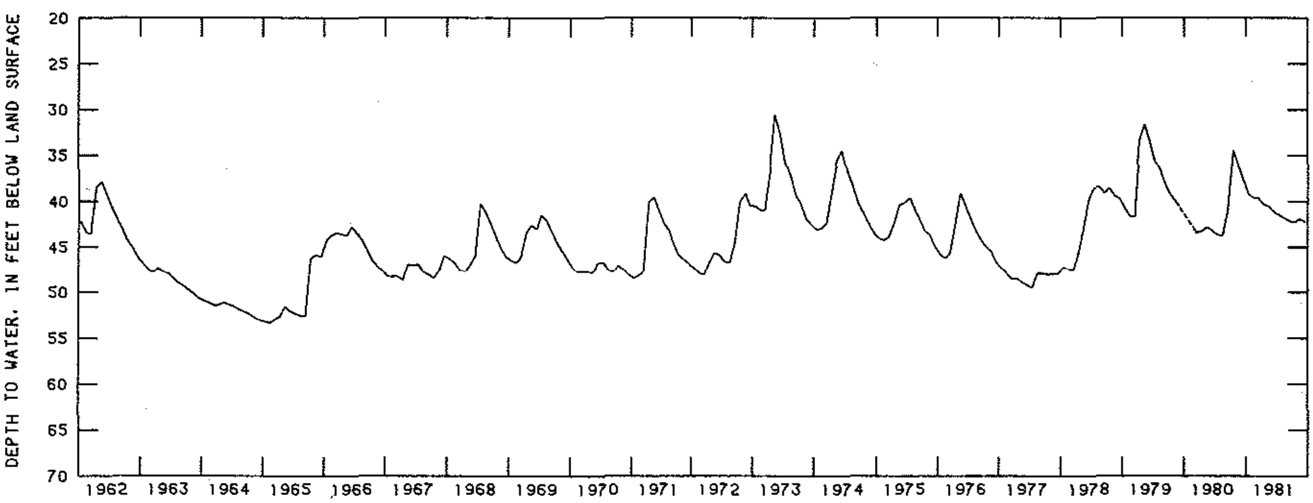

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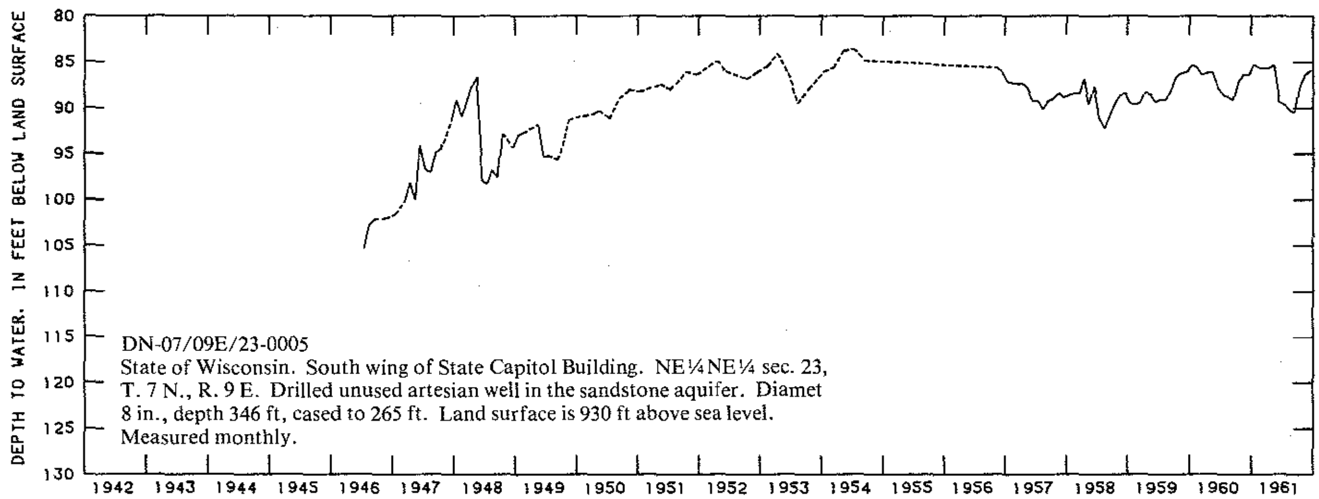

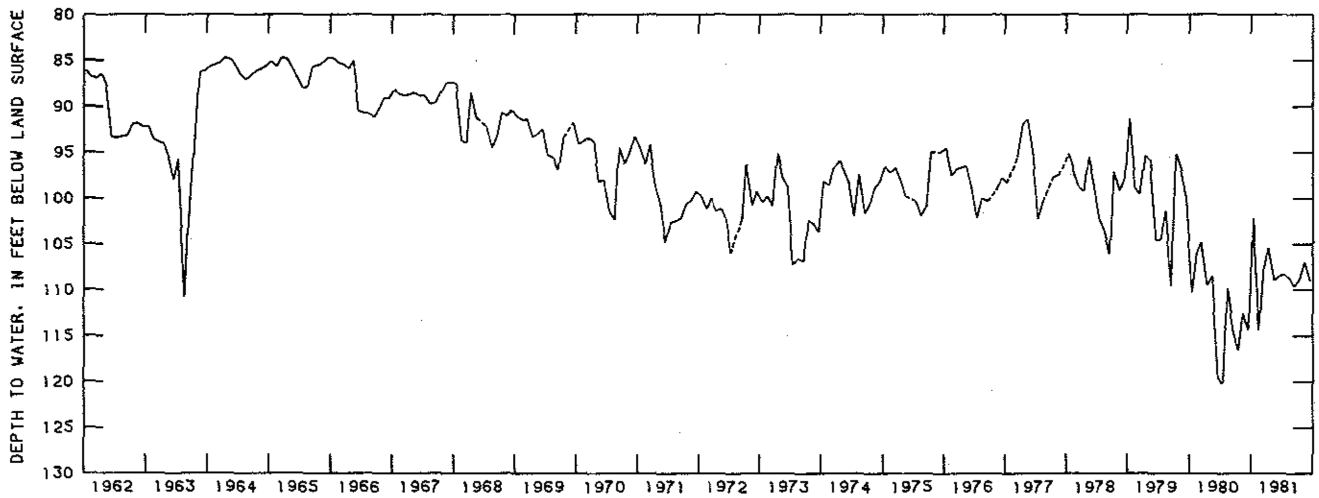

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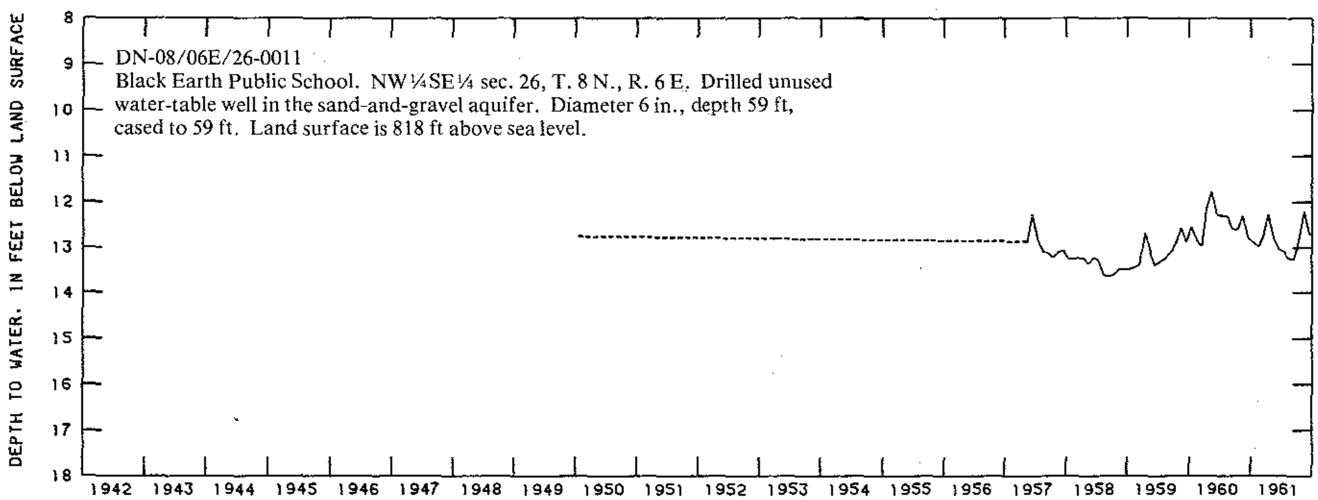

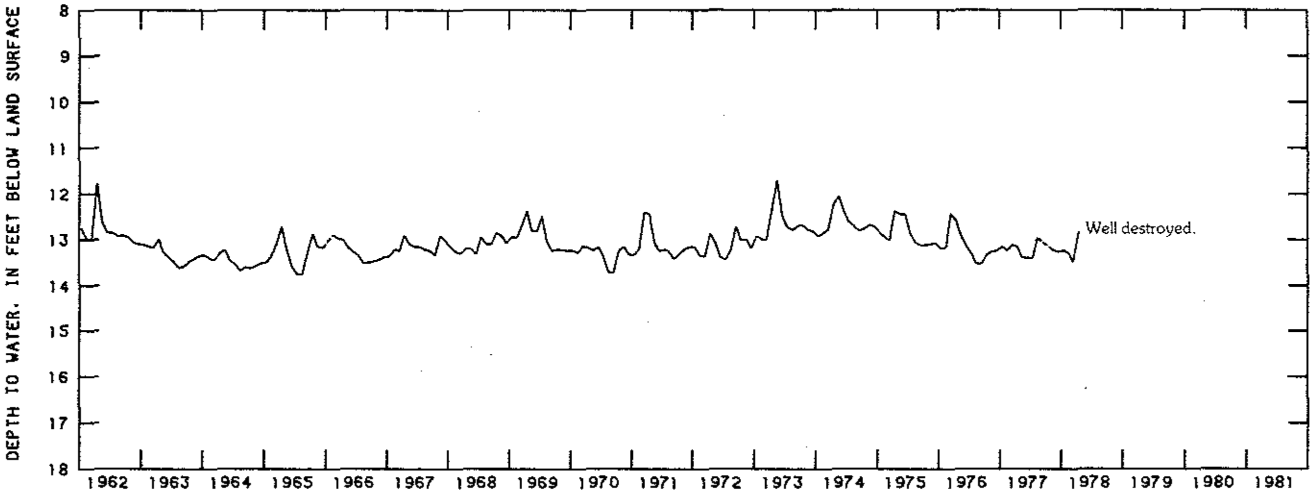

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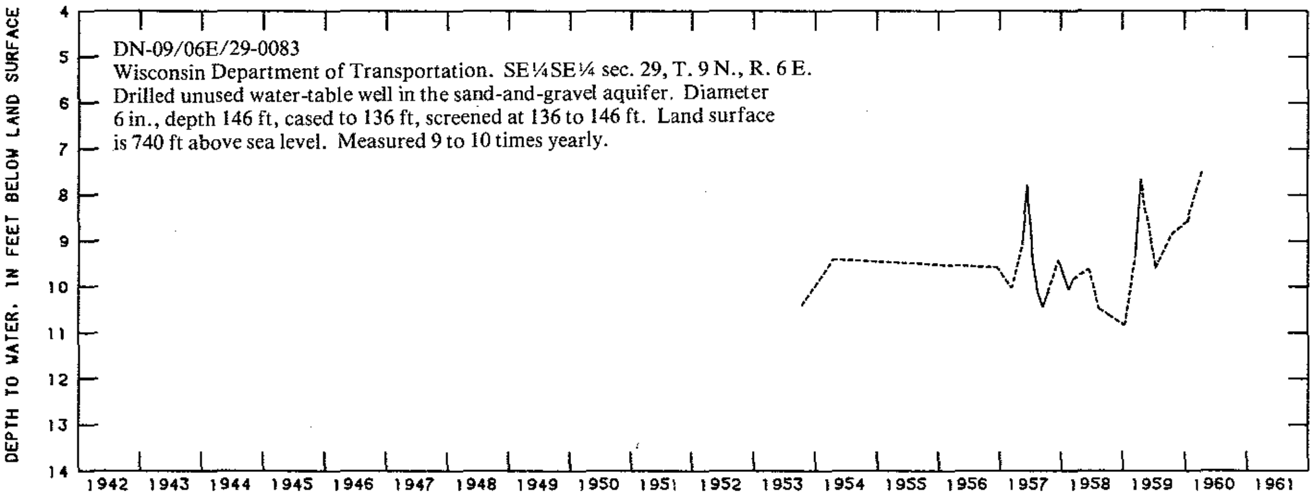

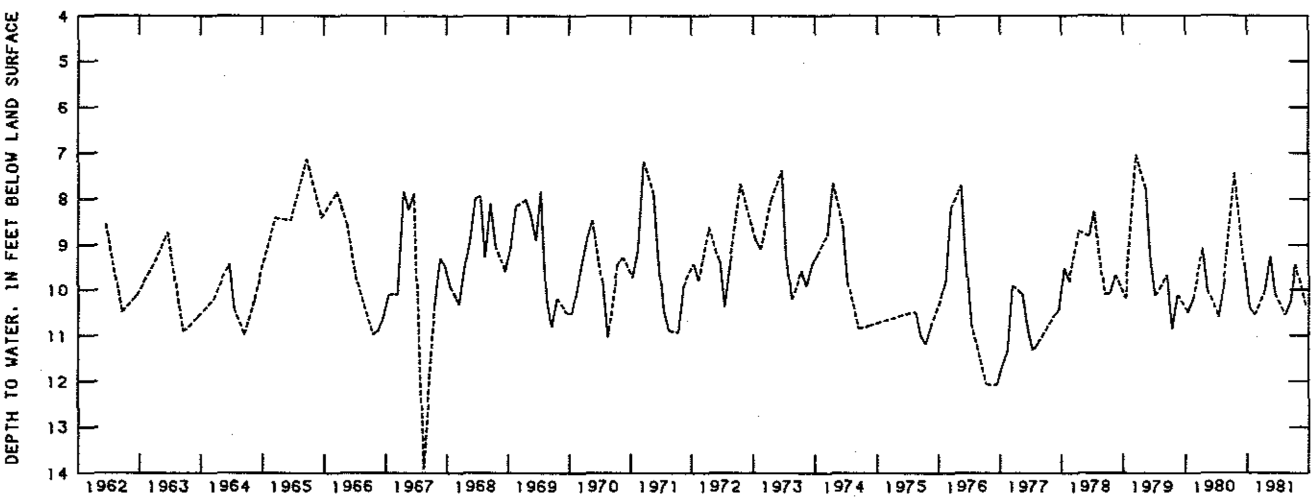

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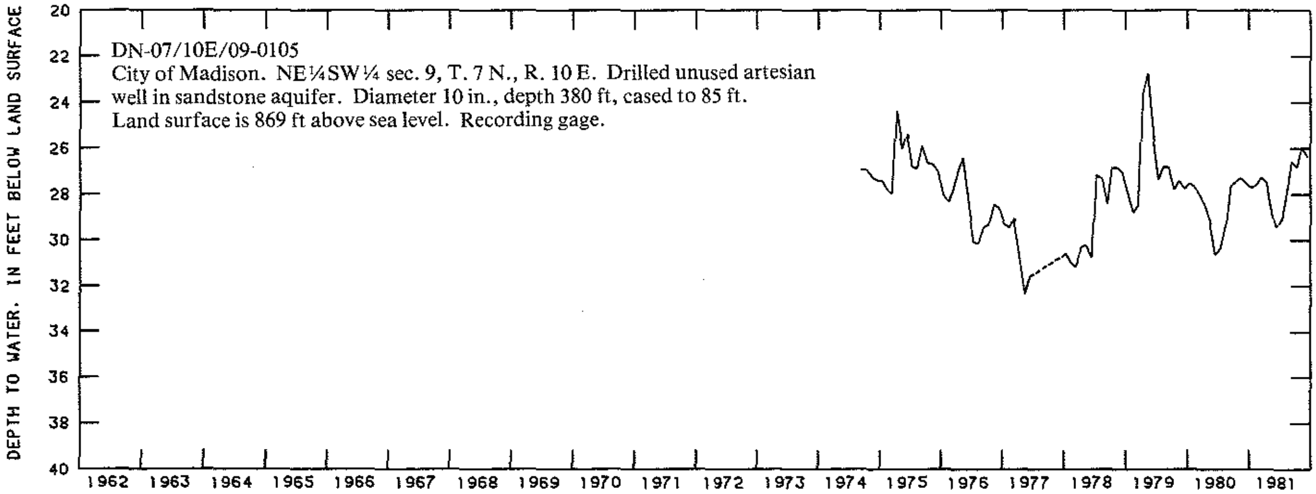

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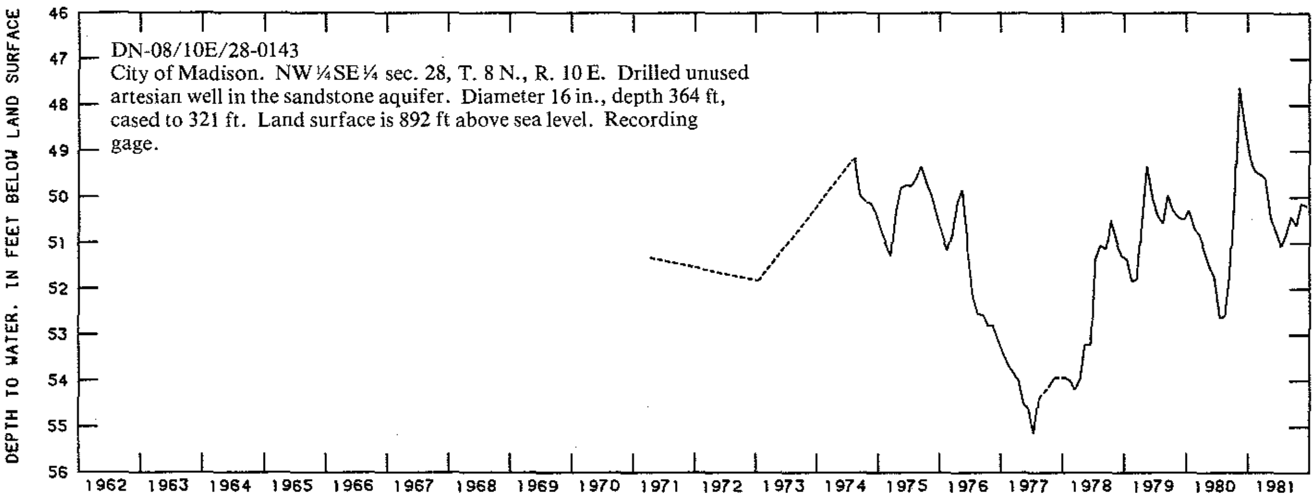

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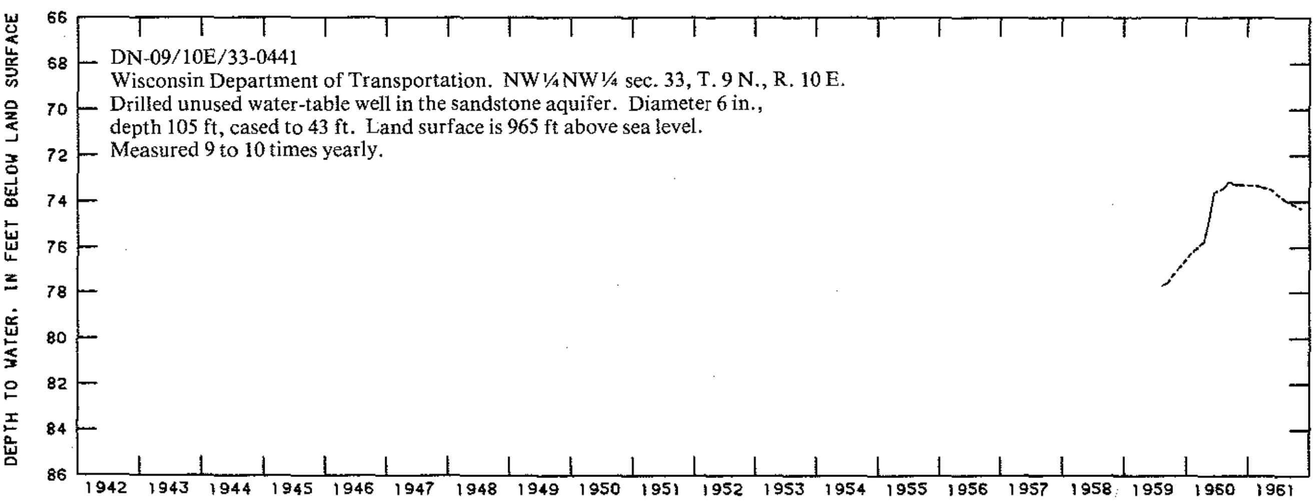

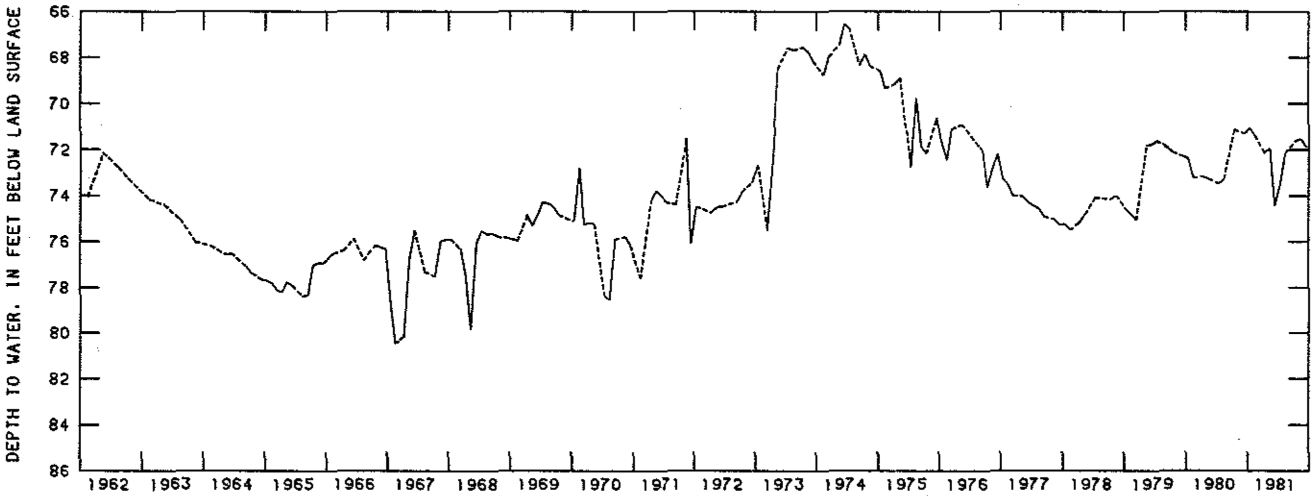

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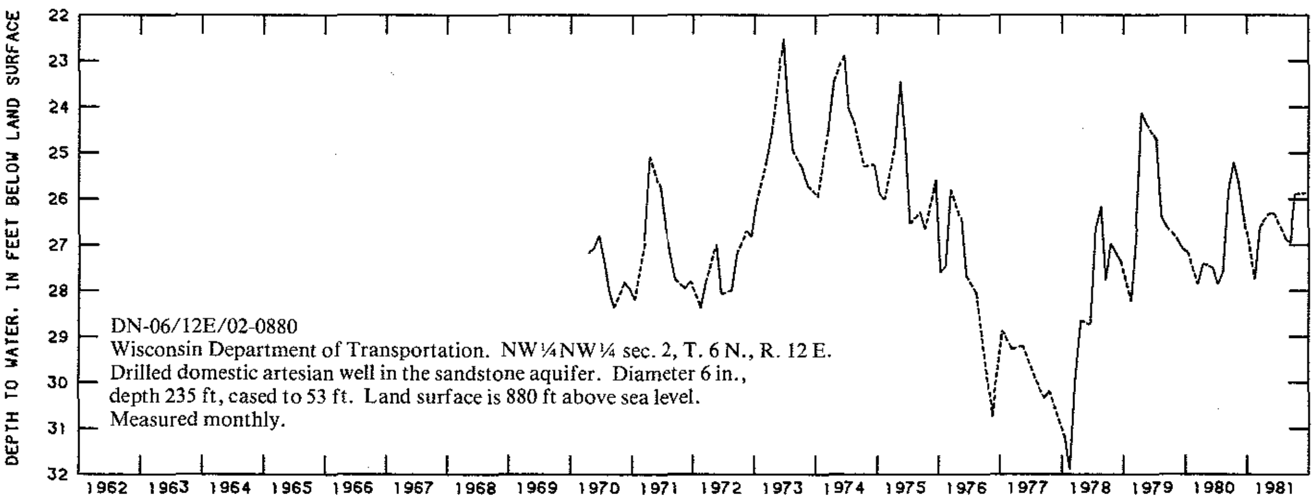

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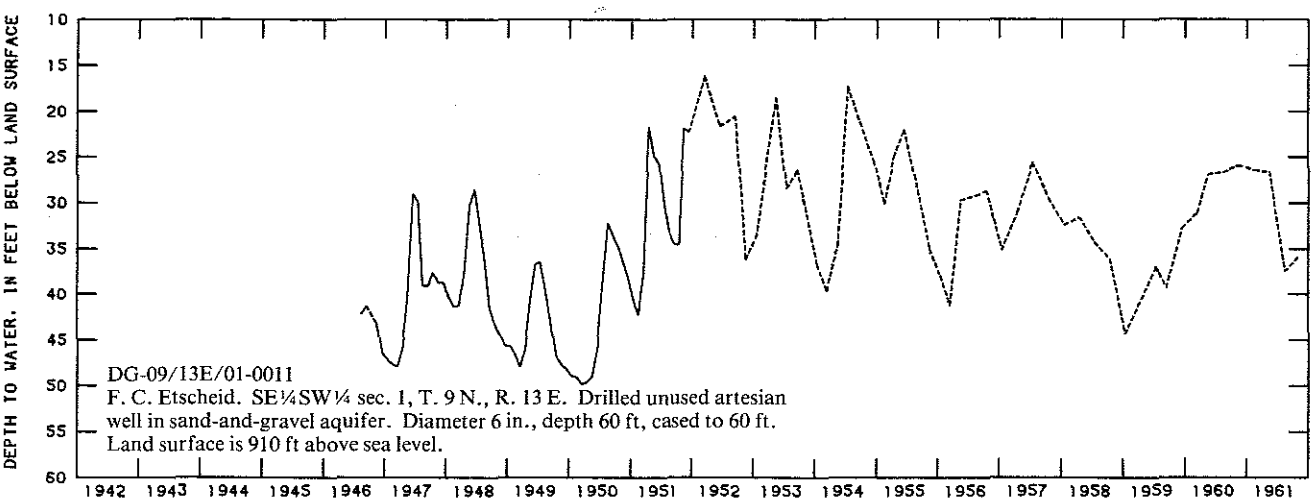

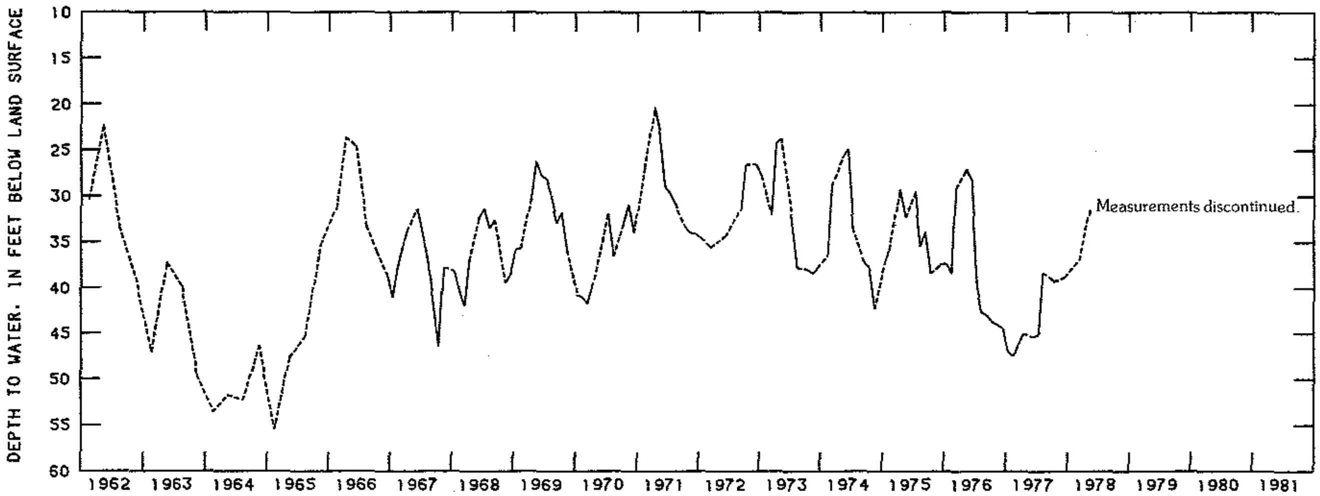

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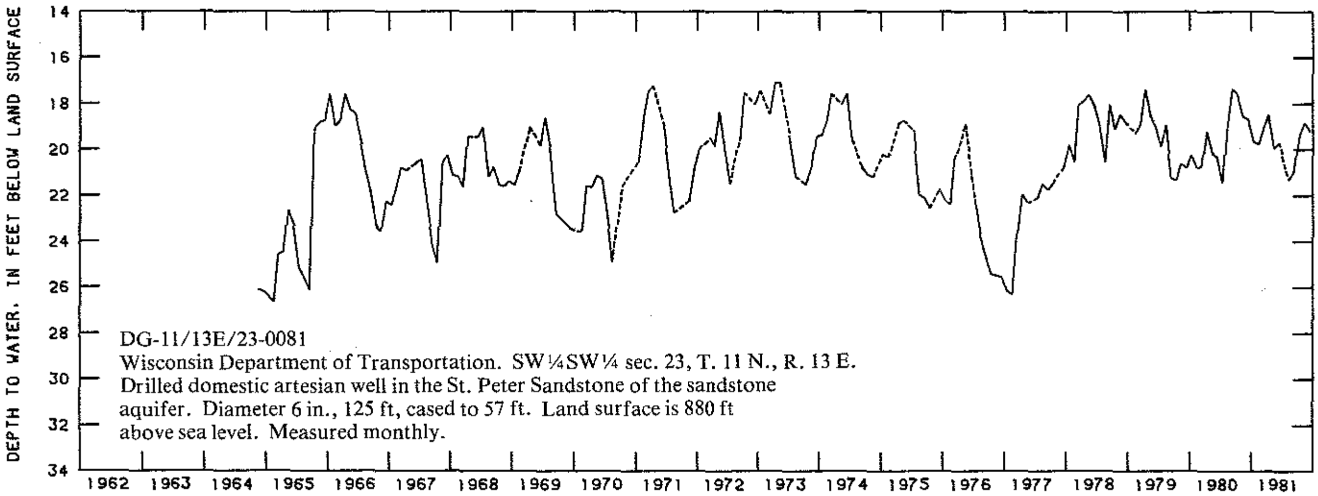
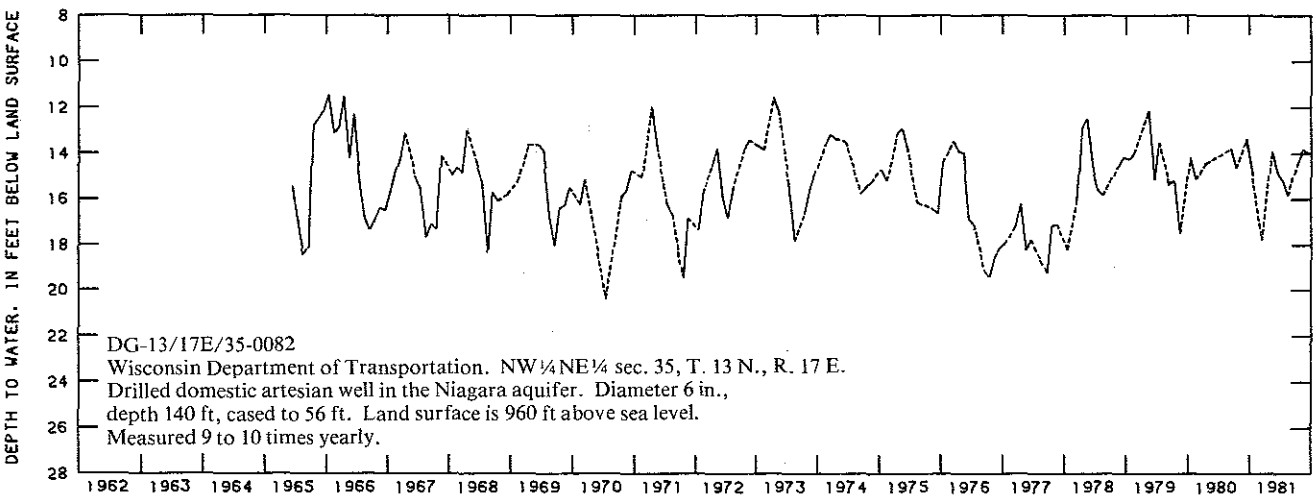


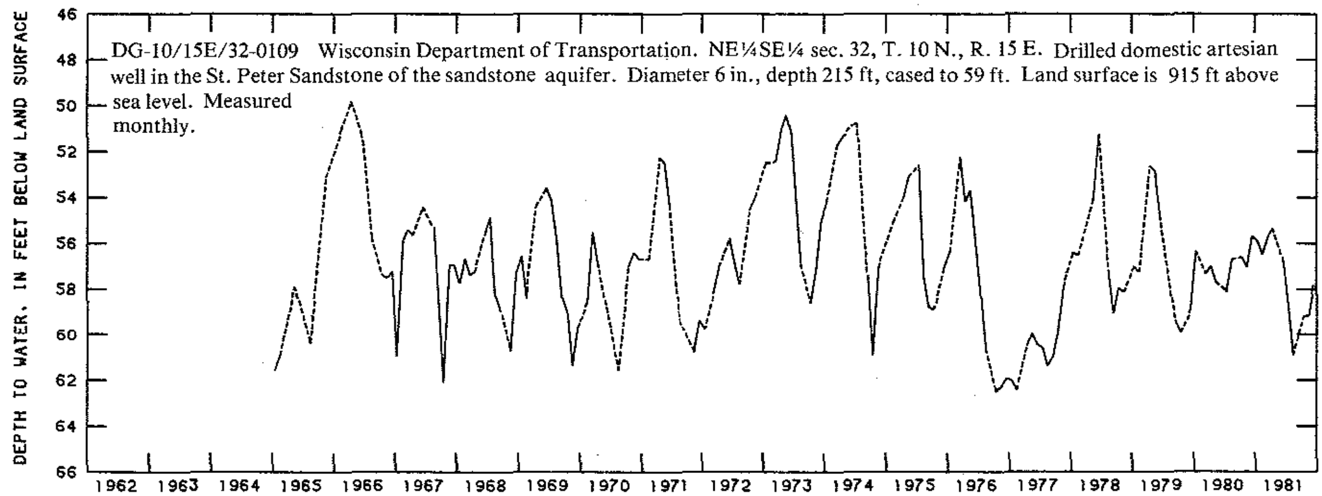
DG-11/13E/23-0081
Wisconsin Department of Transportation. SW¼SW¼ sec. 23, T. 11 N., R. 13 E.
Drilled domestic artesian well in the St. Peter Sandstone of the sandstone aquifer. Diameter 6 in., 125 ft, cased to 57 ft. Land surface is 880 ft above sea level. Measured monthly.

DG-11/13E/23-0081



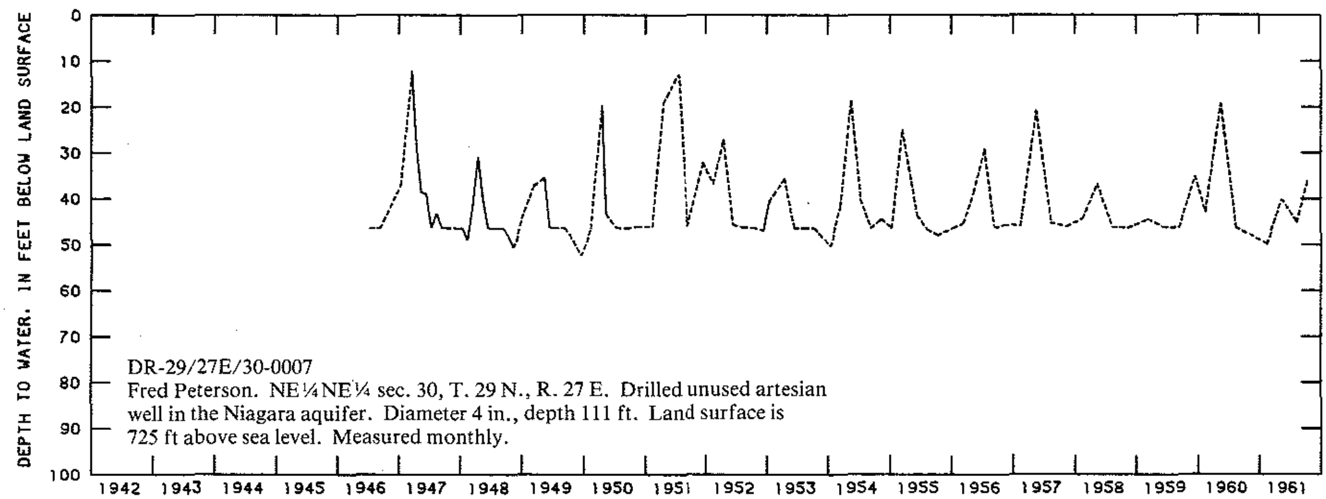
DG-13/17E/35-0082
Wisconsin Department of Transportation. NW¼NE¼ sec. 35, T. 13 N., R. 17 E.
Drilled domestic artesian well in the Niagara aquifer. Diameter 6 in., depth 140 ft, cased to 56 ft. Land surface is 960 ft above sea level. Measured 9 to 10 times yearly.

DG-13/17E/35-0082

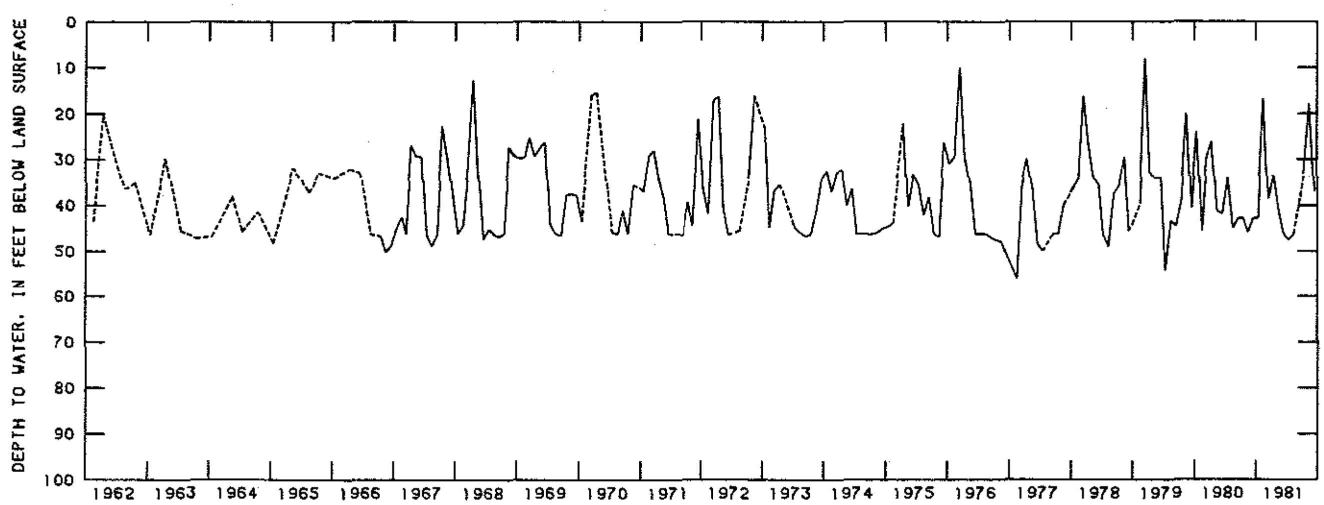


DG-10/15E/32-0109 Wisconsin Department of Transportation. NE¼SE¼ sec. 32, T. 10 N., R. 15 E. Drilled domestic artesian well in the St. Peter Sandstone of the sandstone aquifer. Diameter 6 in., depth 215 ft, cased to 59 ft. Land surface is 915 ft above sea level. Measured monthly.

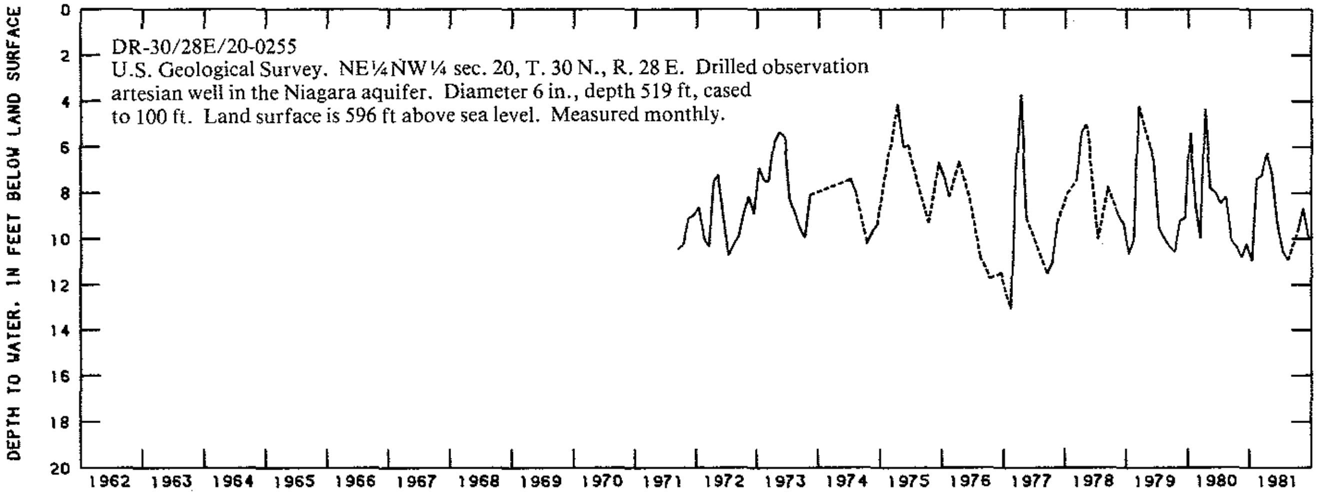
DG-10/15E/32-0109



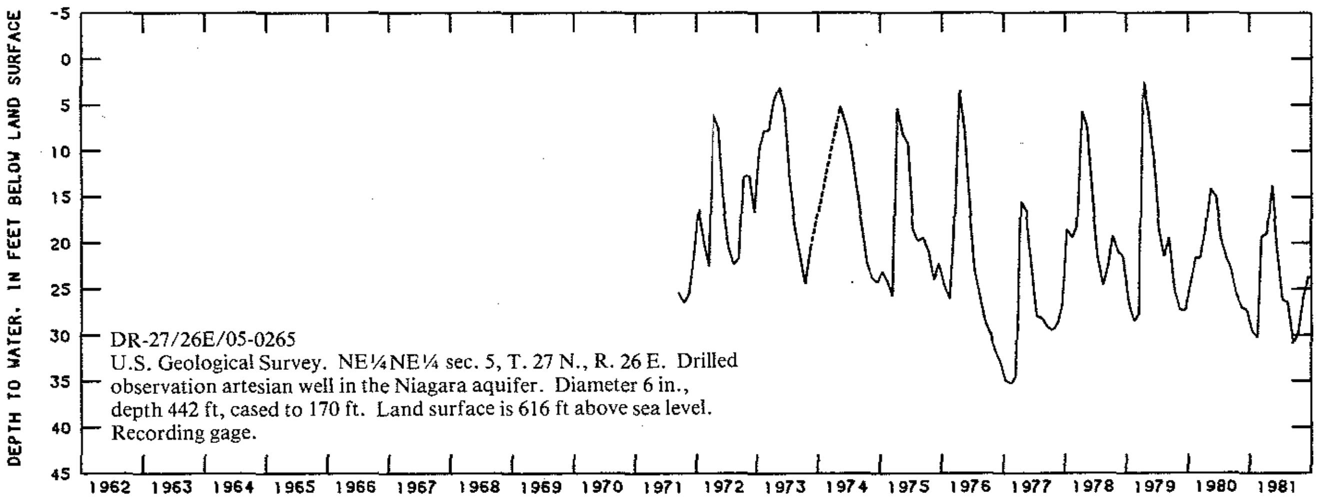
DR-29/27E/30-0007
Fred Peterson. NE¼NE¼ sec. 30, T. 29 N., R. 27 E. Drilled unused artesian well in the Niagara aquifer. Diameter 4 in., depth 111 ft. Land surface is 725 ft above sea level. Measured monthly.



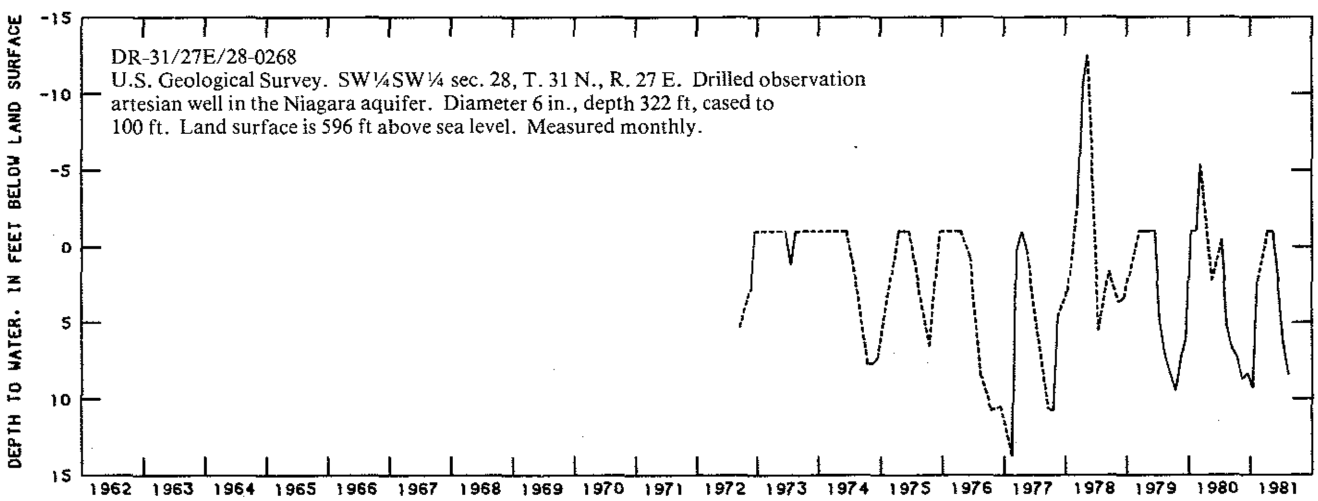
DR-29/27E/30-0007



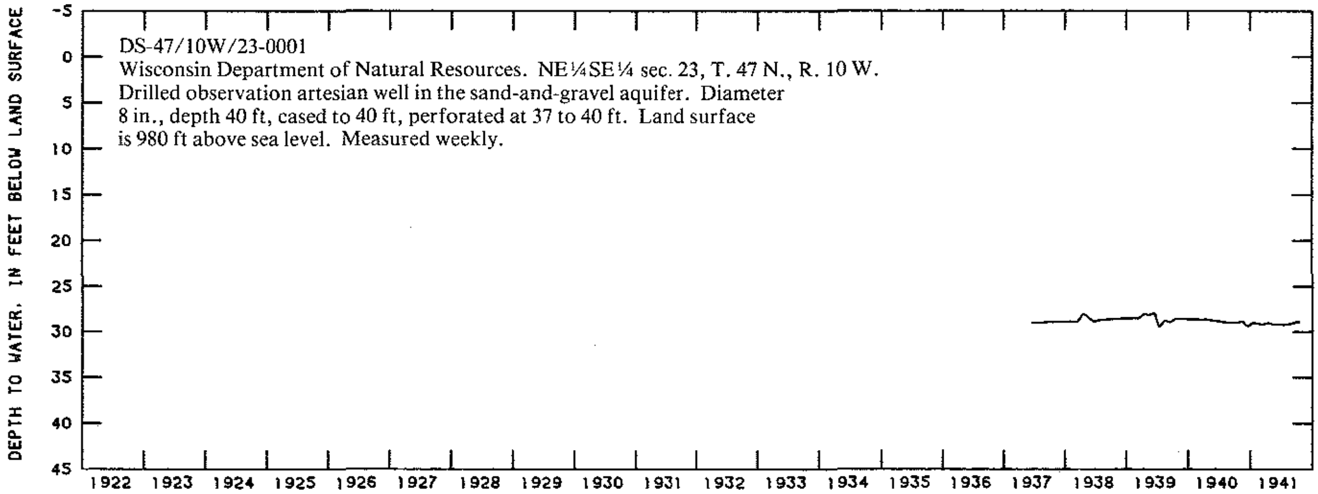
DR-30/28E/20-0255

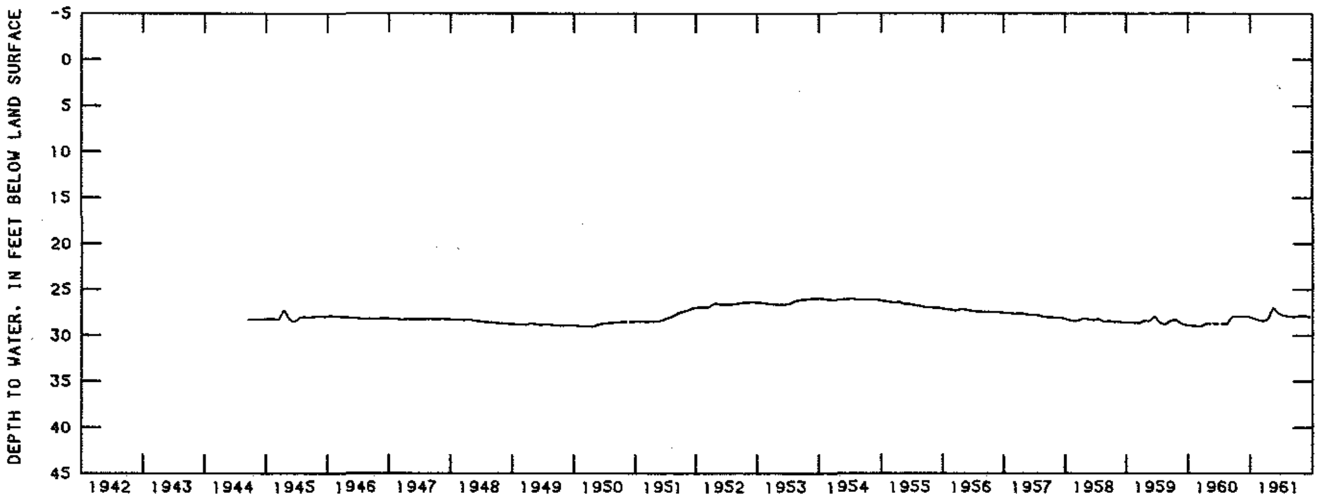


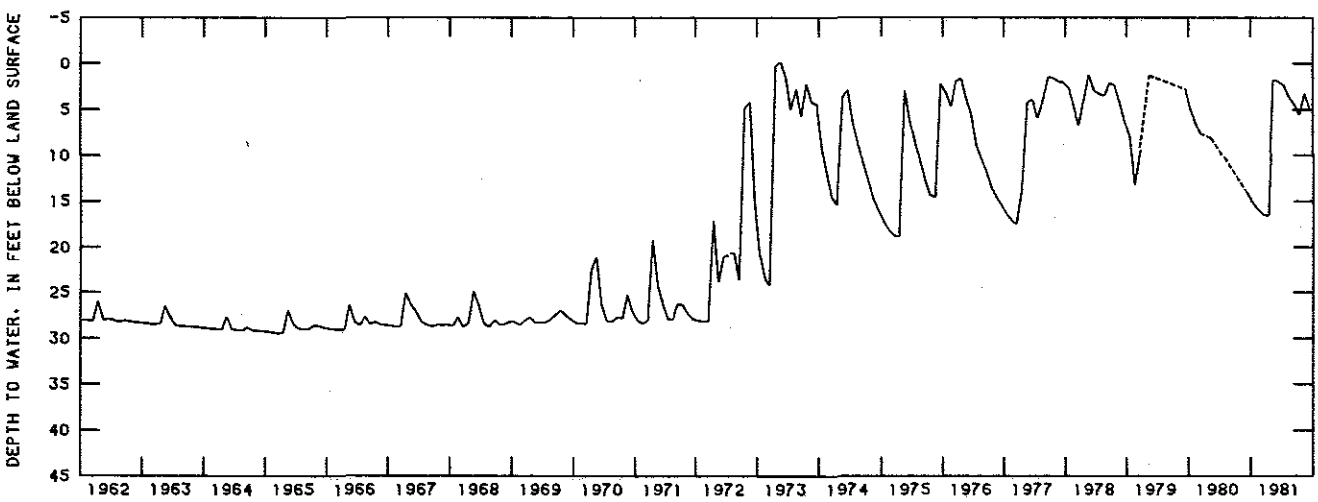
DR-27/26E/05-0265



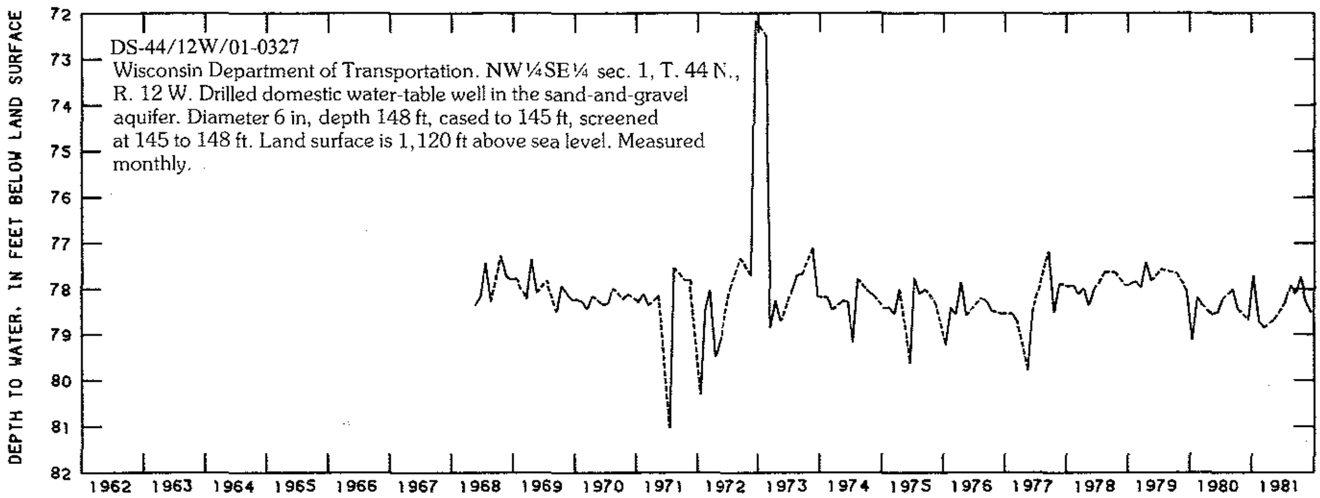
DR-31/27E/28-0268



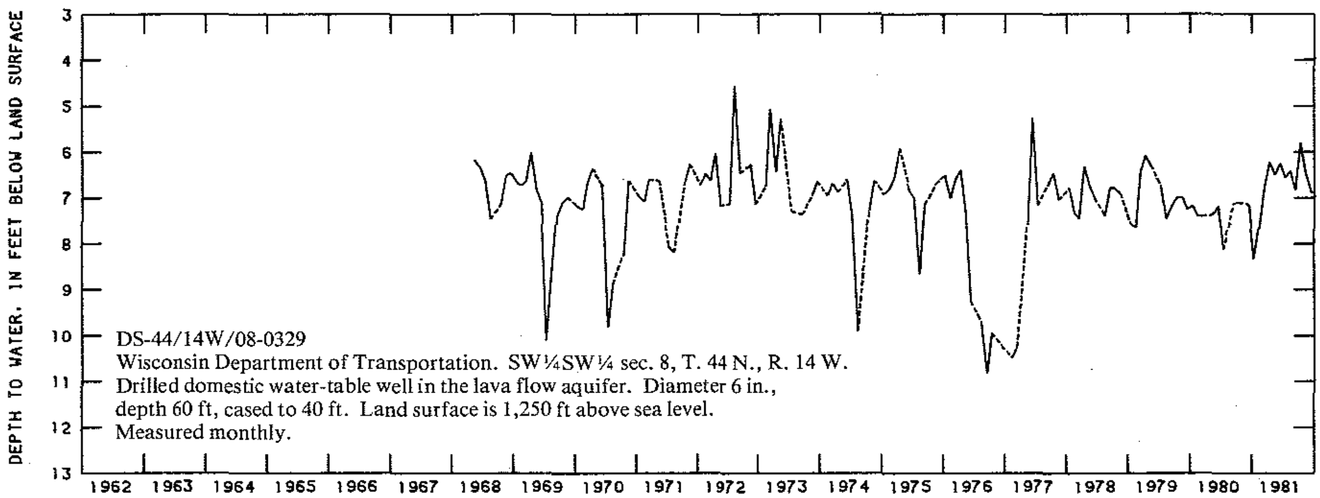




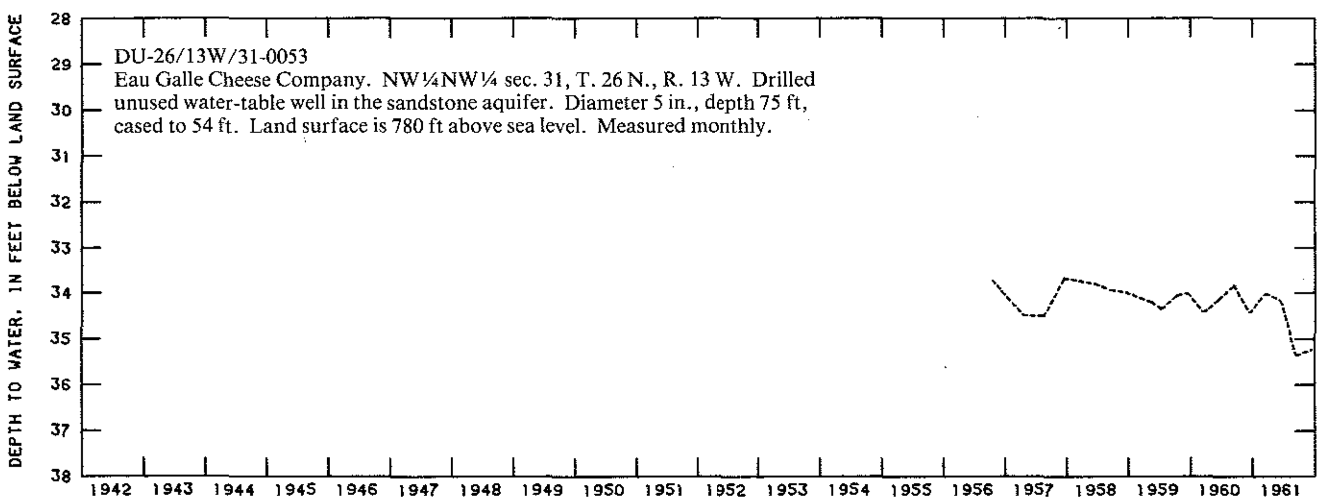
DS-47/10W/23-0001

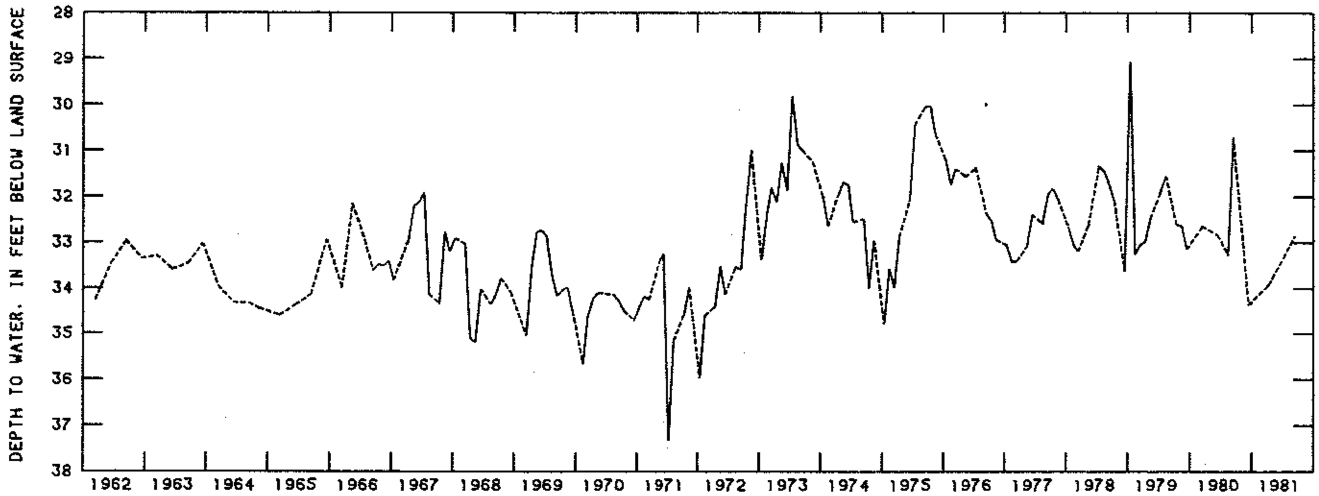


DS-44/12W/01-0327

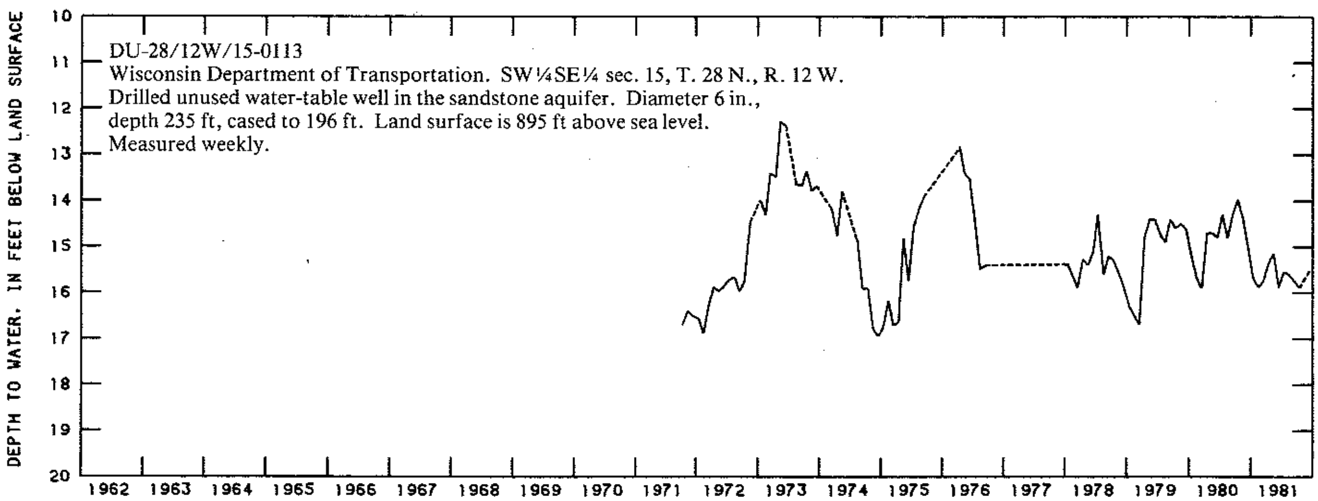


DS-44/14W/08-0329

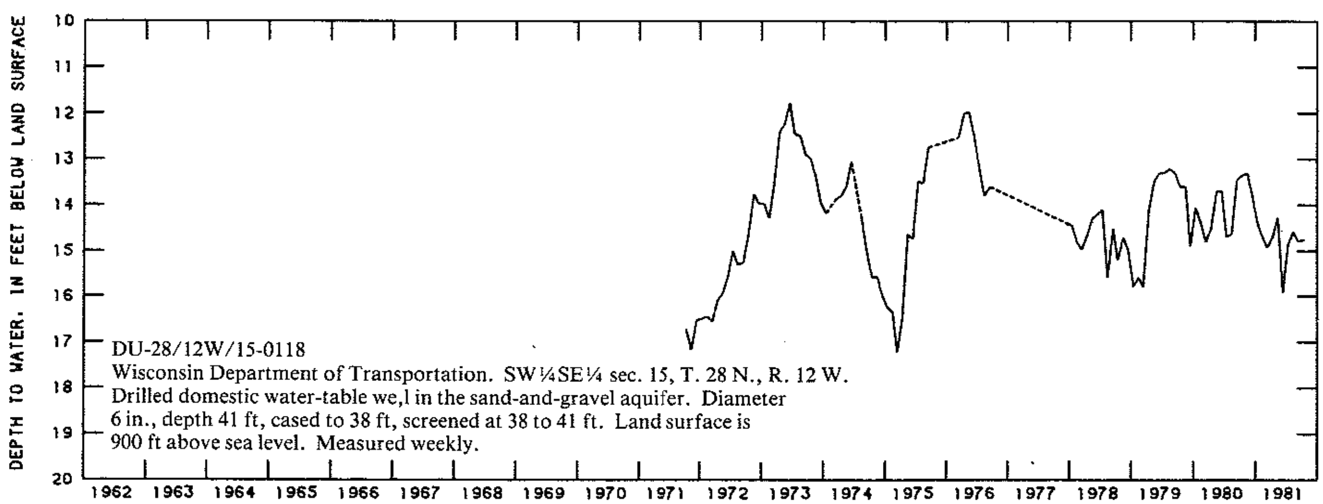




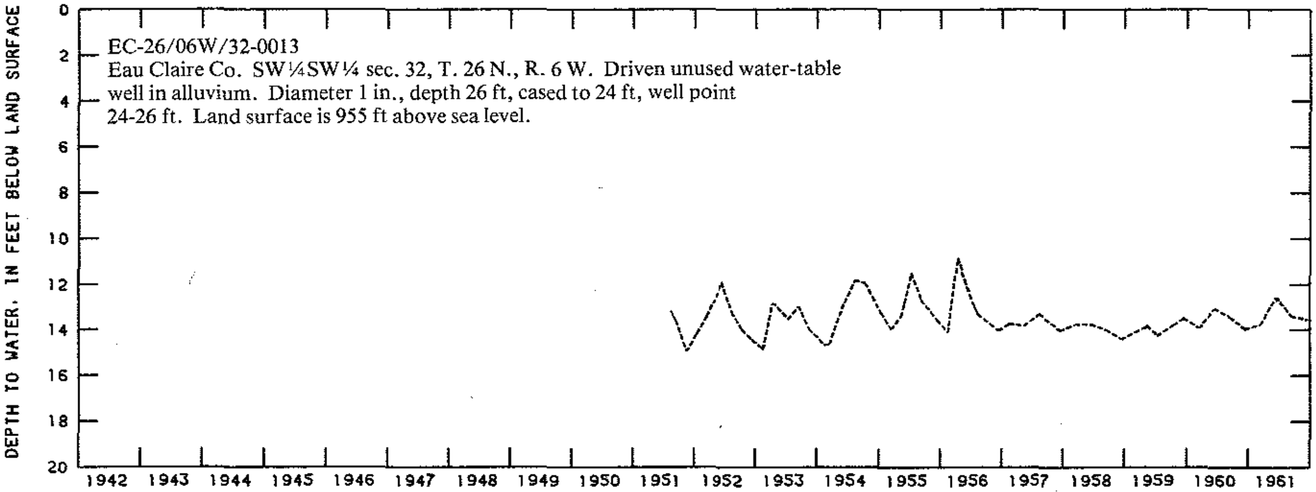
DU-26/13W/31-0053

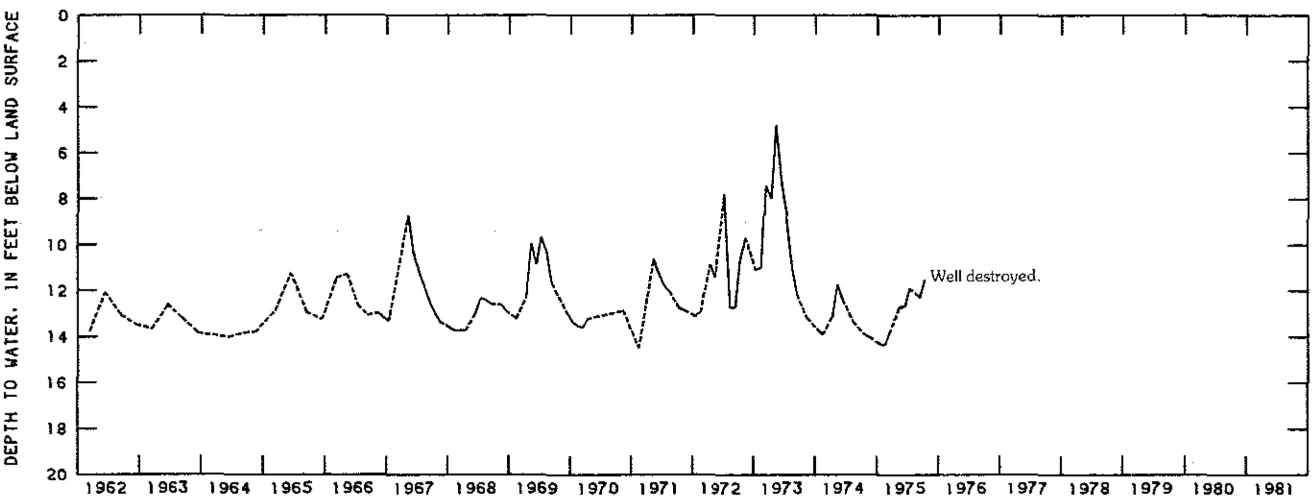


DU-28/12W/15-0113

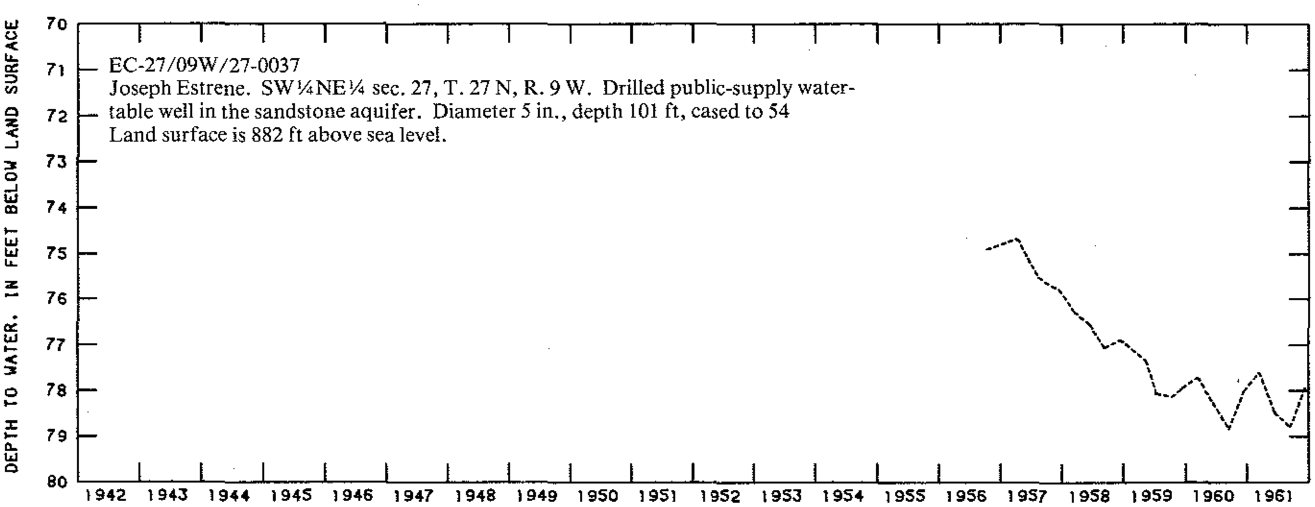


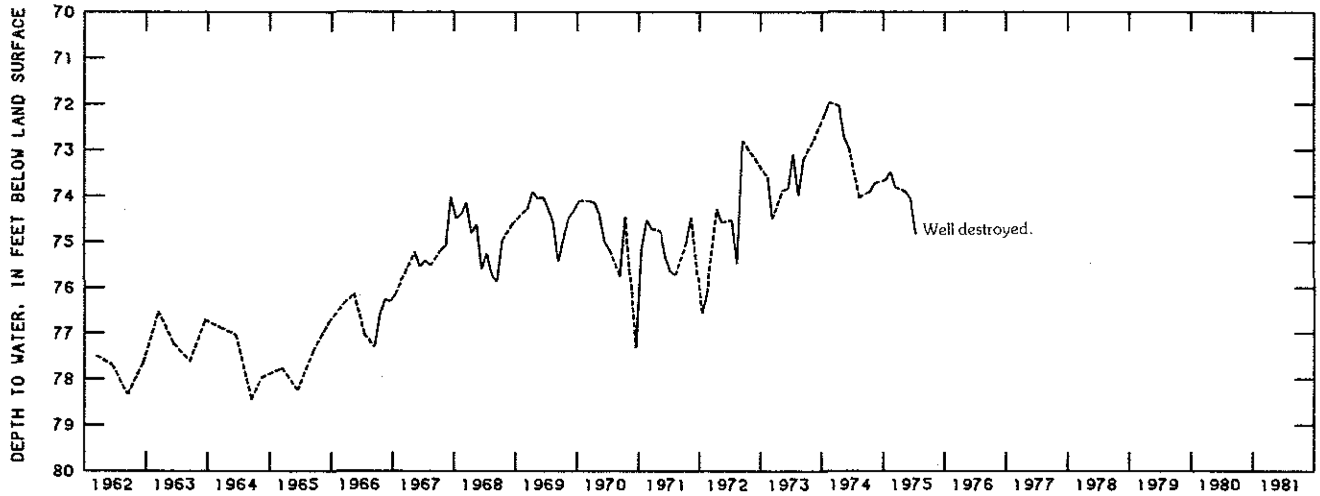
DU-28/12W/15-0118



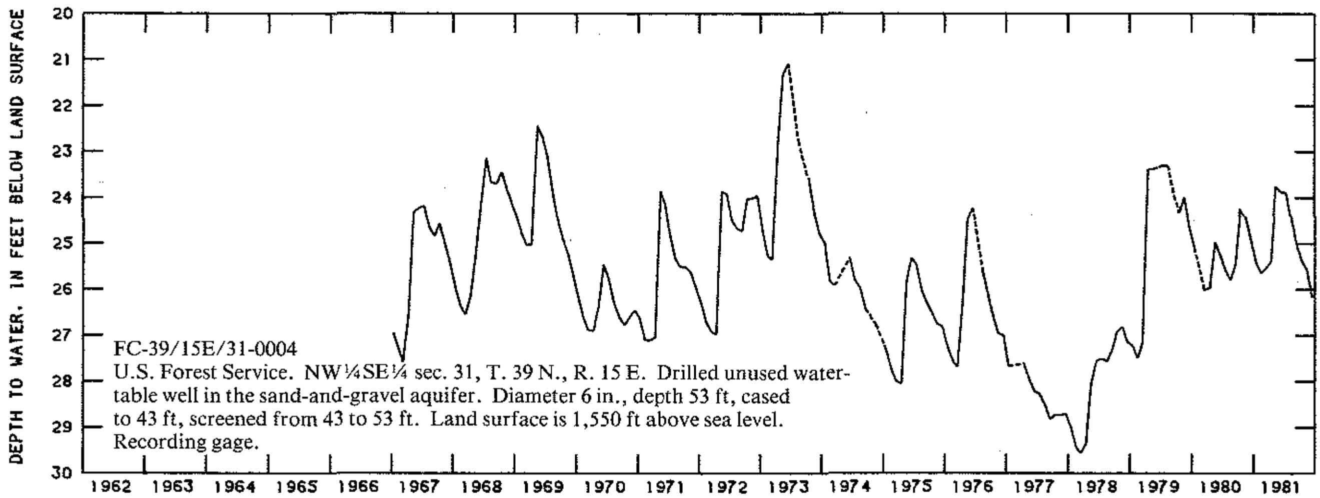


EC-26/06W/32-0013

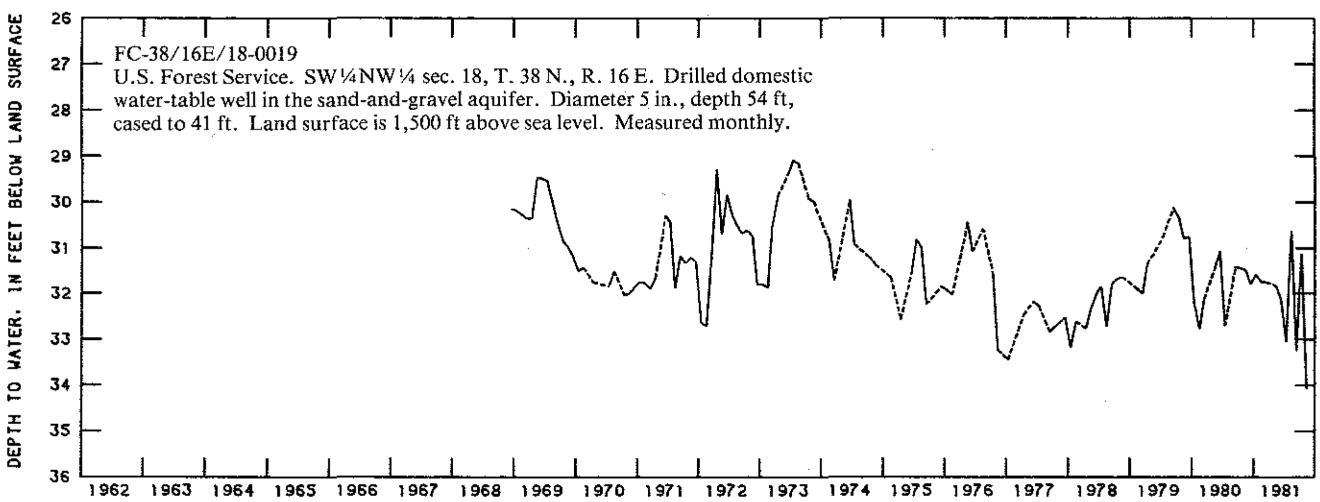




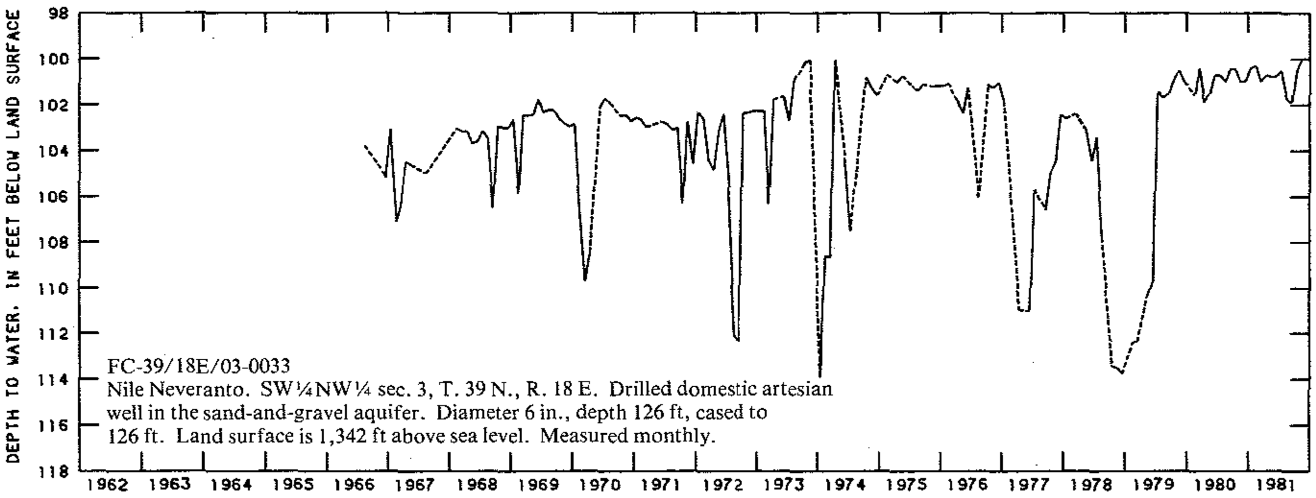
EC-27/09W/27-0037



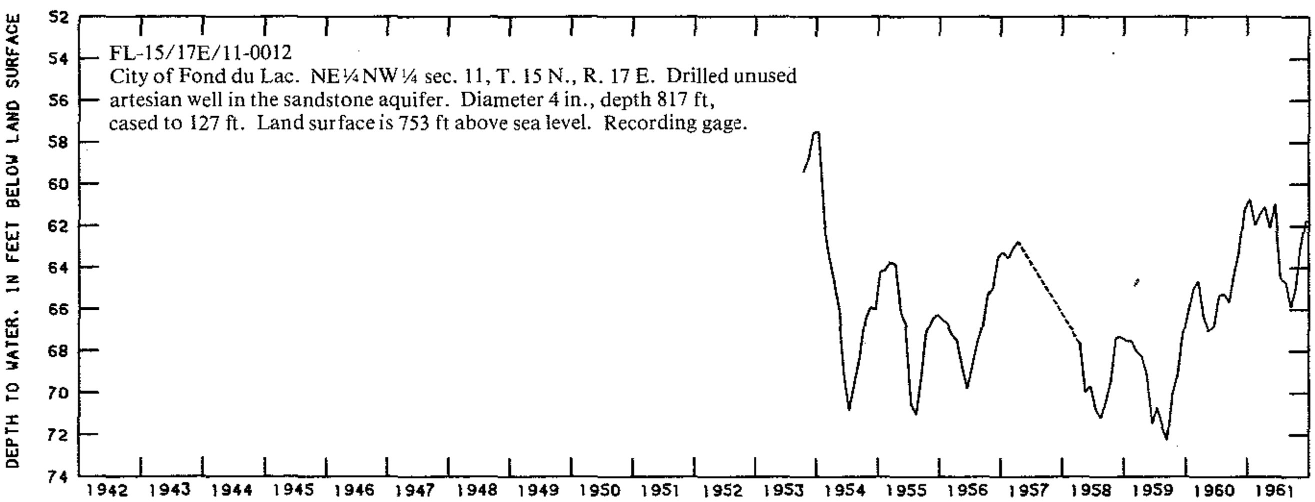
FC-39/15E/31-0004

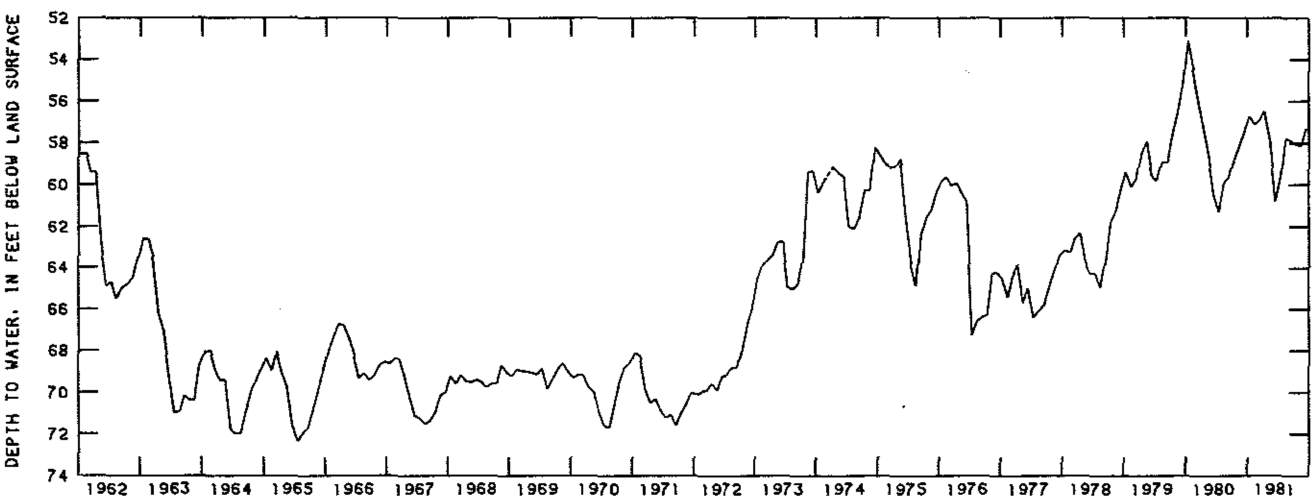


FC-38/16E/18-0019

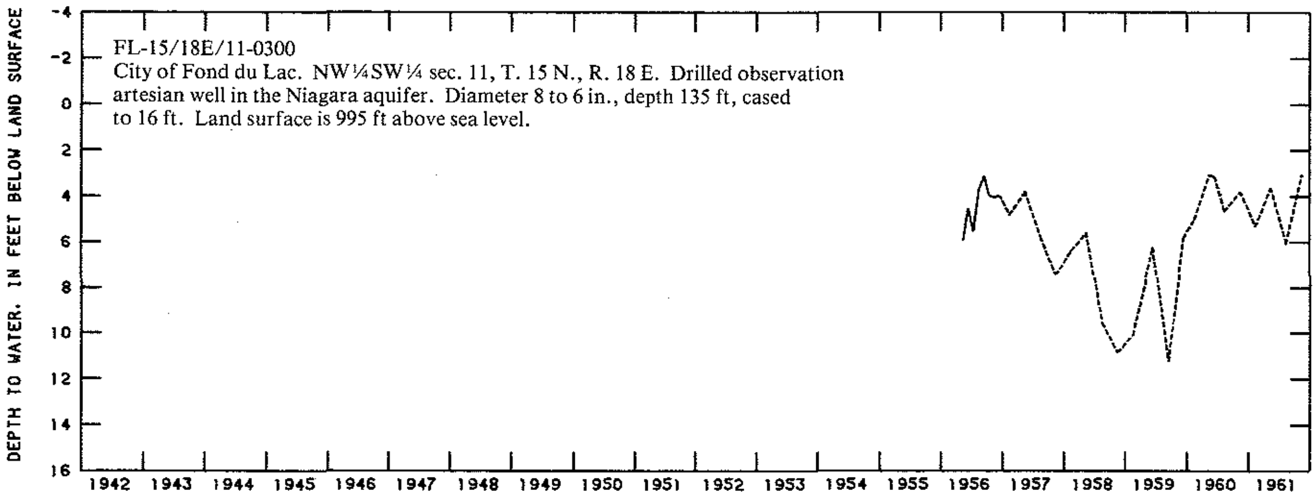


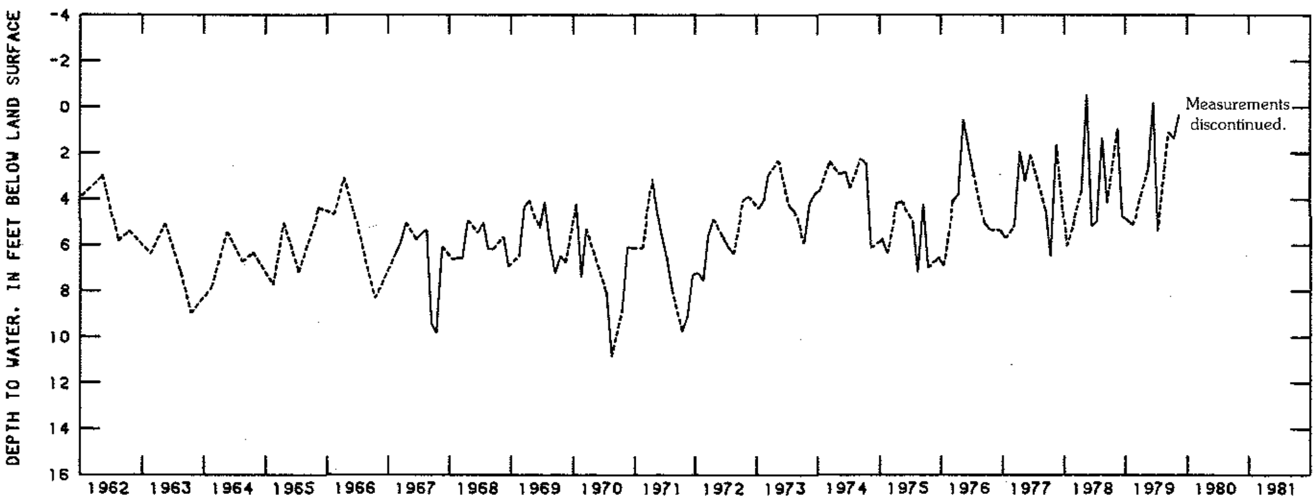
FC-39/18E/03-0033





FL-15/17E/11-0012





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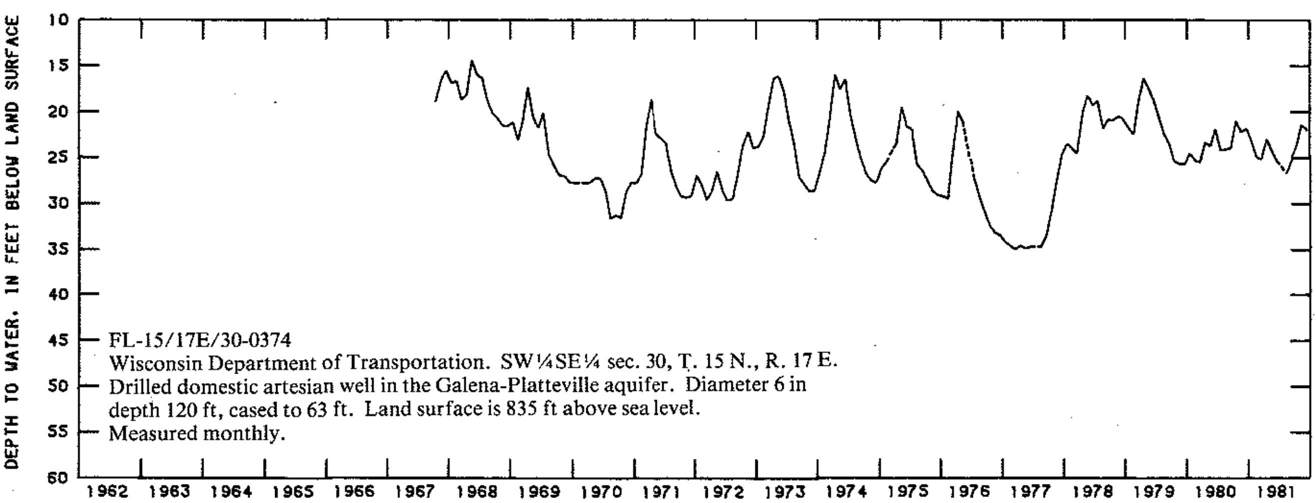
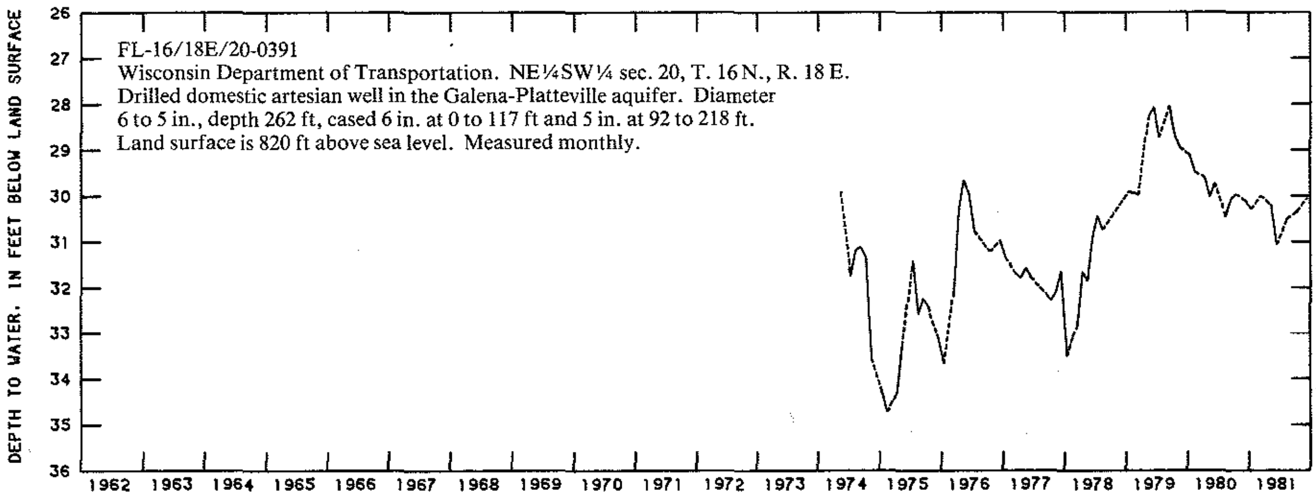


FL-15/17E/30-0374



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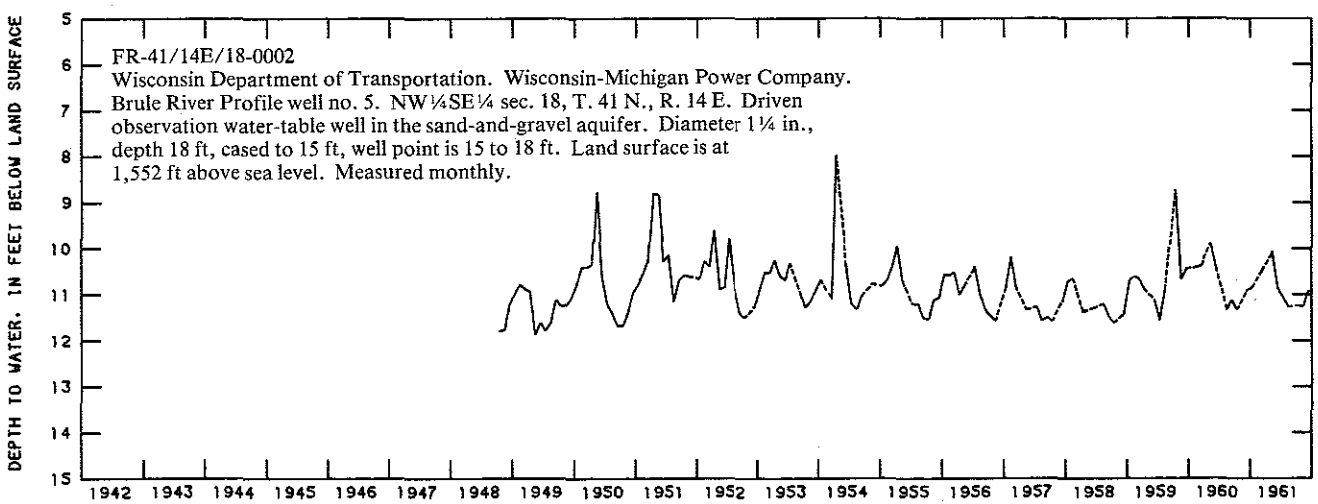
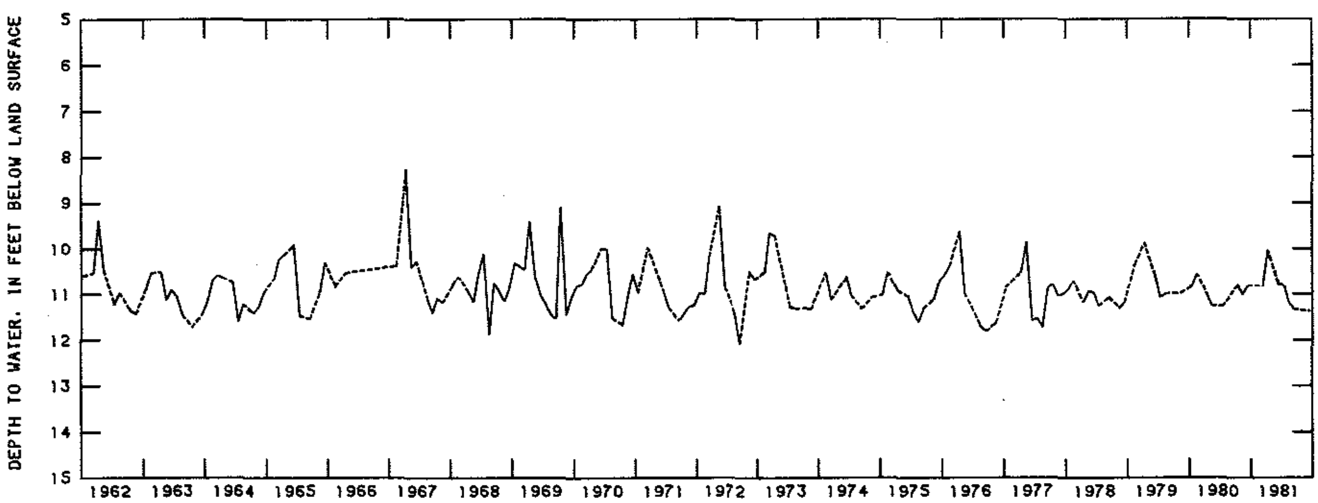
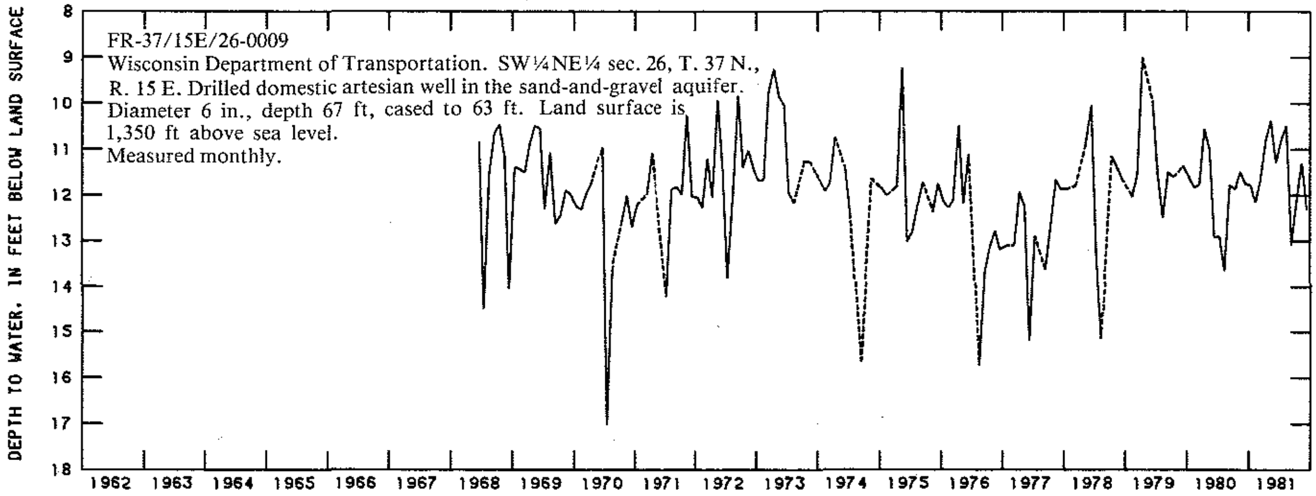
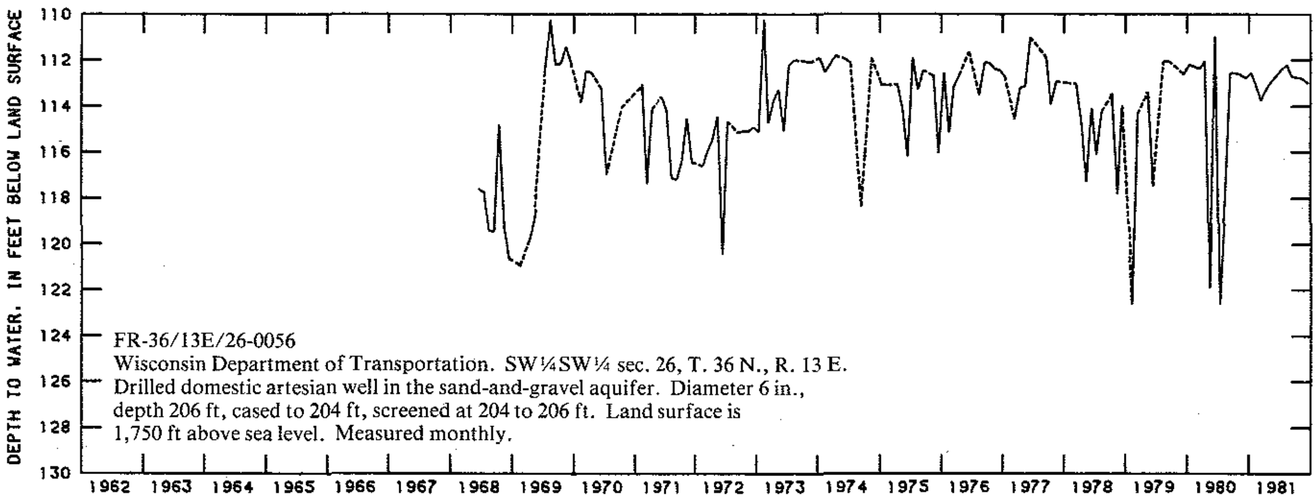




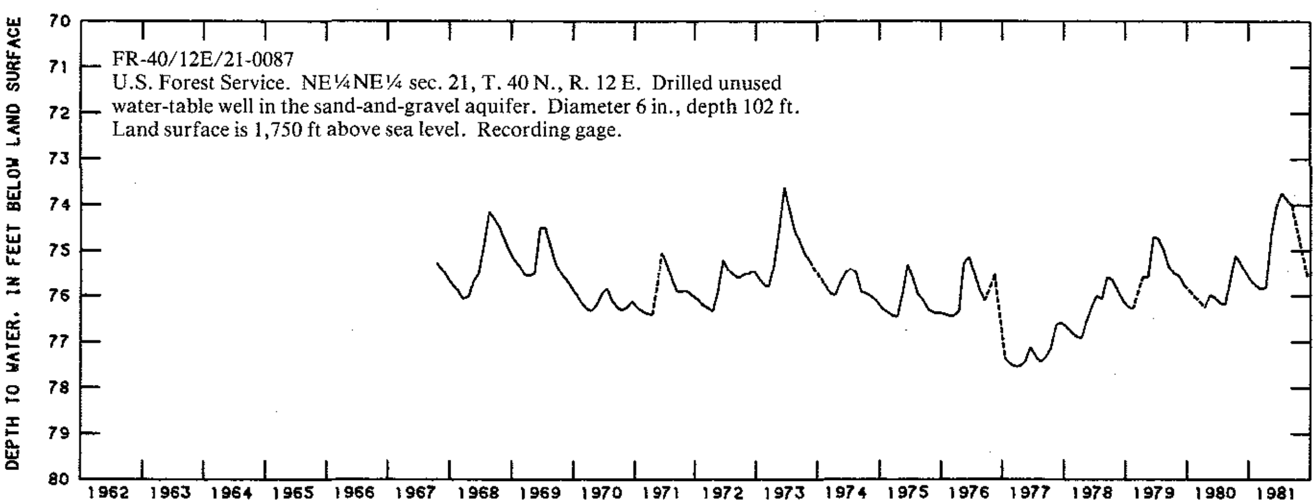
FR-41/14E/18-0002



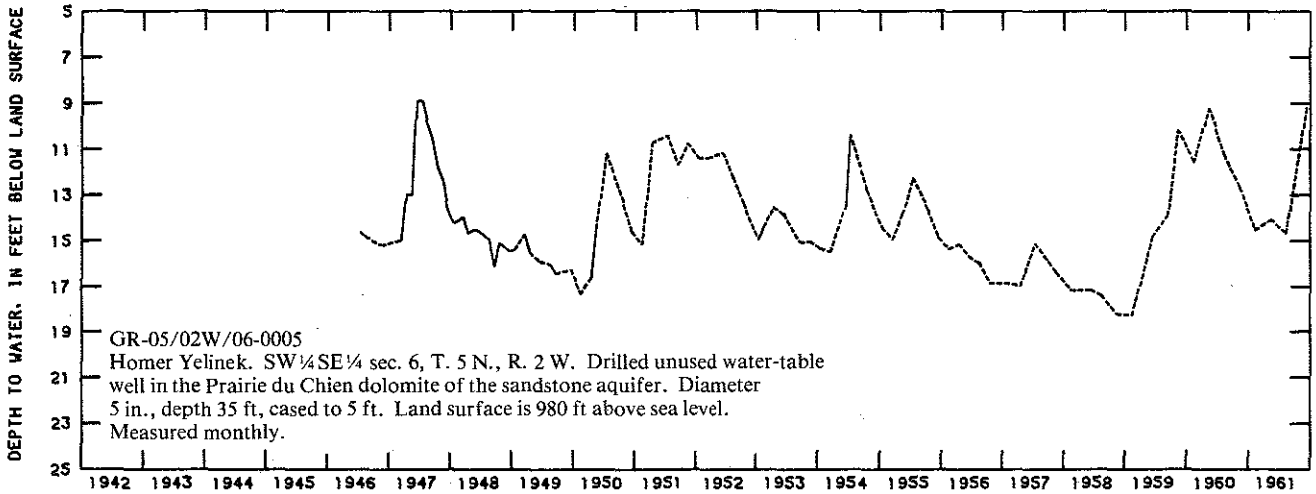
FR-37/15E/26-0009



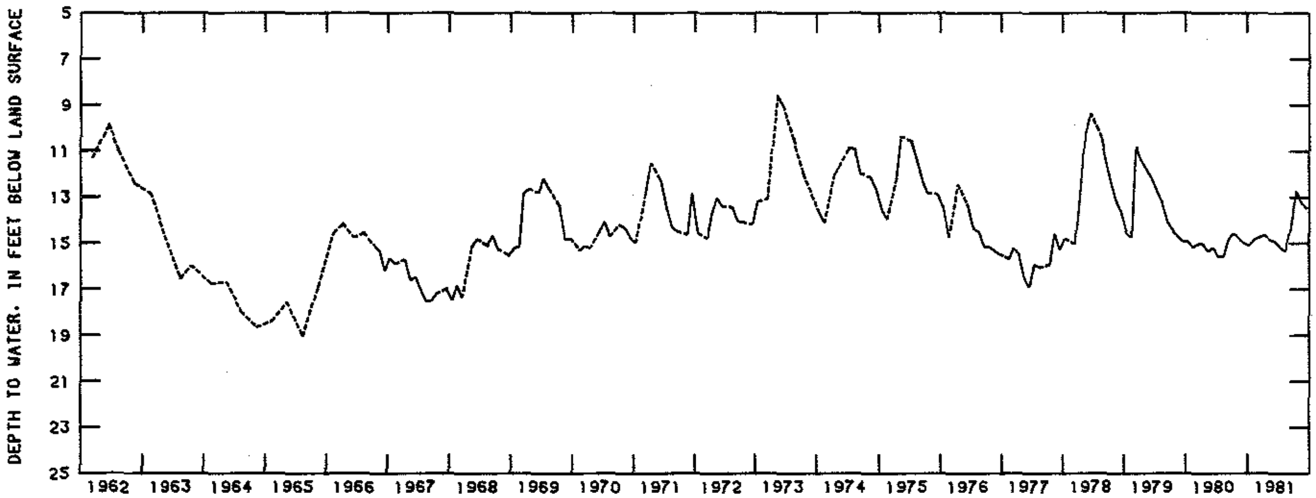
FR-36/13E/26-0056



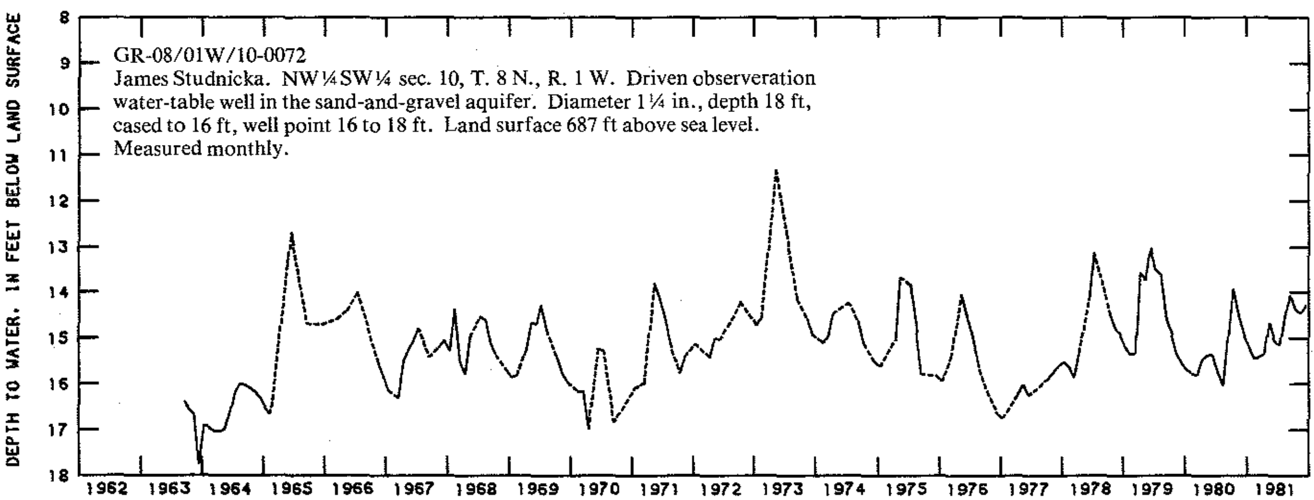
FR-40/12E/21-0087



GR-05/02W/06-0005
Homer Yelinek. SW¼SE¼ sec. 6, T. 5 N., R. 2 W. Drilled unused water-table well in the Prairie du Chien dolomite of the sandstone aquifer. Diameter 5 in., depth 35 ft, cased to 5 ft. Land surface is 980 ft above sea level. Measured monthly.

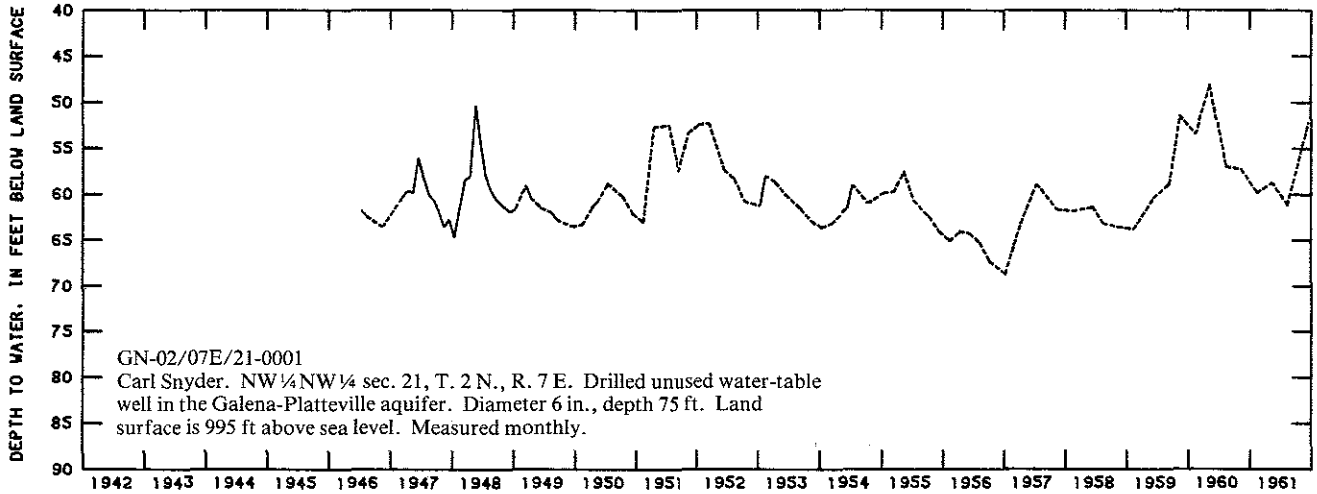


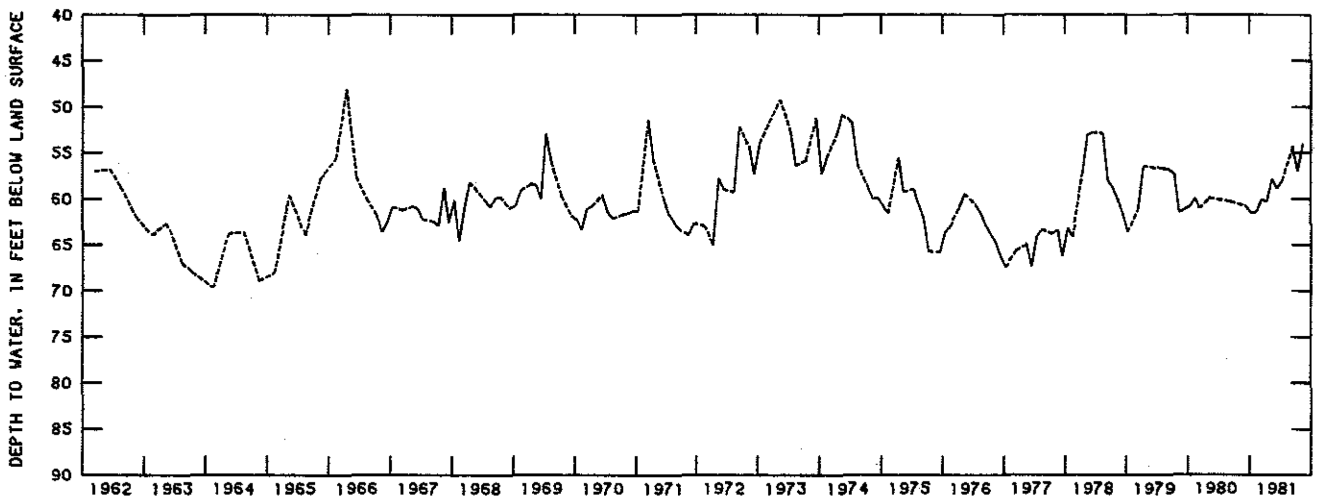
GR-05/02W/06-0005



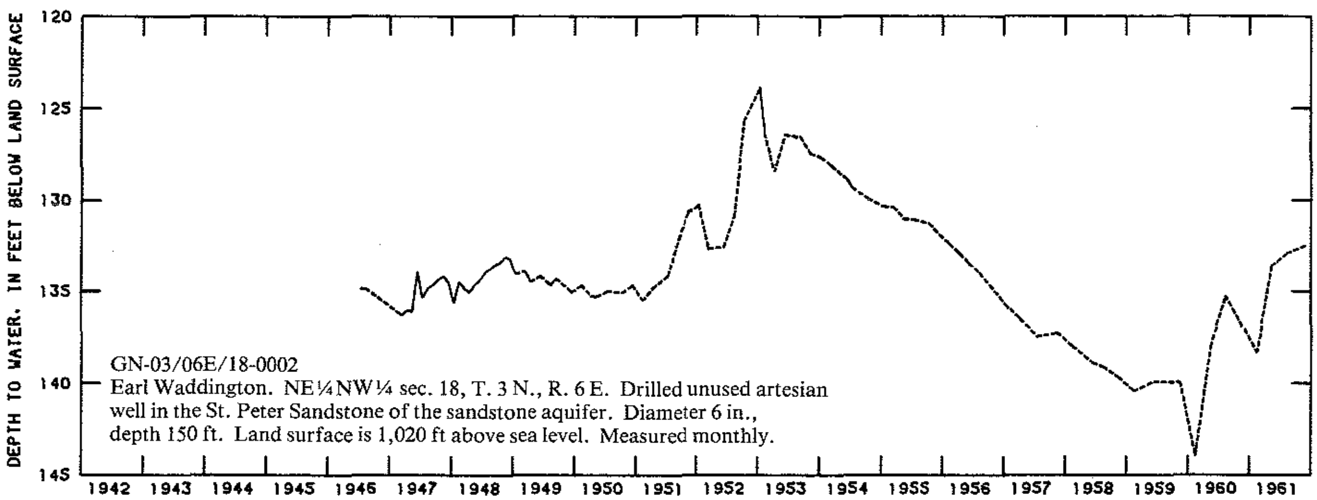
GR-08/01W/10-0072
James Studnicka. NW¼SW¼ sec. 10, T. 8 N., R. 1 W. Driven observeration water-table well in the sand-and-gravel aquifer. Diameter 1¼ in., depth 18 ft, cased to 16 ft, well point 16 to 18 ft. Land surface 687 ft above sea level. Measured monthly.

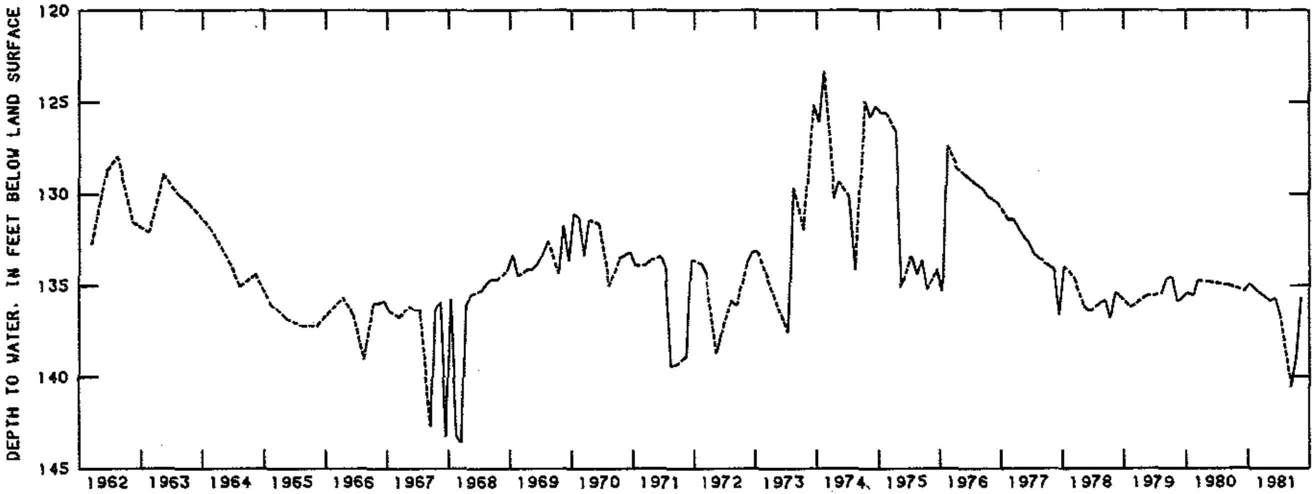
GR-08/01W/10-0072



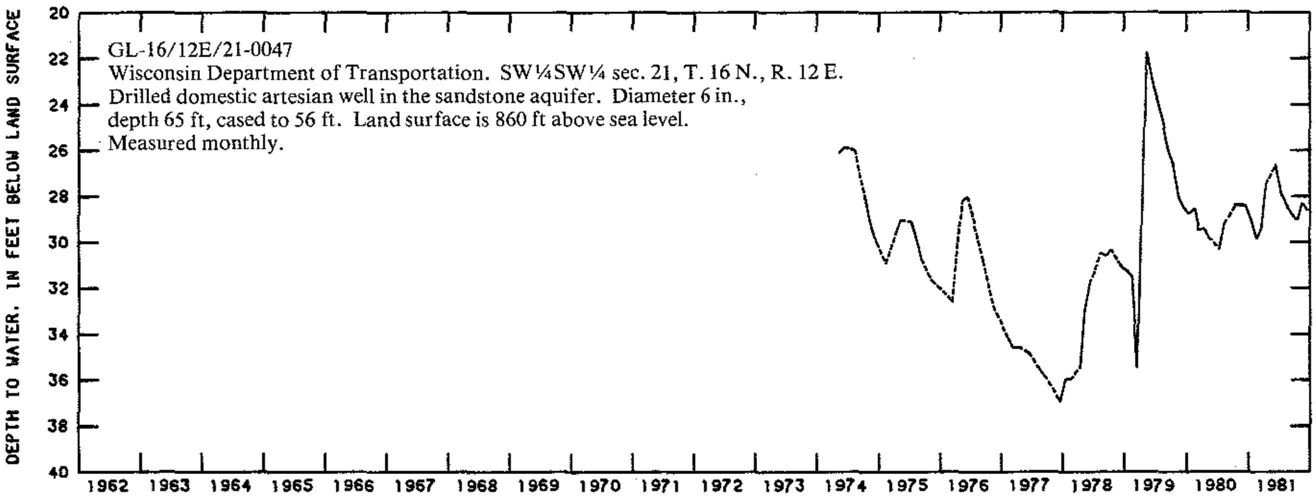


GN-02/07E/21-0001

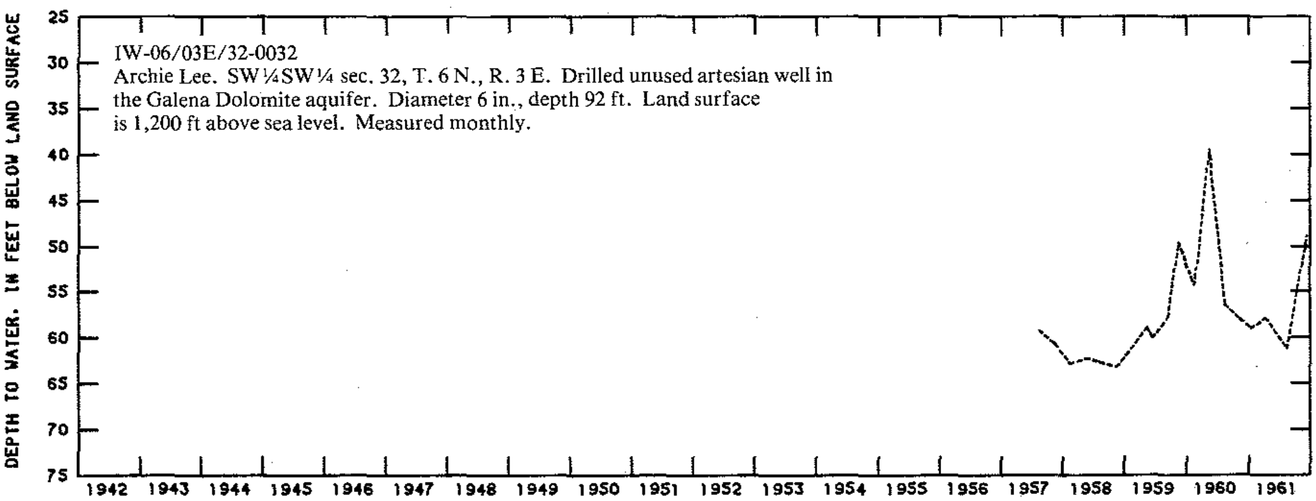


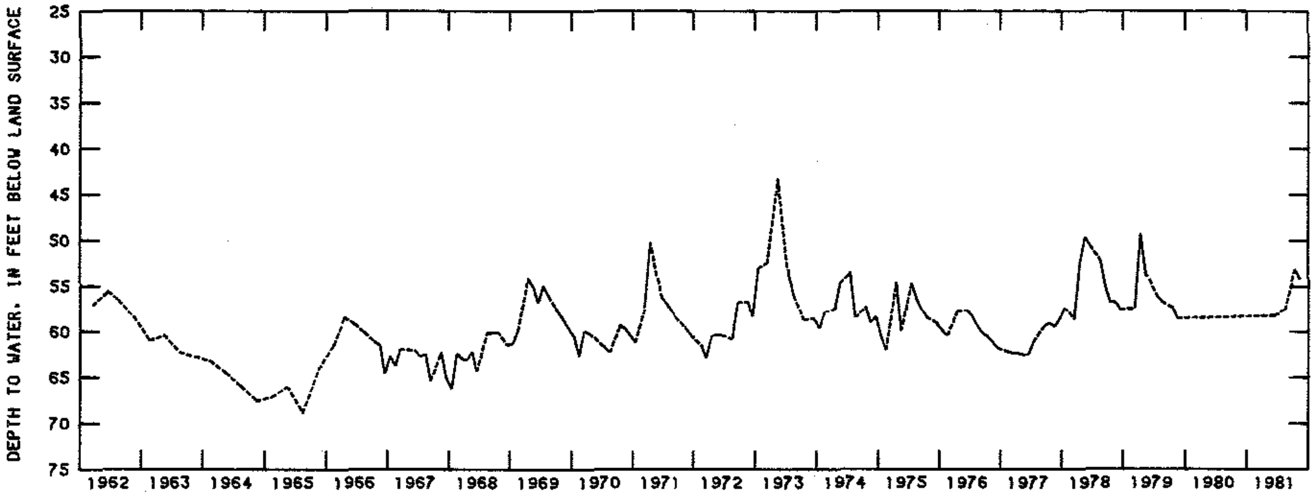


GN-03/06E/18-0002

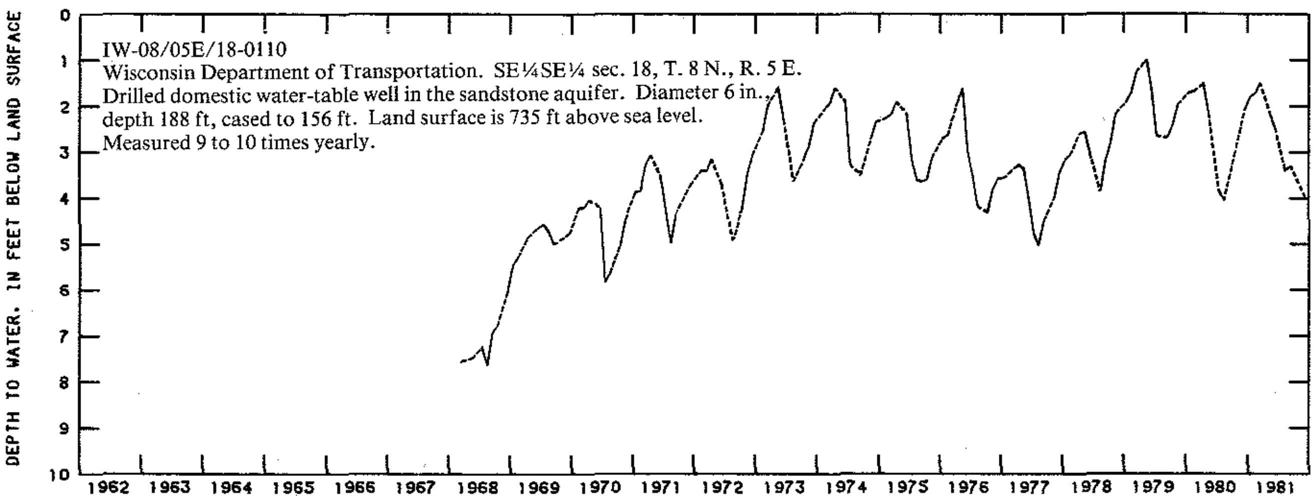


GL-16/12E/21-0047

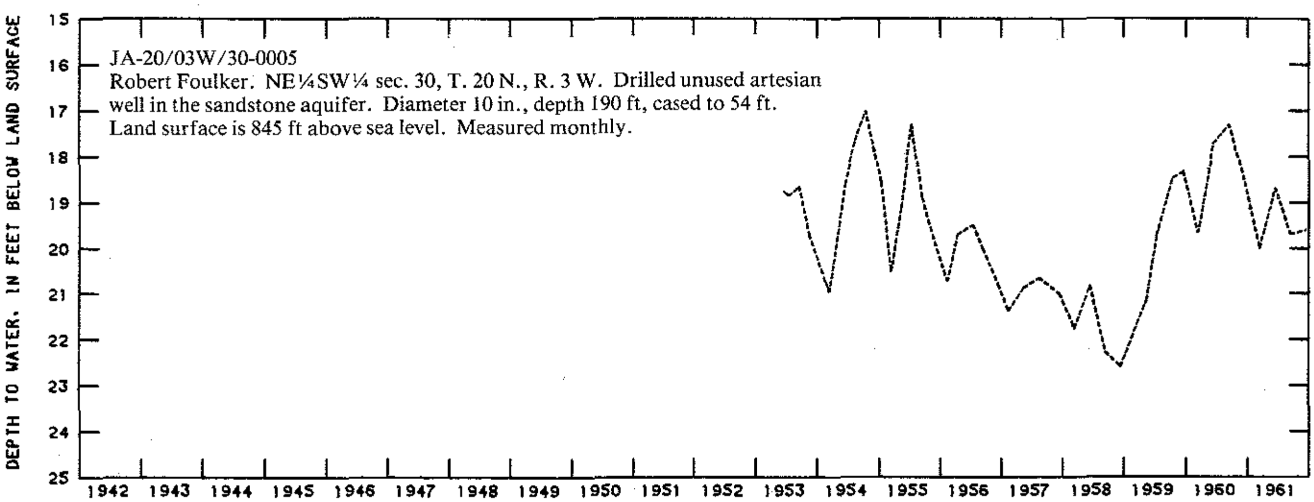


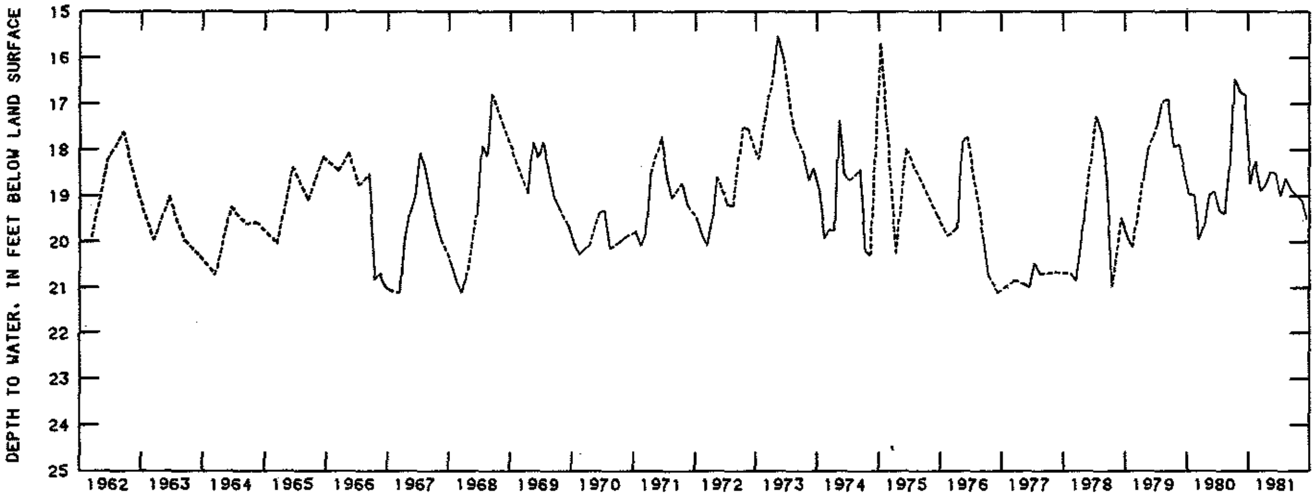


IW-06/03E/32-0032

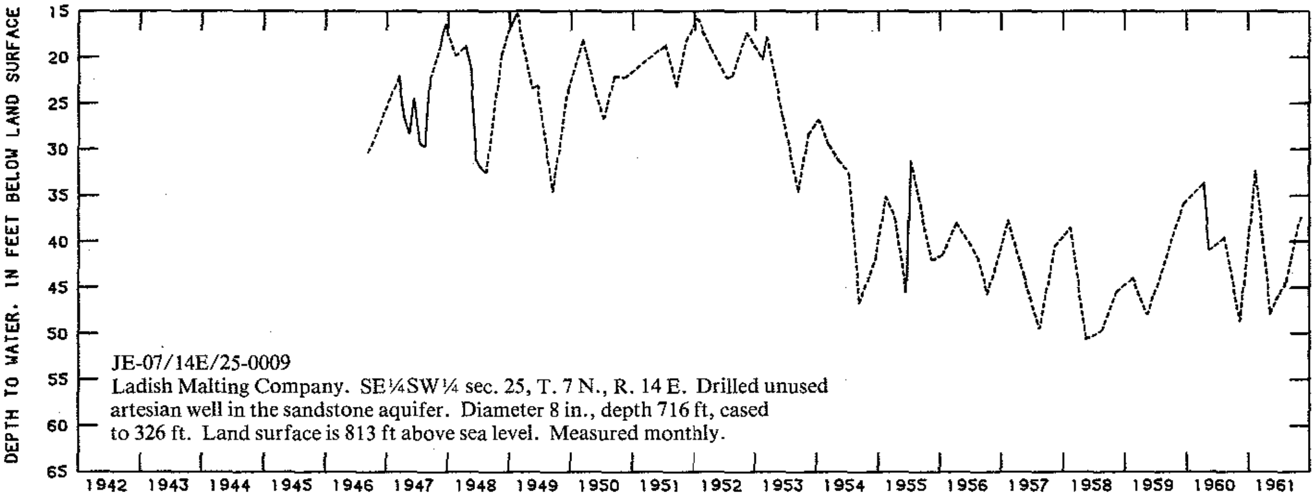


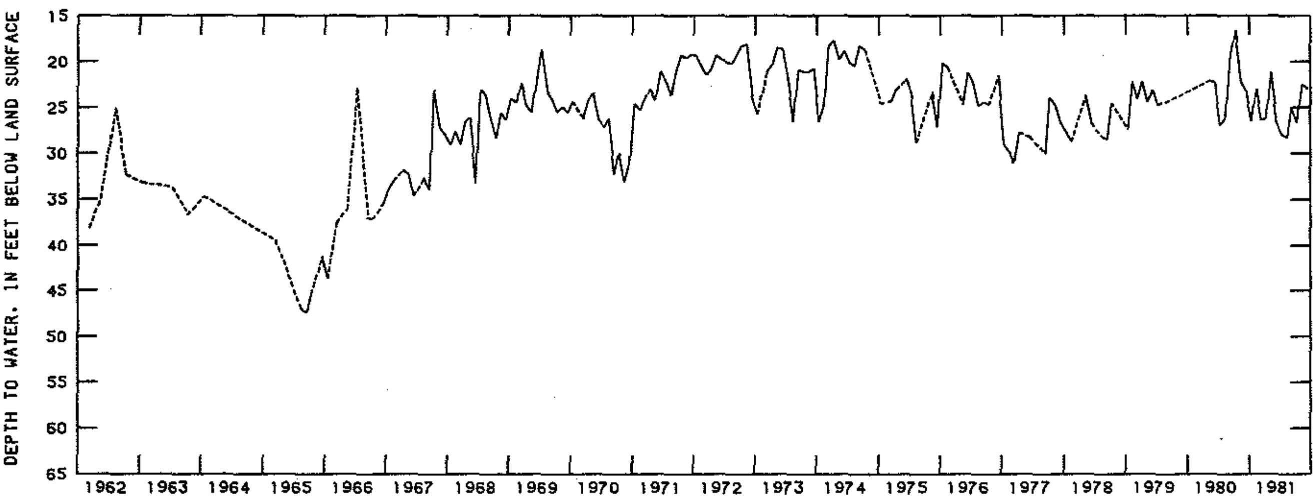
IW-08/05E/18-0110



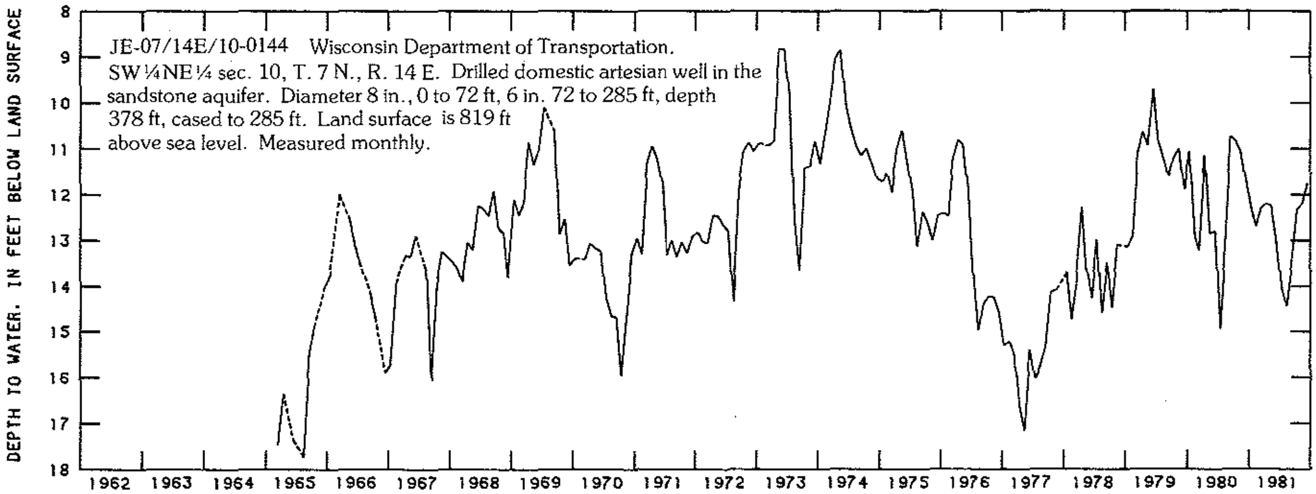


JA-20/03W/30-0005





JE-07/14E/25-0009



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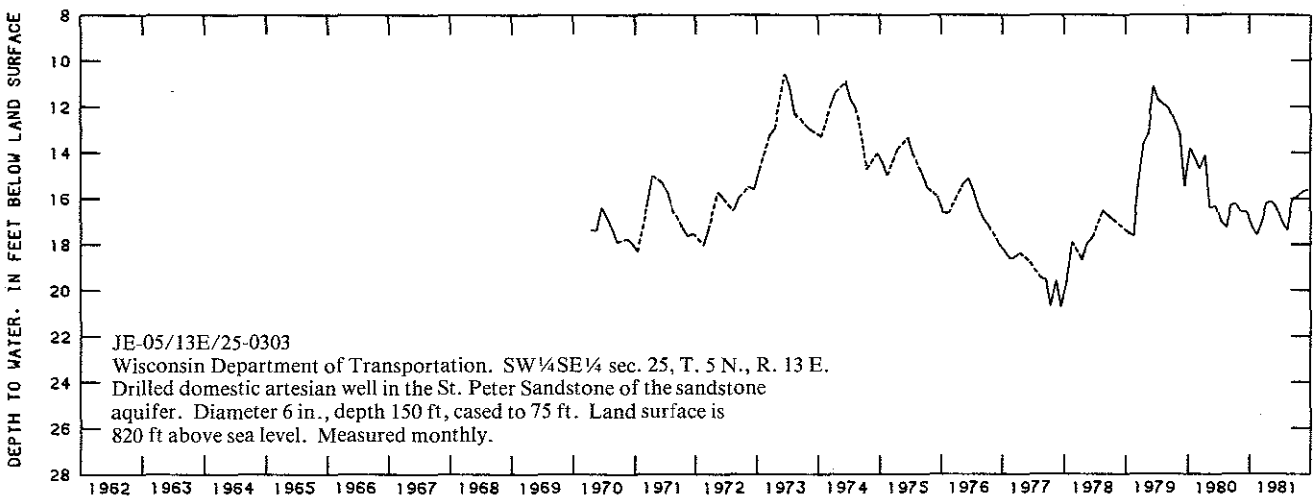
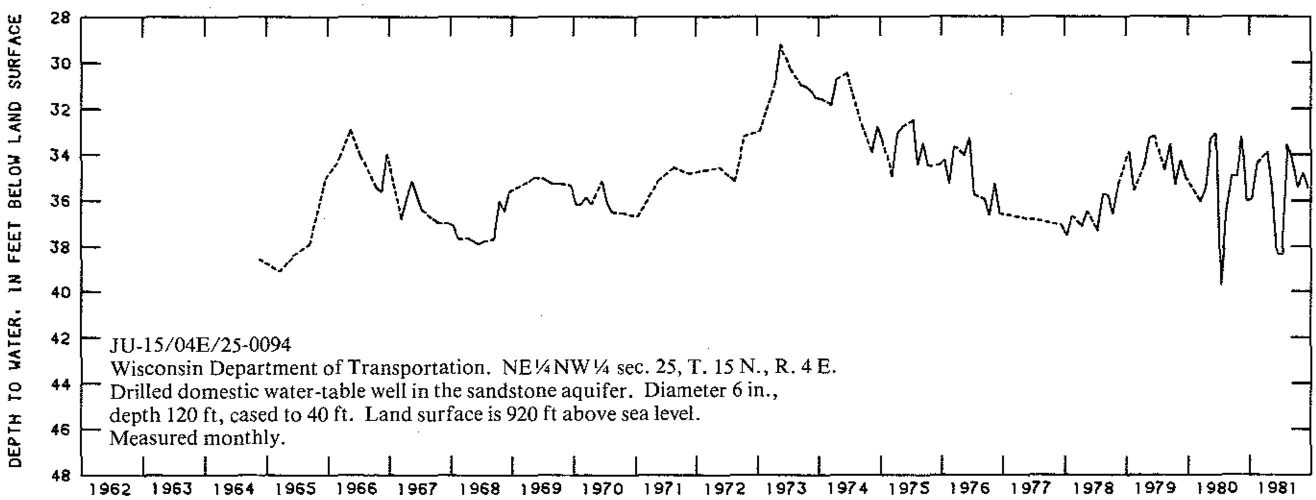
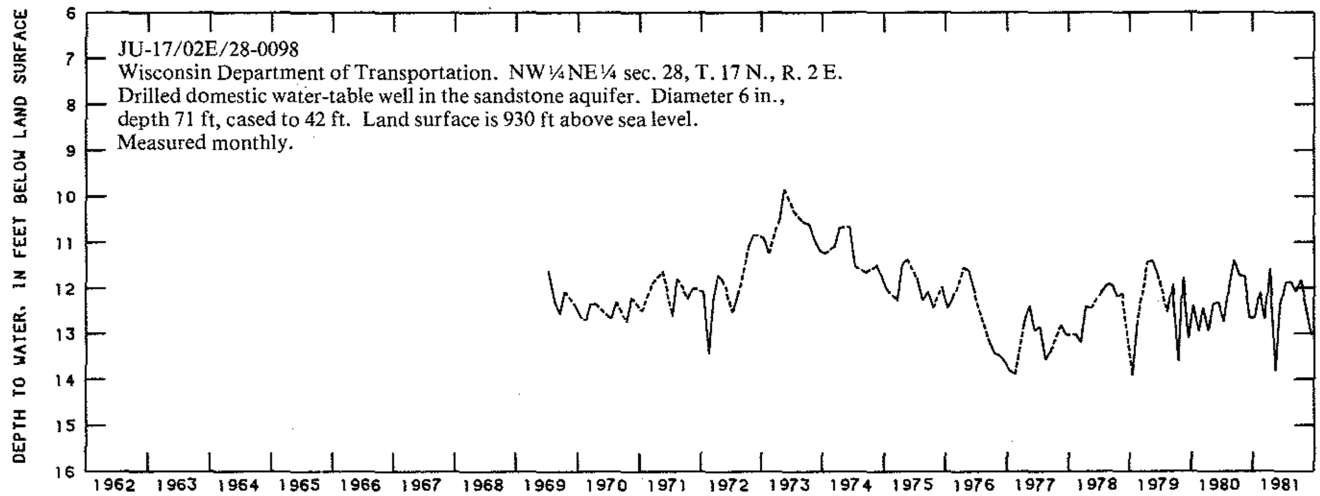


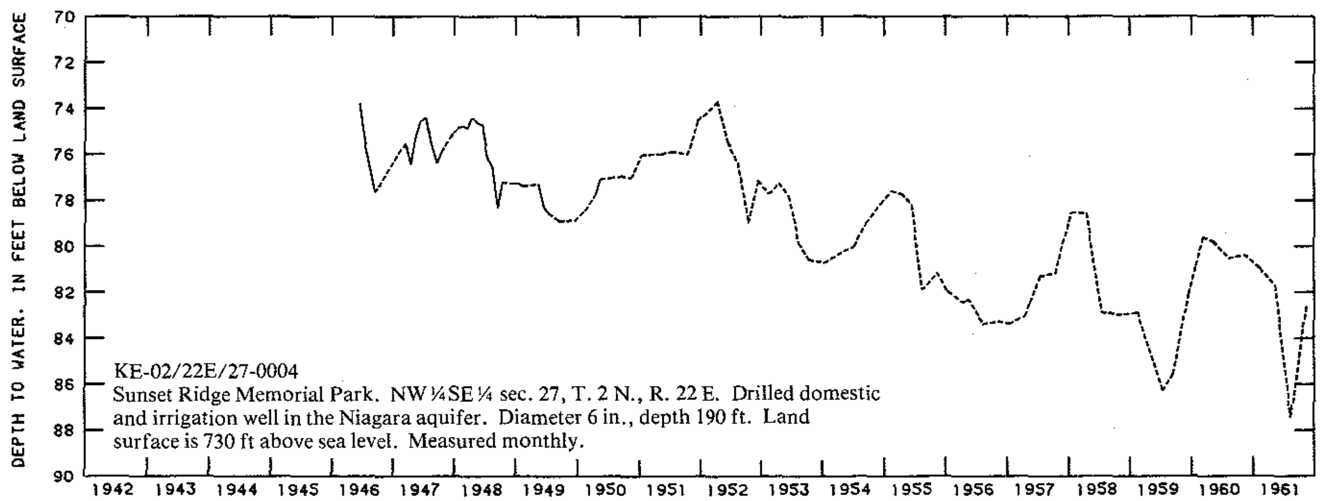
JE-05/13E/25-0303

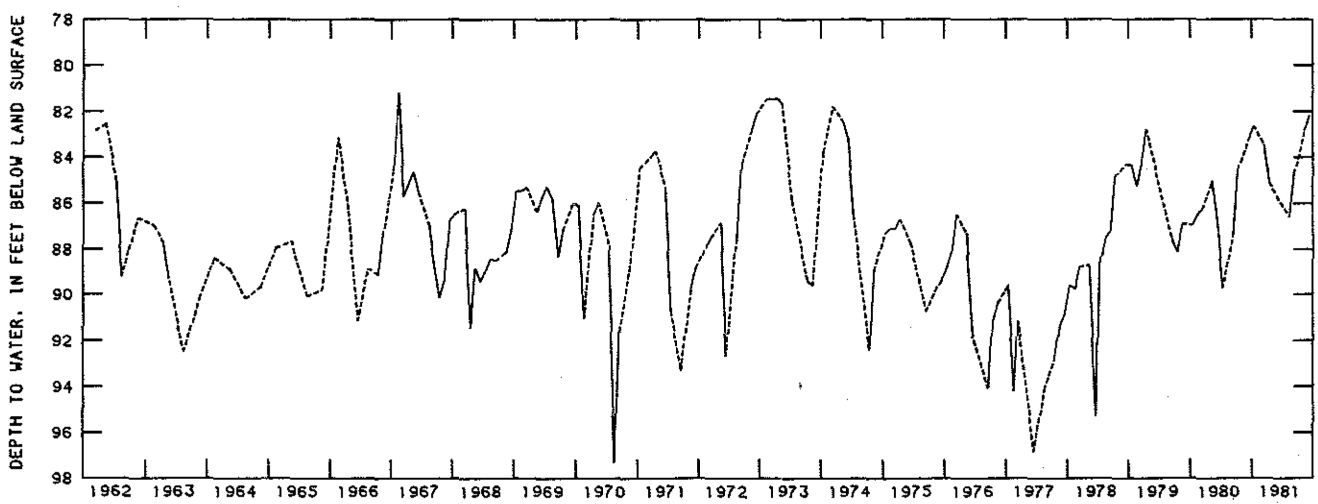


JU-15/04E/25-0094

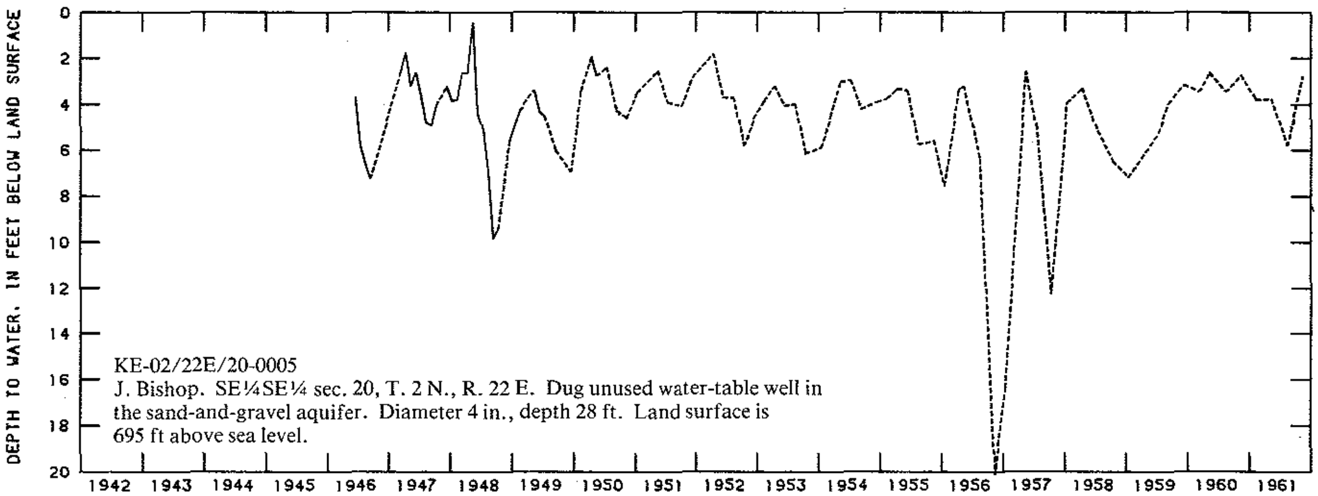


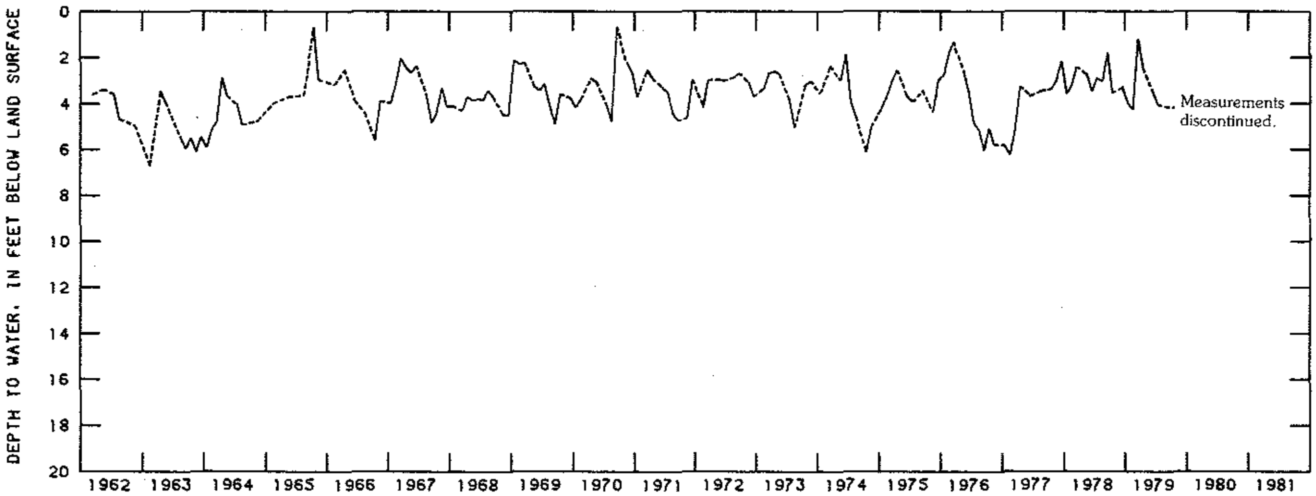
JU-17/02E/28-0098



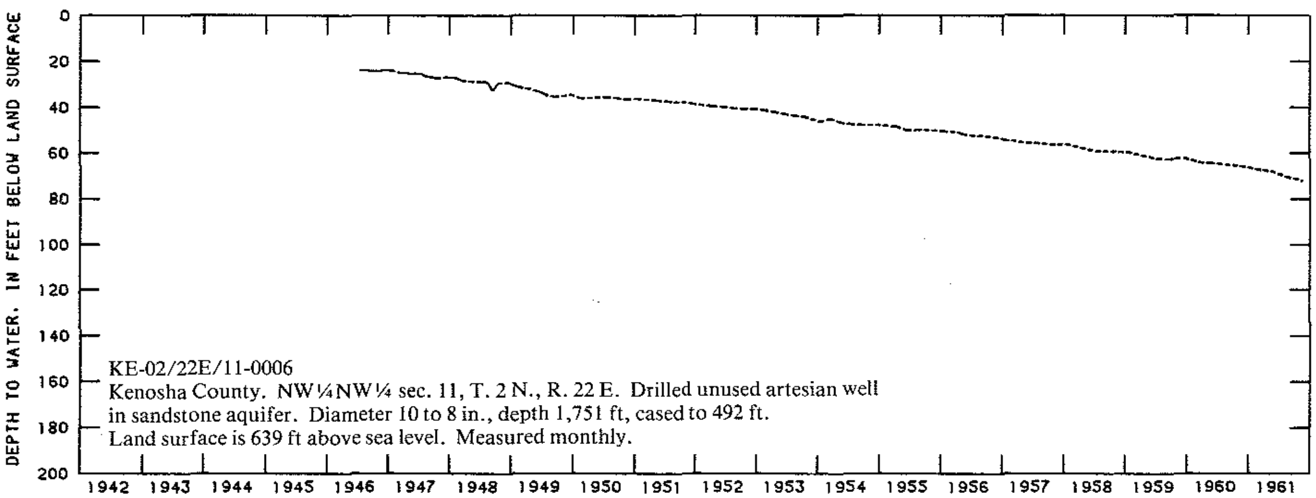


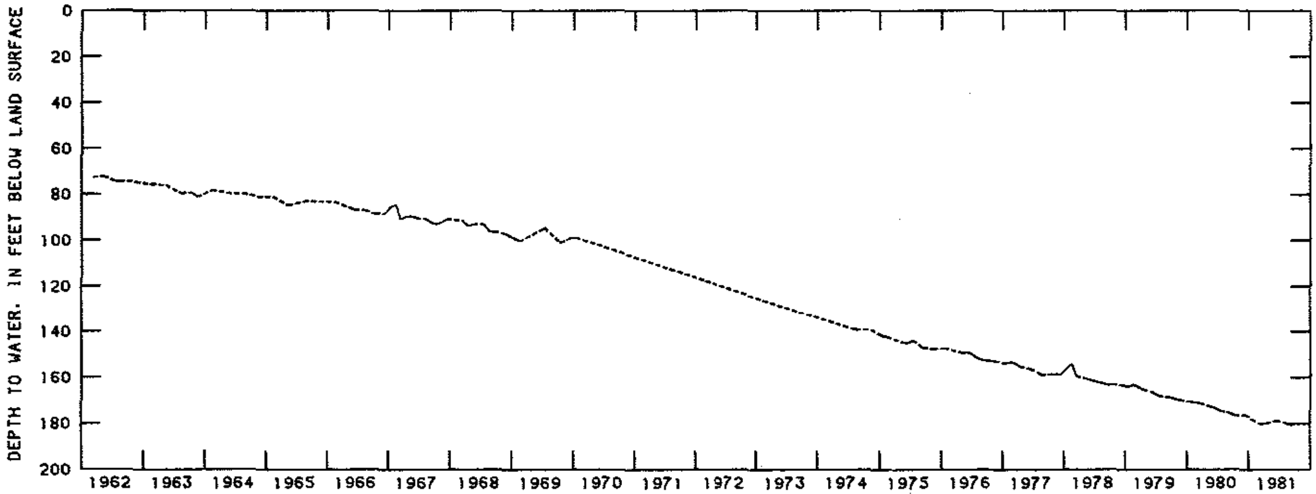
KE-02/22E/27-0004





KE-02/22E/20-0005





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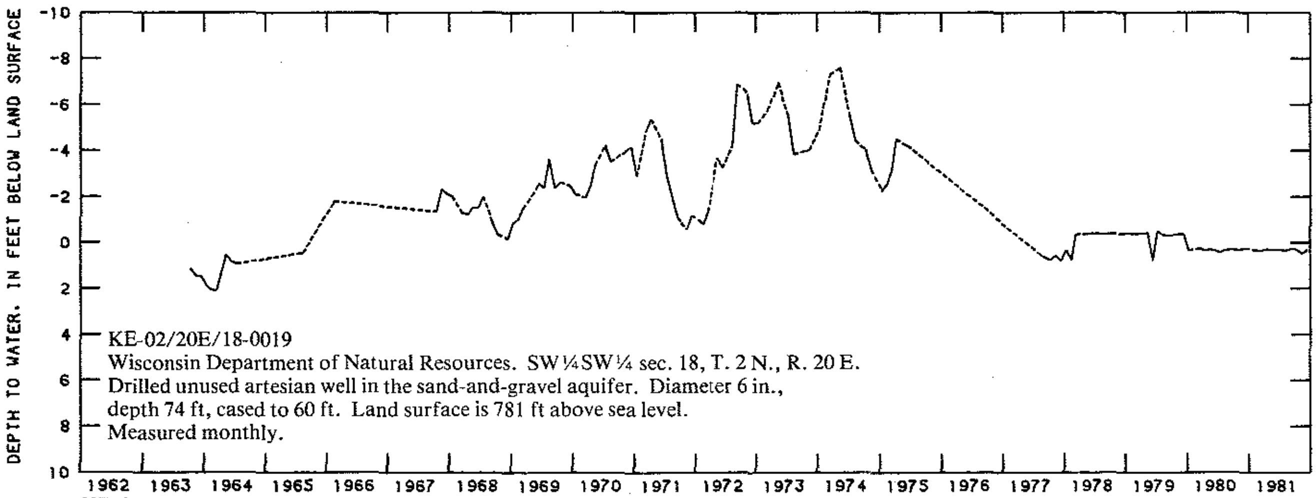
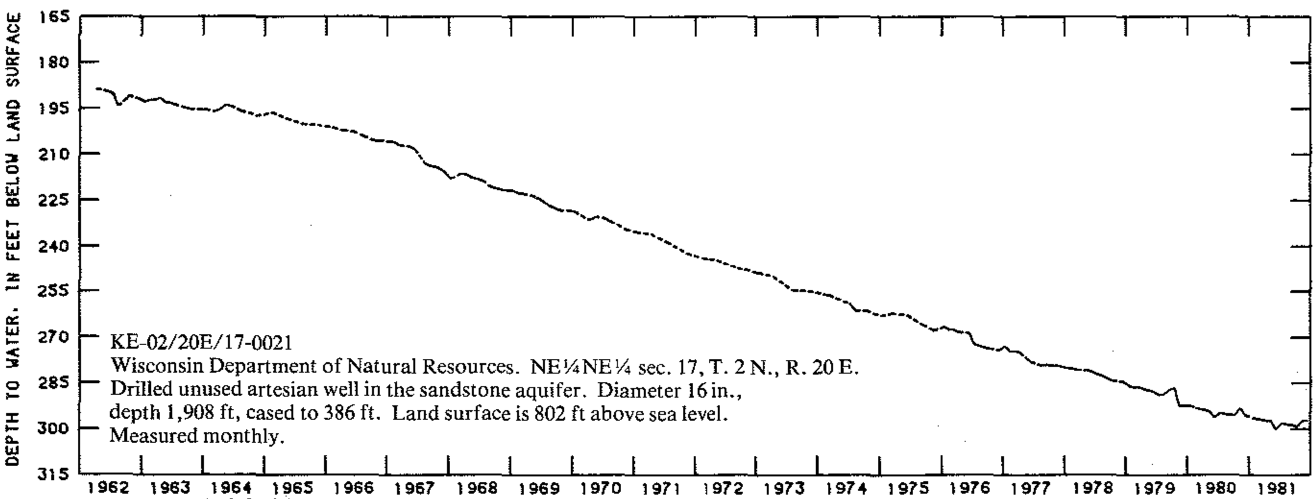
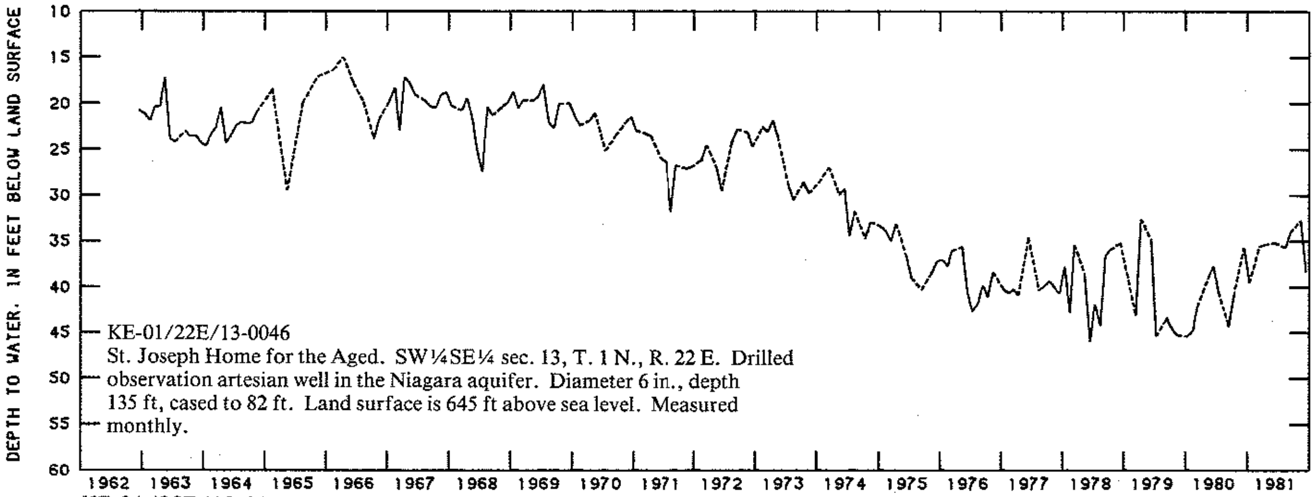


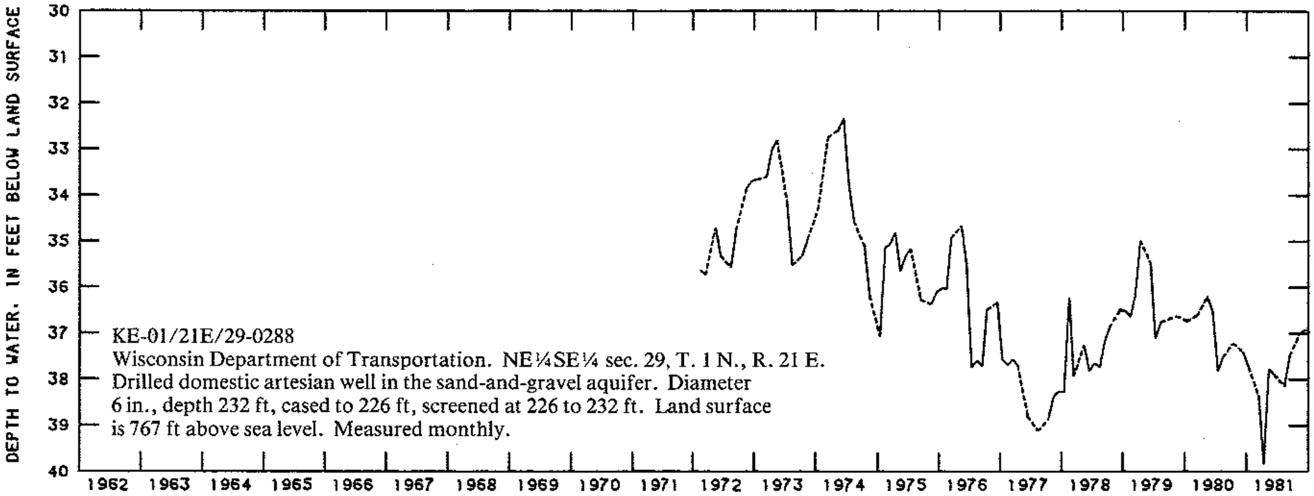
KE-02/20E/18-0019



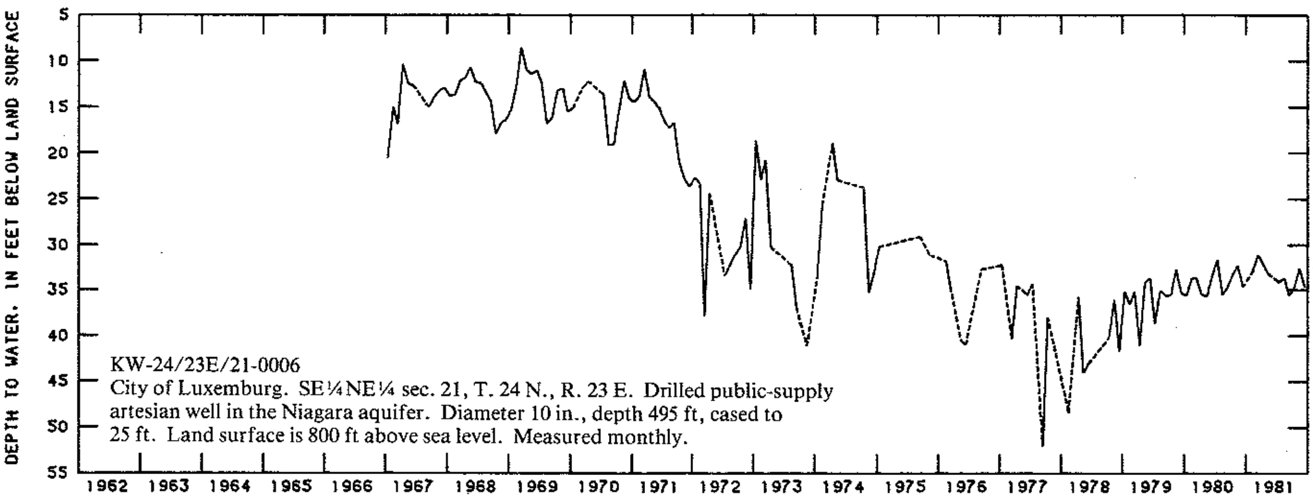
KE-02/20E/17-0021



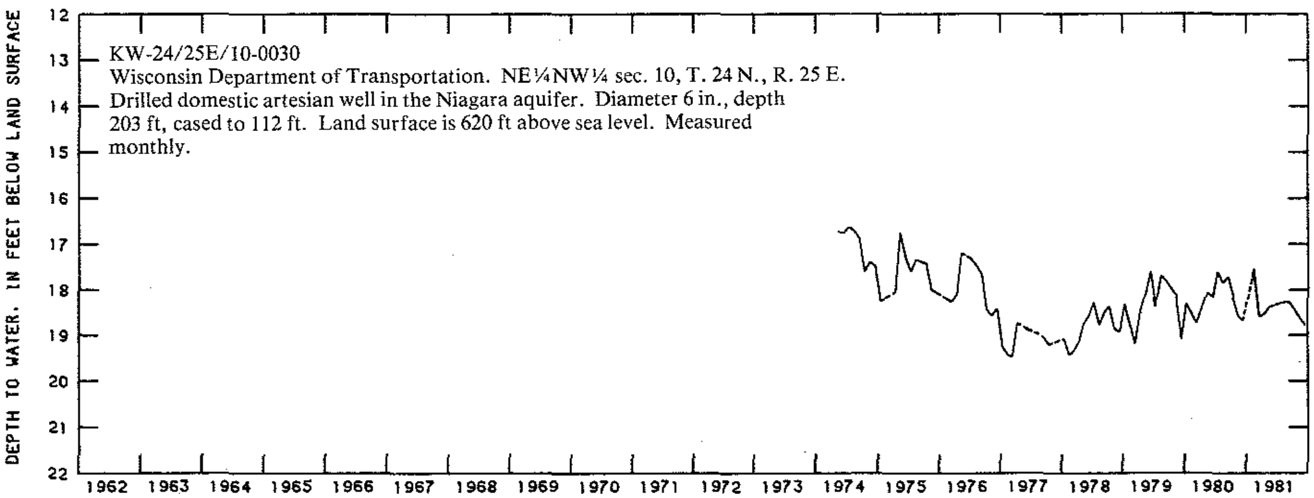
KE-01/22E/13-0046



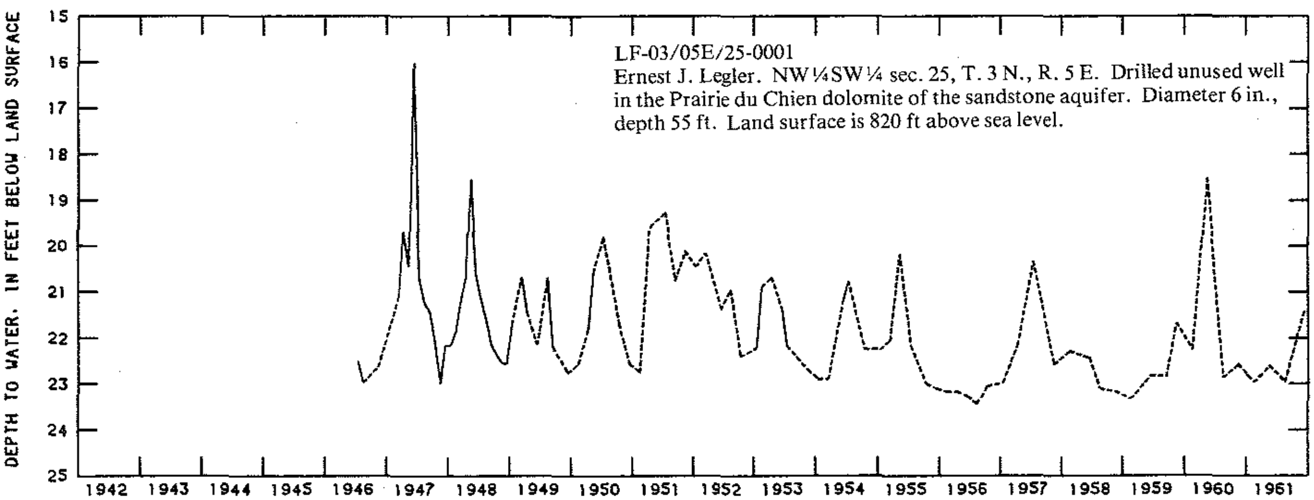
KE-01/21E/29-0288

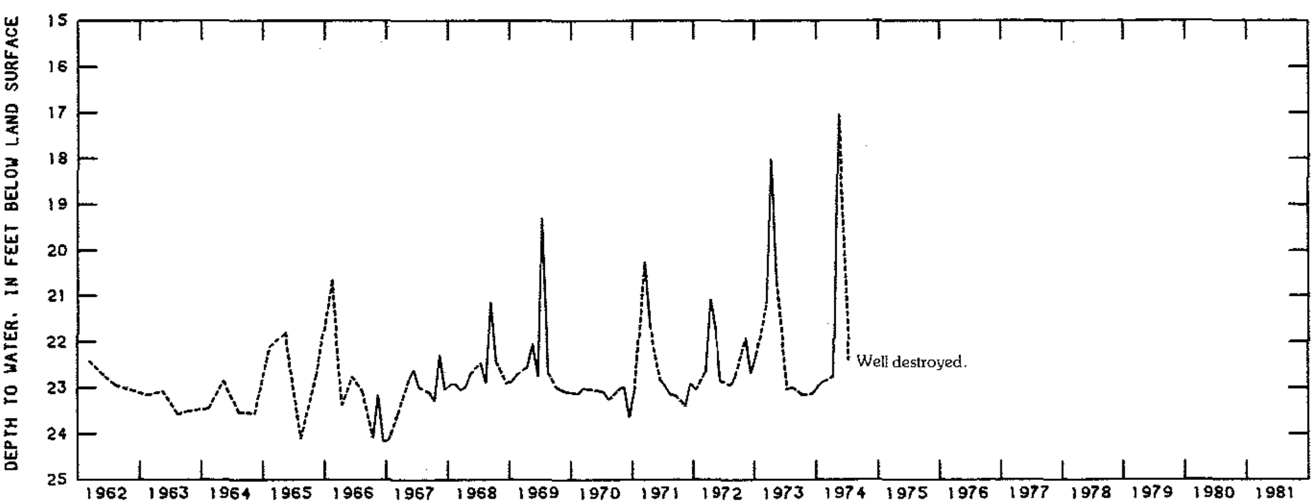


KW-24/23E/21-0006

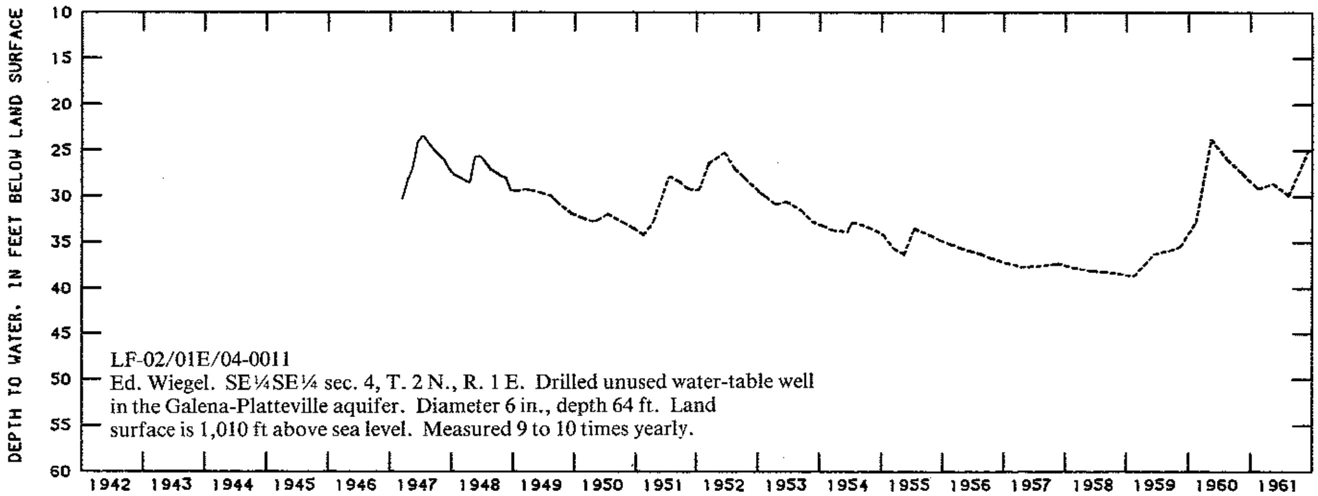


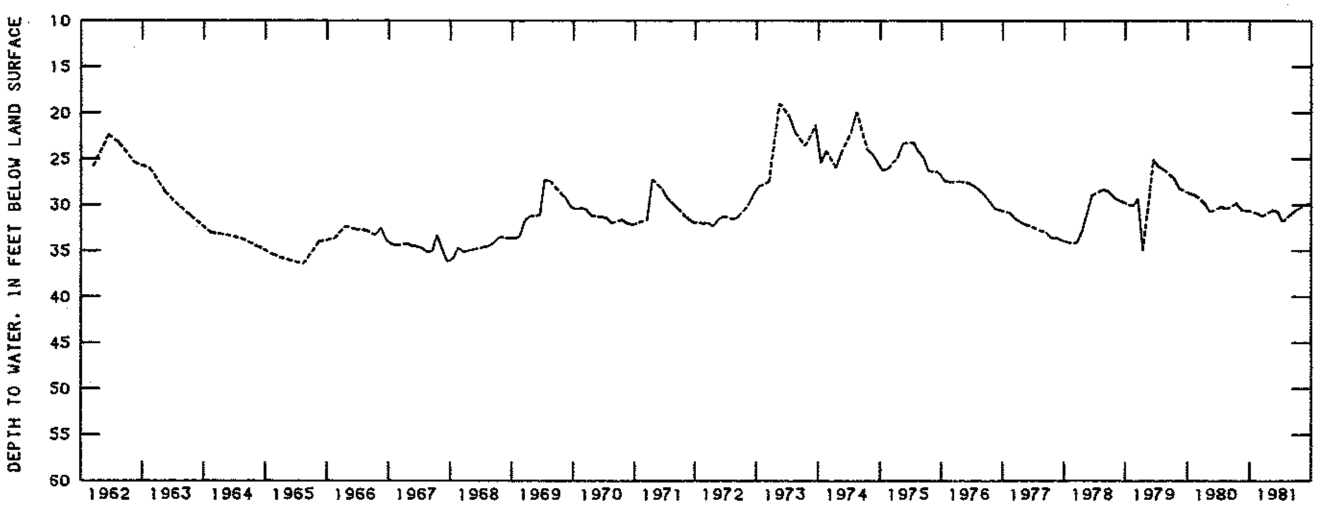
KW-24/25E/10-0030





LF-03/05E/25-0001





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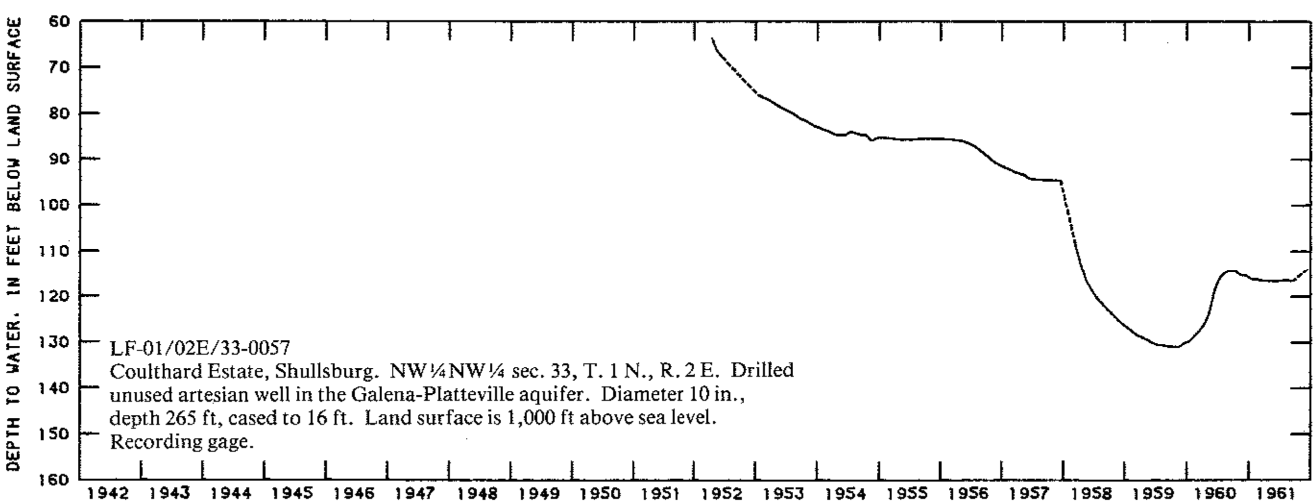

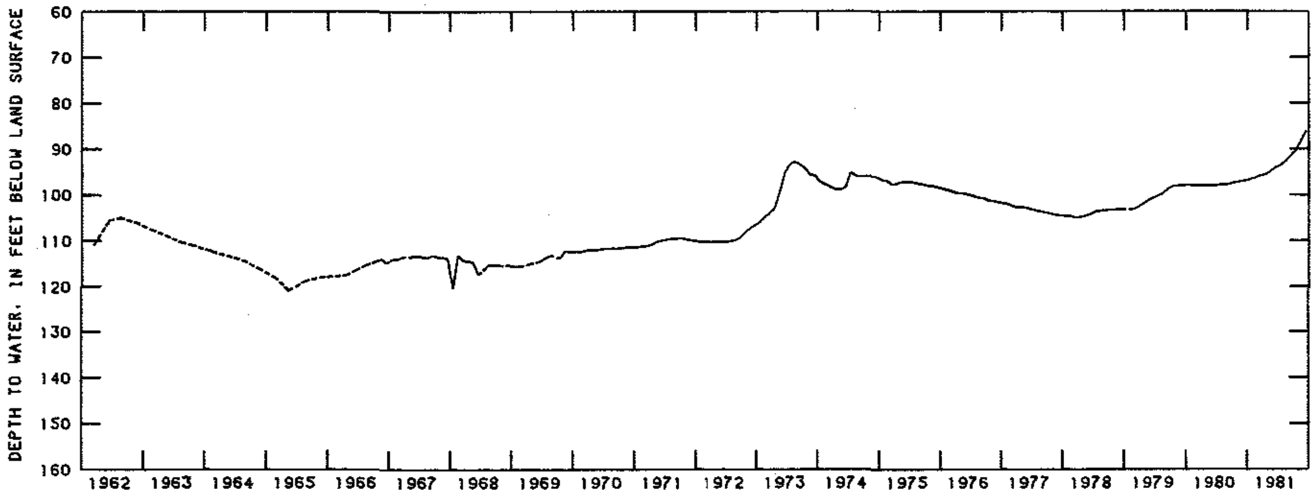

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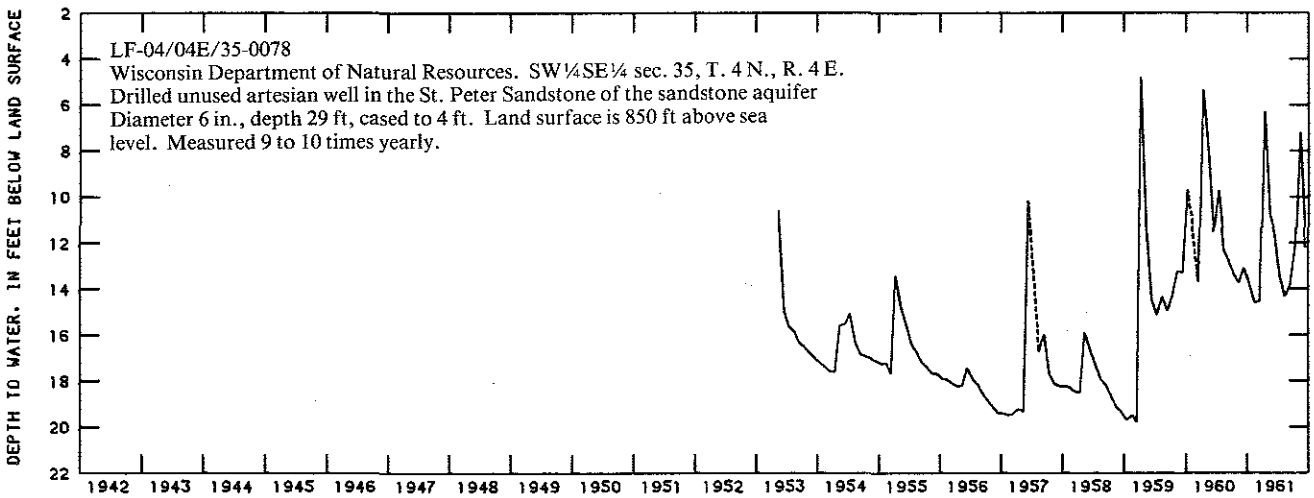
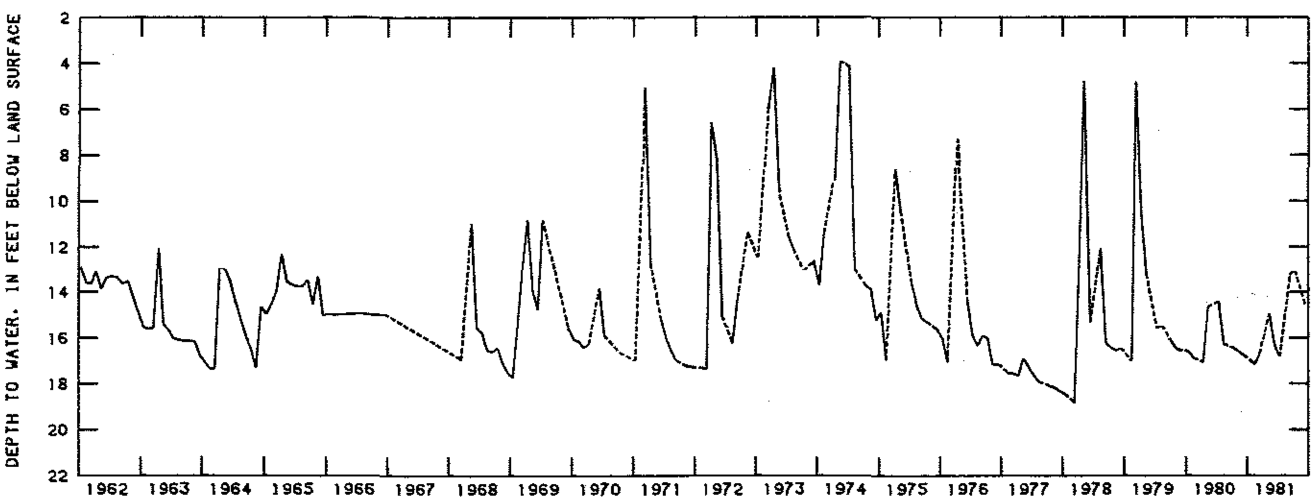
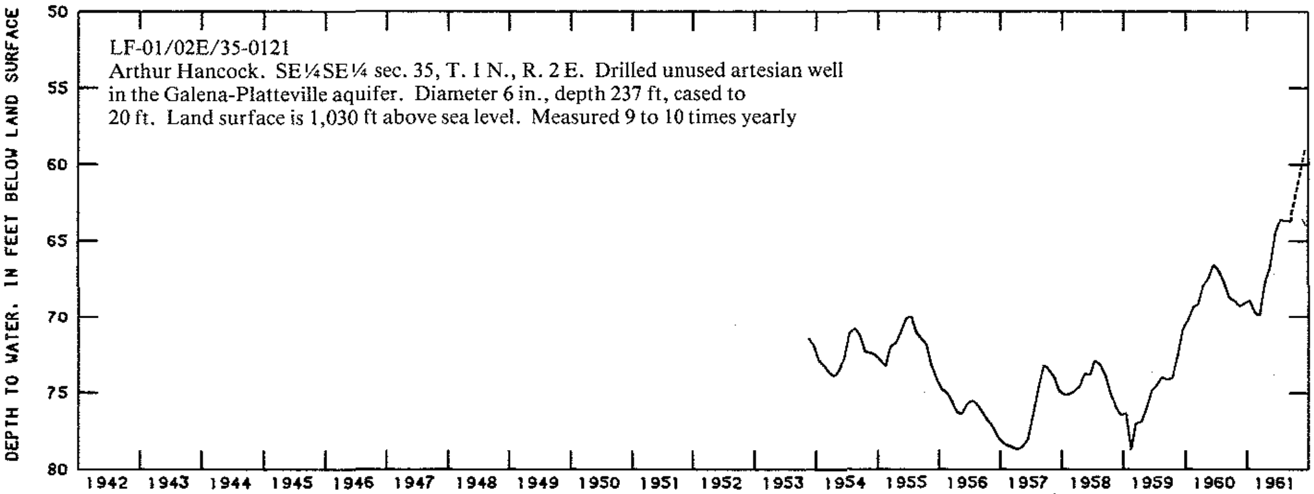
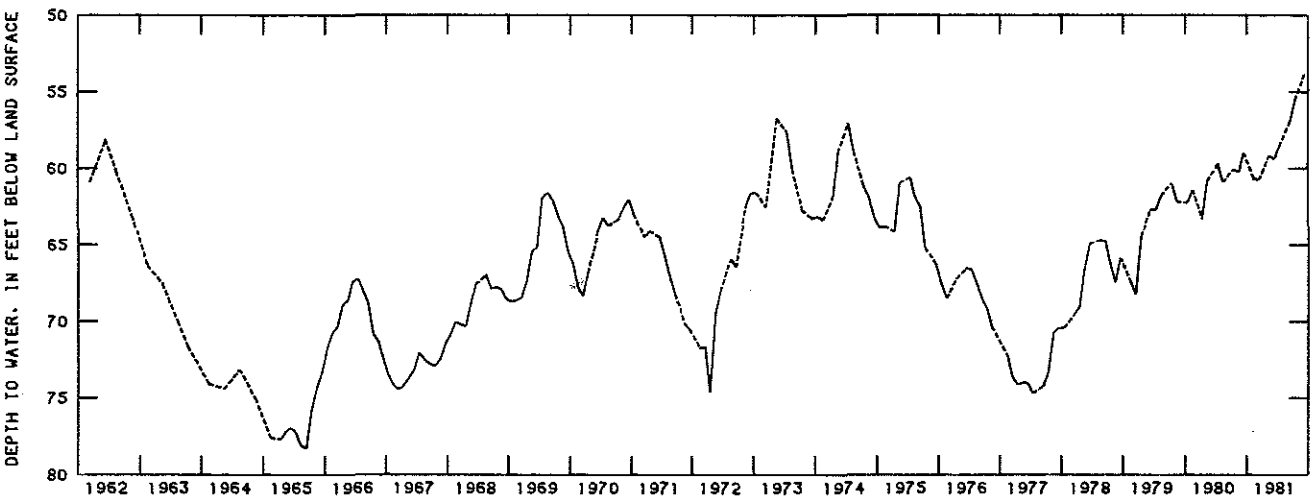




LF-04/04E/35-0078





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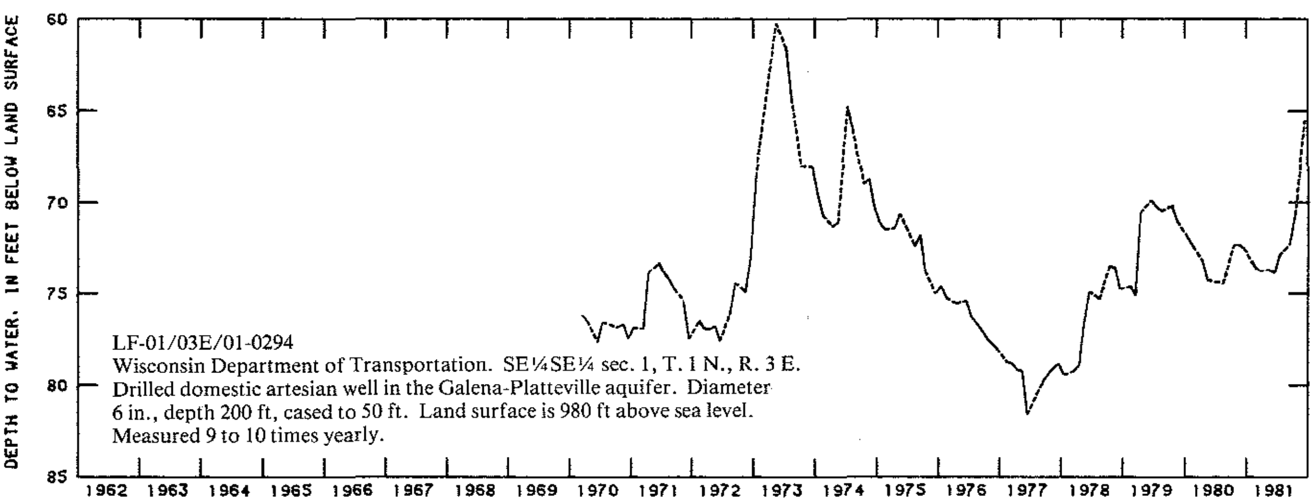

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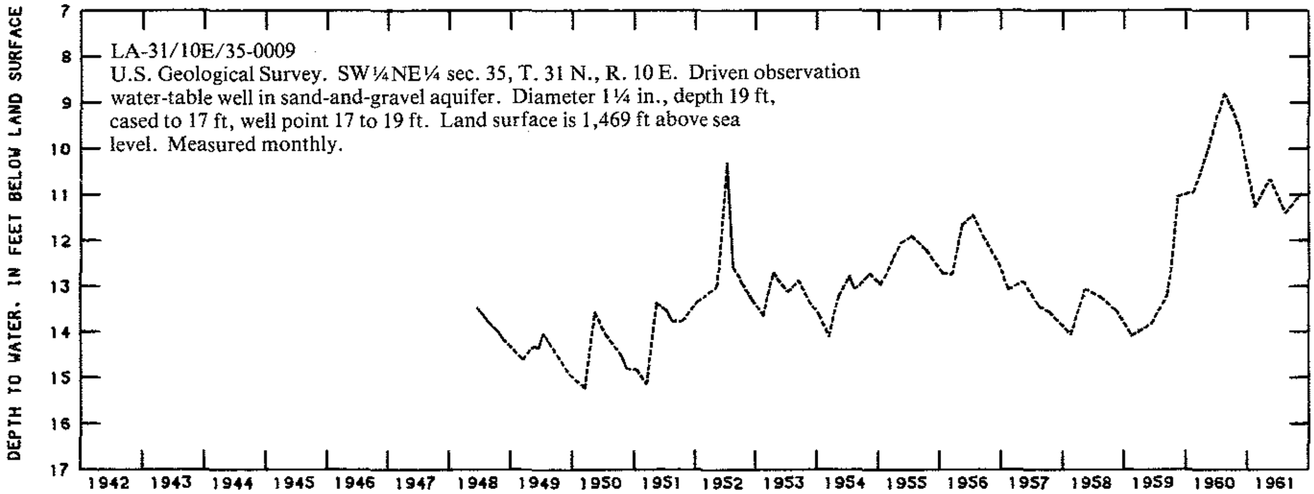

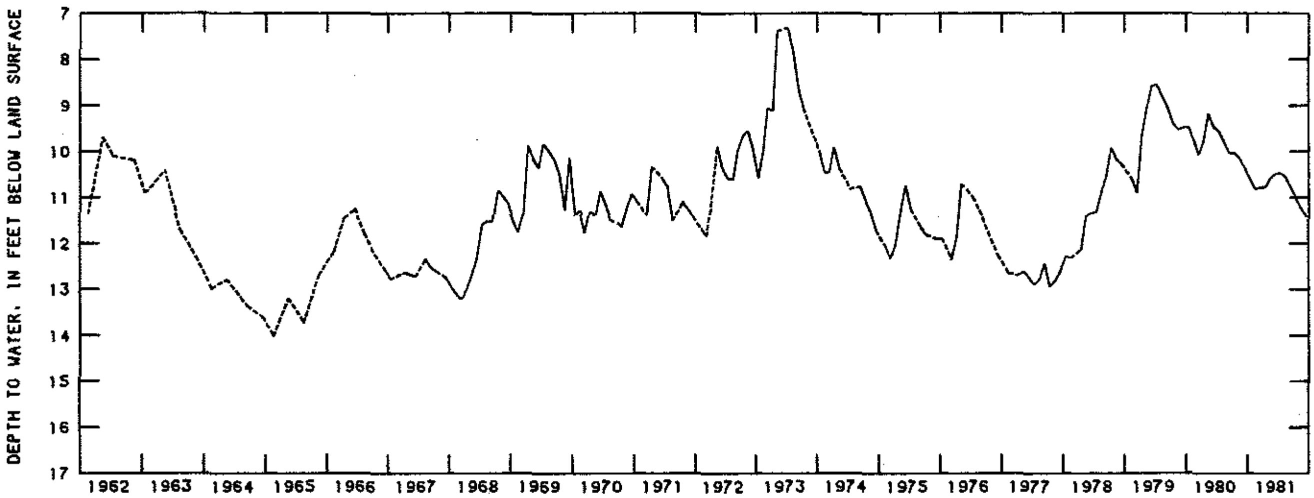

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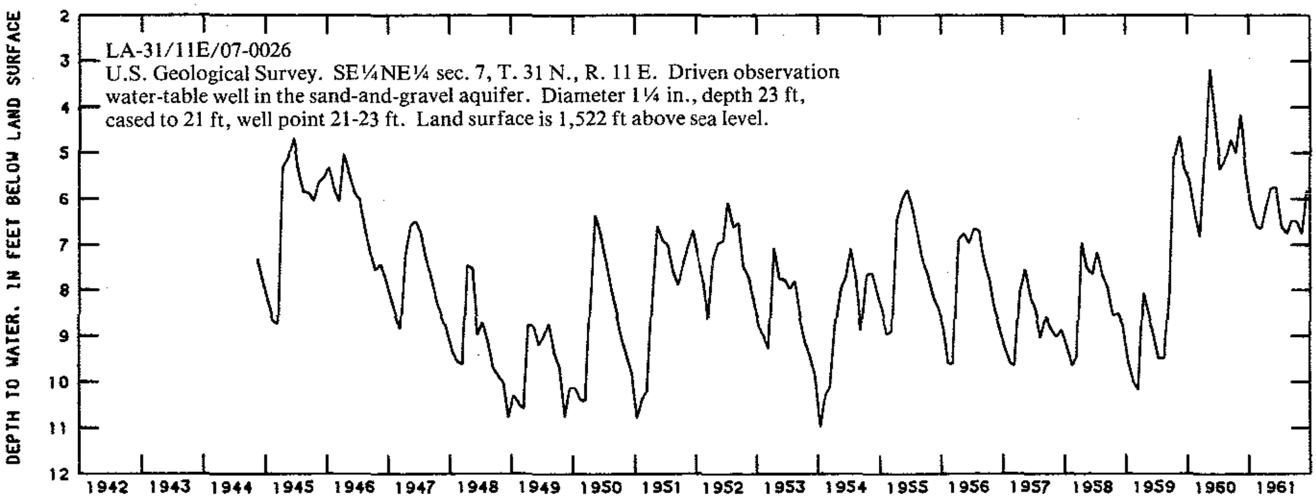

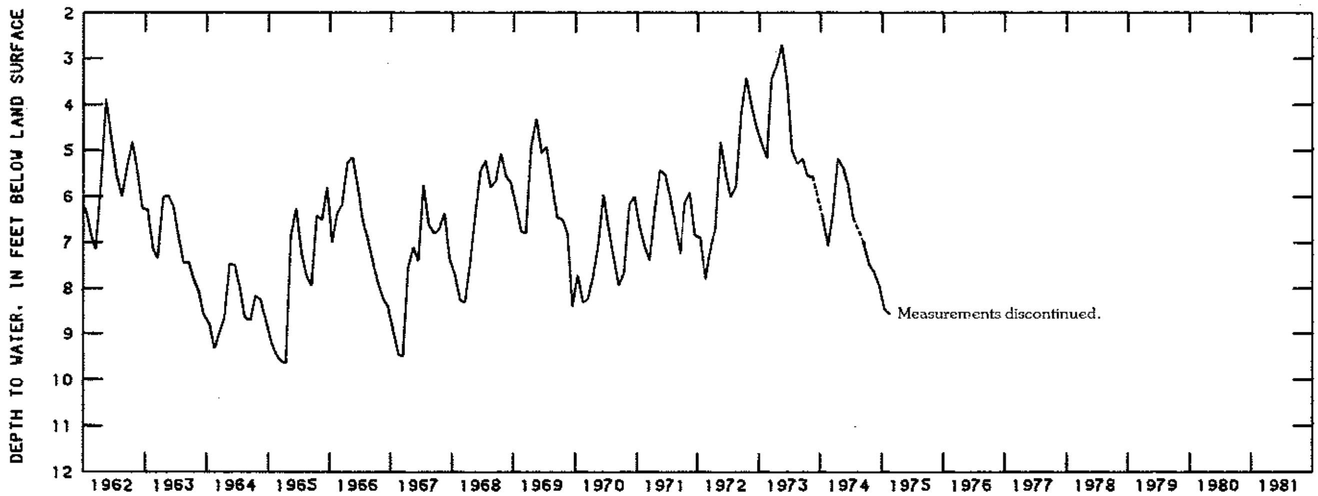

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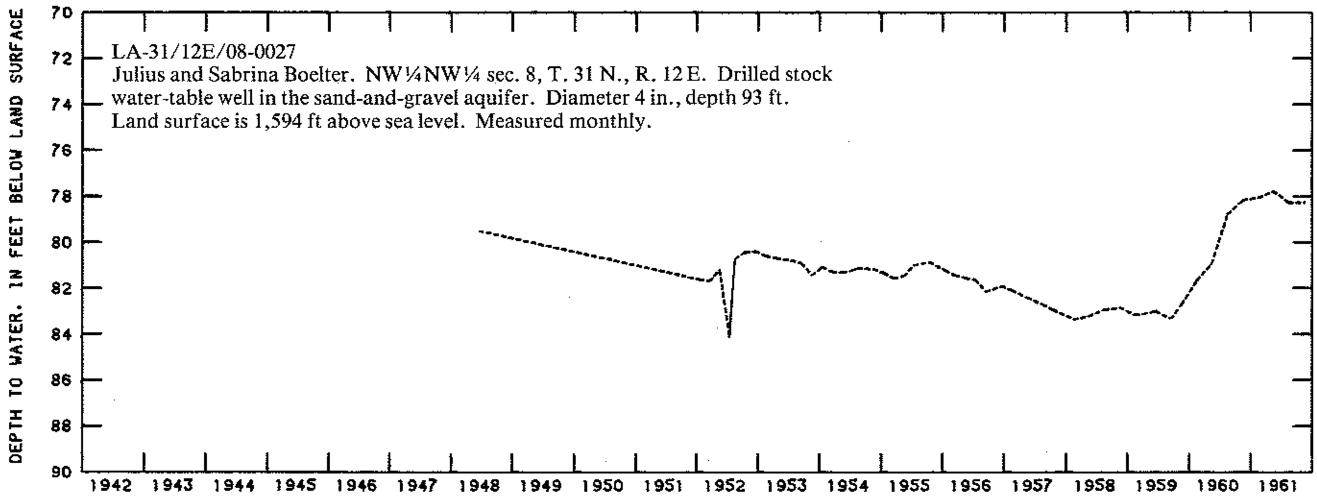

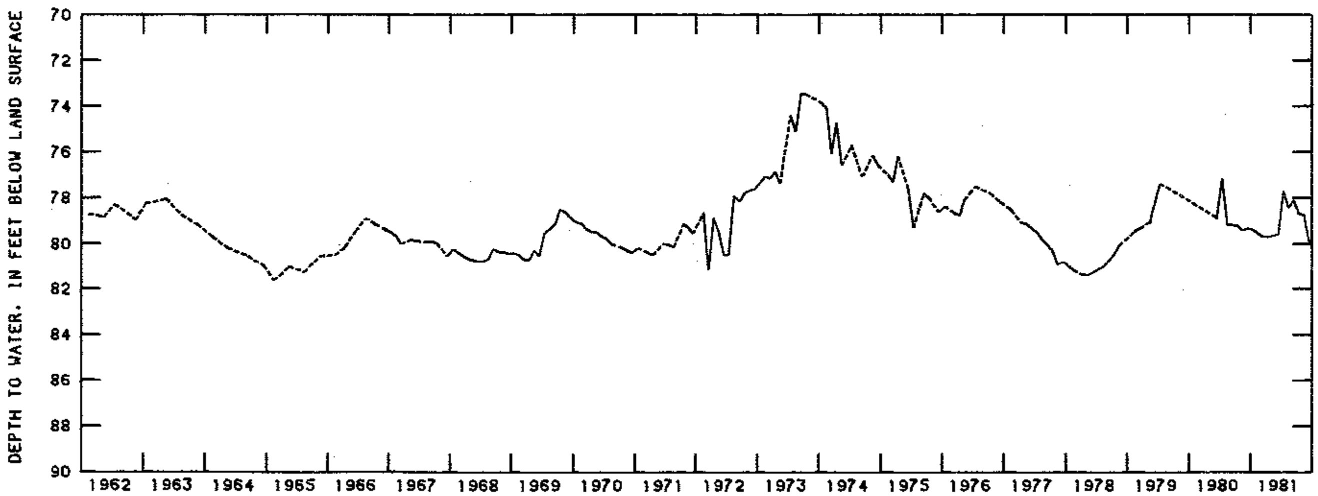

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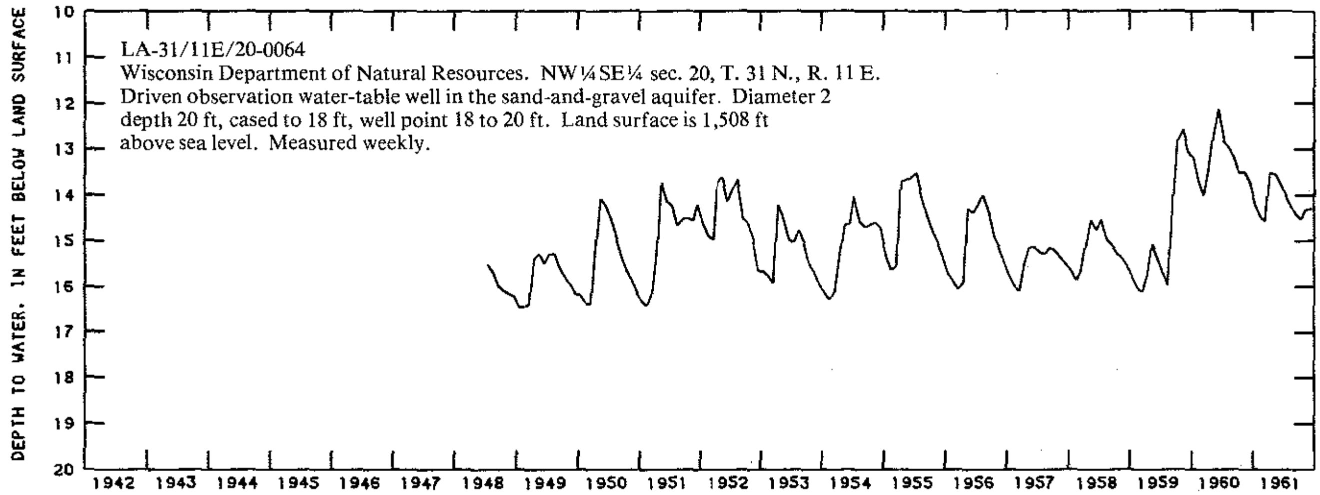

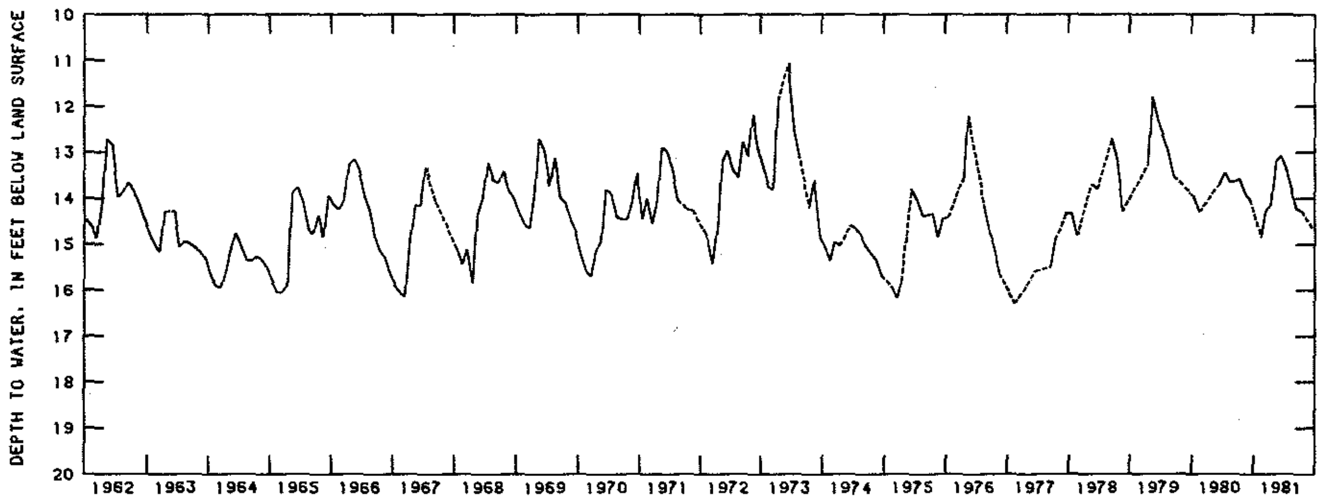

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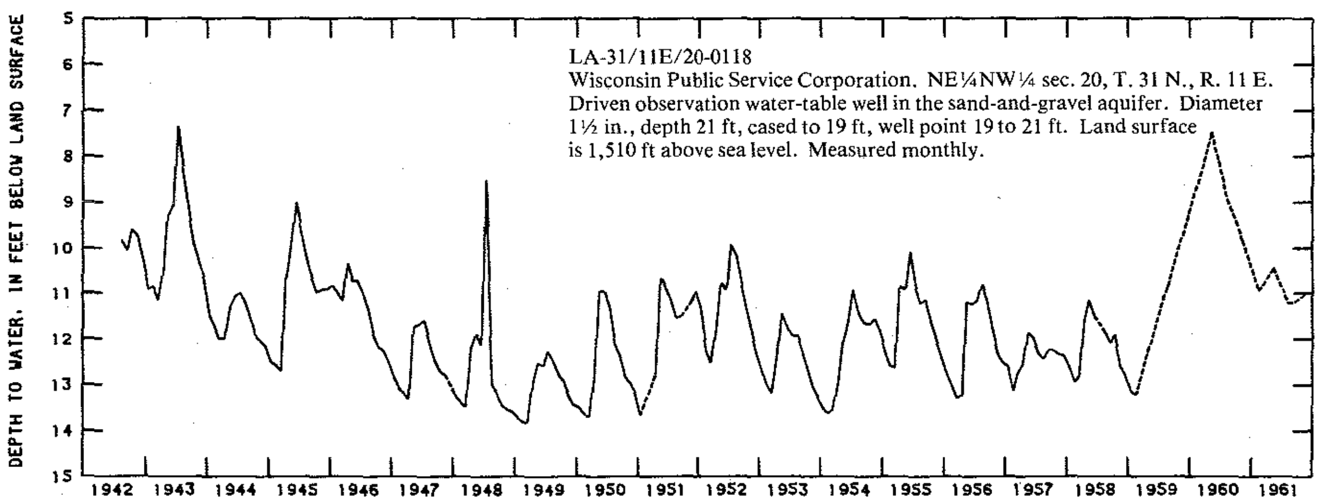

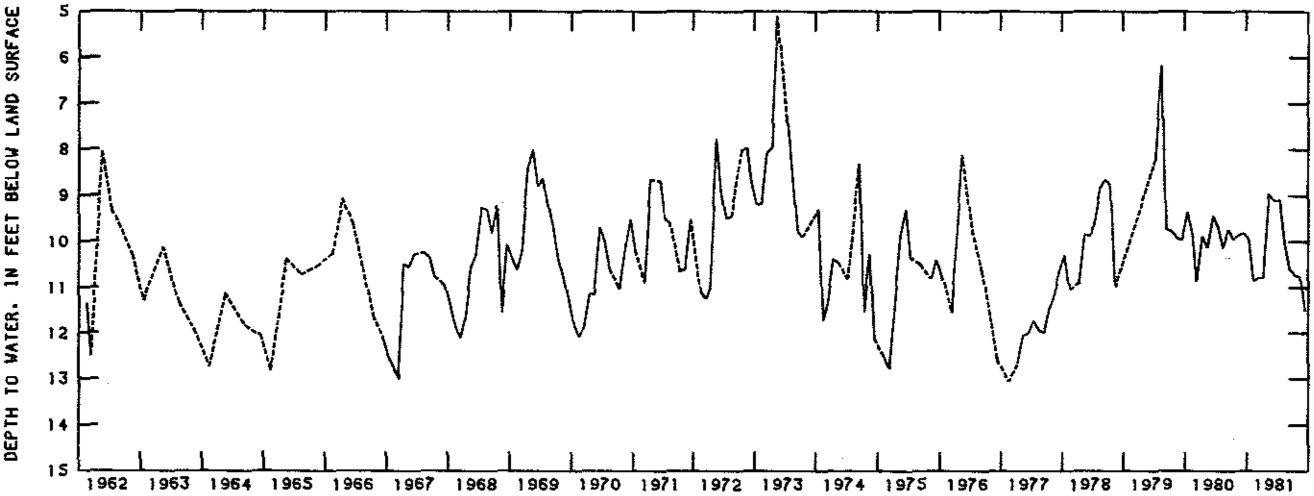

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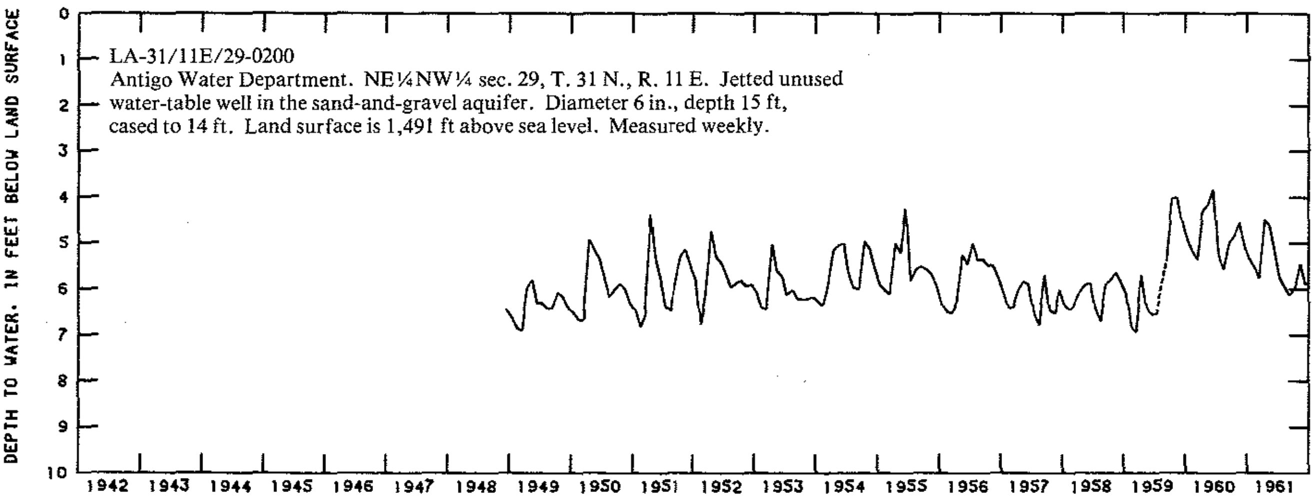

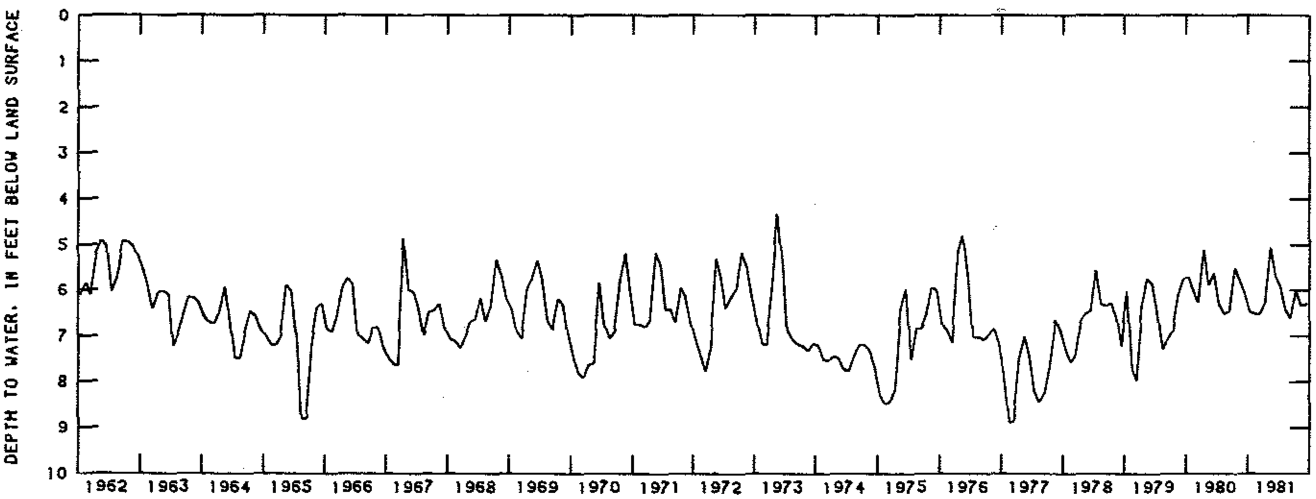

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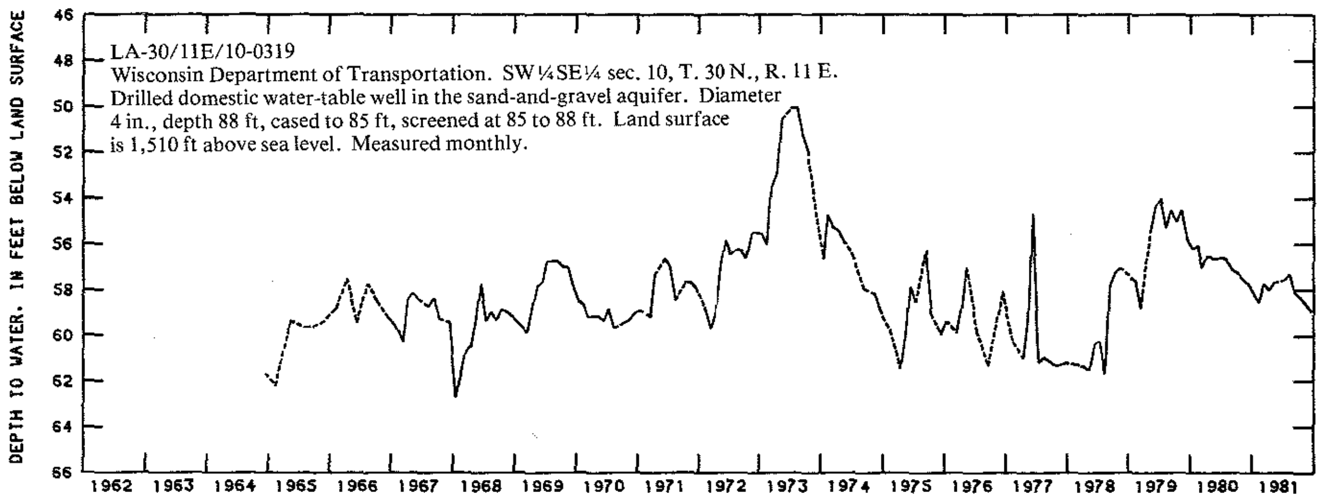

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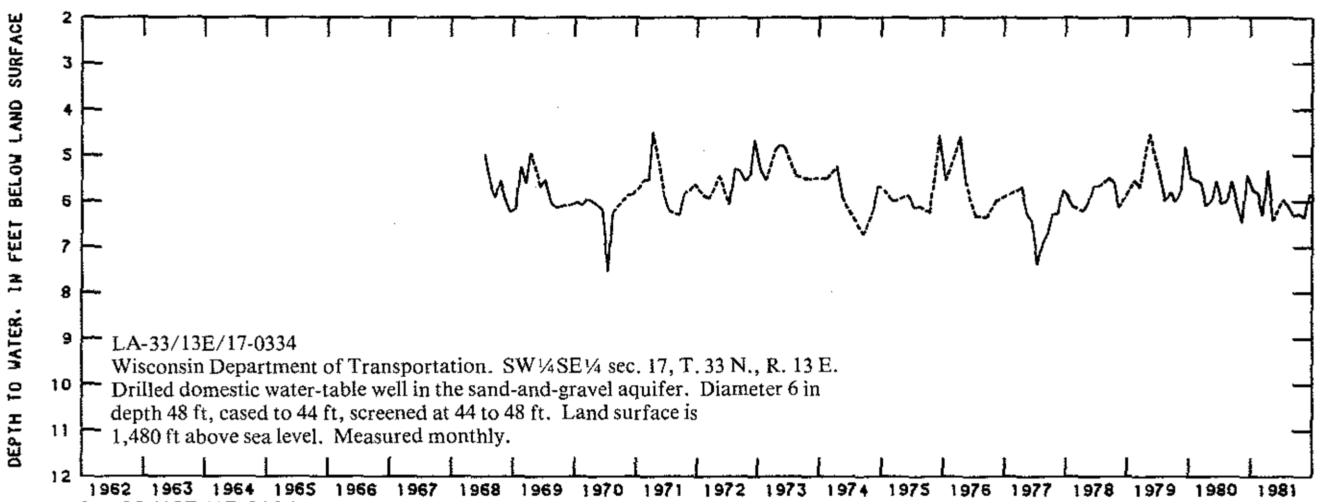

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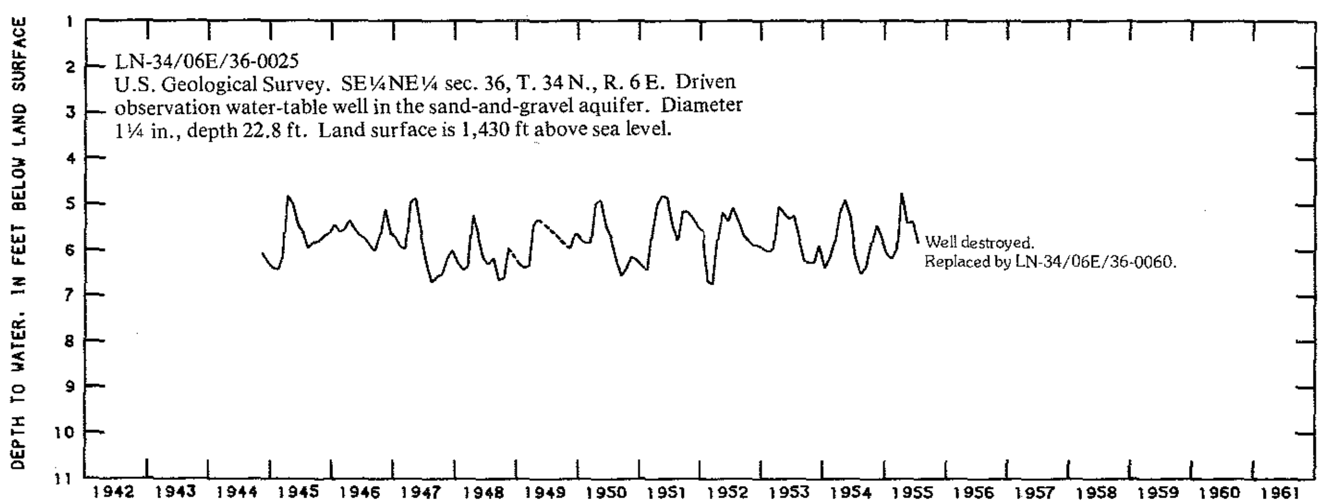

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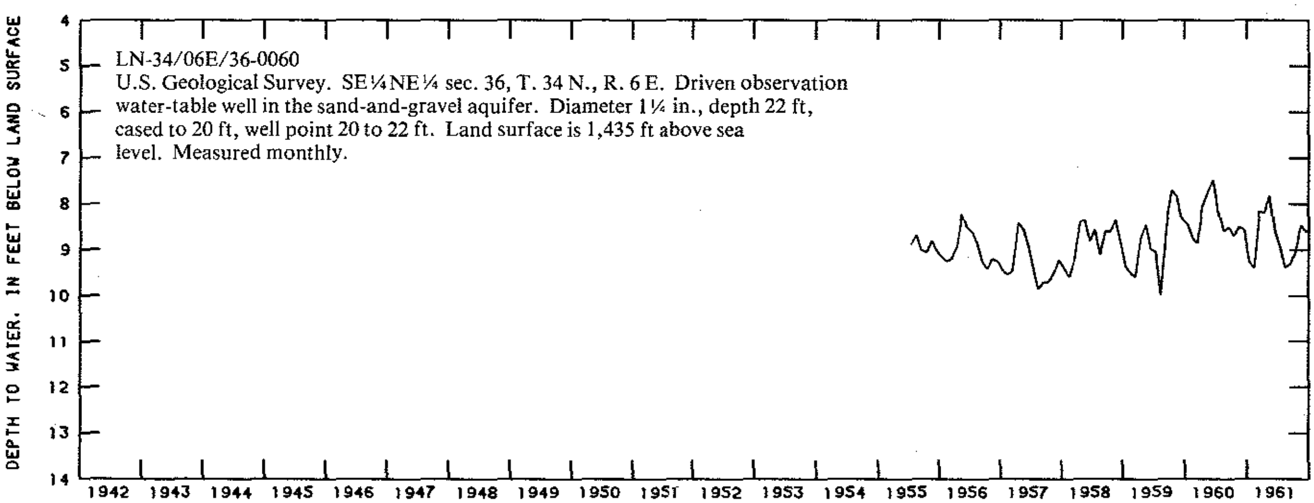

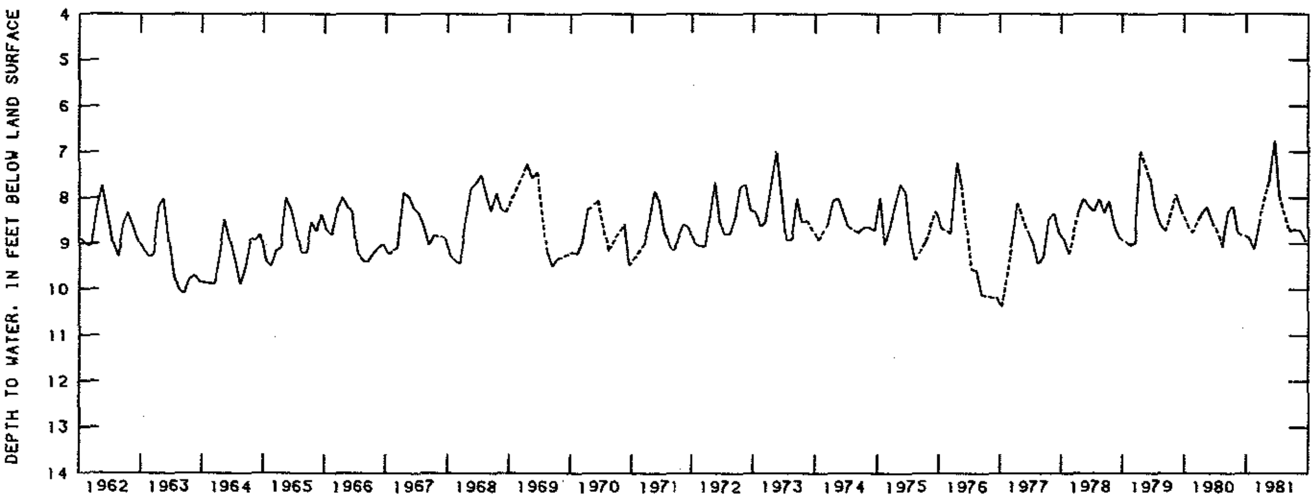

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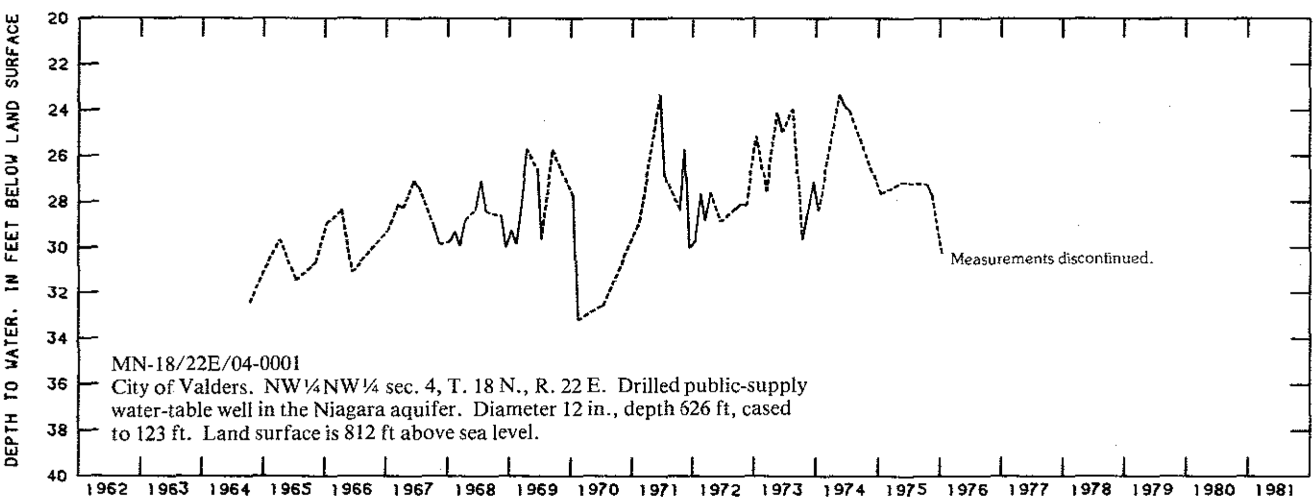

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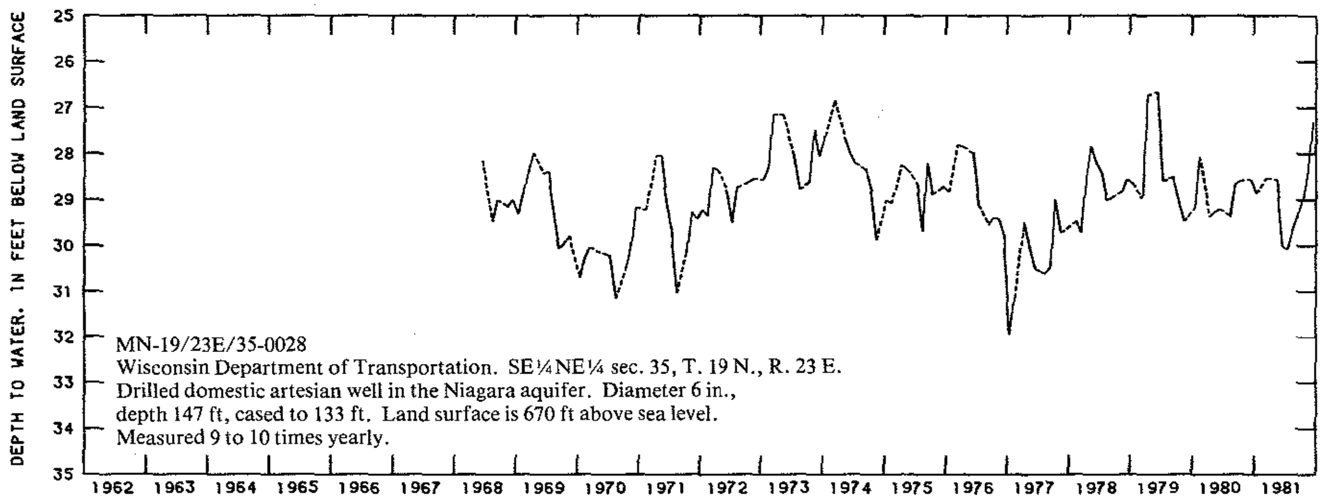

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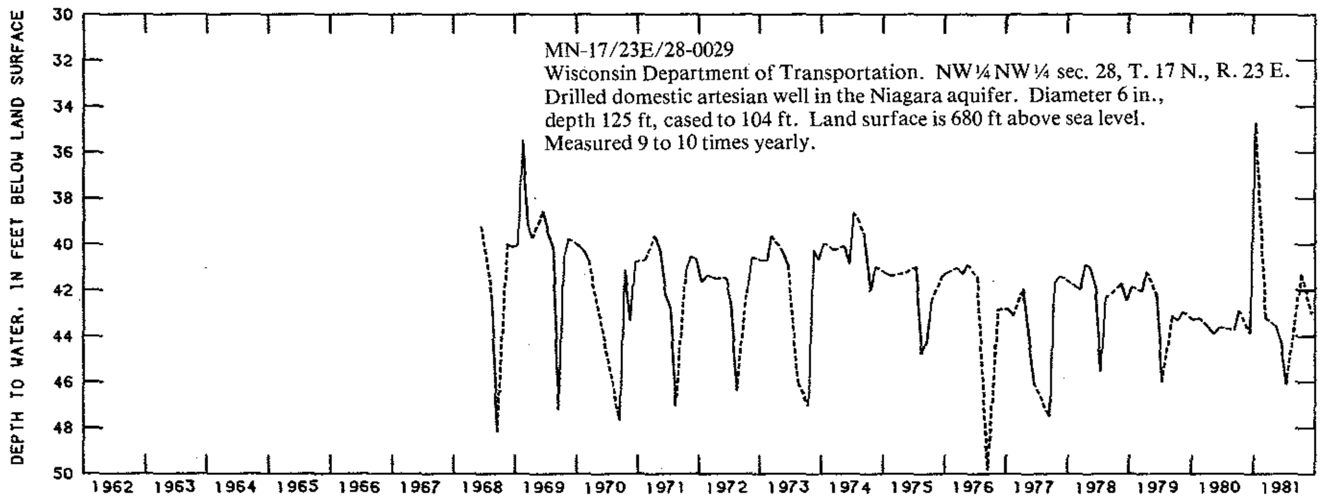

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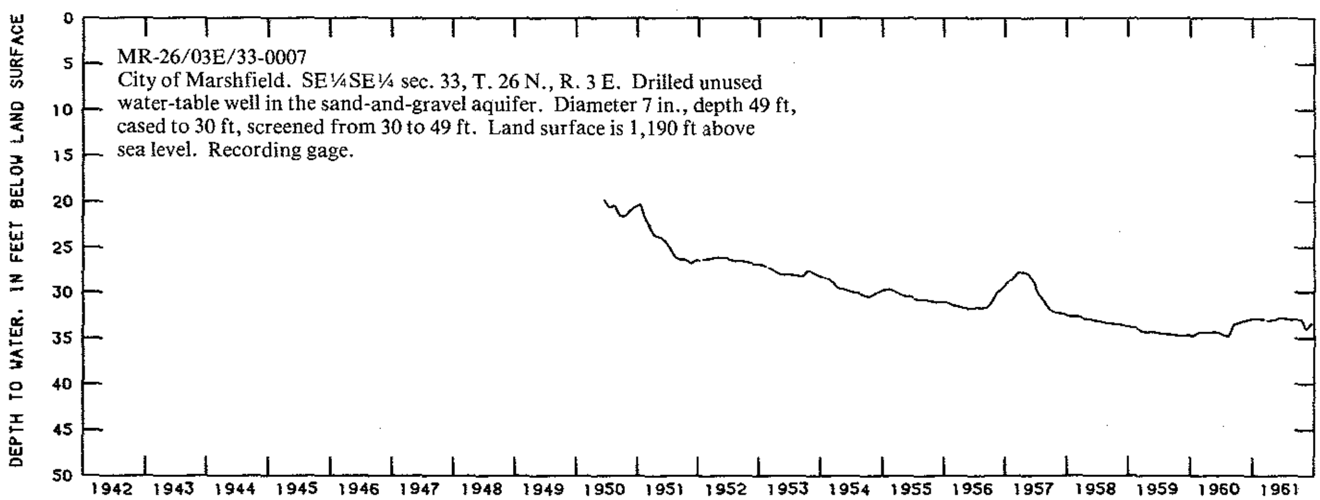

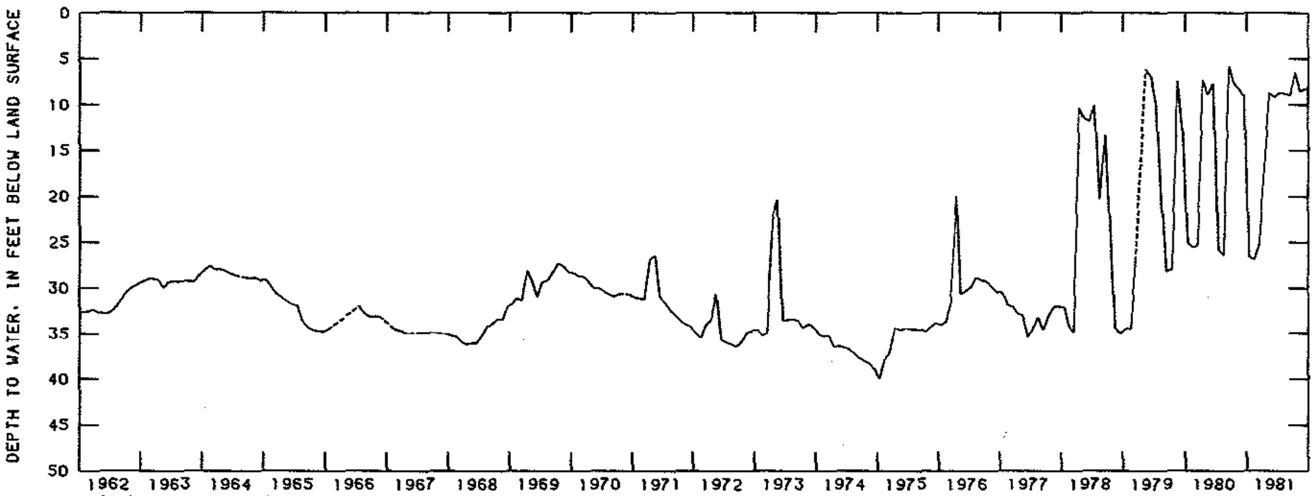

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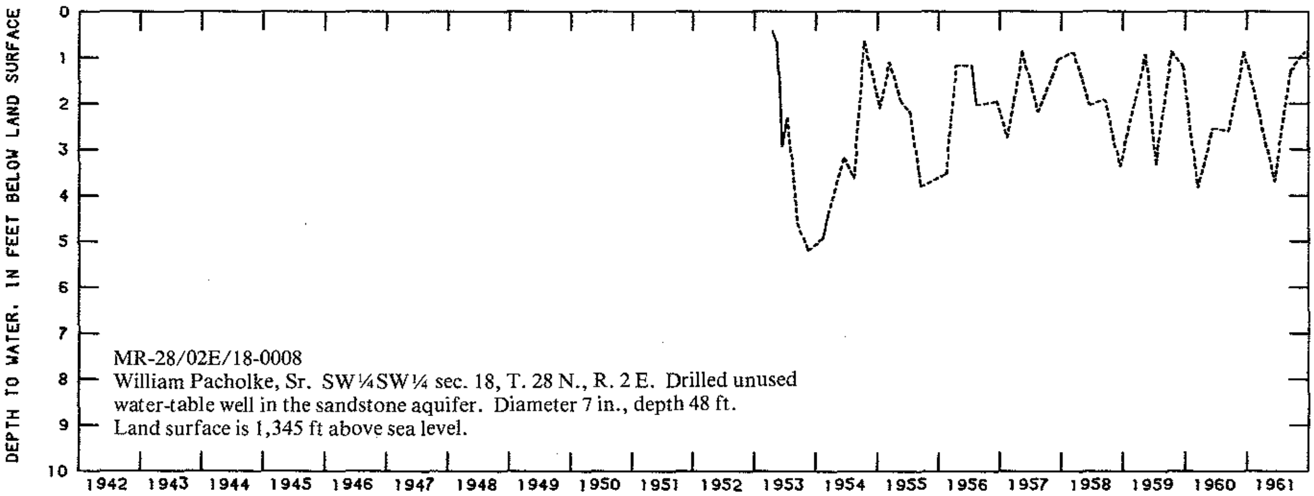

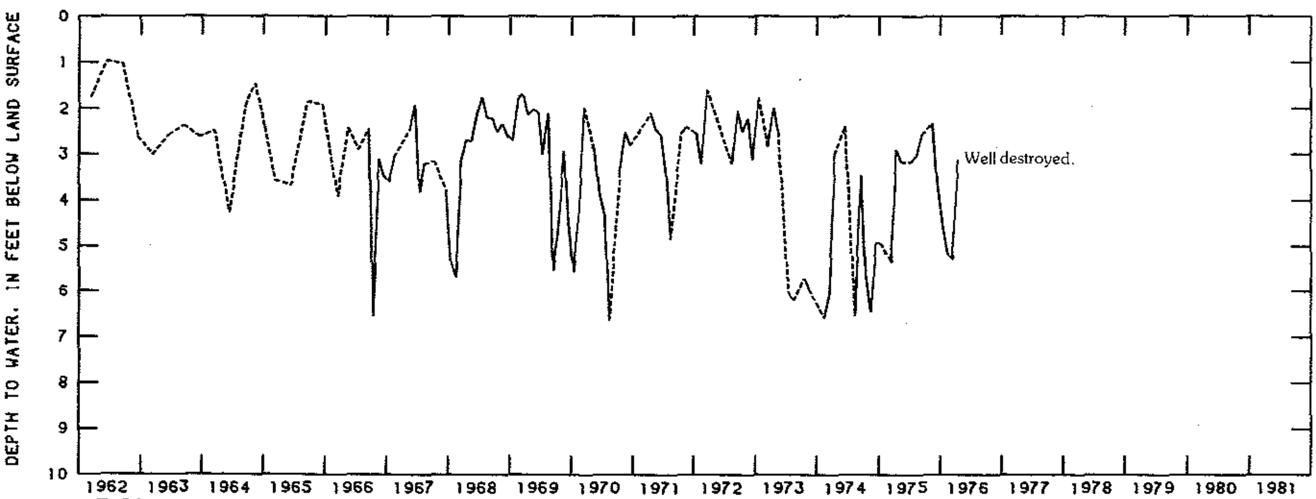

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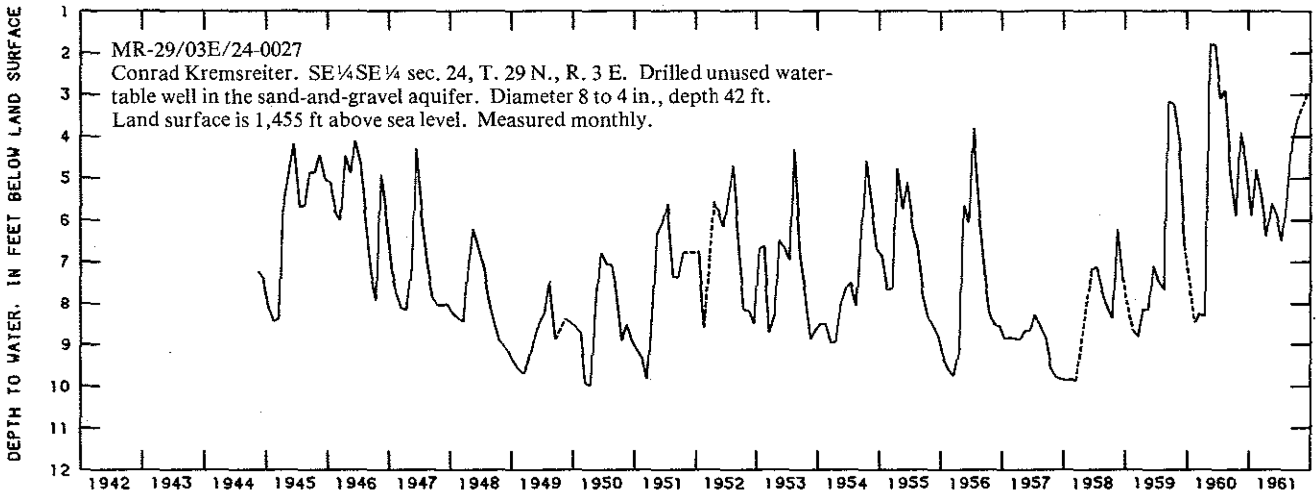

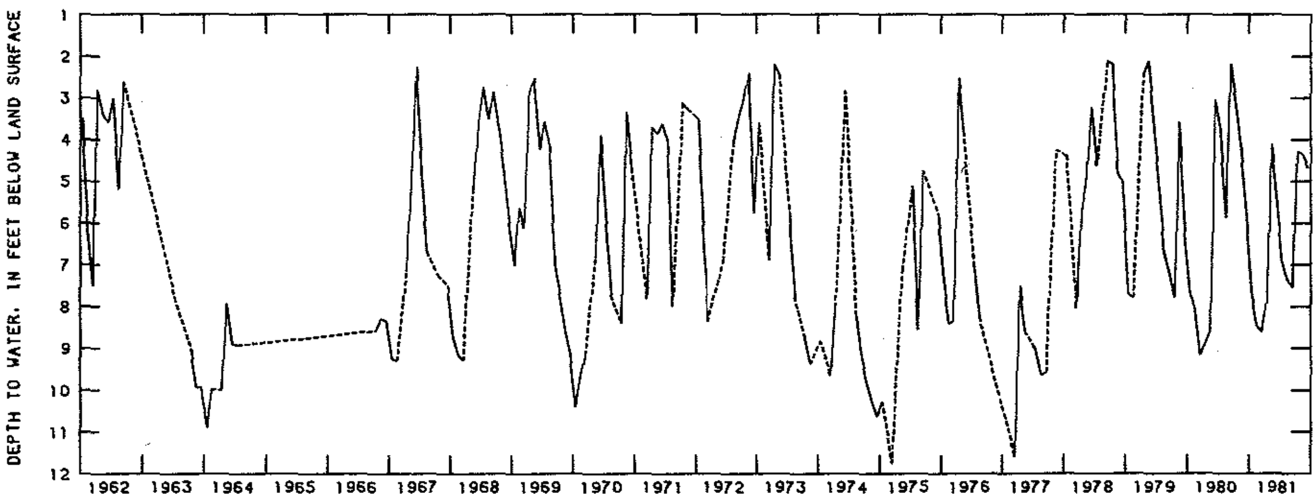

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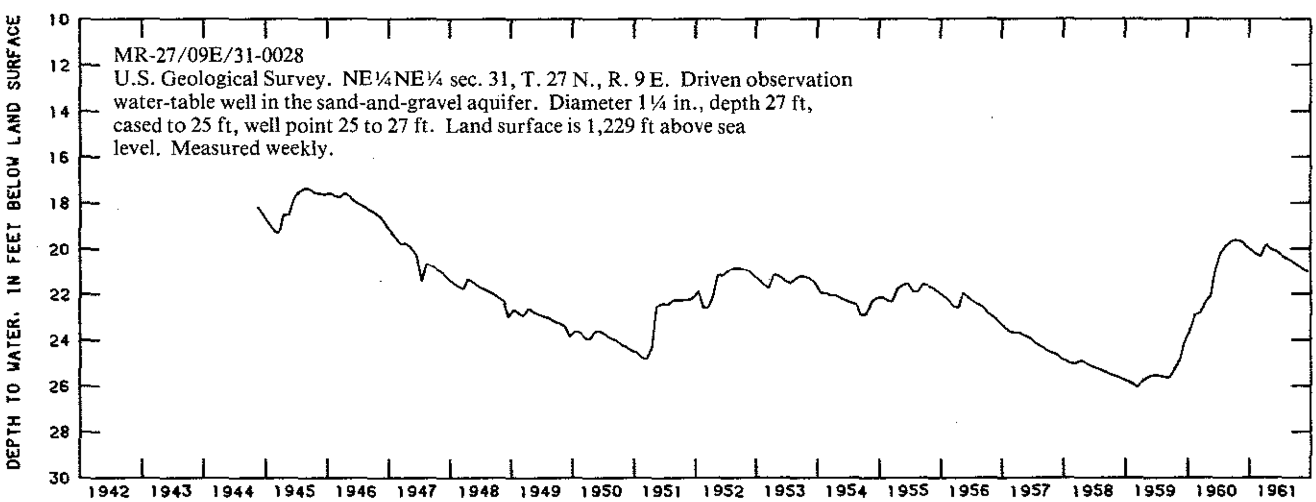

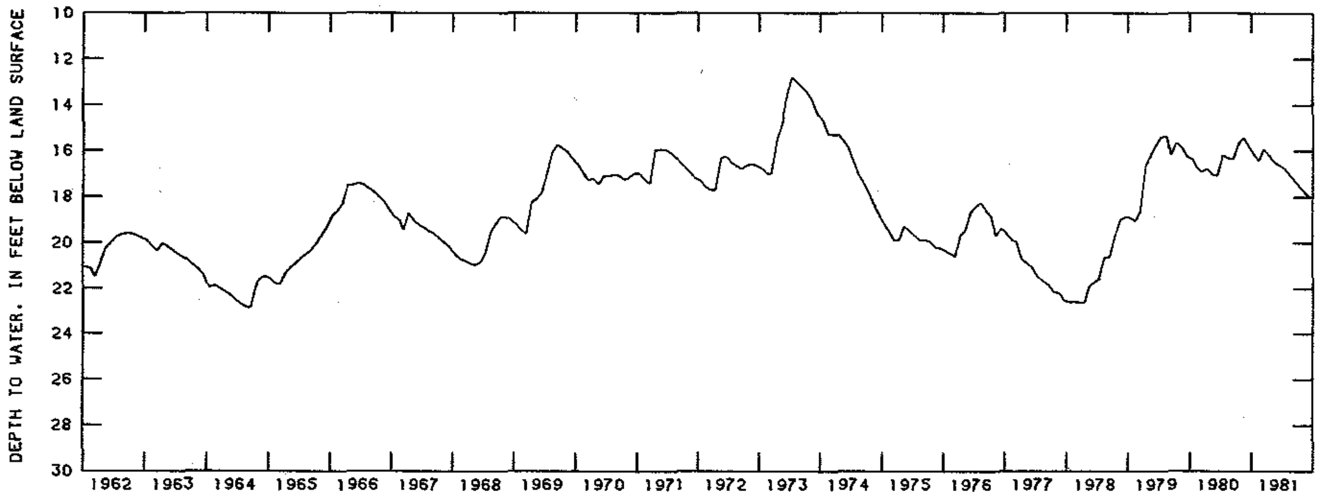

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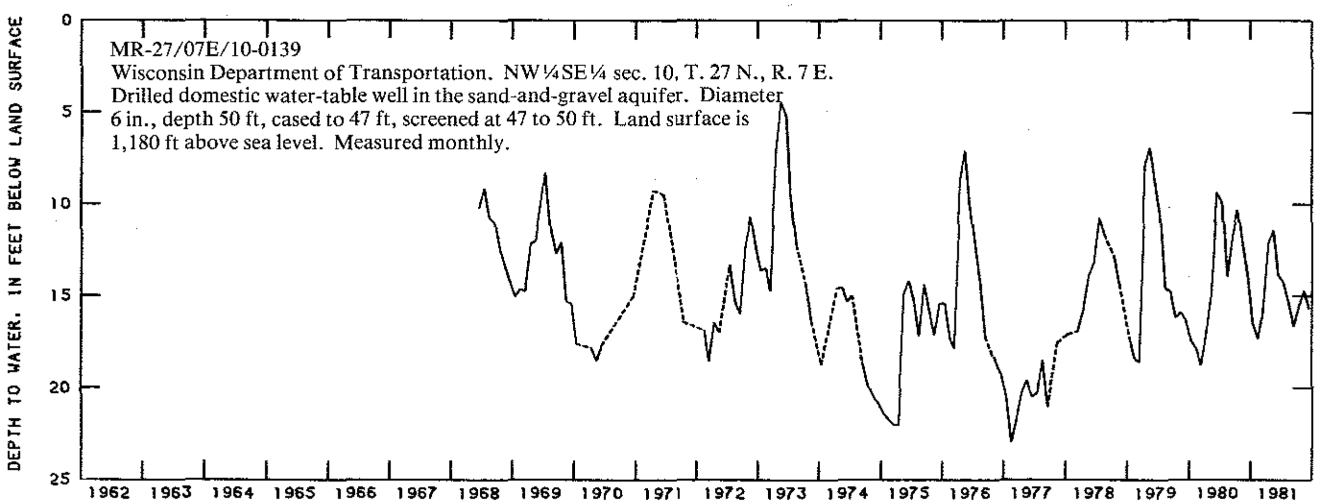

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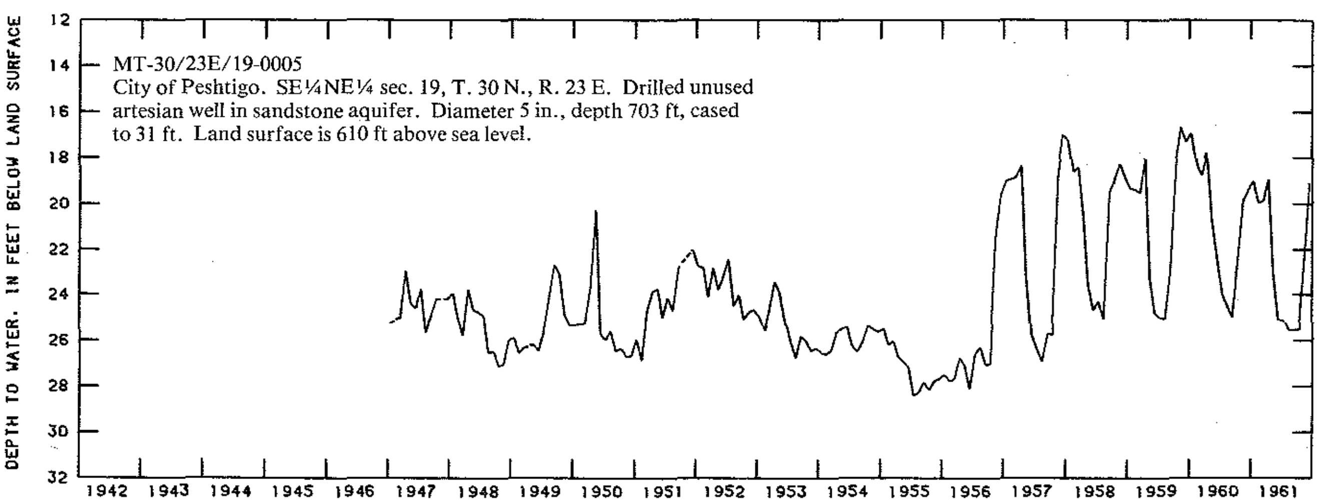

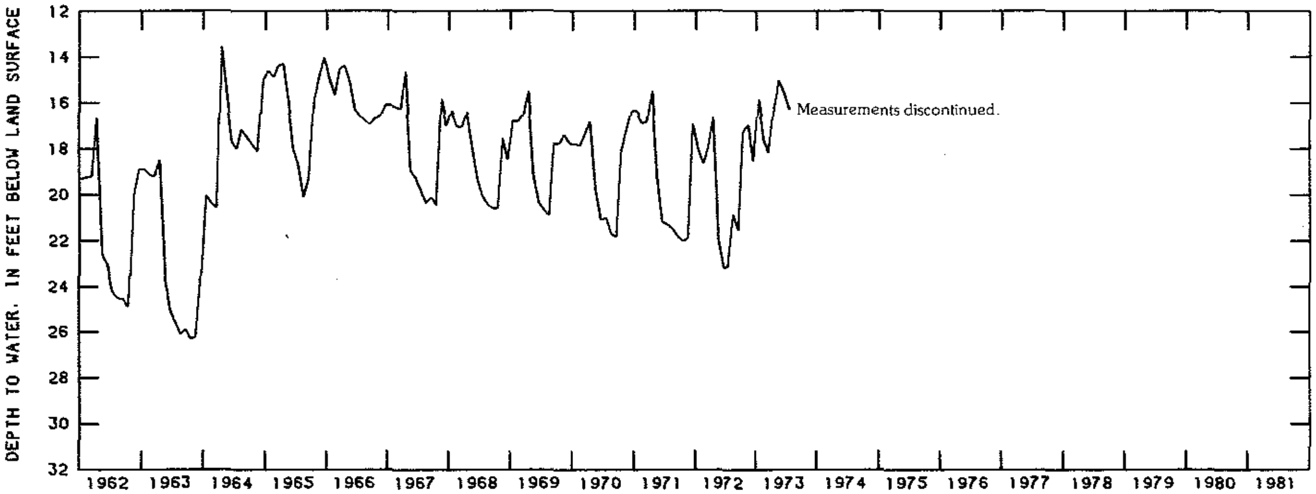

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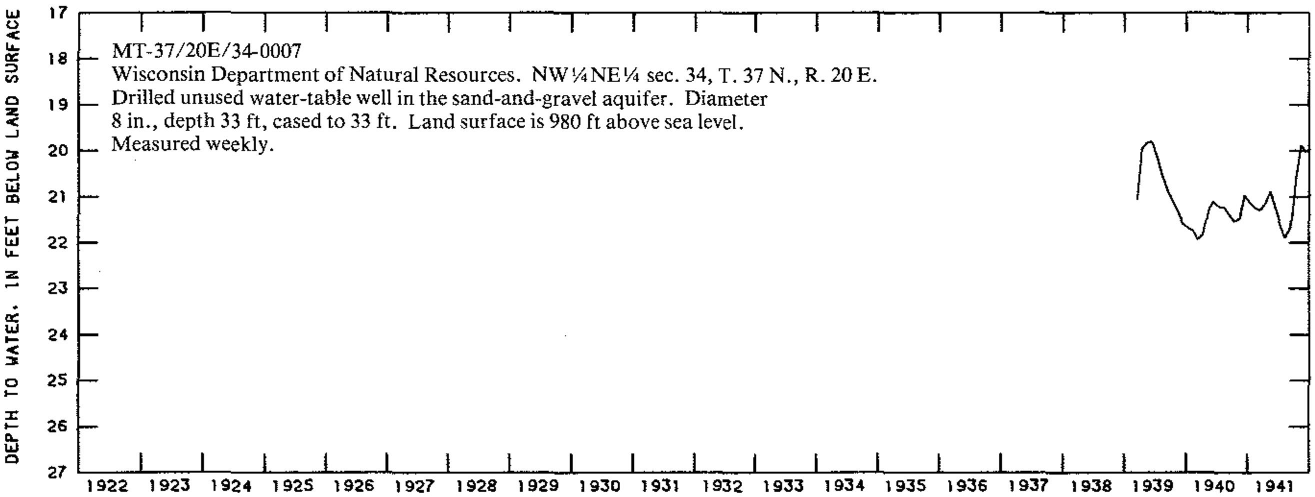

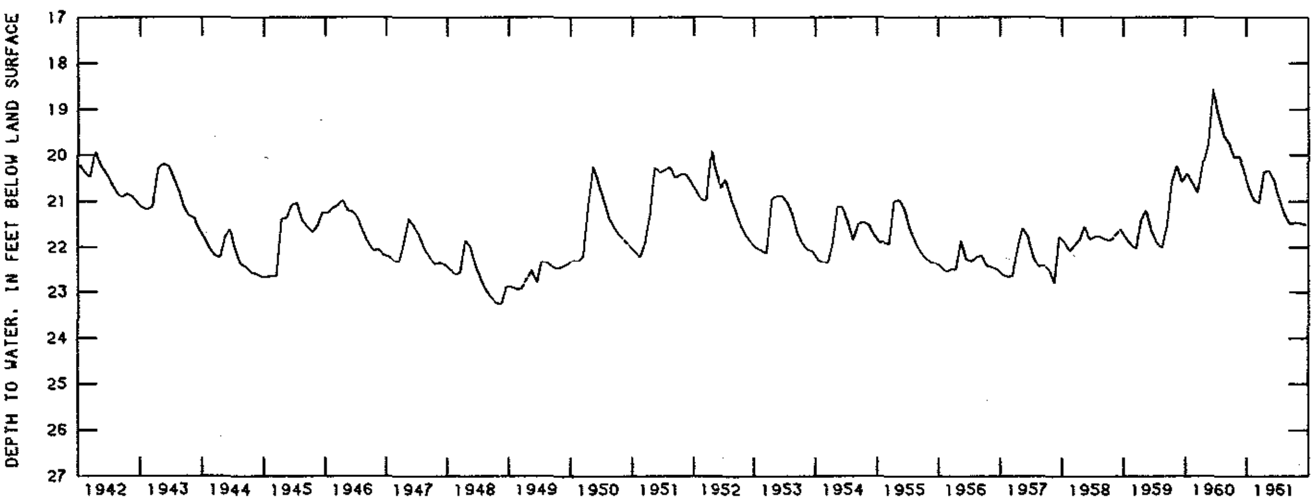

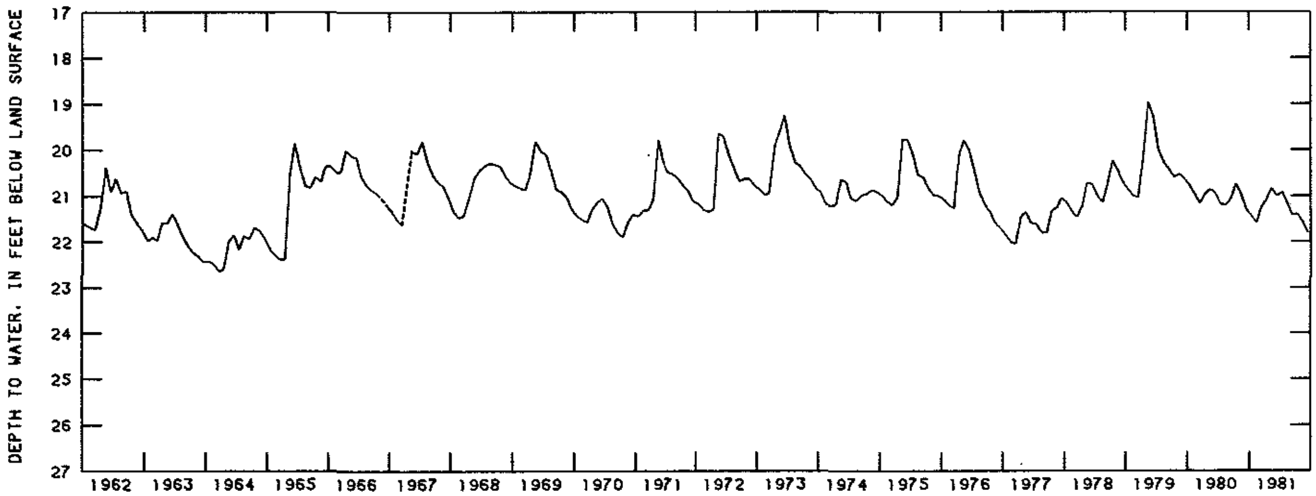

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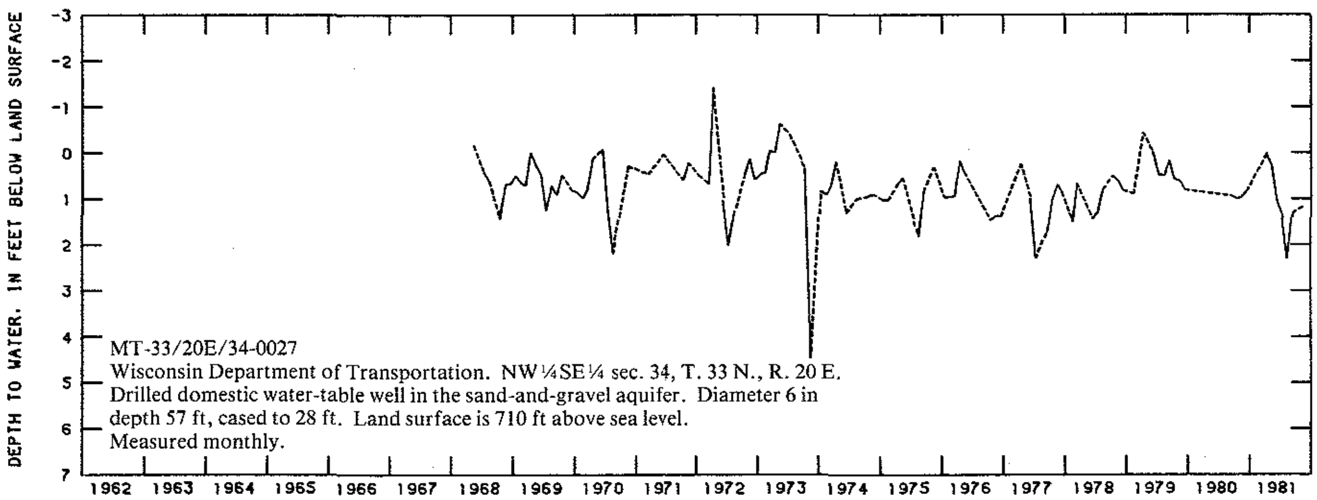

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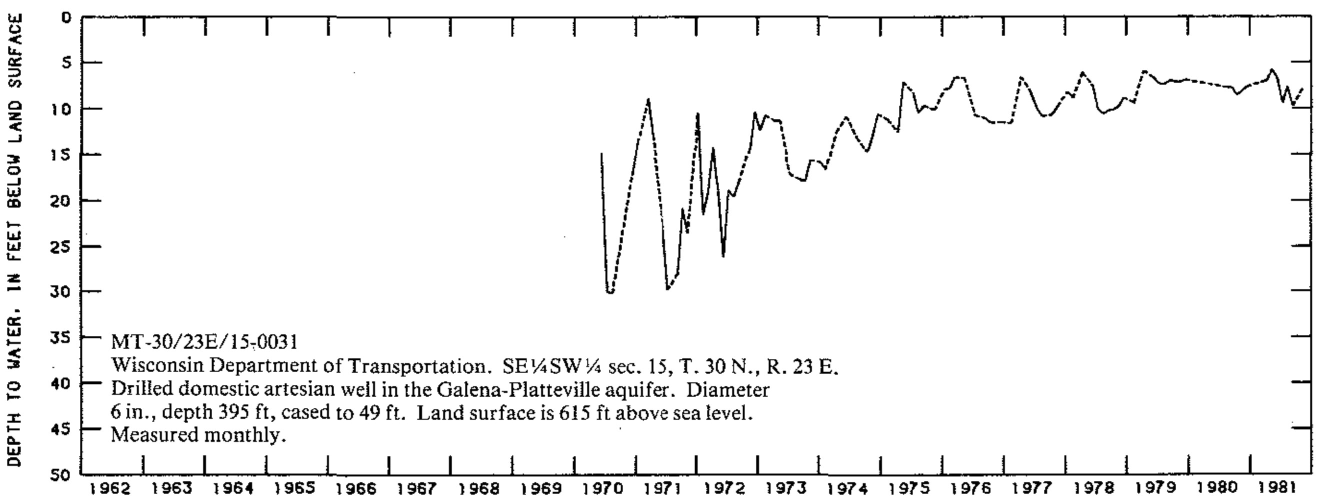

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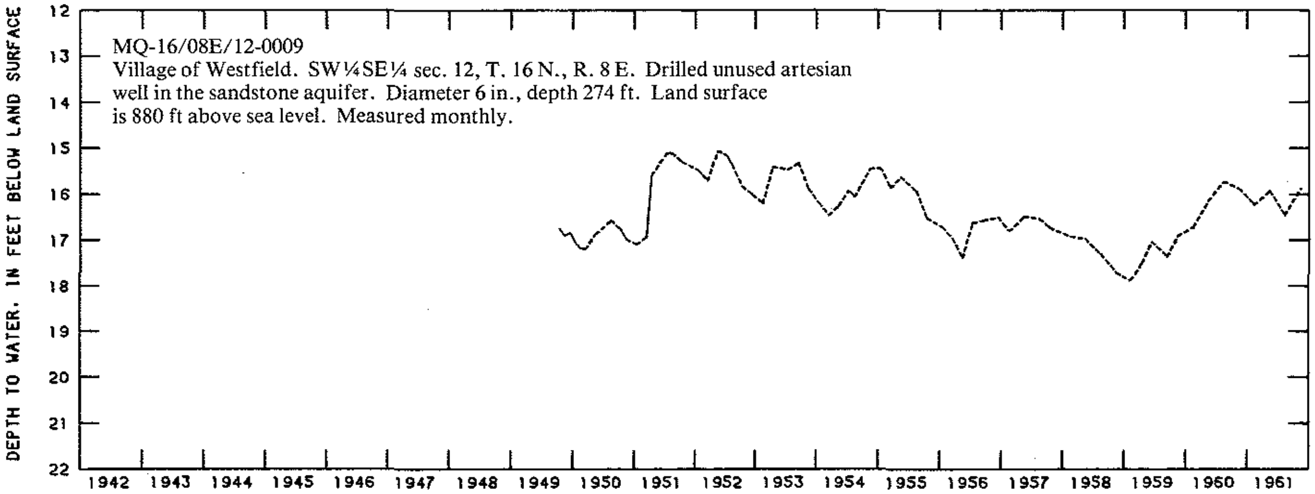

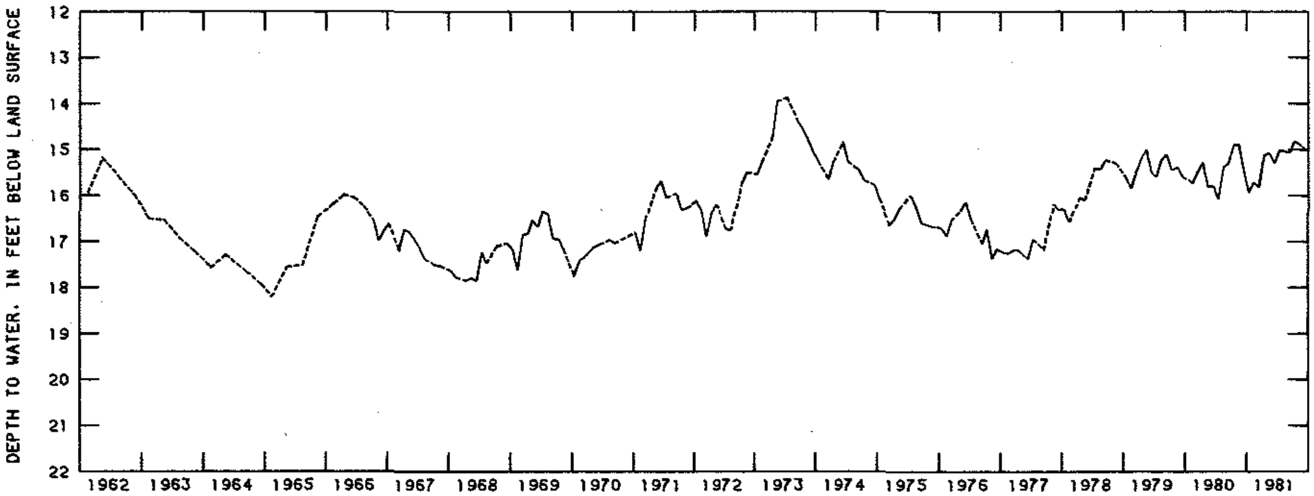

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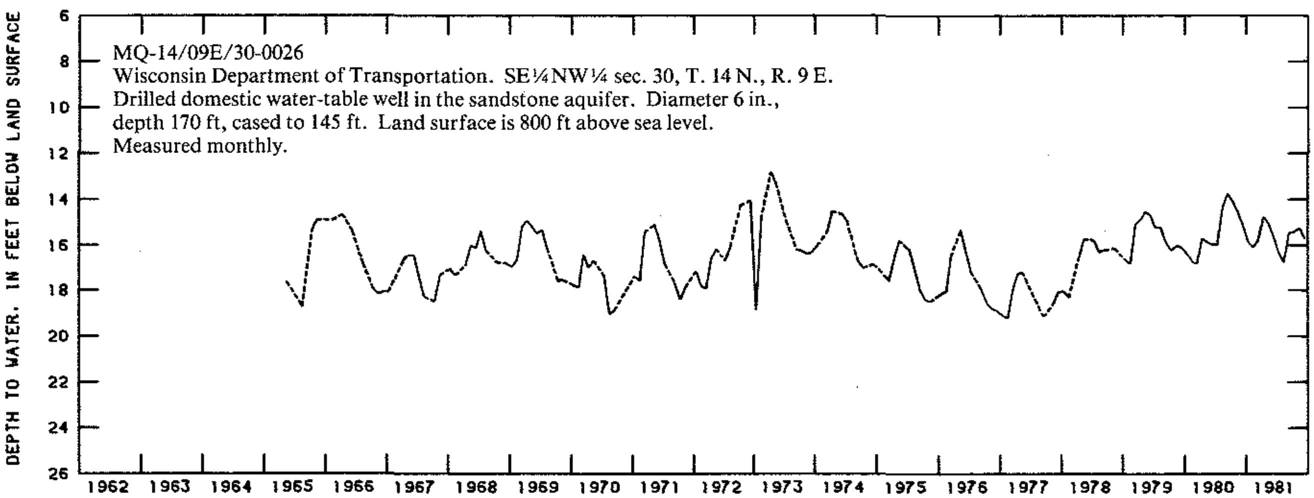

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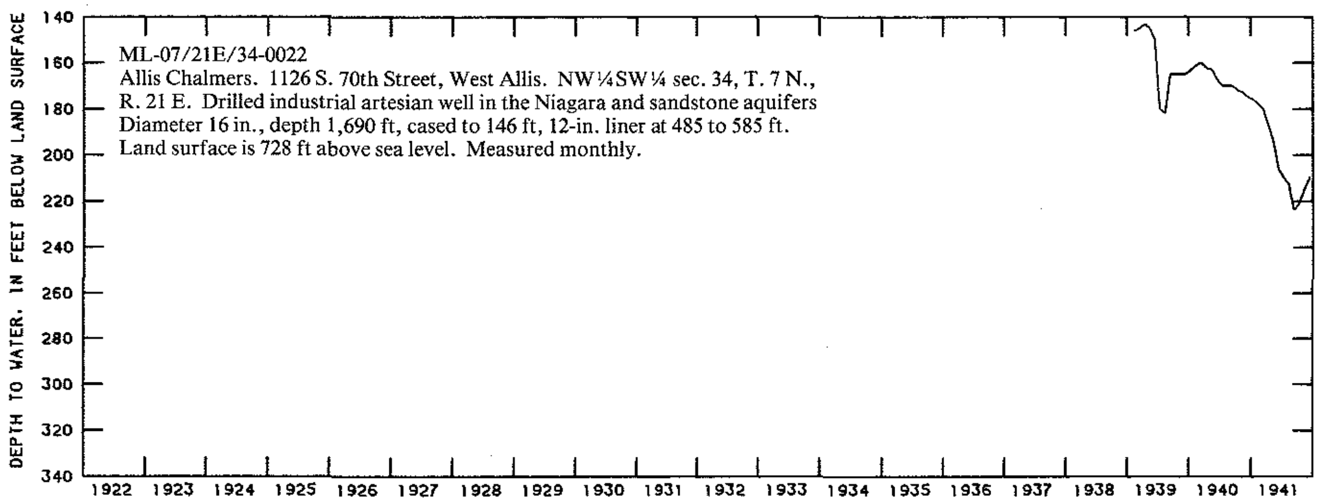

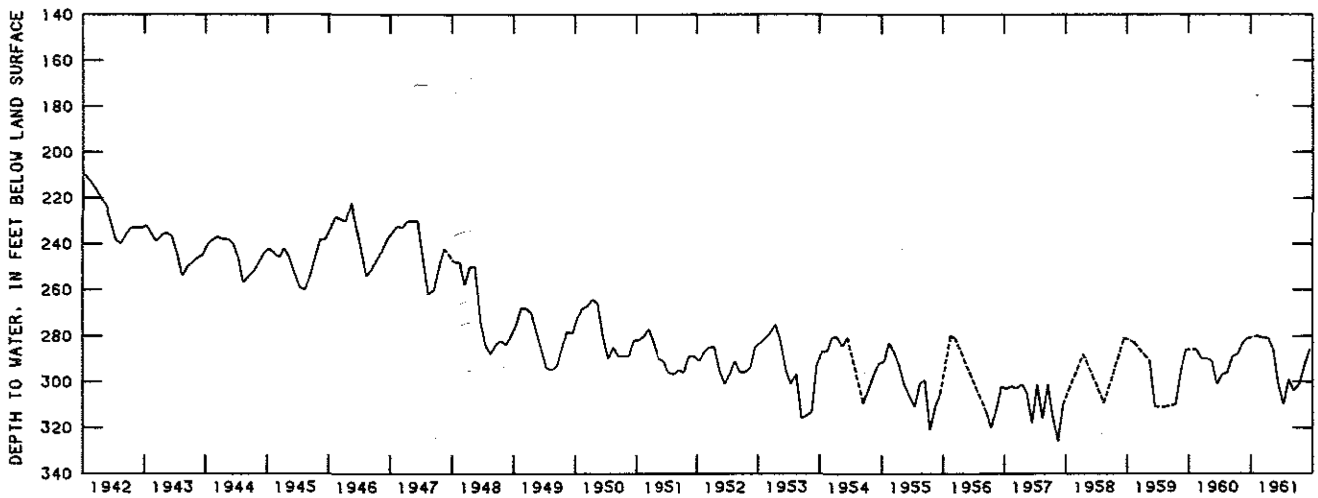

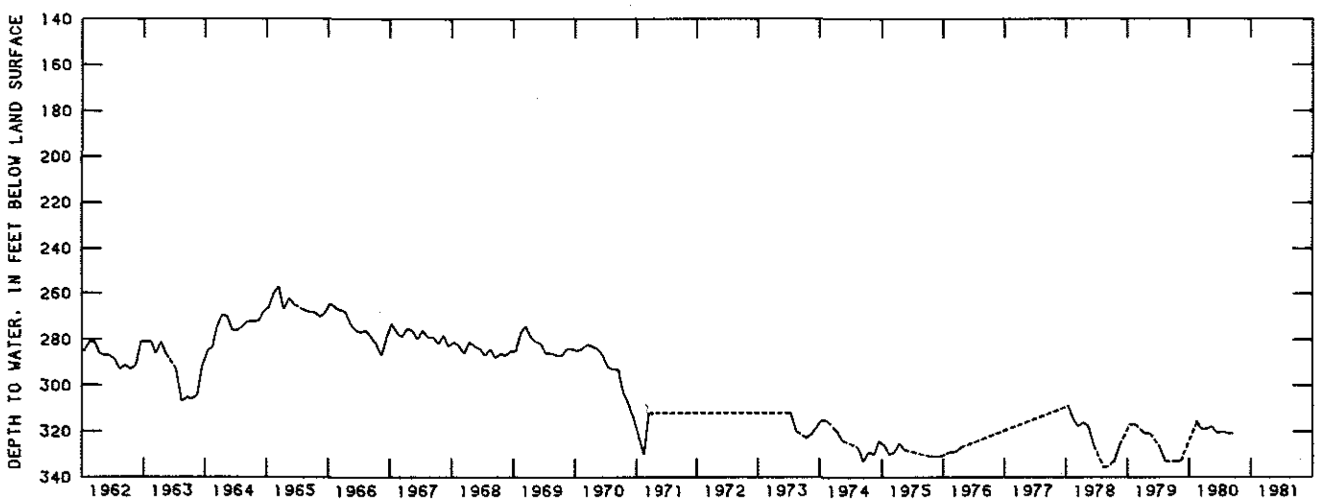

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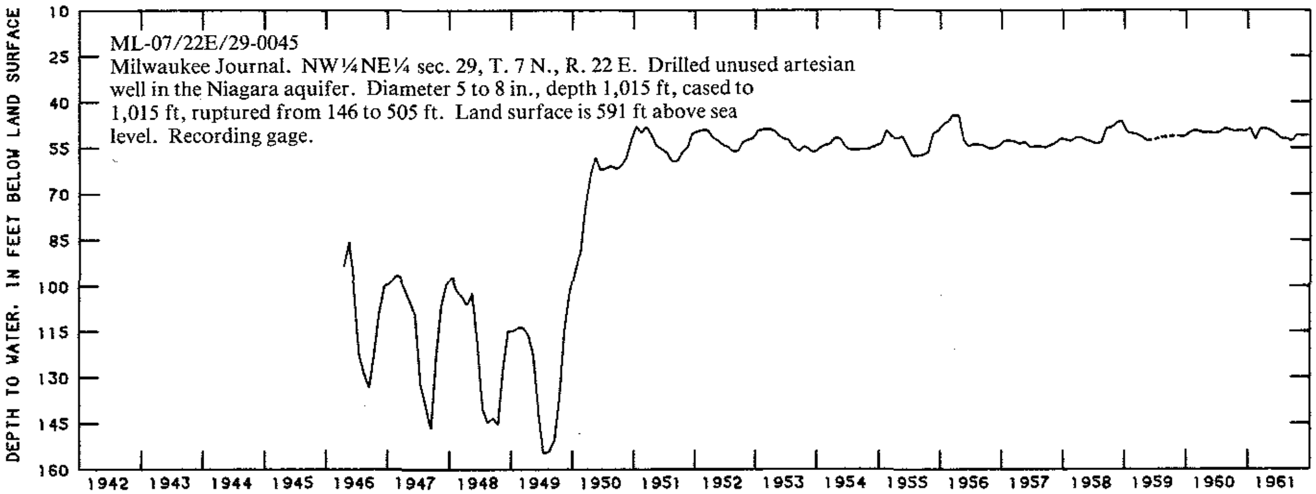

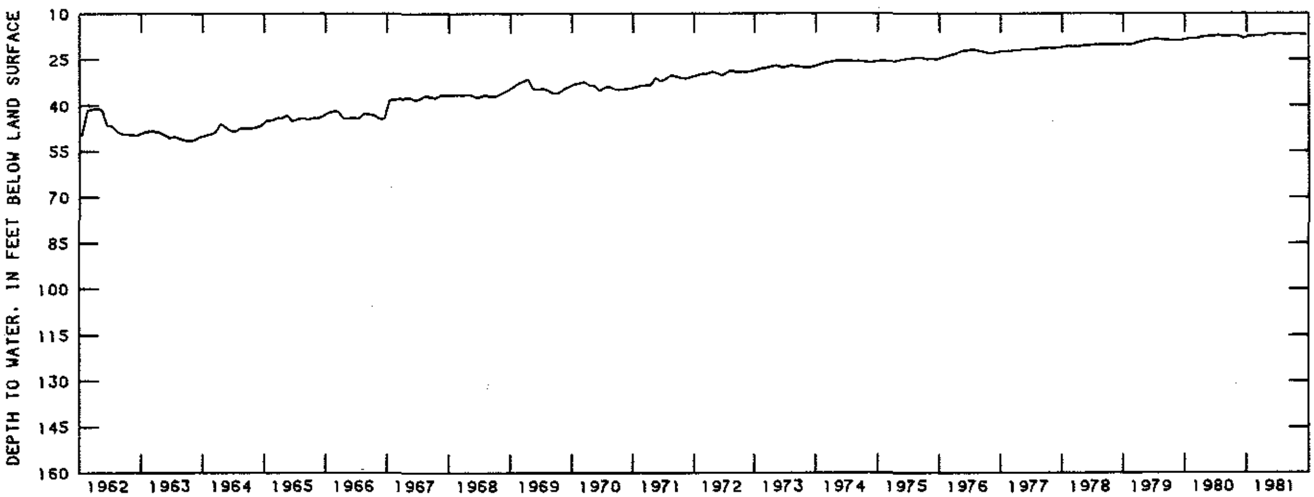

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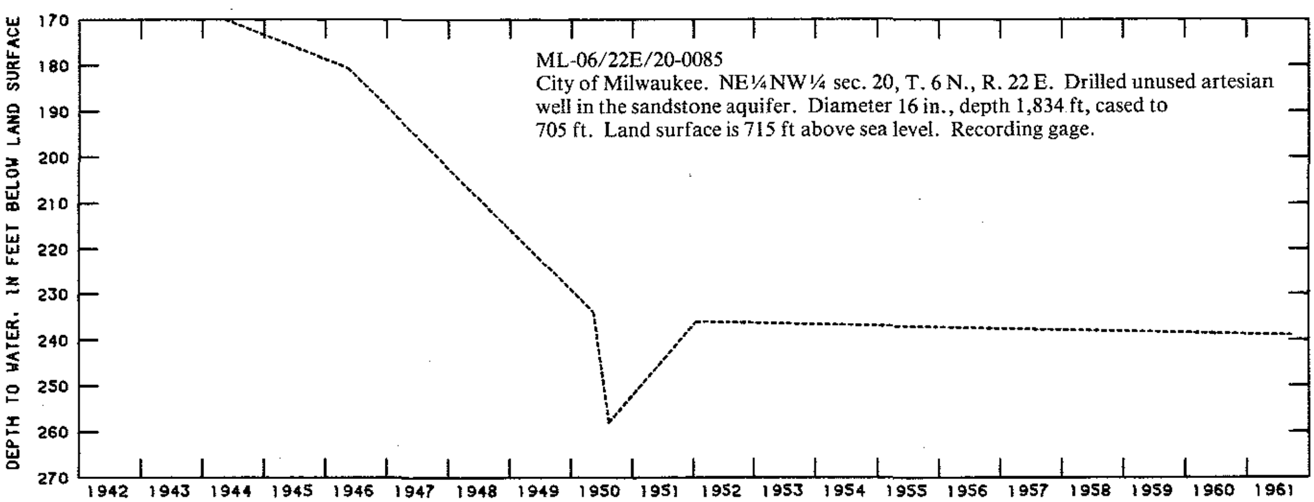

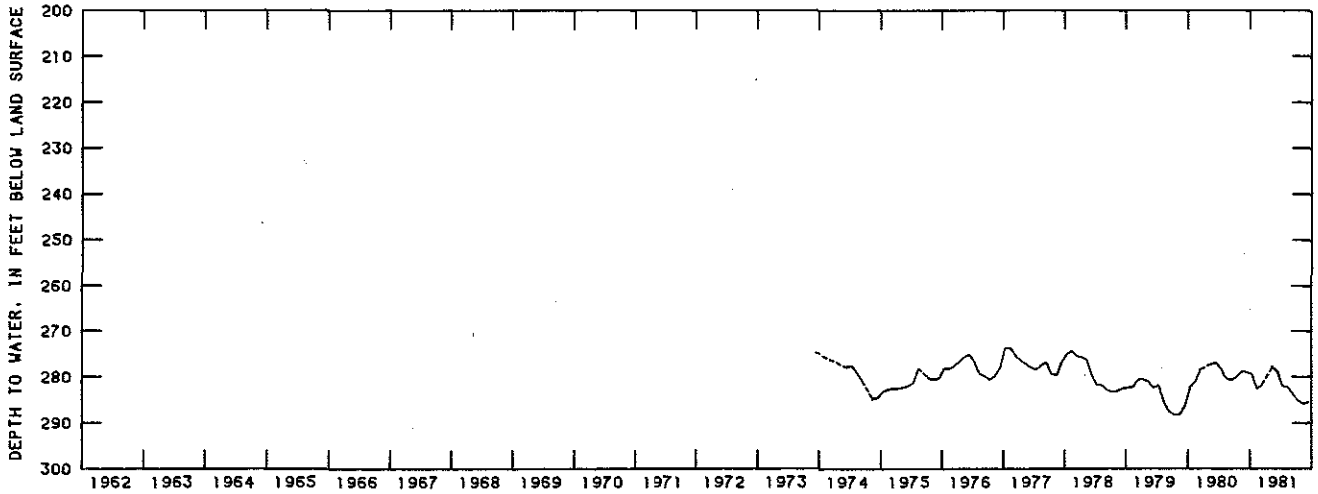

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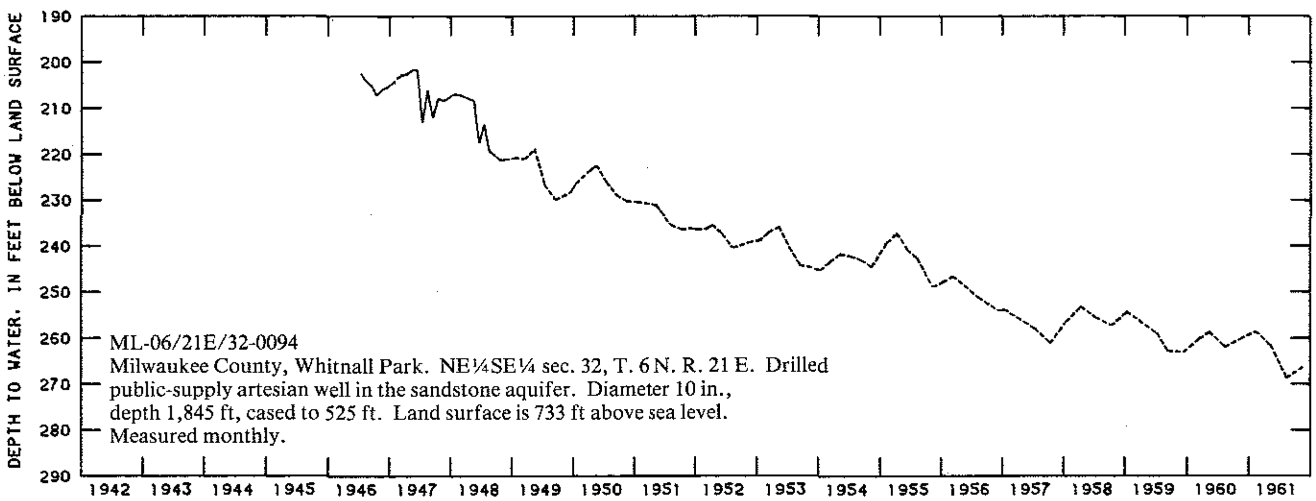

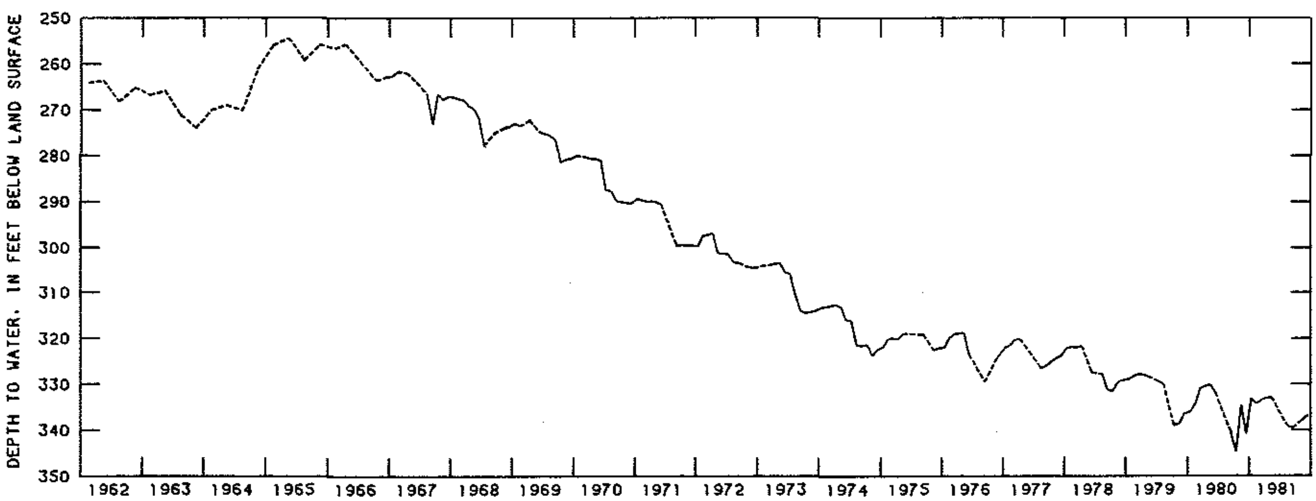

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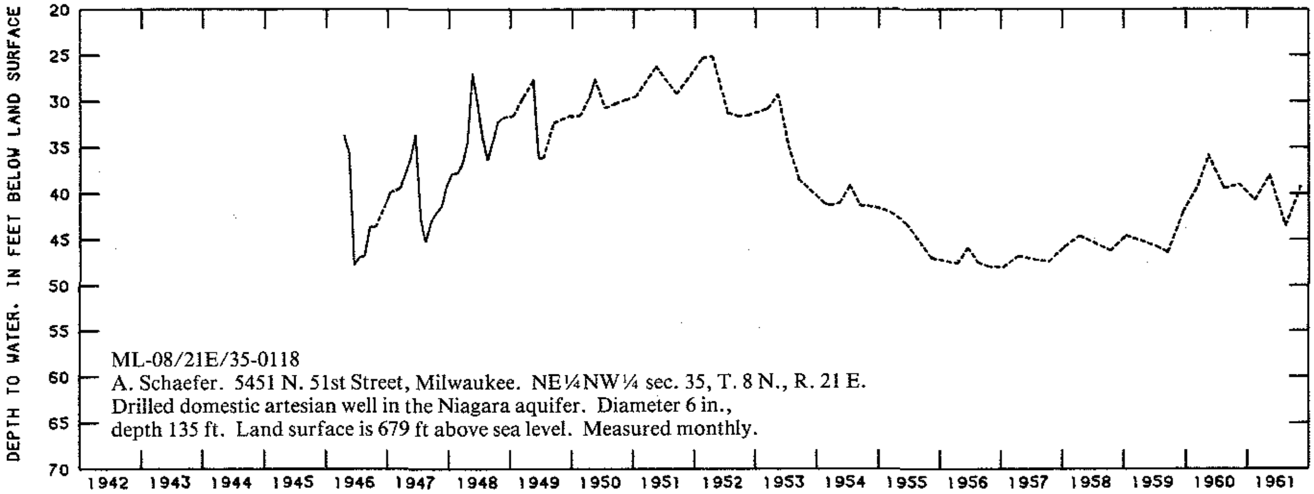

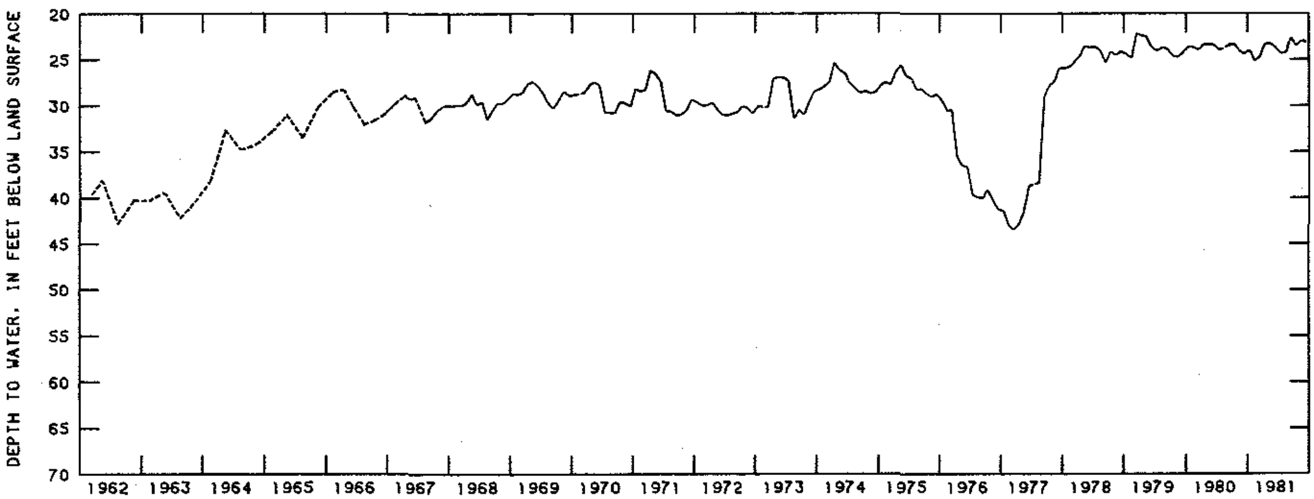

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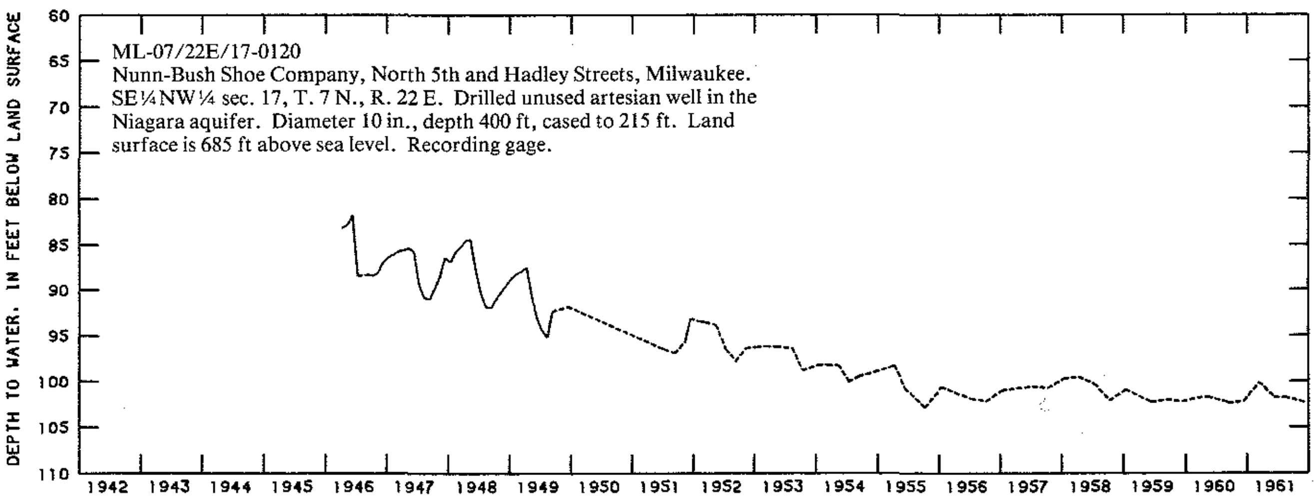

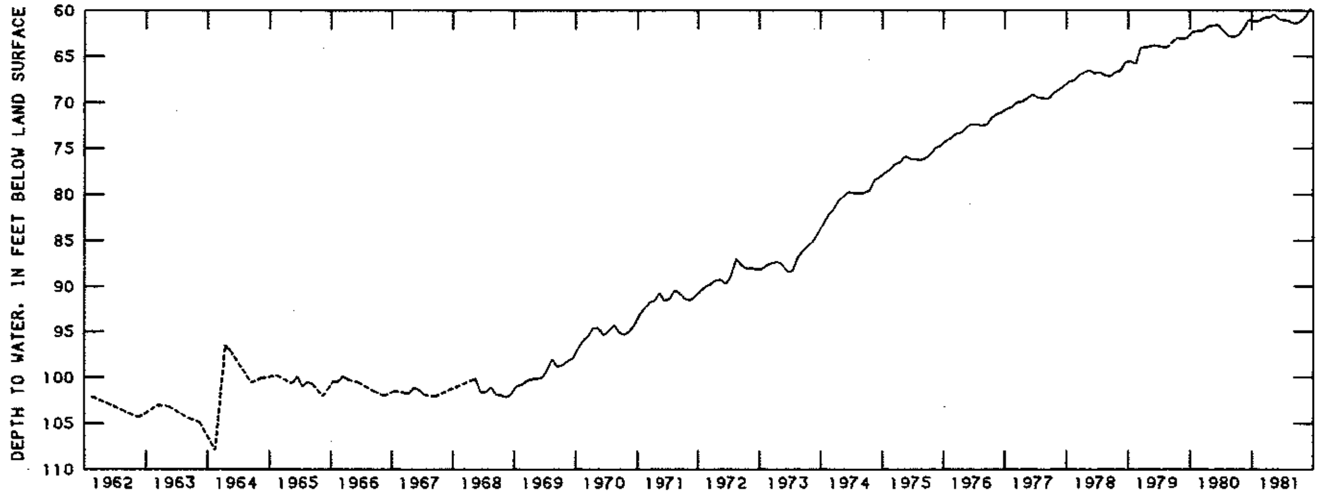

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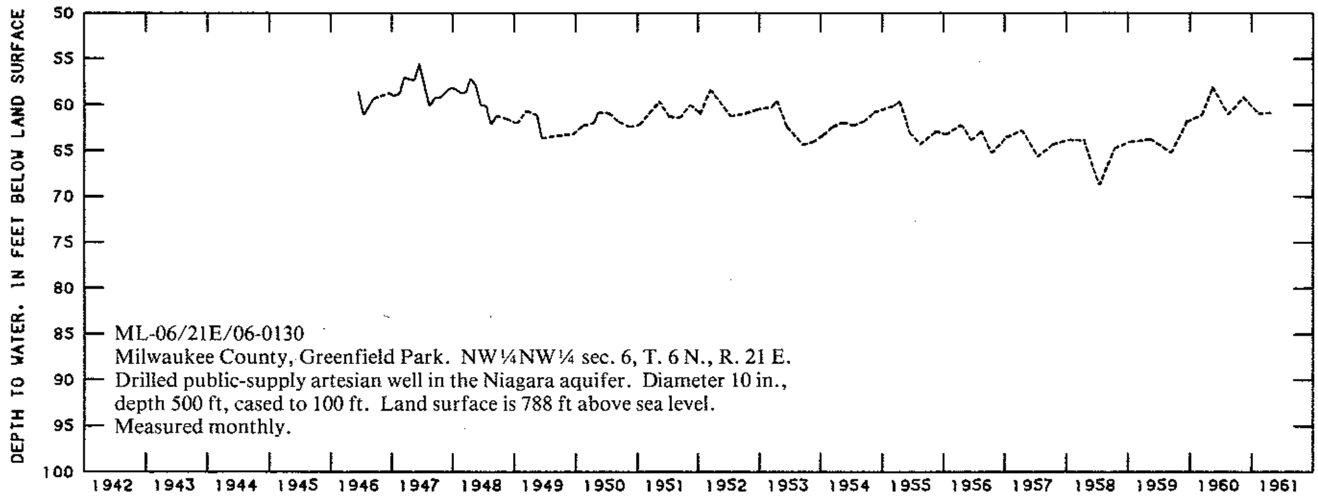

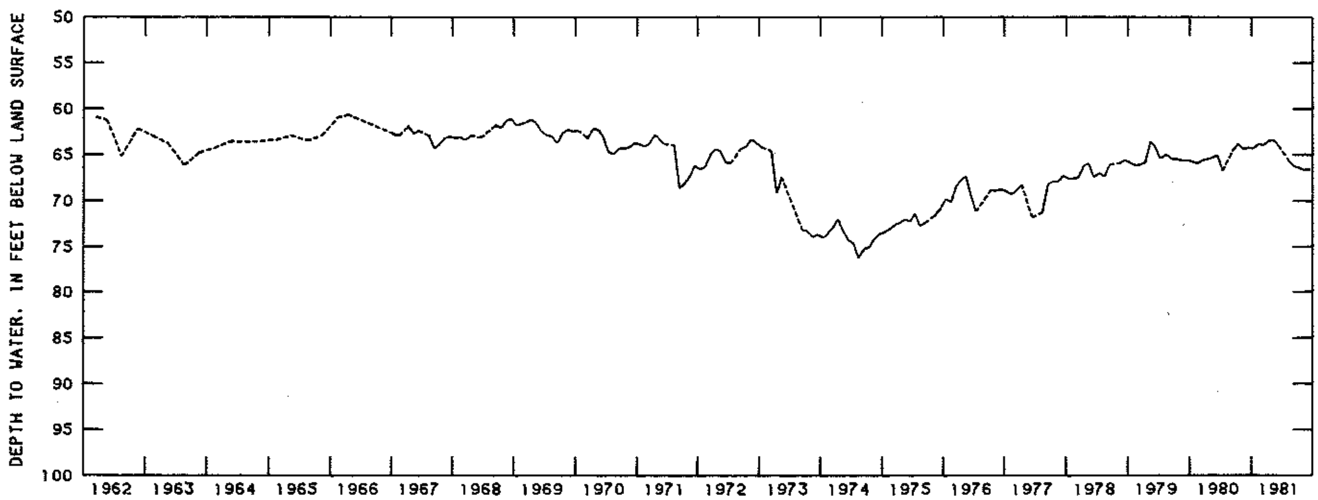

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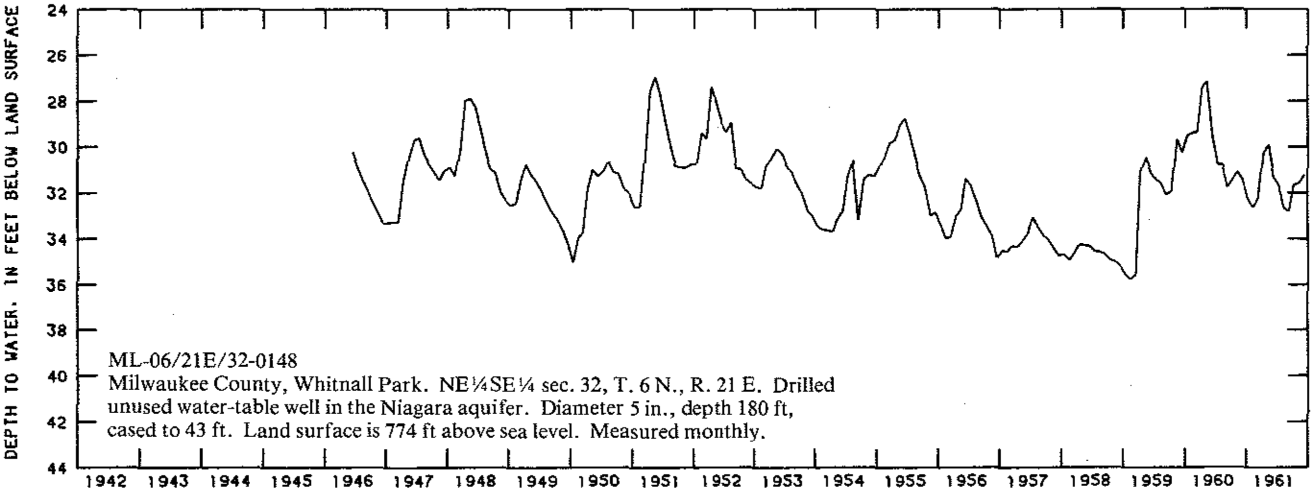

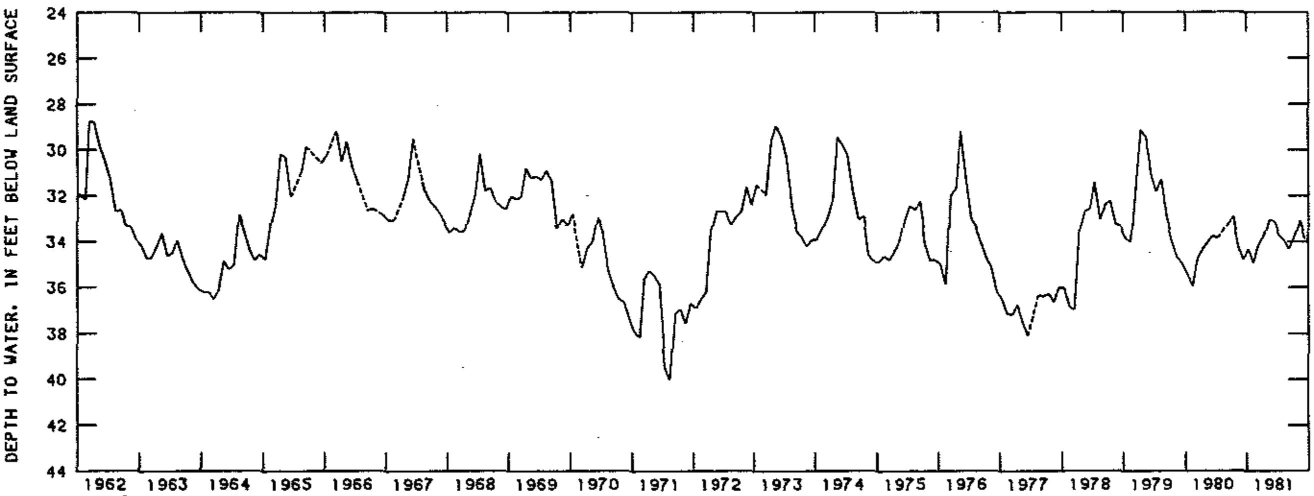

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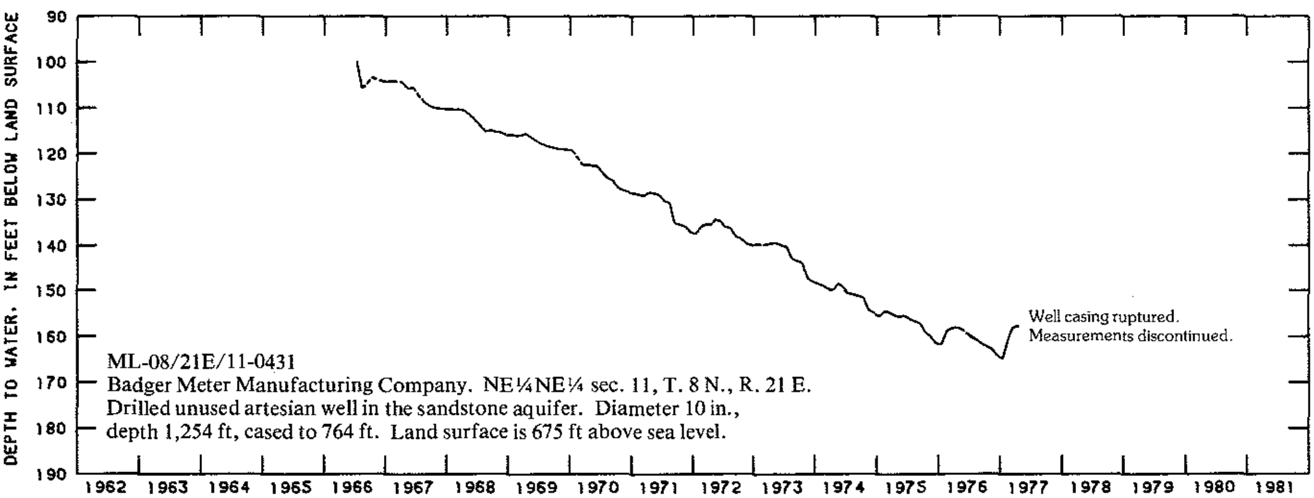

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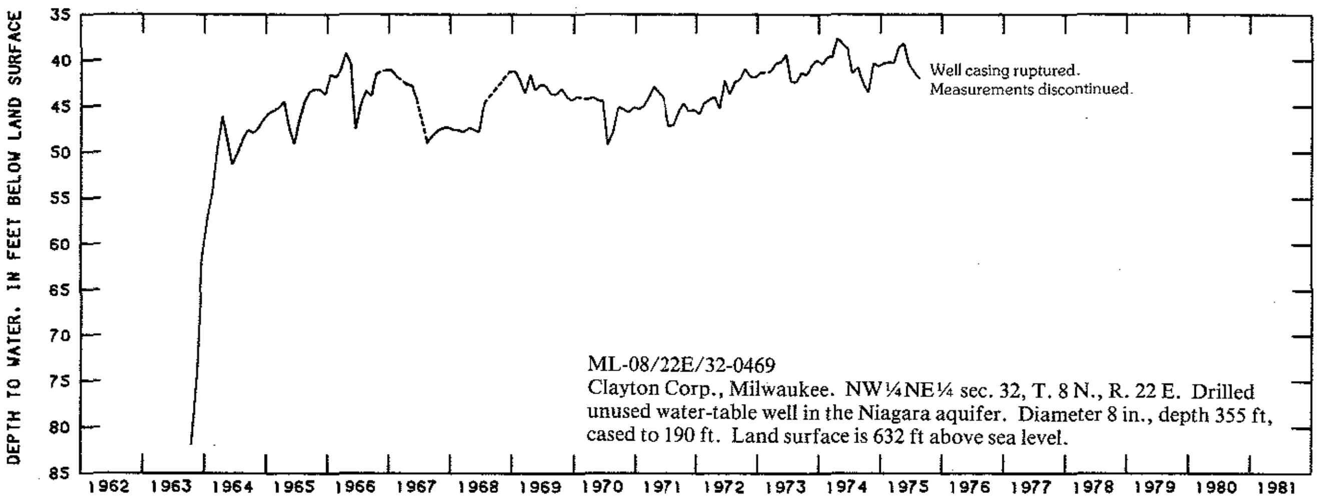

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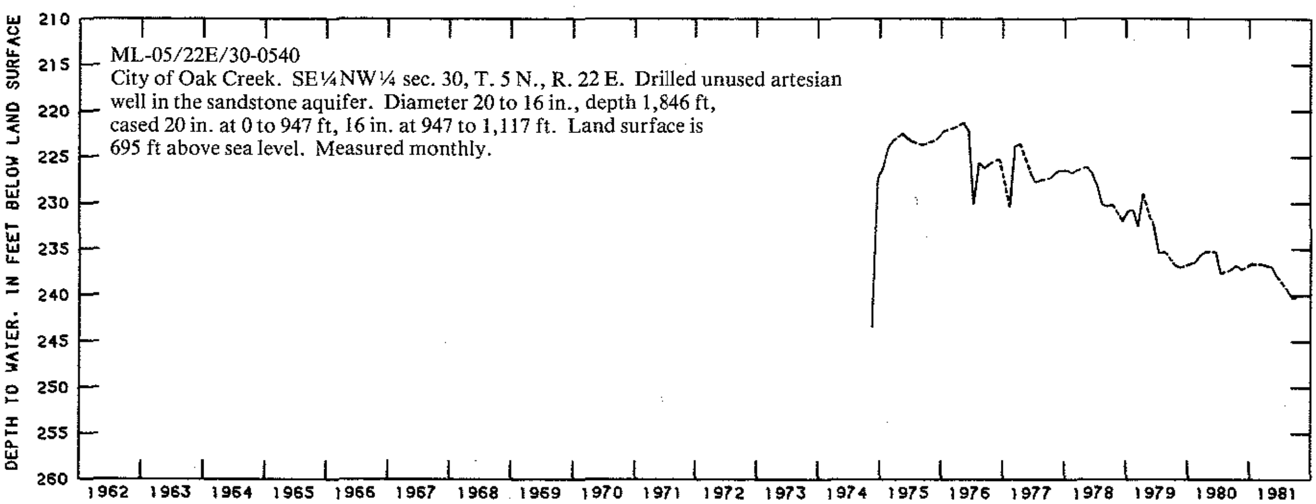

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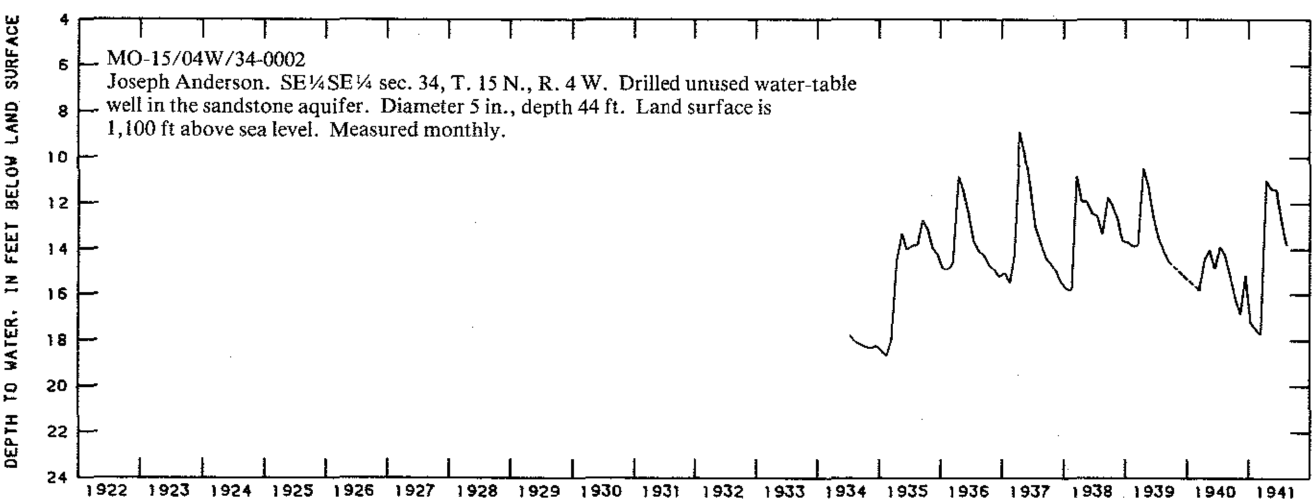

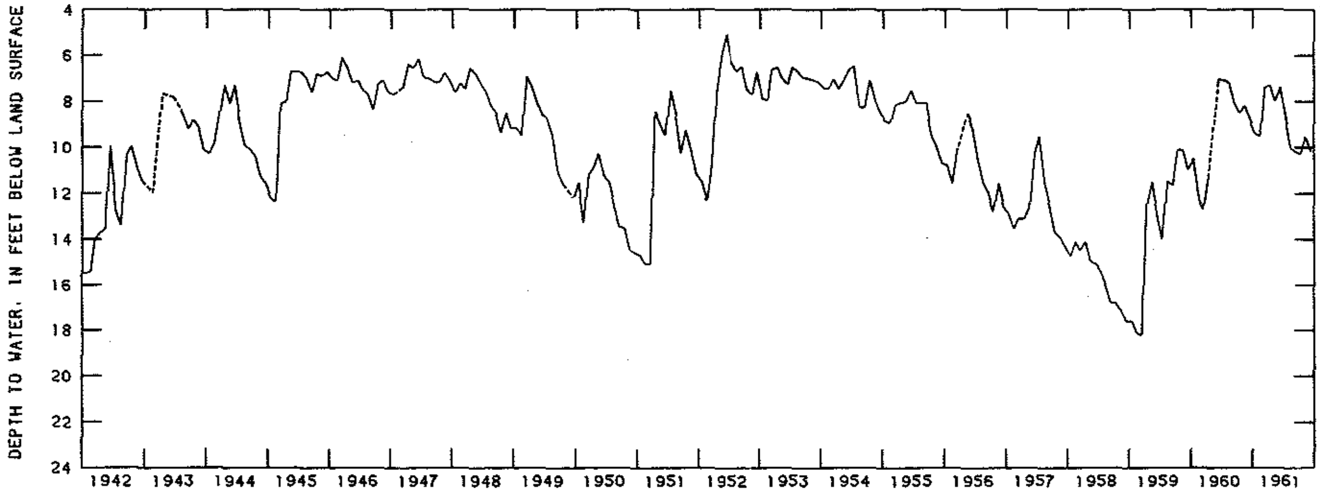

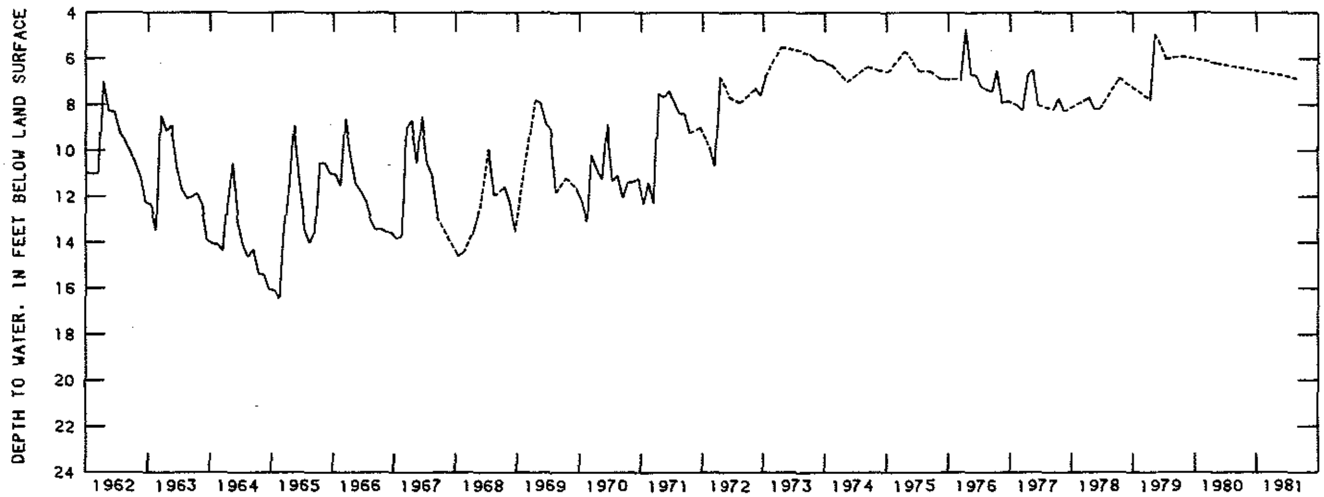

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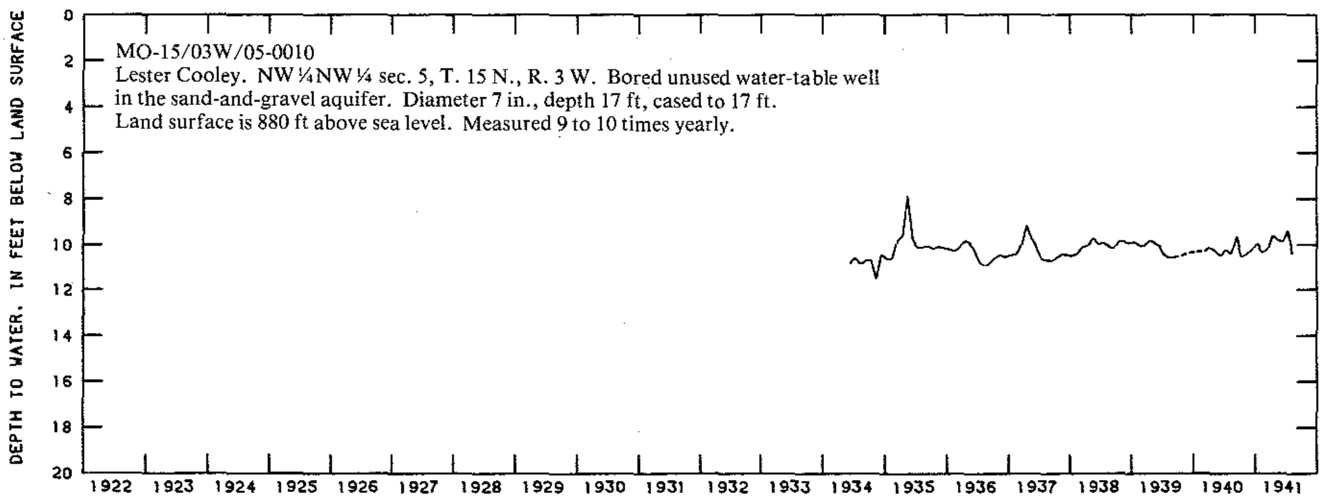

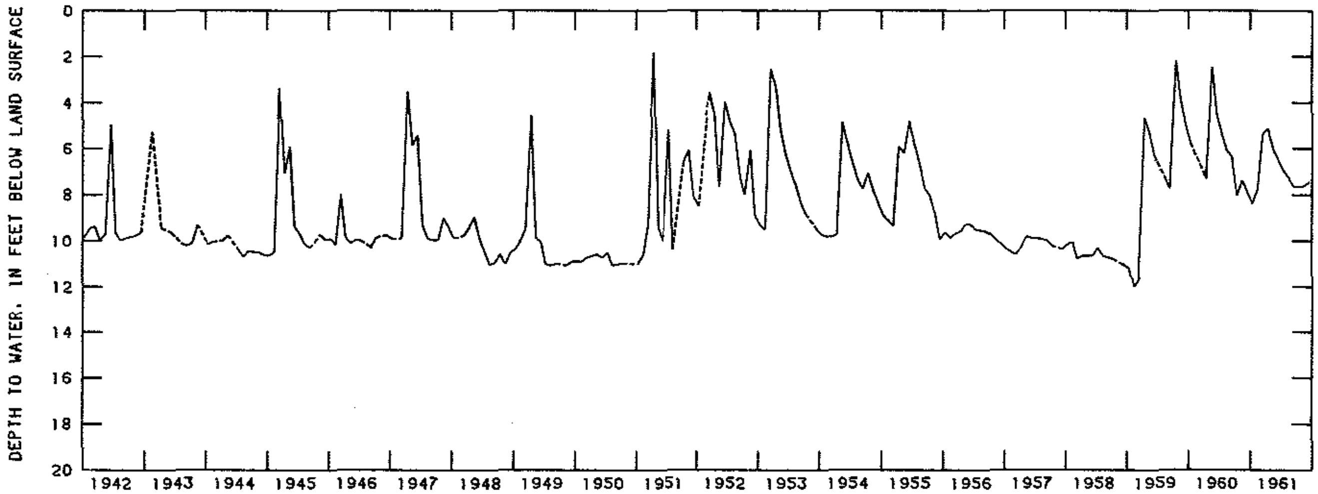

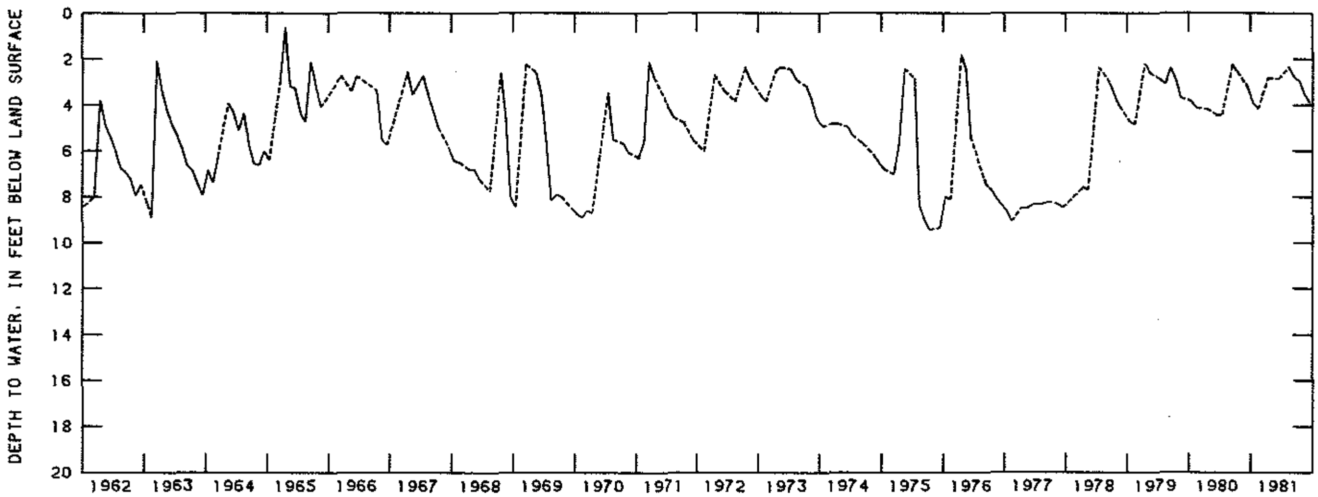

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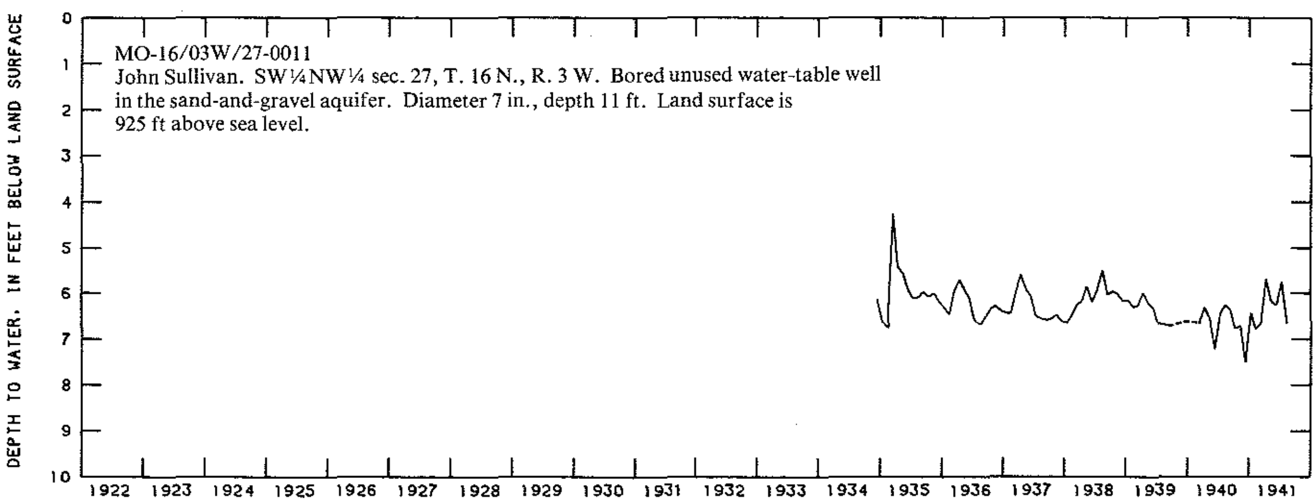

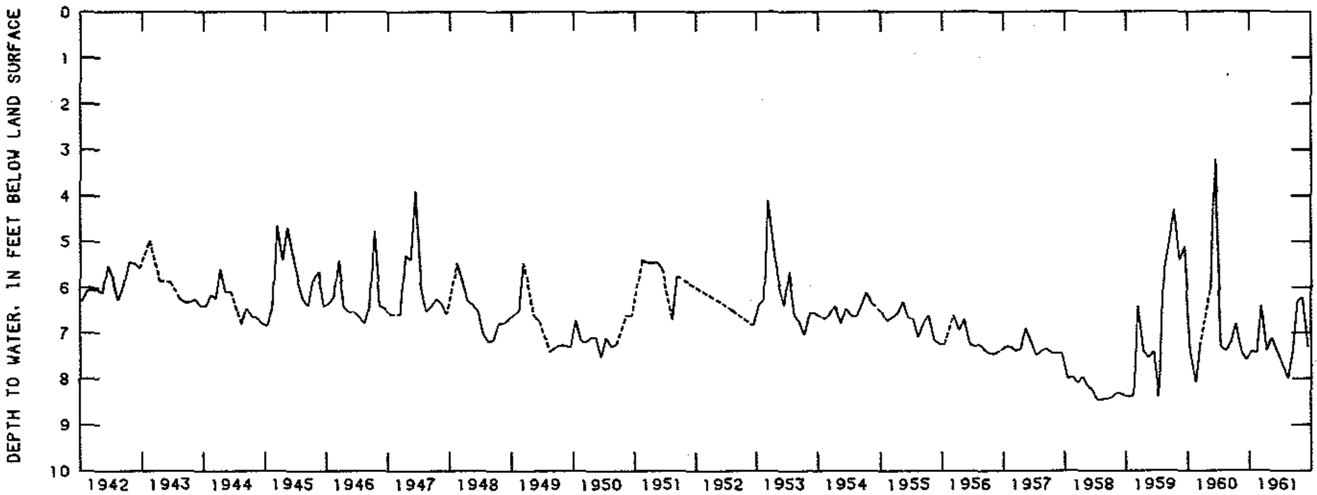

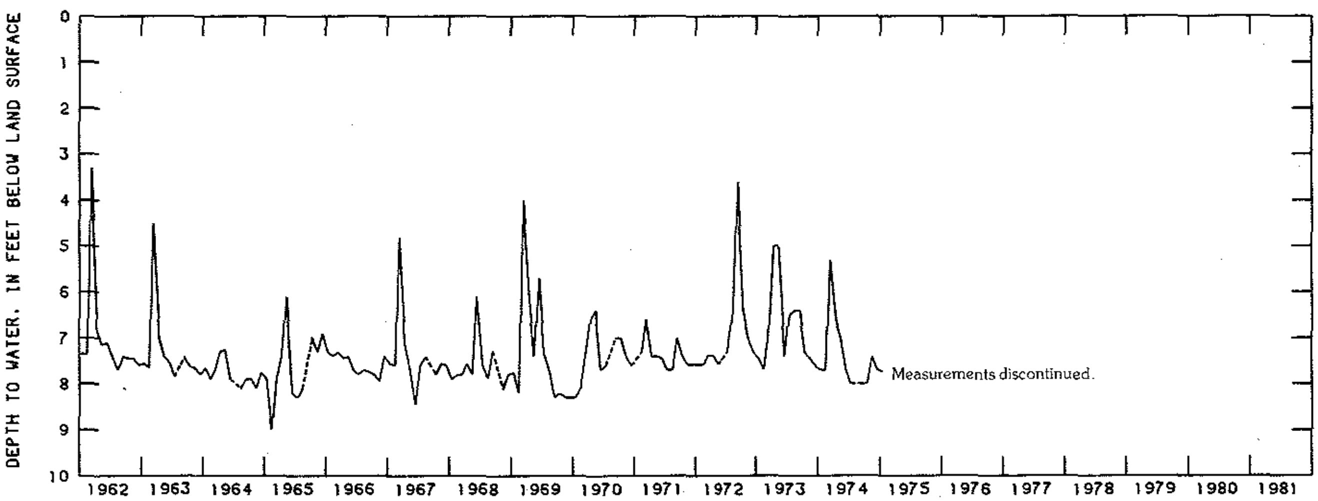

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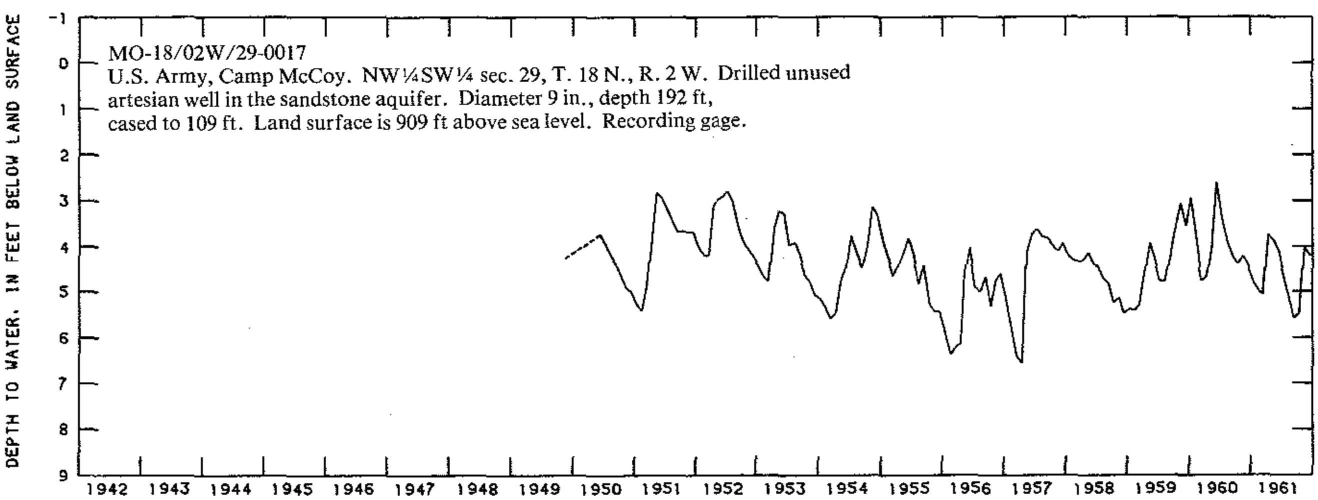
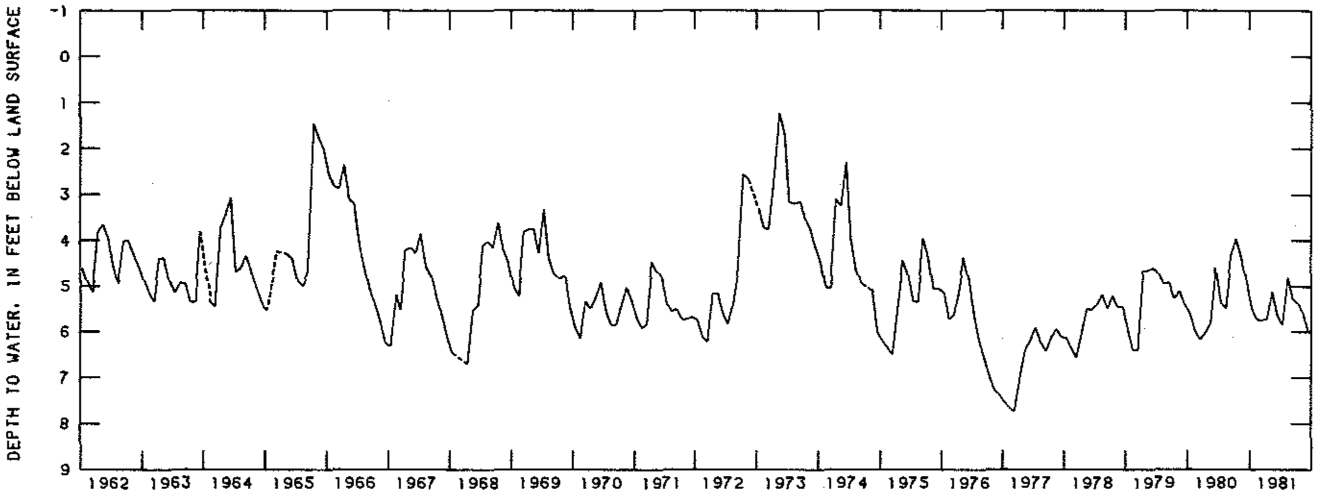
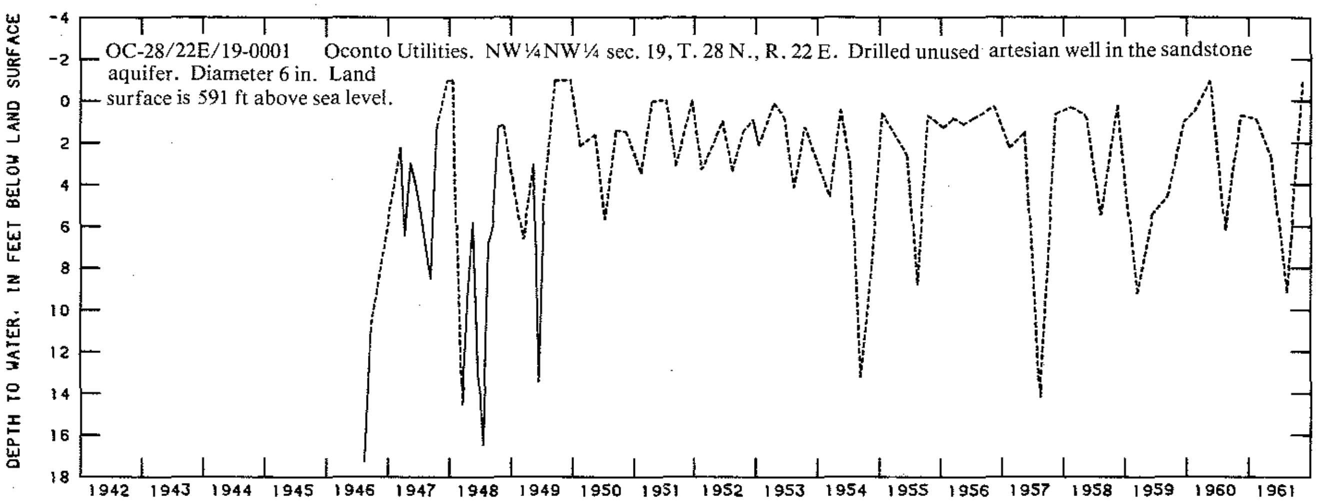
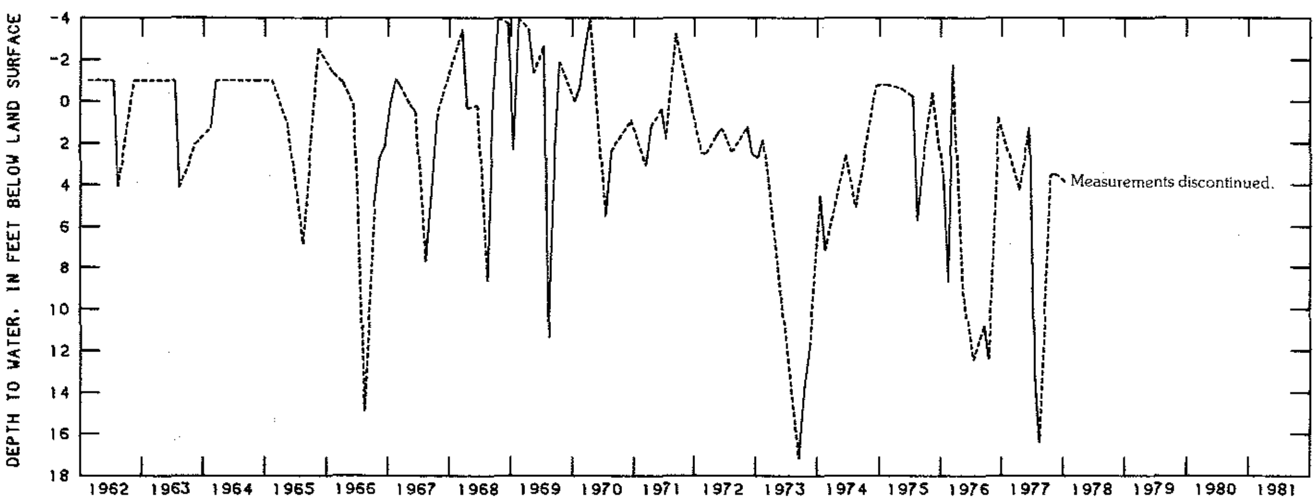


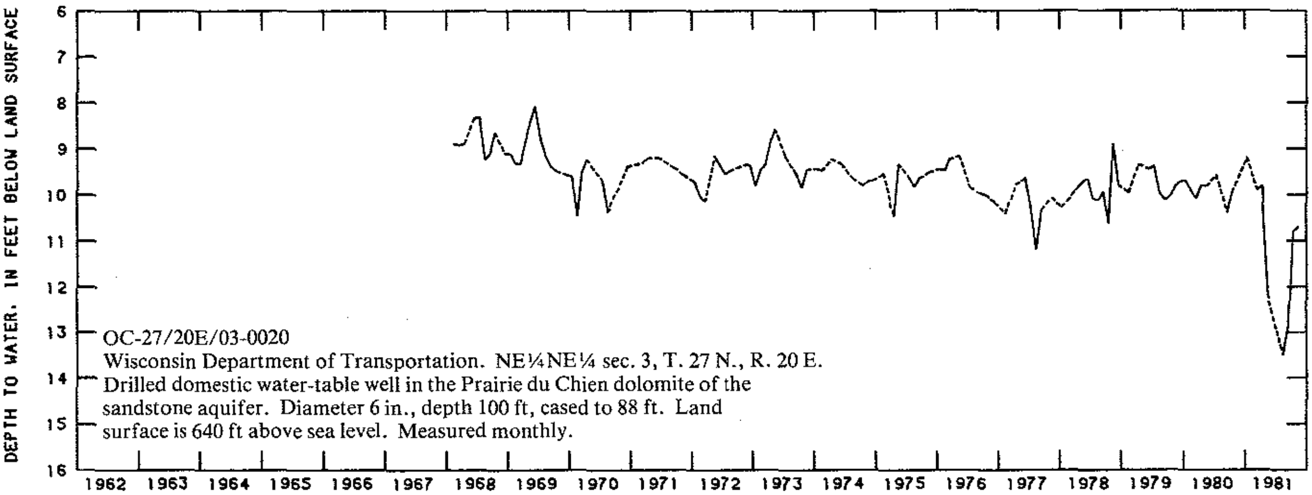


MO-18/02W/29-0017

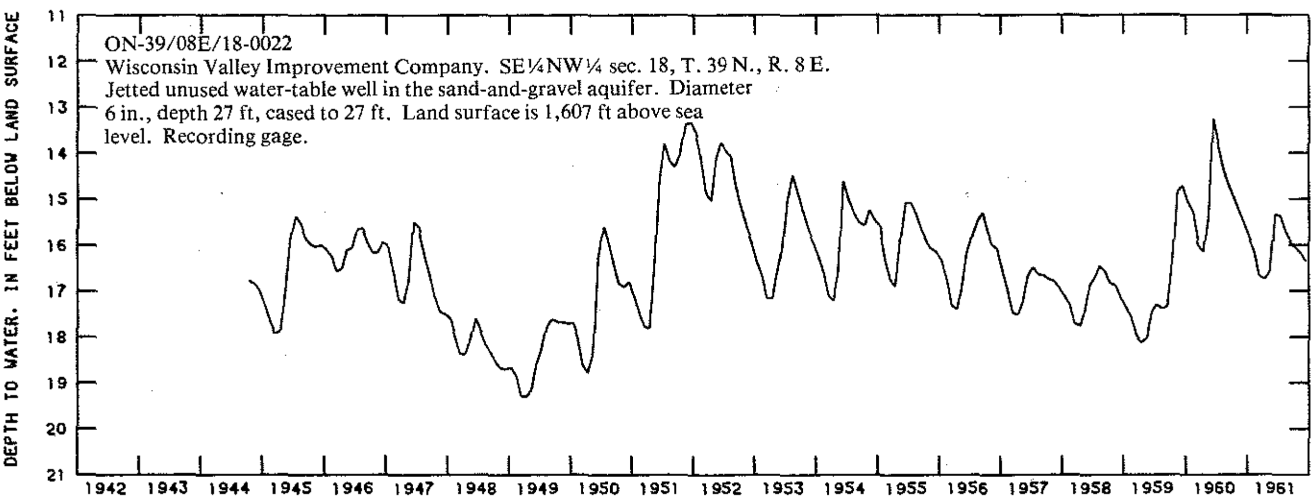


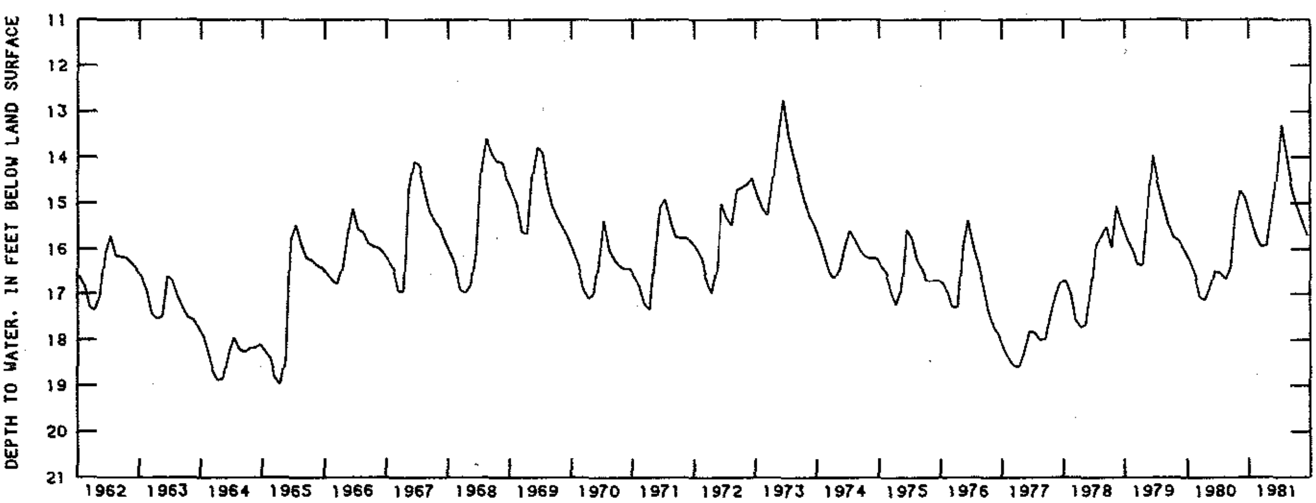


OC-28/22E/19-0001

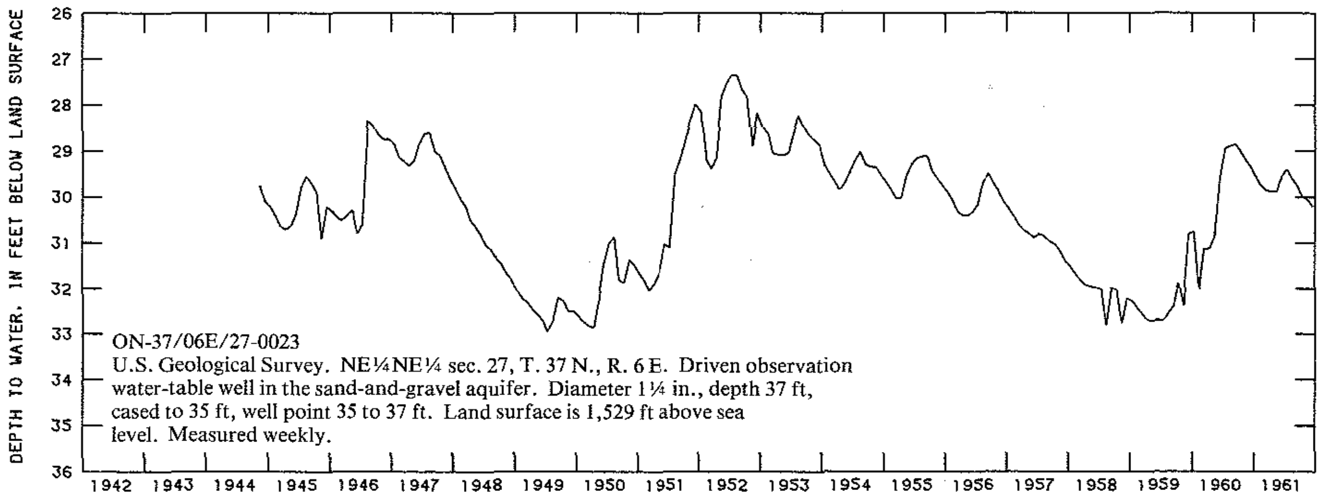


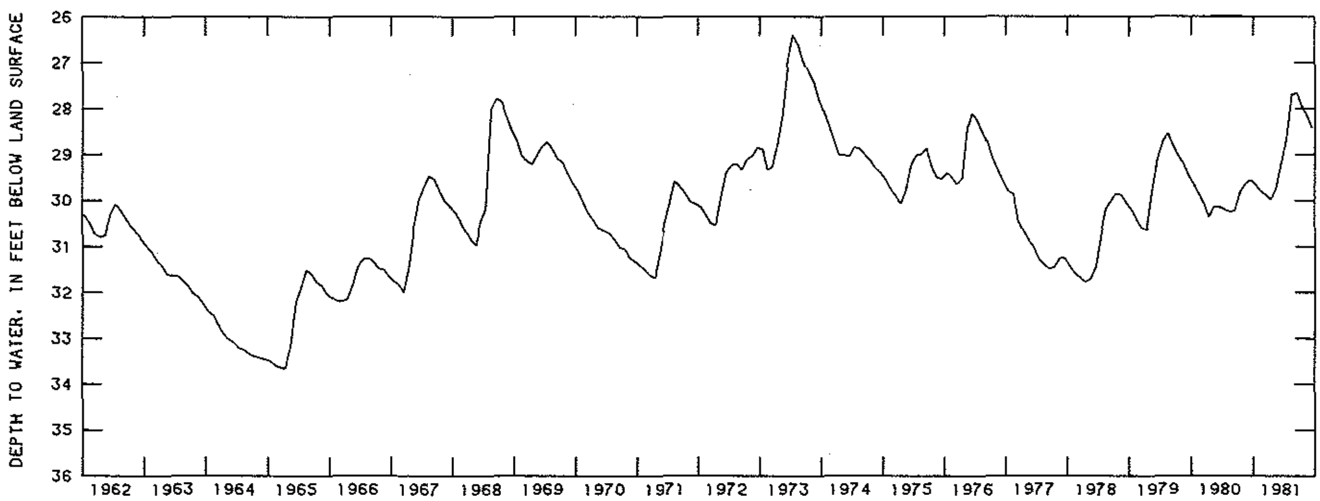
OC-27/20E/03-0020



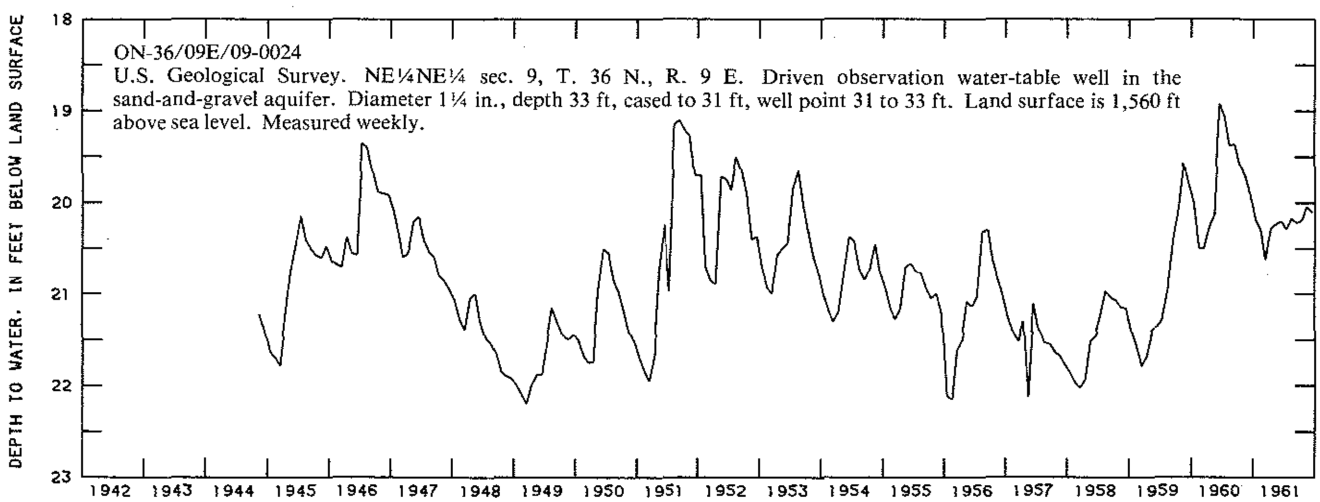


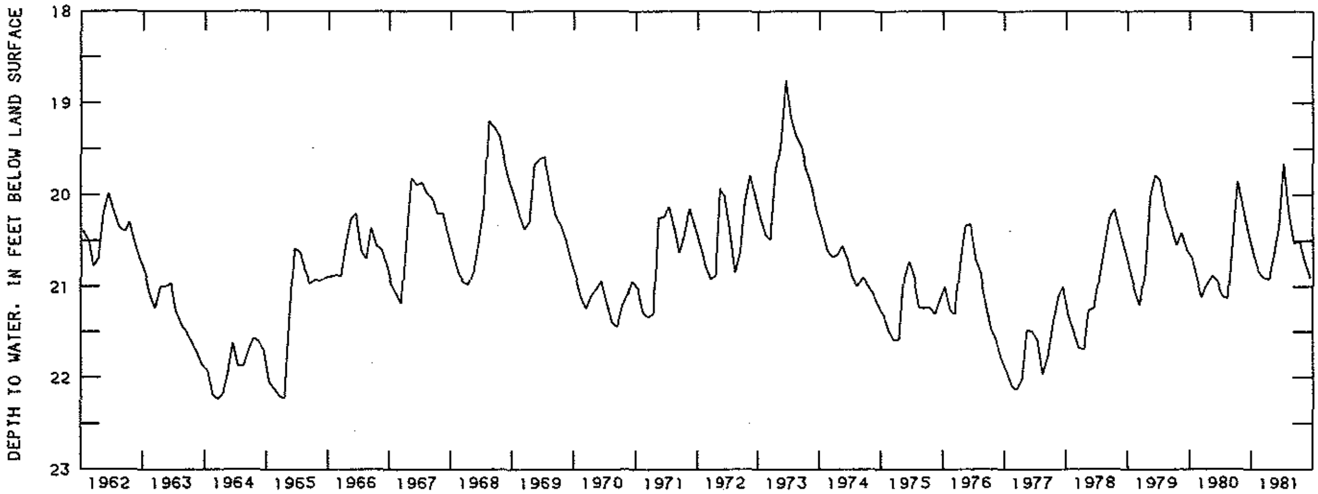
ON-39/08E/18-0022



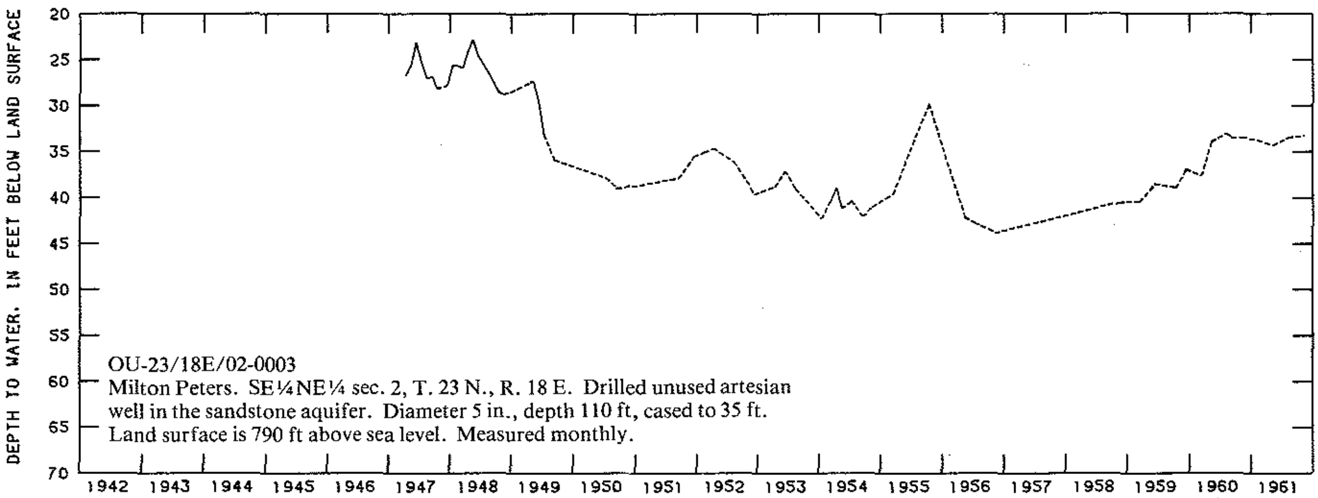


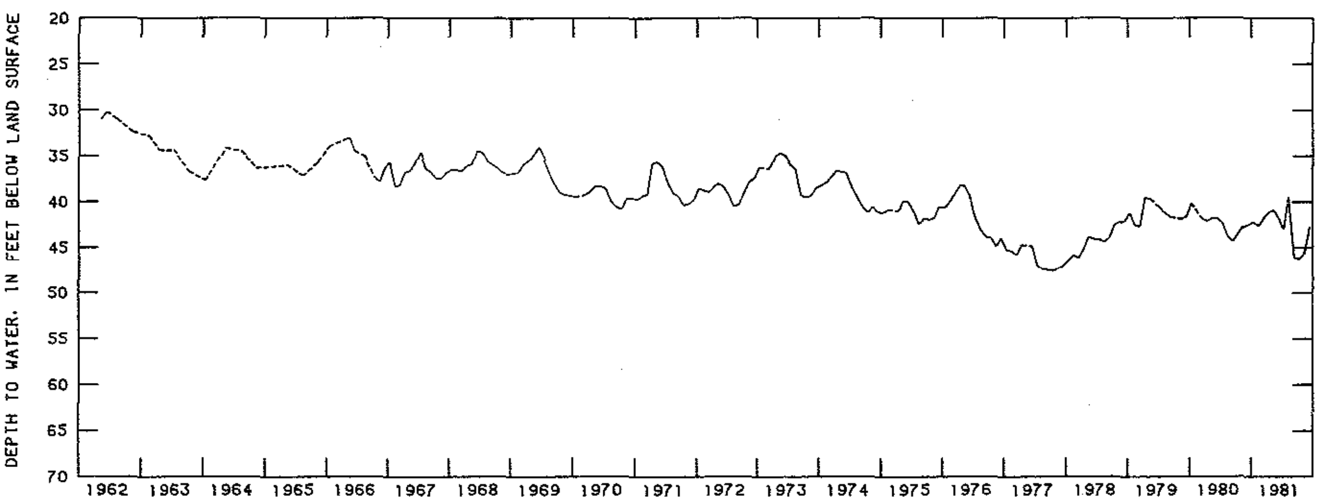
ON-37/06E/27-0023



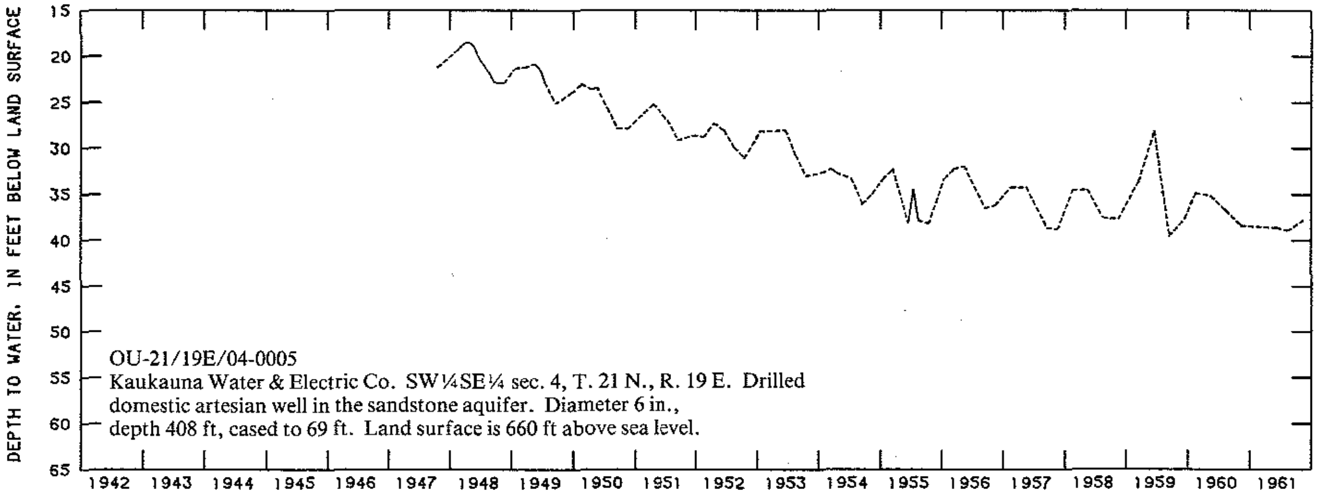


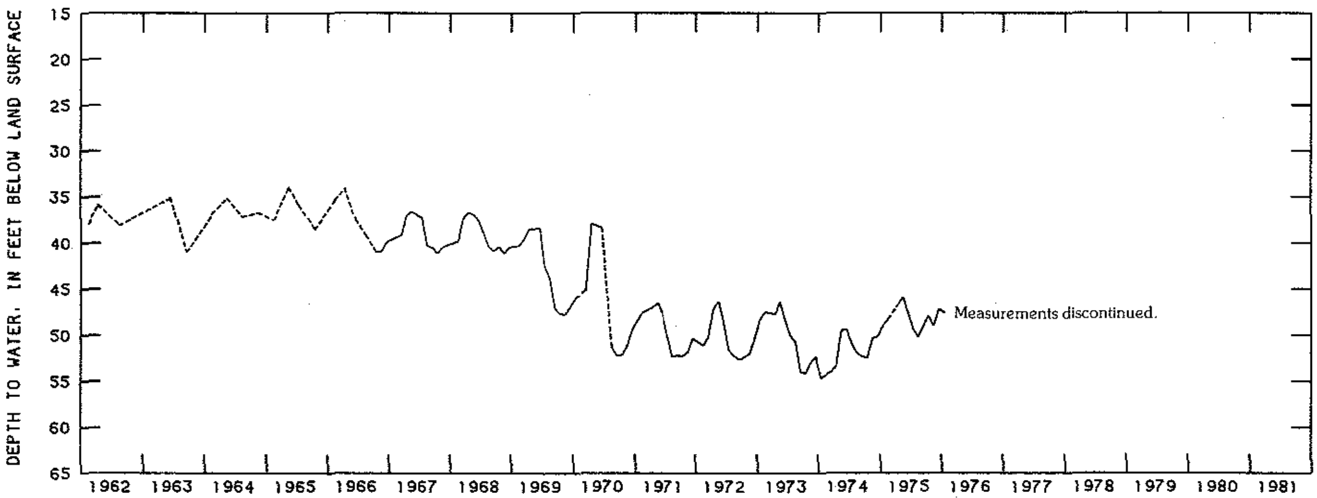
ON-36/09E/09-0024



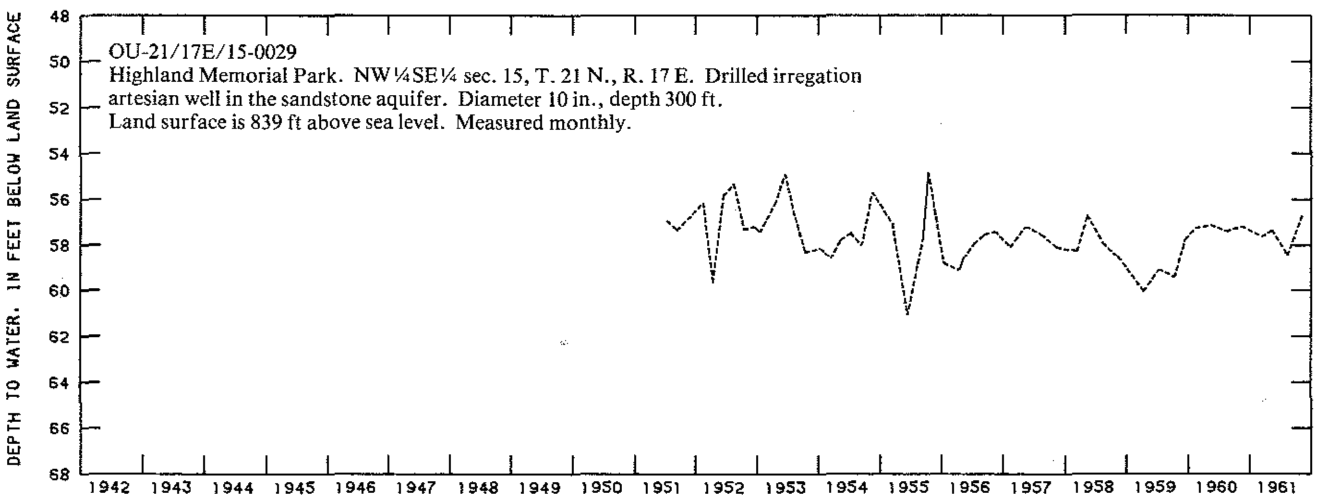


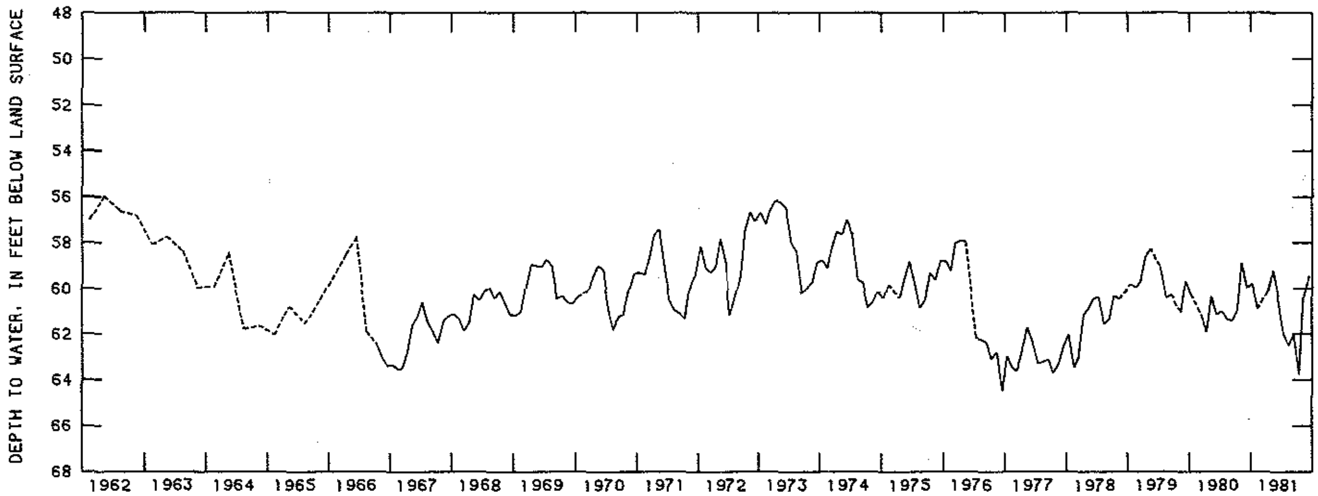
OU-23/18E/02-0003



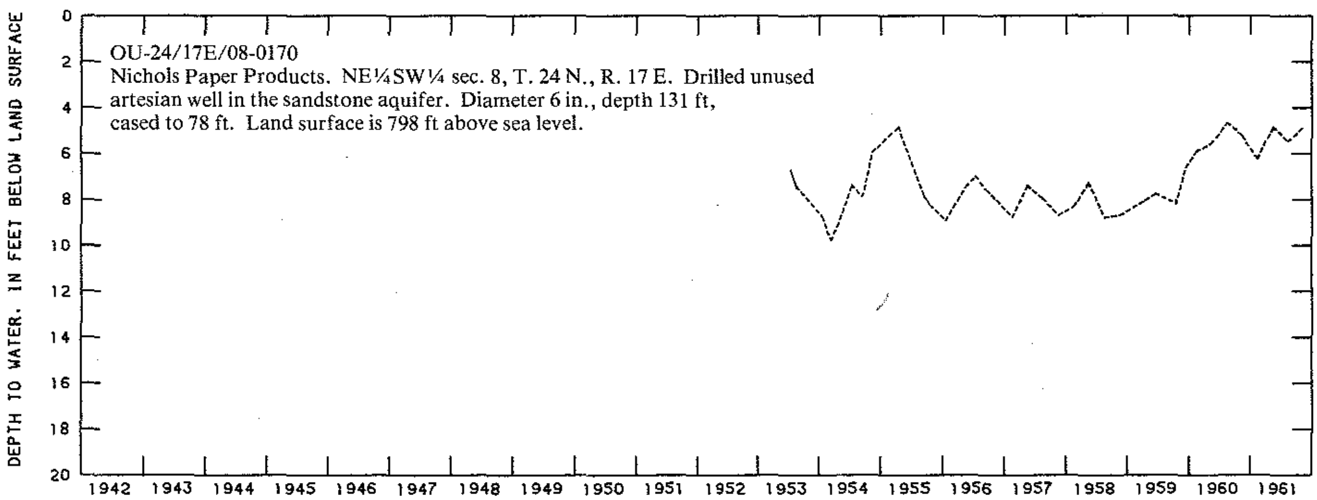


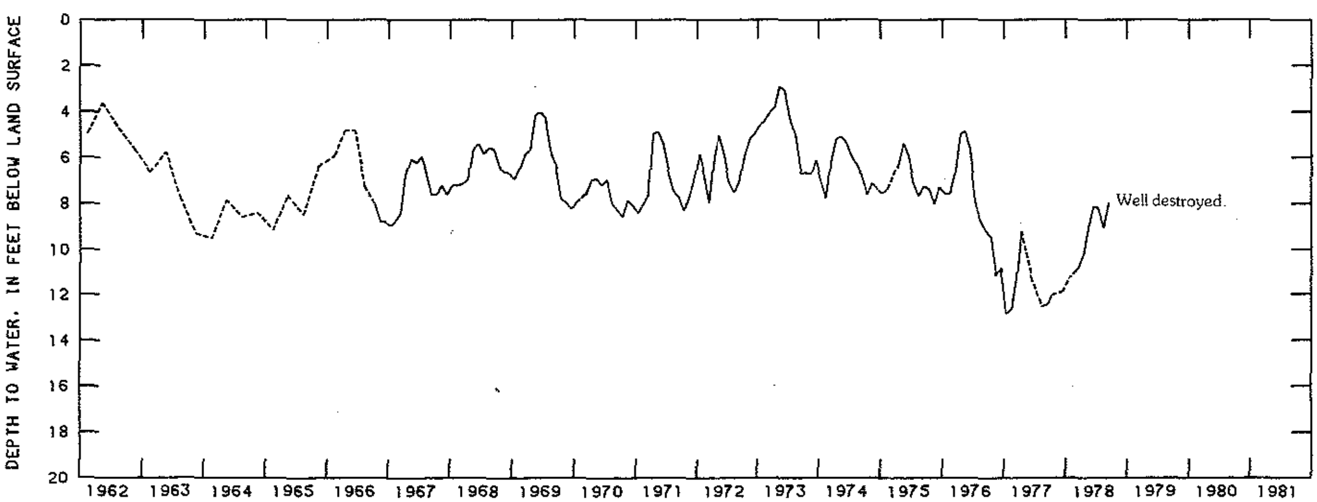
OU-21/19E/04-0005



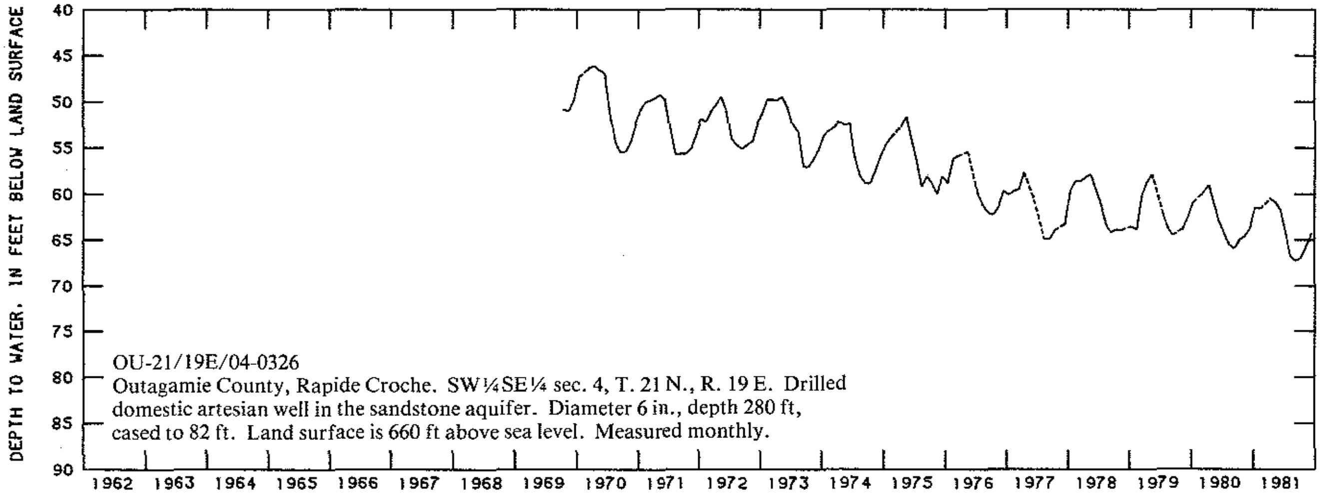


OU-21/17E/15-0029

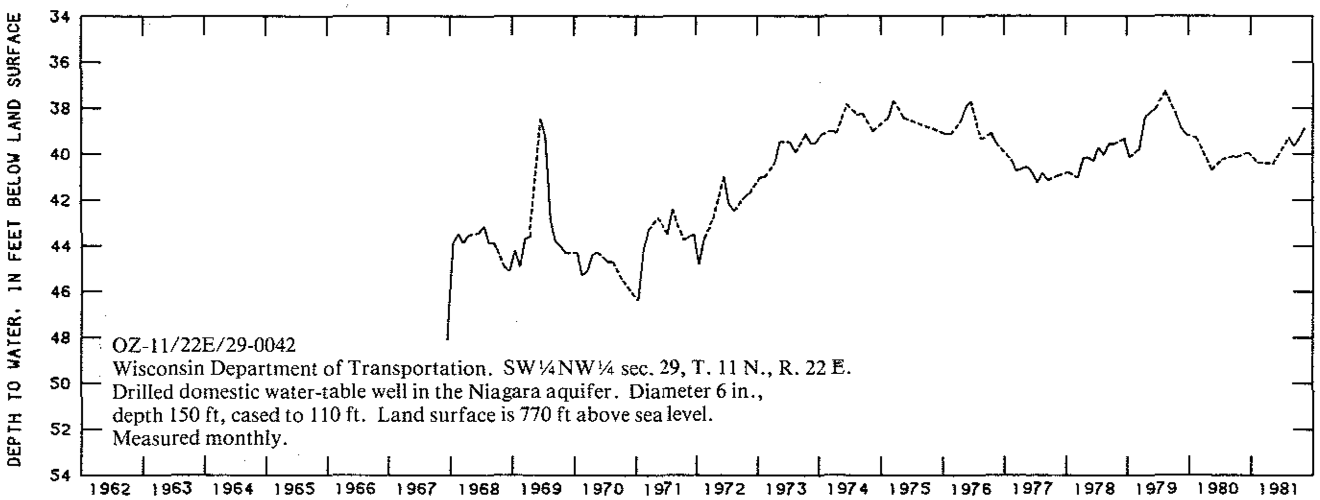




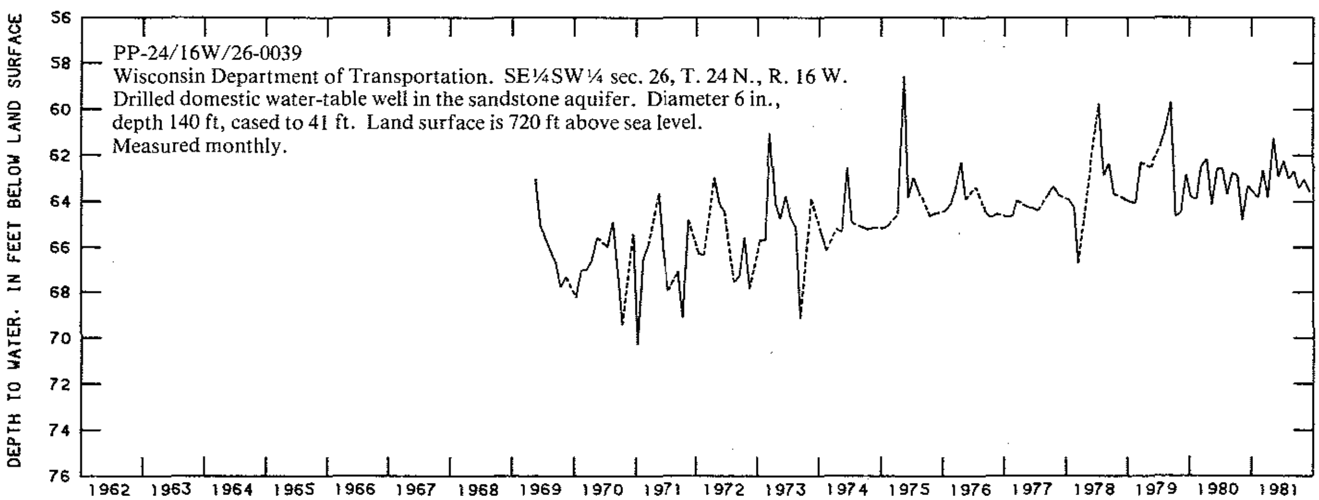
OU-24/17E/08-0170



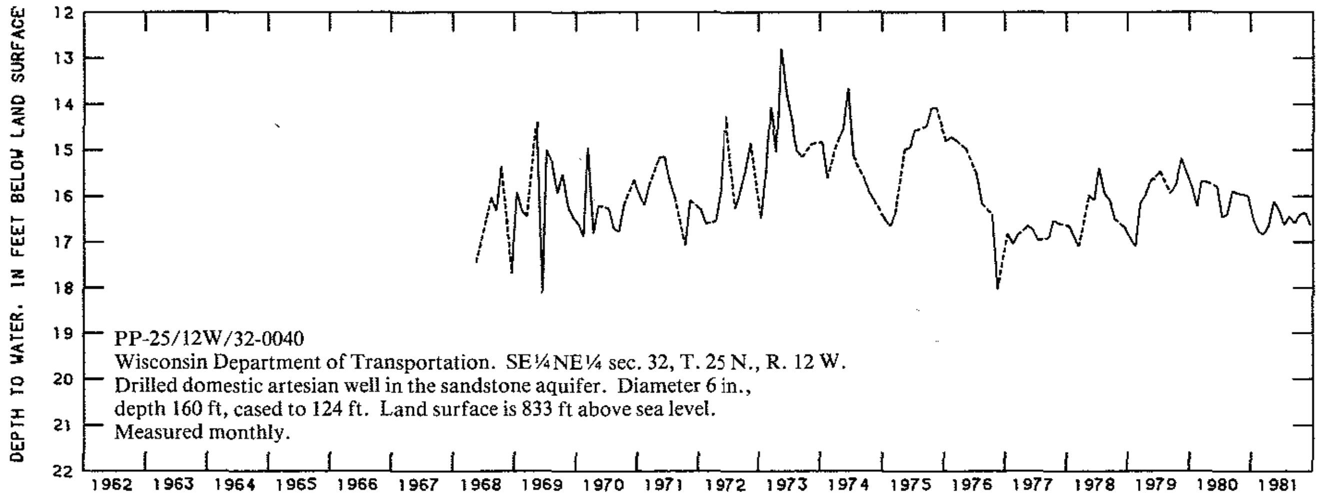
OU-21/19E/04-0326



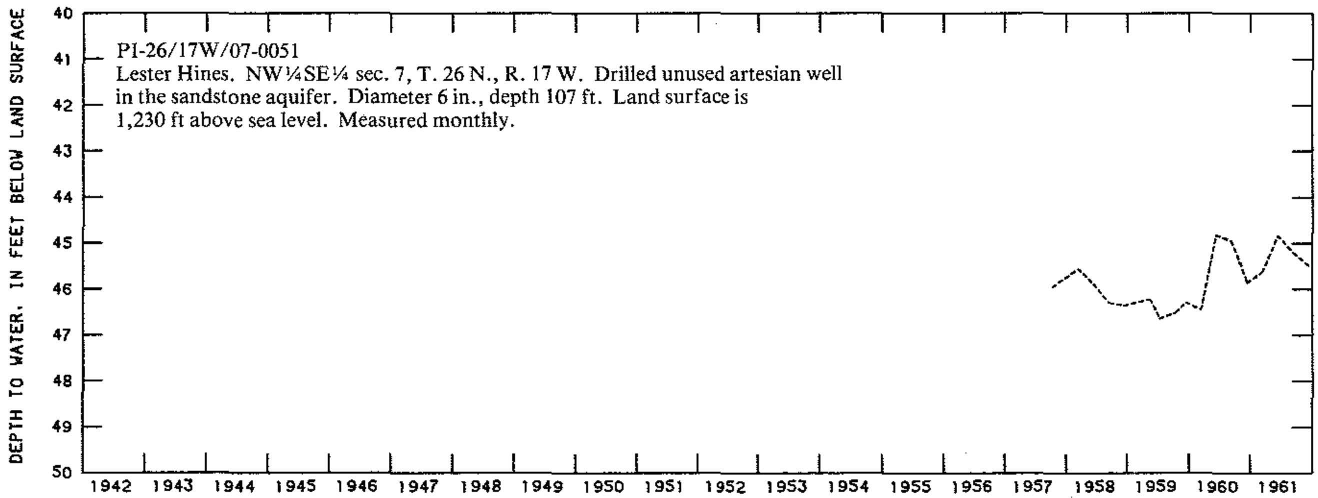
OZ-11/22E/29-0042

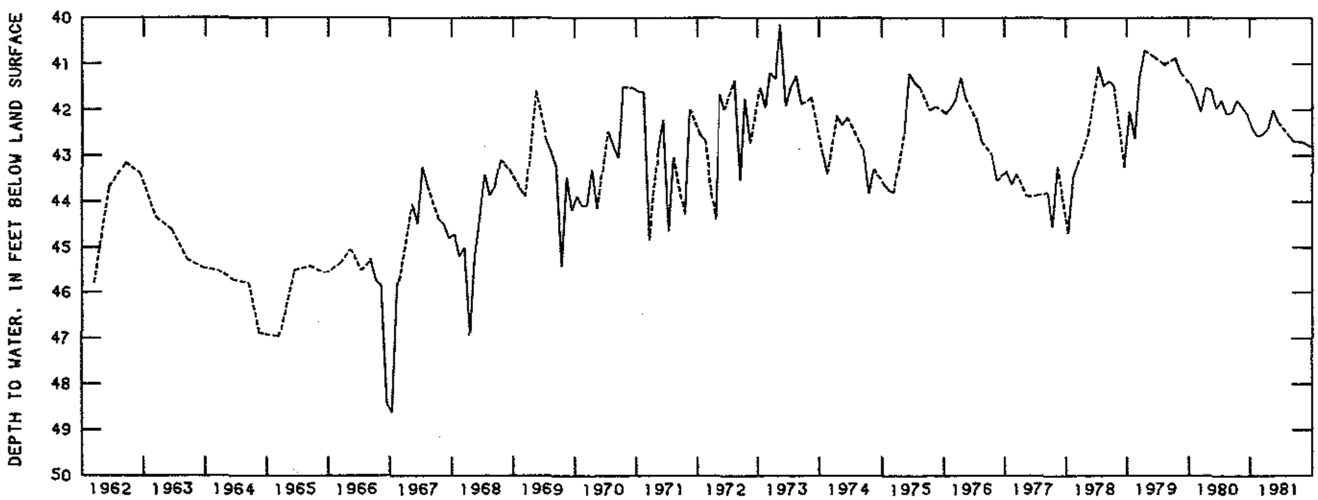


PP-24/16W/26-0039

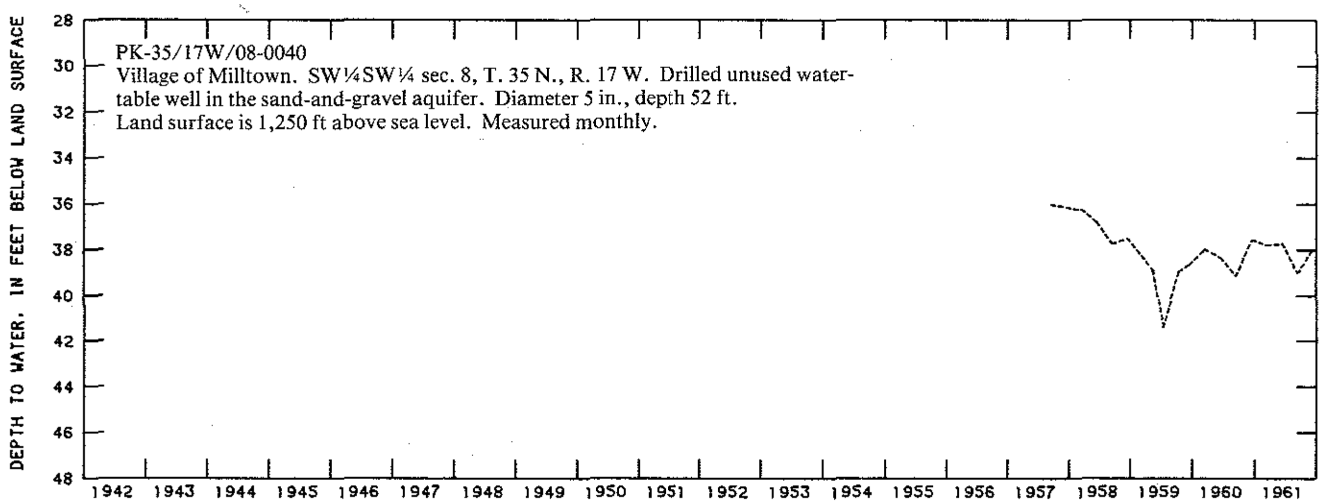


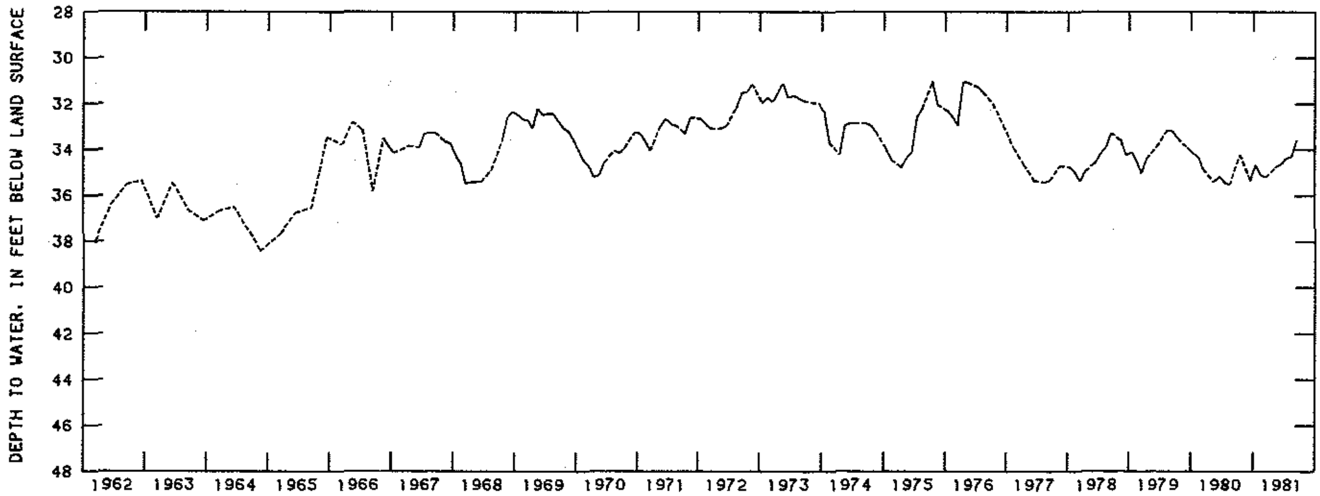
PP-25/12W/32-0040



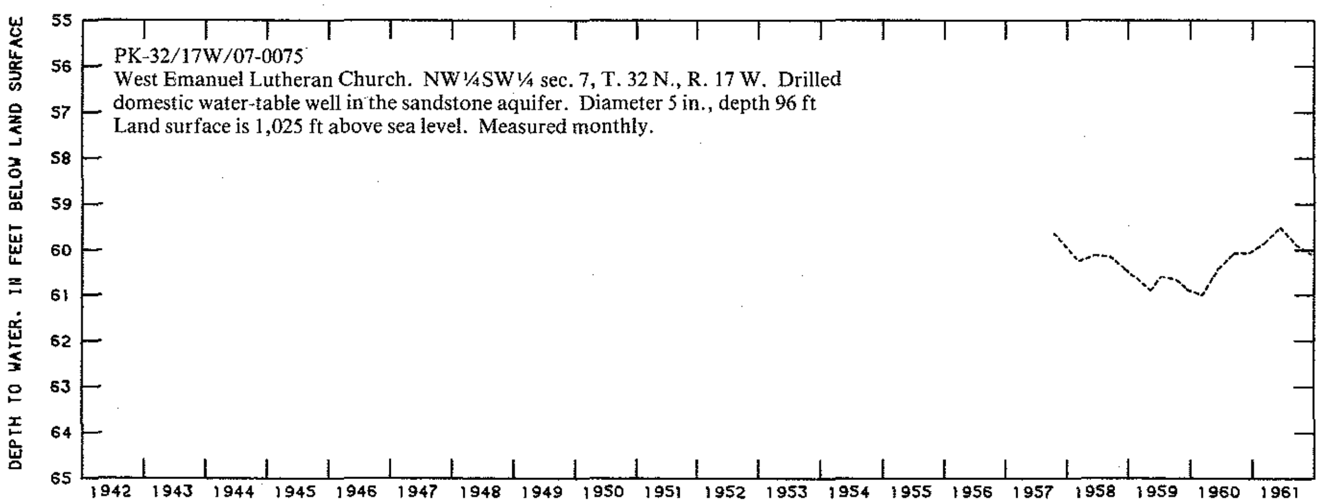


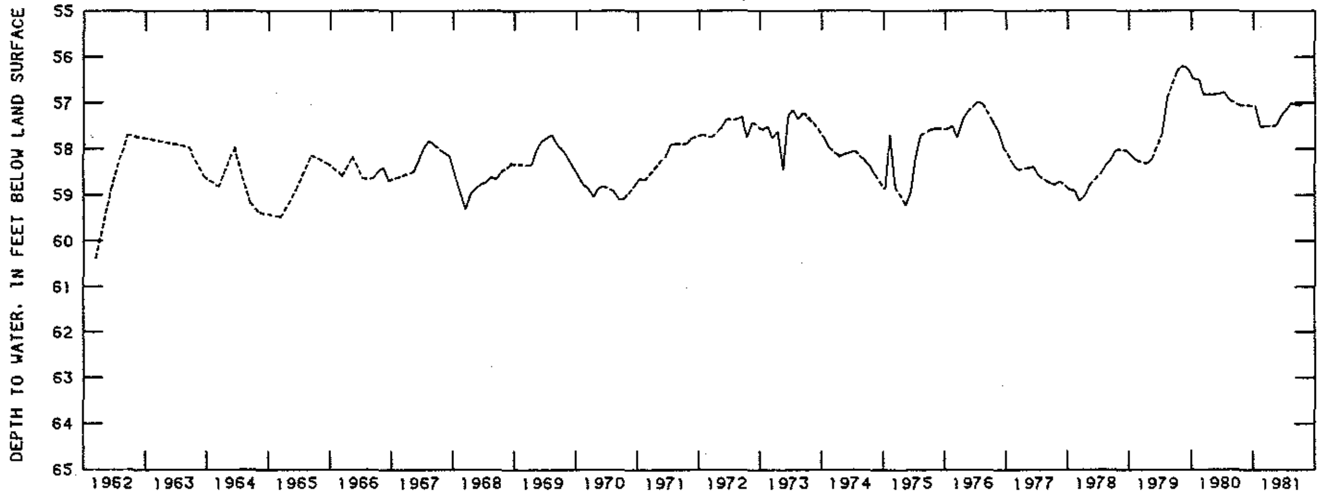
PI-26/17W/07-0051



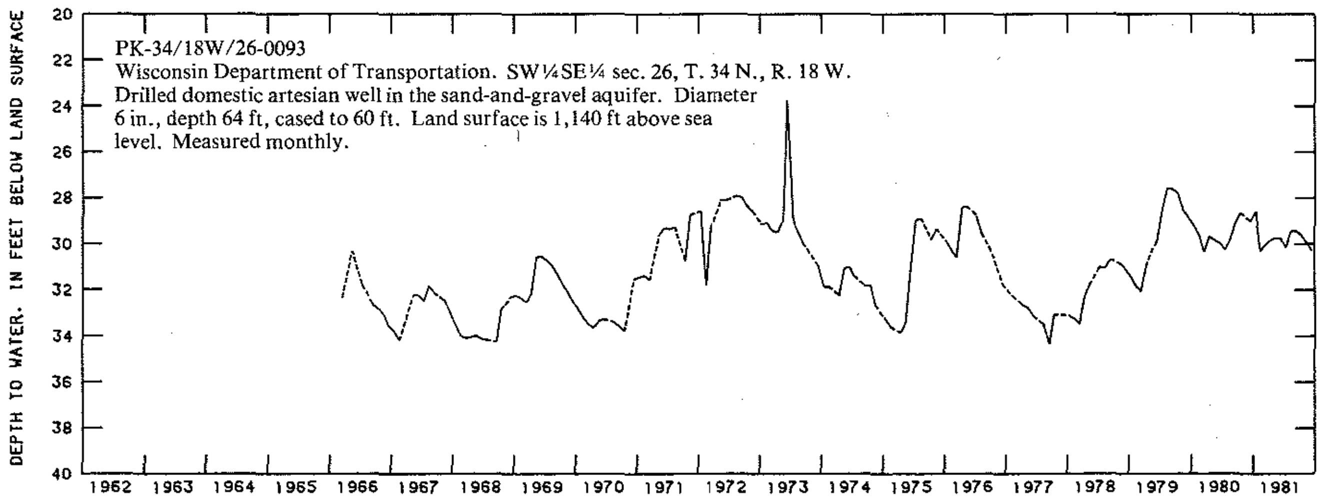


PK-35/17W/08-0040

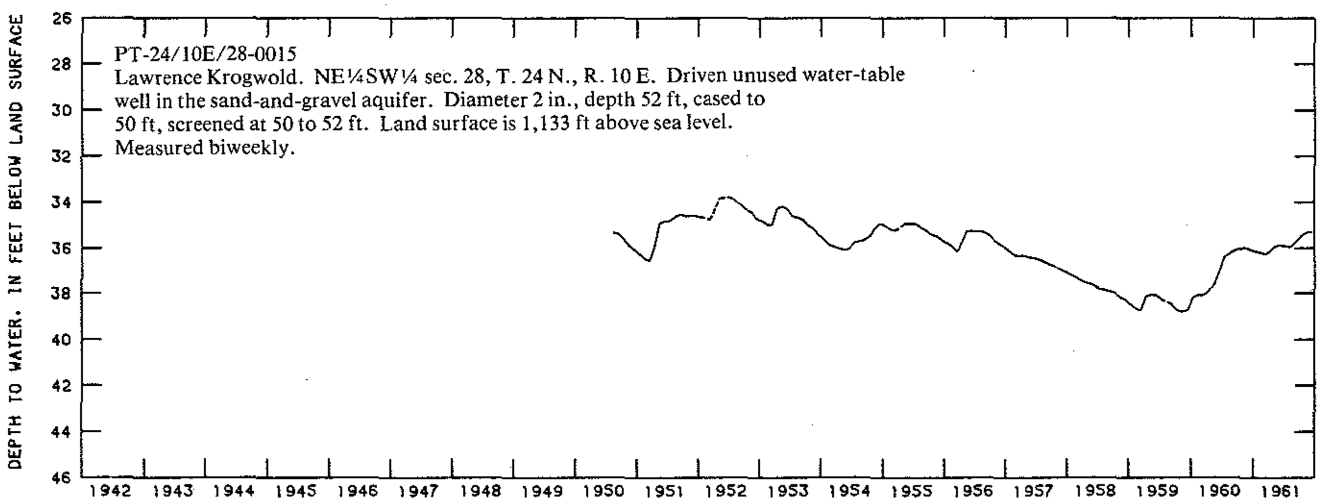


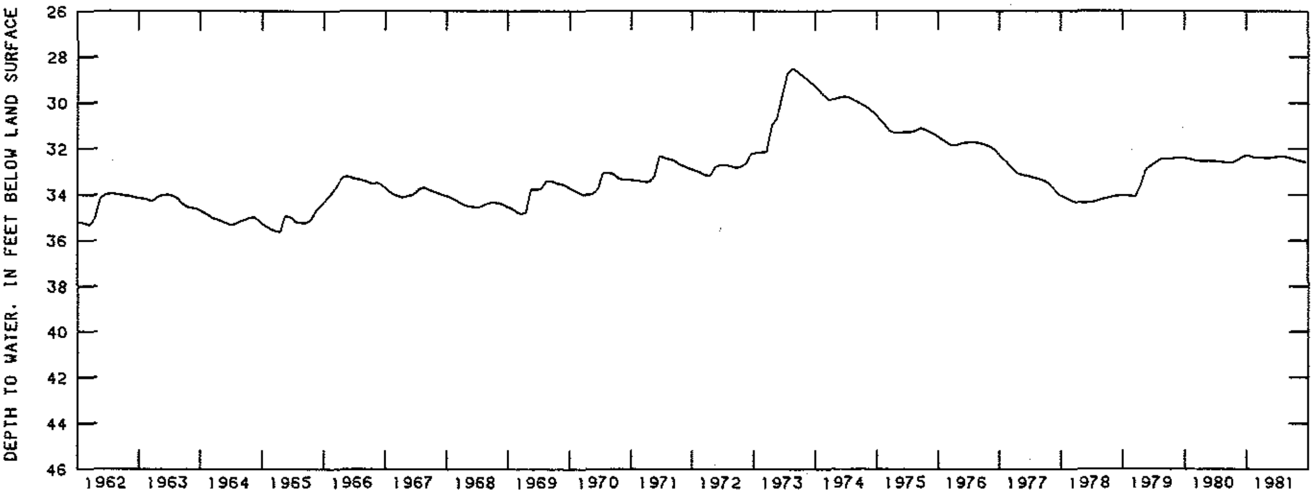


PK-32/17W/07-0075

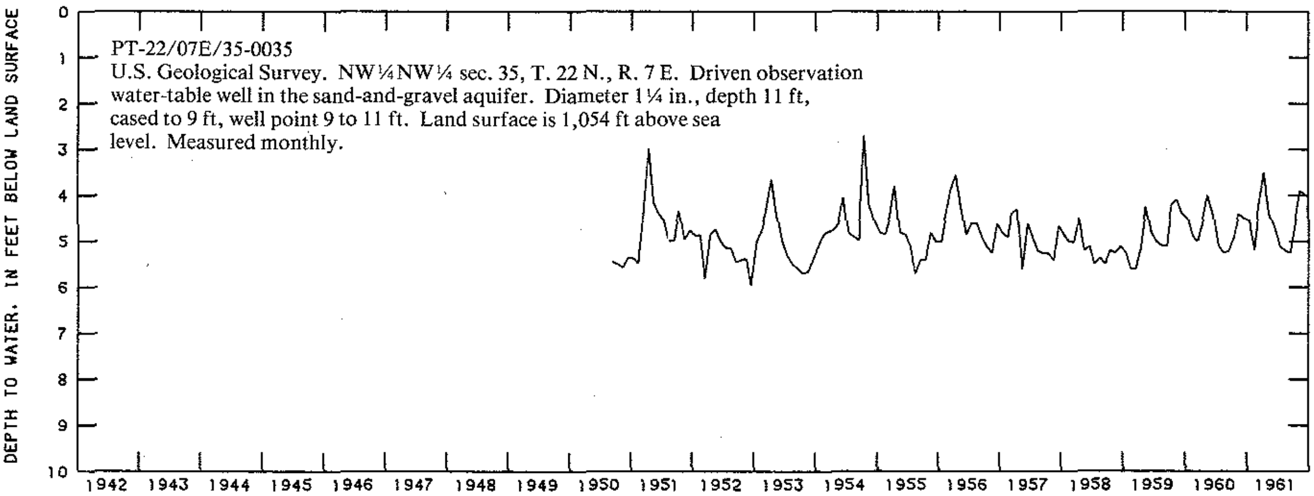


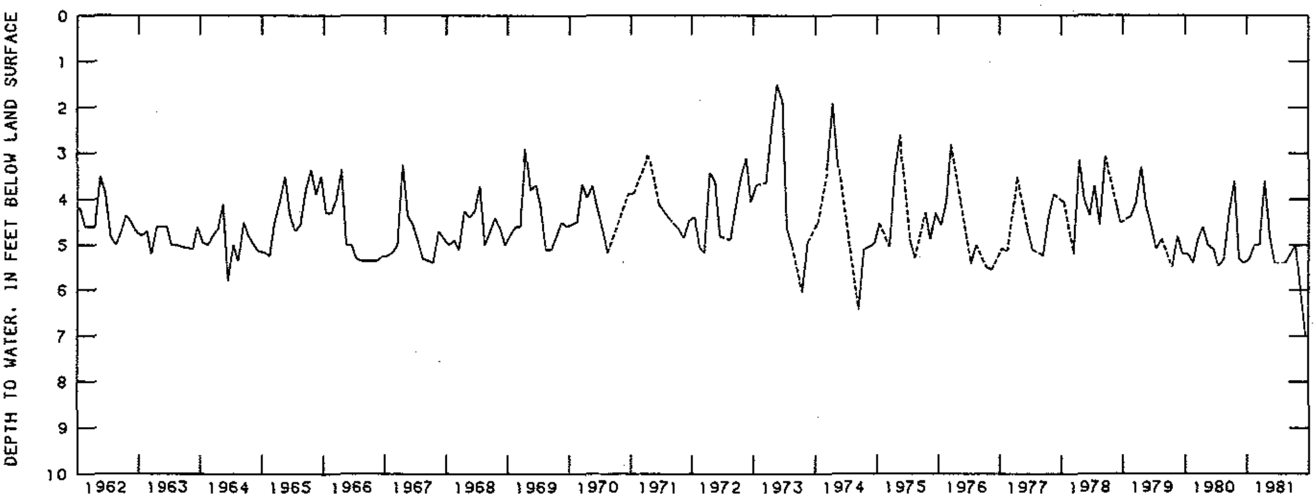
PK-34/18W/26-0093



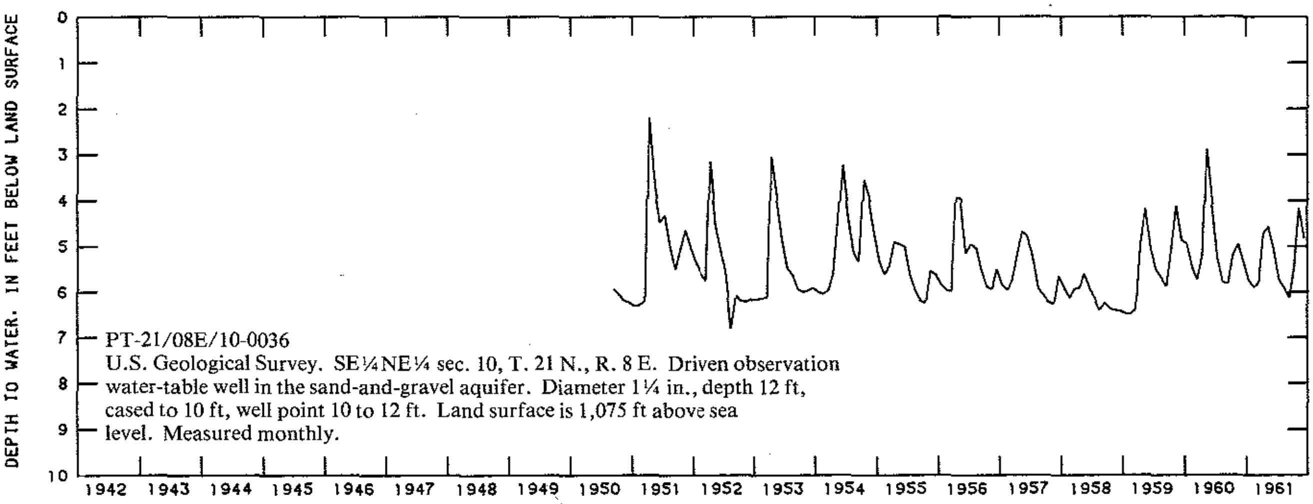


PT-24/10E/28-0015

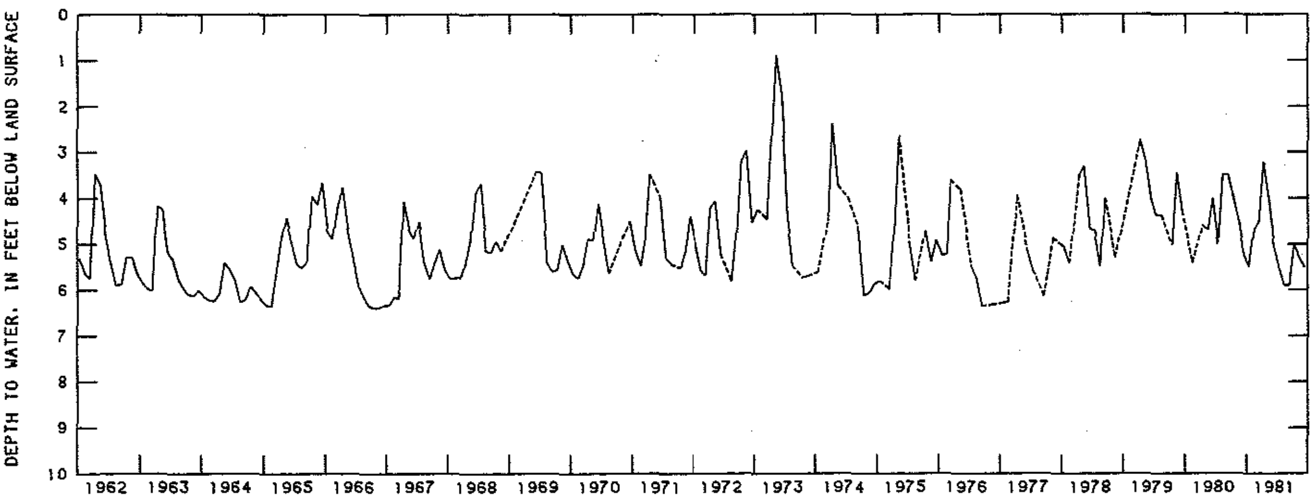




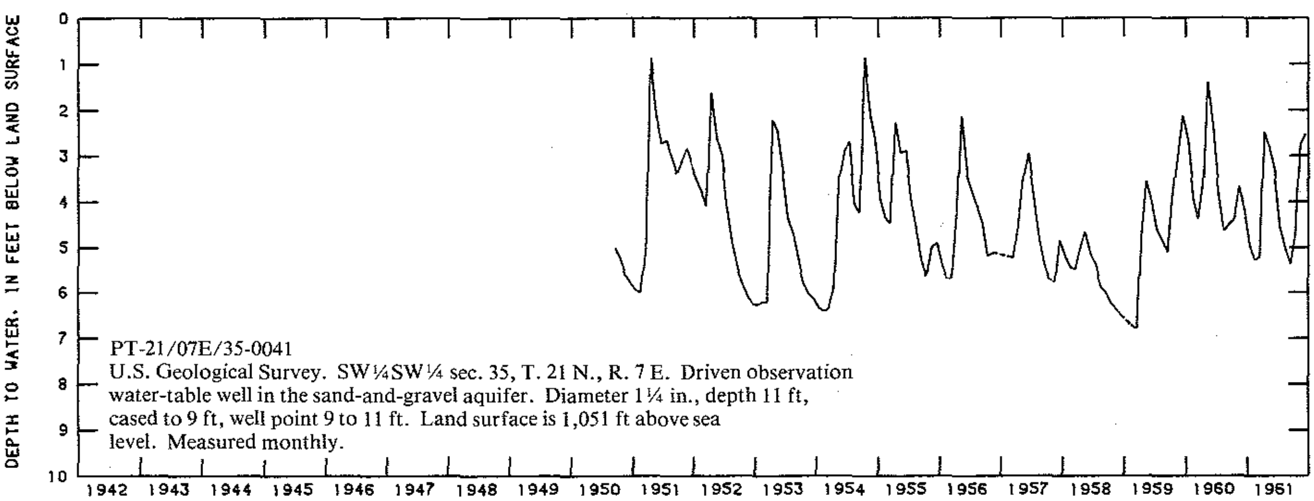
PT-22/07E/35-0035



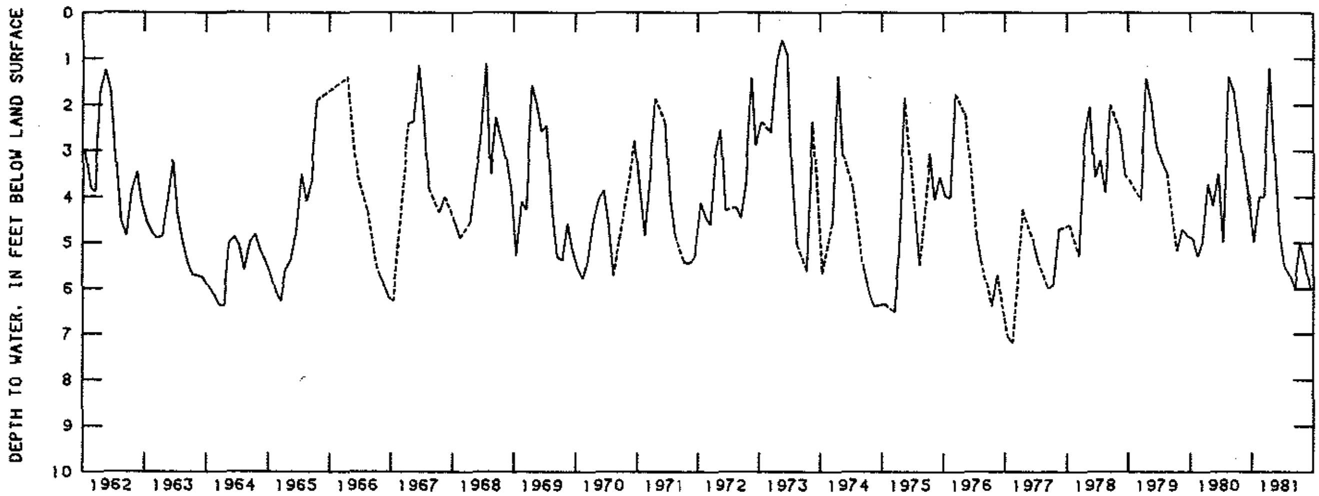
PT-21/08E/10-0036
U.S. Geological Survey. SE¼NE¼ sec. 10, T. 21 N., R. 8 E. Driven observation water-table well in the sand-and-gravel aquifer. Diameter 1¼ in., depth 12 ft, cased to 10 ft, well point 10 to 12 ft. Land surface is 1,075 ft above sea level. Measured monthly.



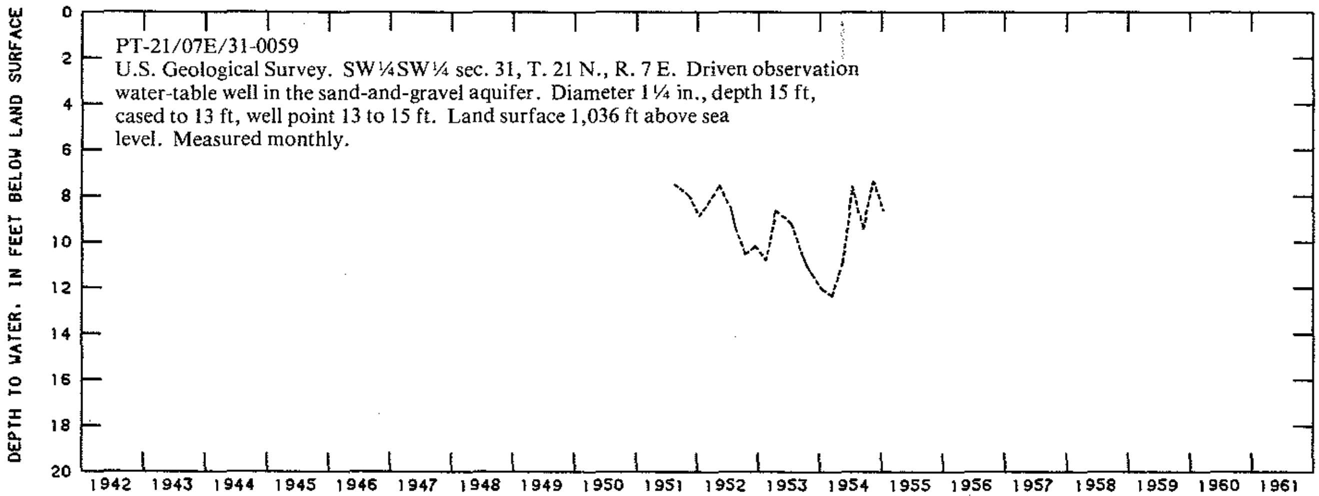
PT-21/08E/10-0036

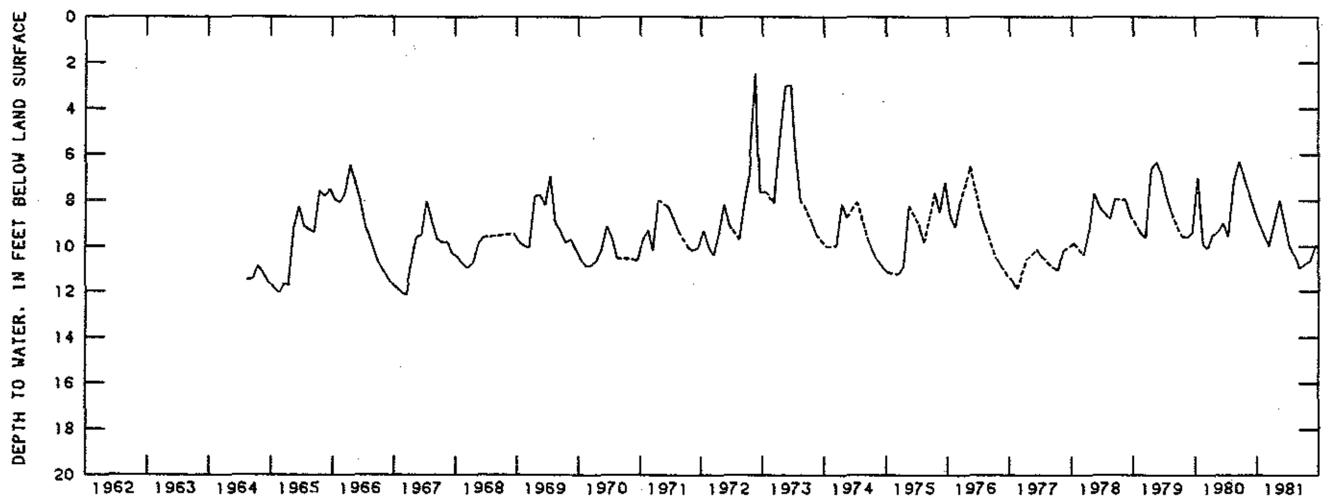


PT-21/07E/35-0041
U.S. Geological Survey. SW¼SW¼ sec. 35, T. 21 N., R. 7 E. Driven observation water-table well in the sand-and-gravel aquifer. Diameter 1¼ in., depth 11 ft, cased to 9 ft, well point 9 to 11 ft. Land surface is 1,051 ft above sea level. Measured monthly.

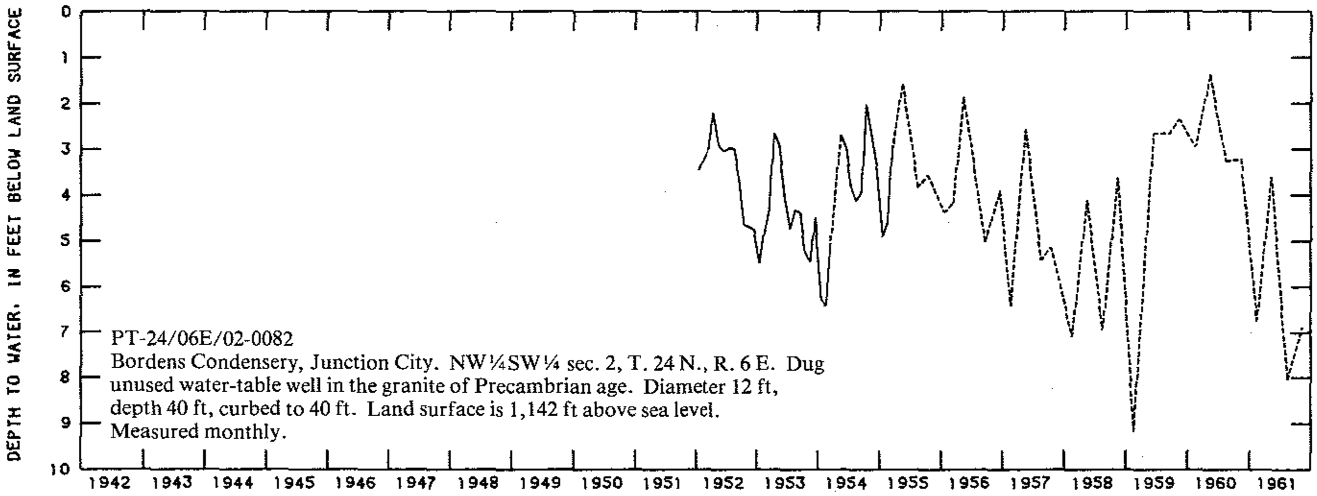


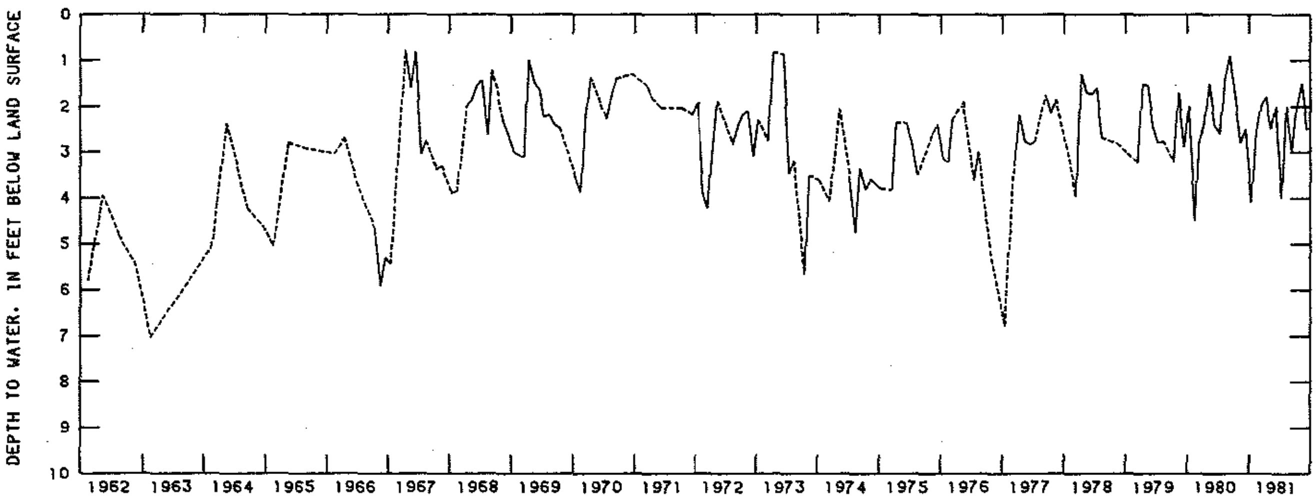
PT-21/07E/35-0041



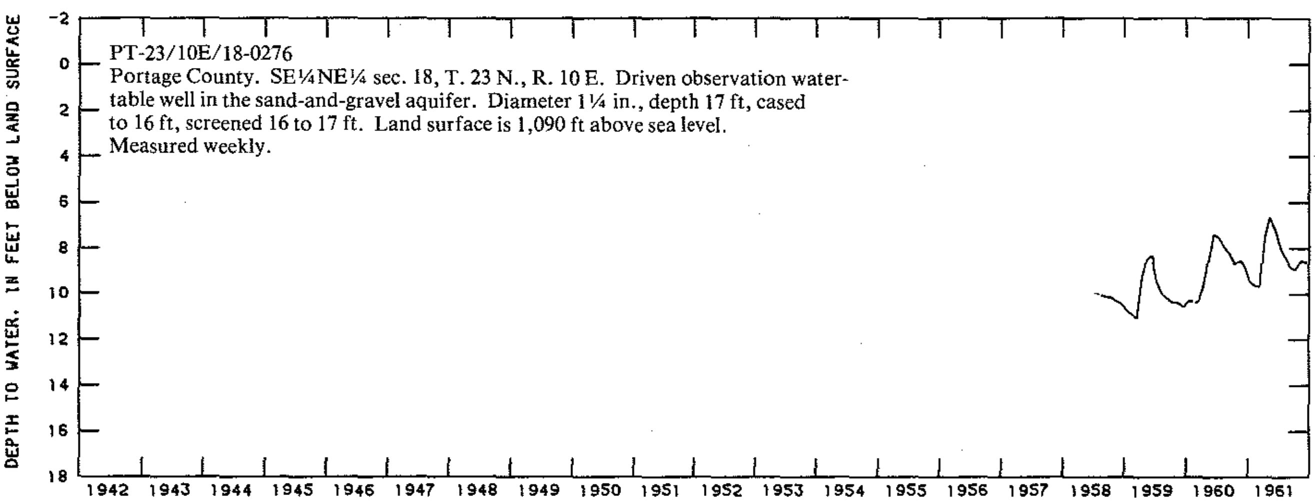


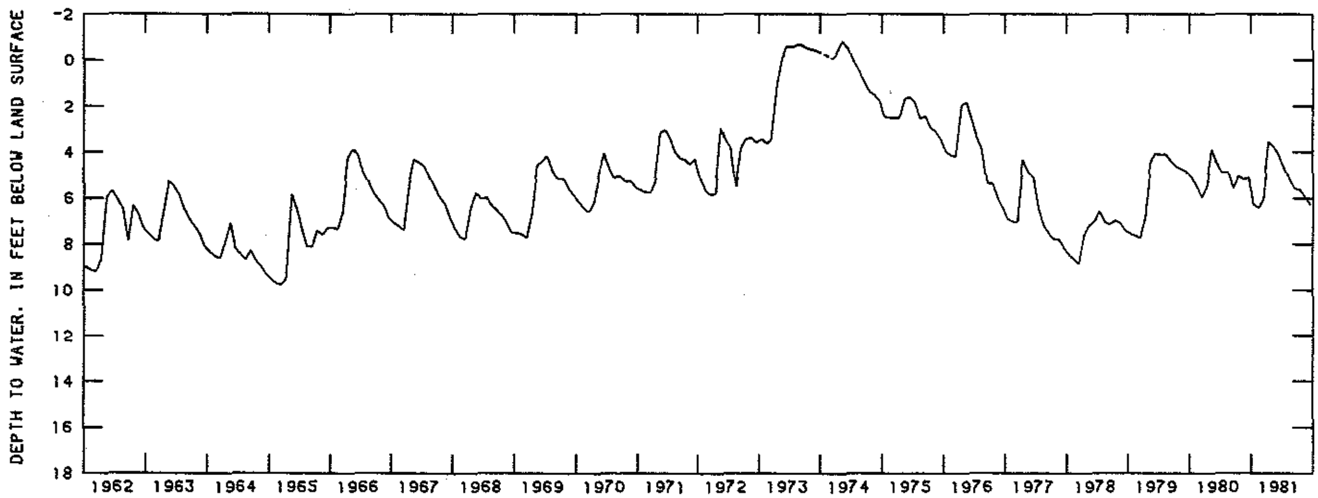
PT-21/07E/31-0059



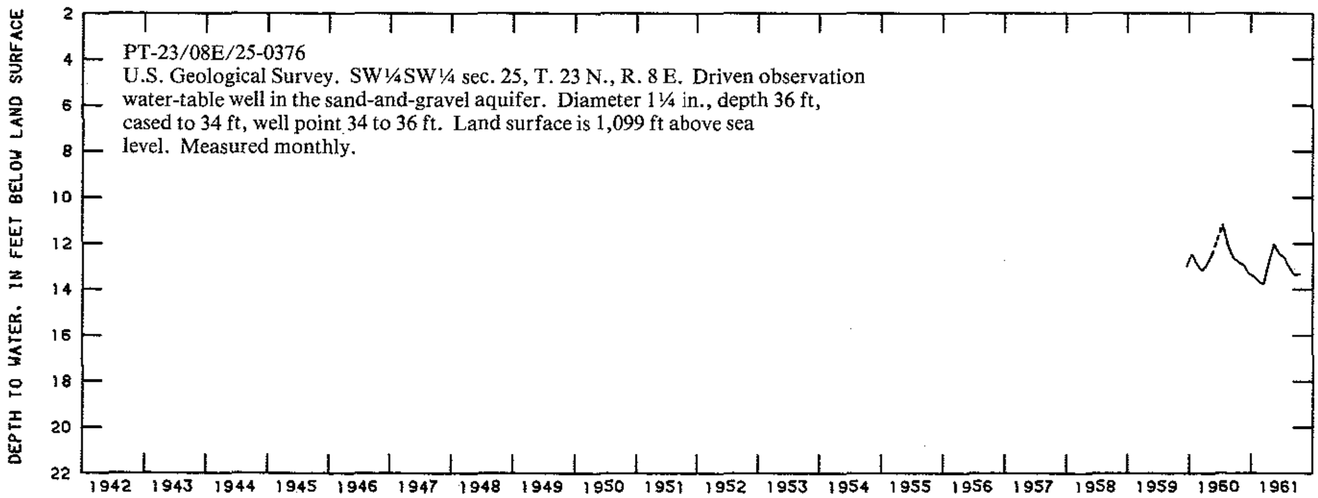


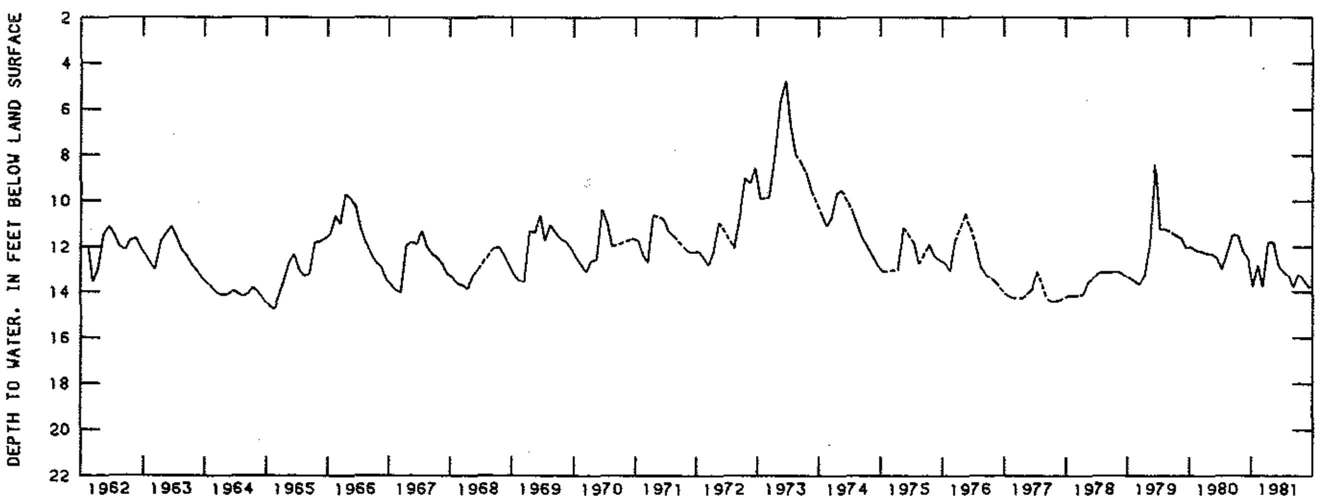
PT-24/06E/02-0082



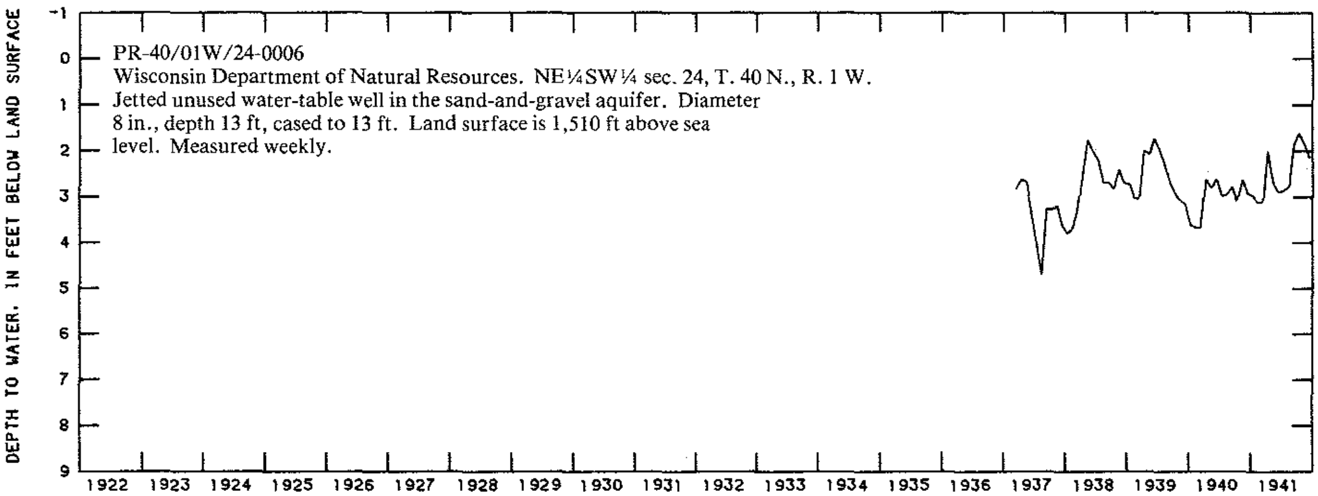


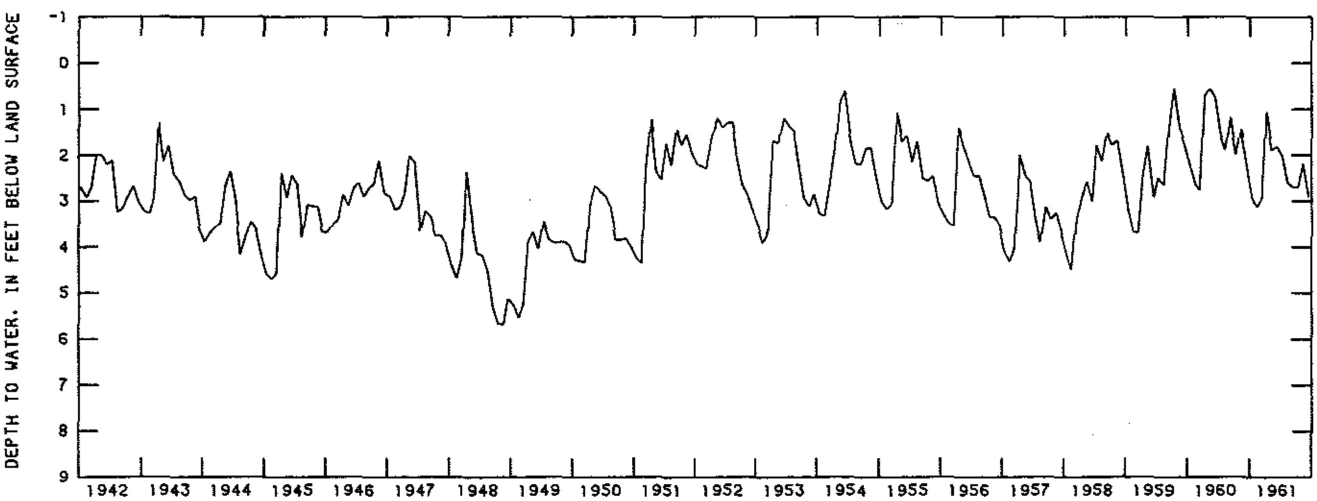
PT-23/10E/18-0276

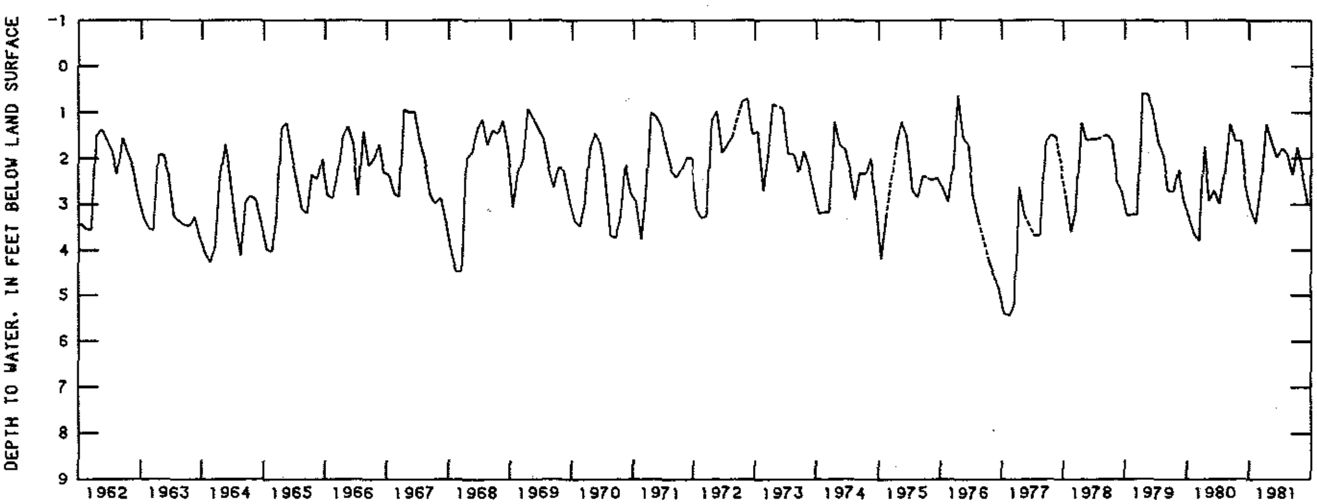




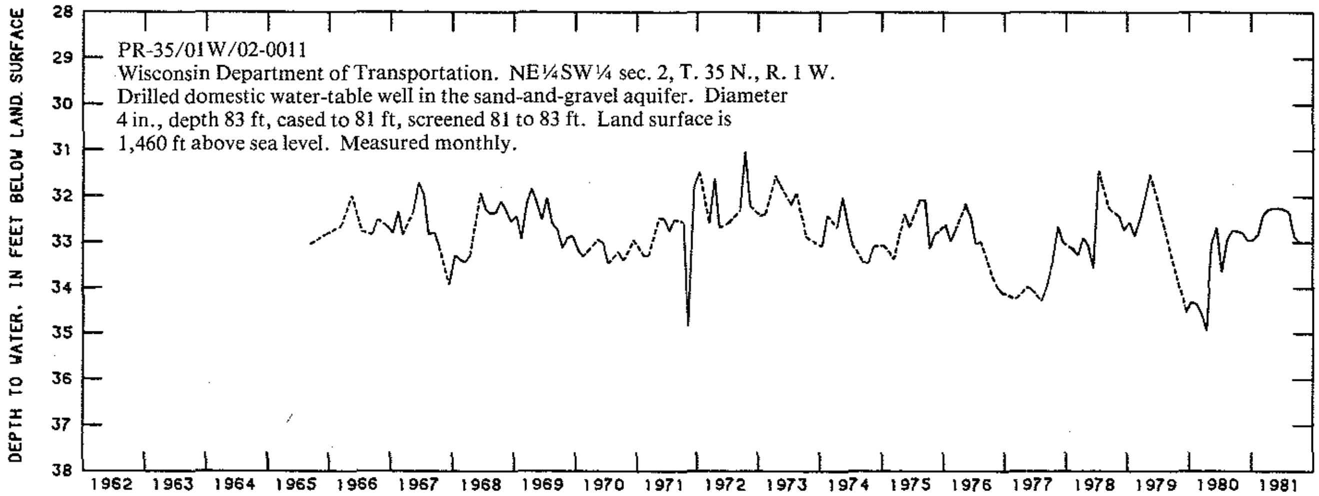
PT-23/08E/25-0376



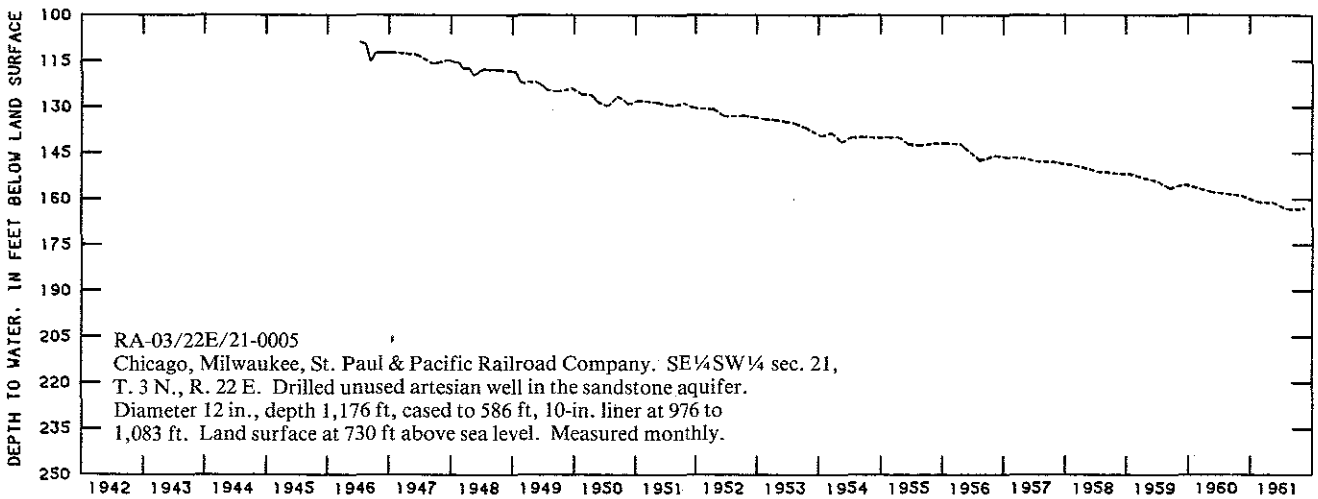


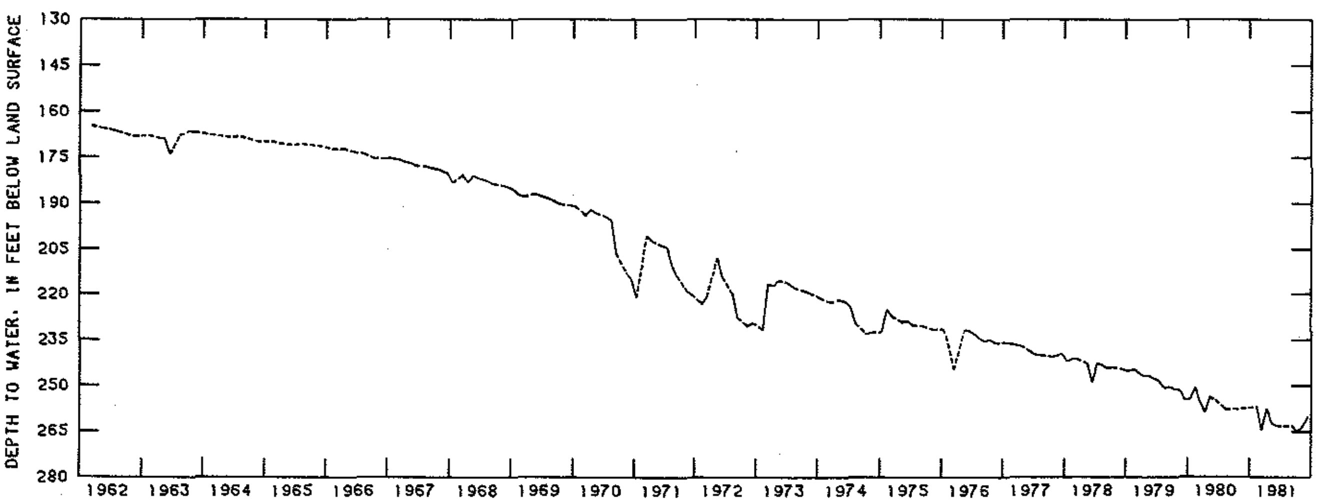


PR-40/01W/24-0006

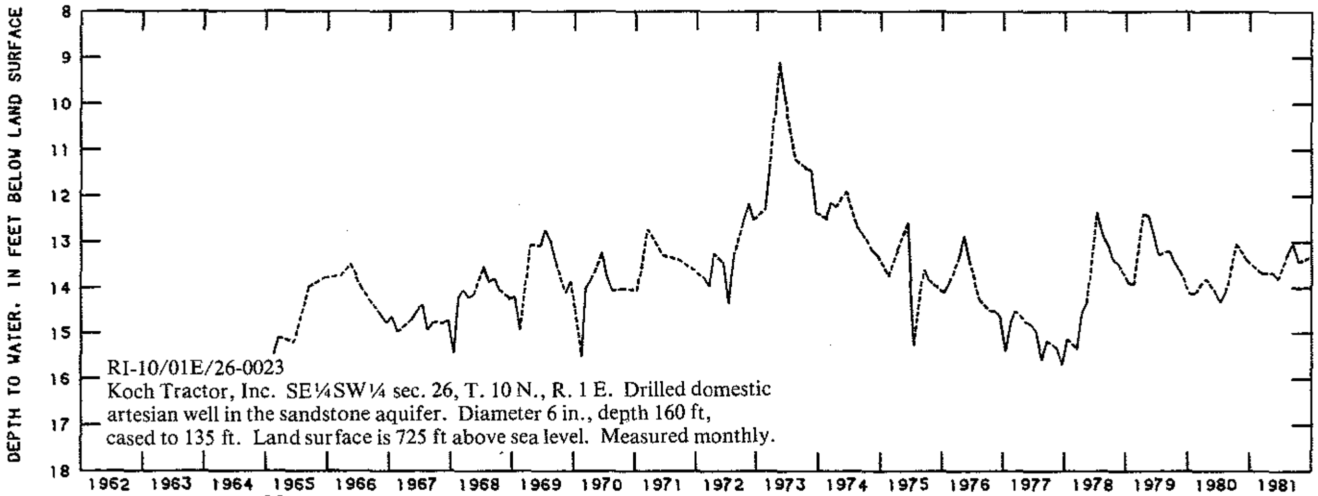


PR-35/01W/02-0011

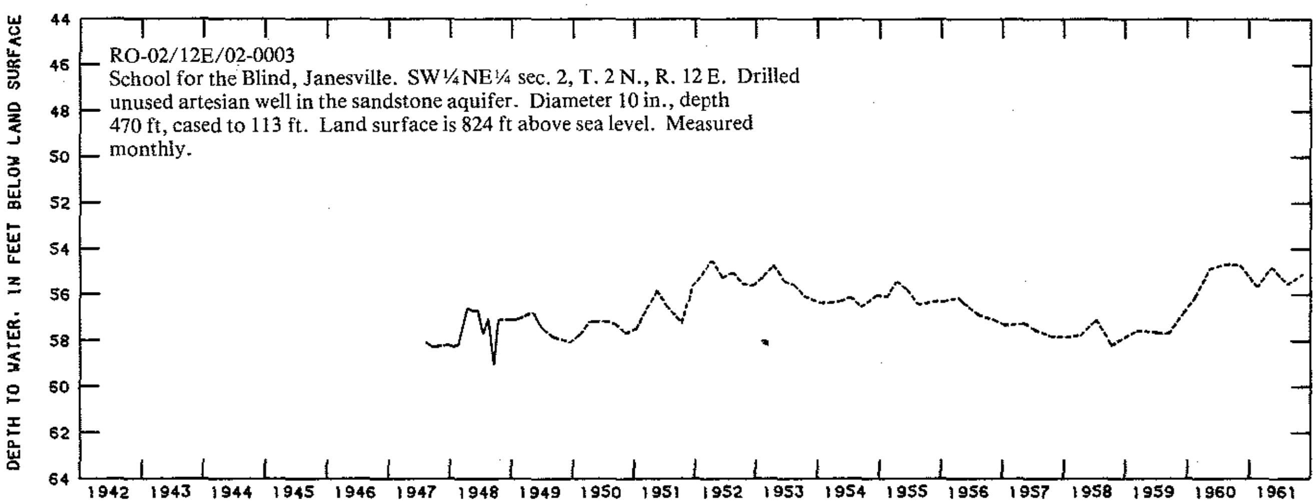


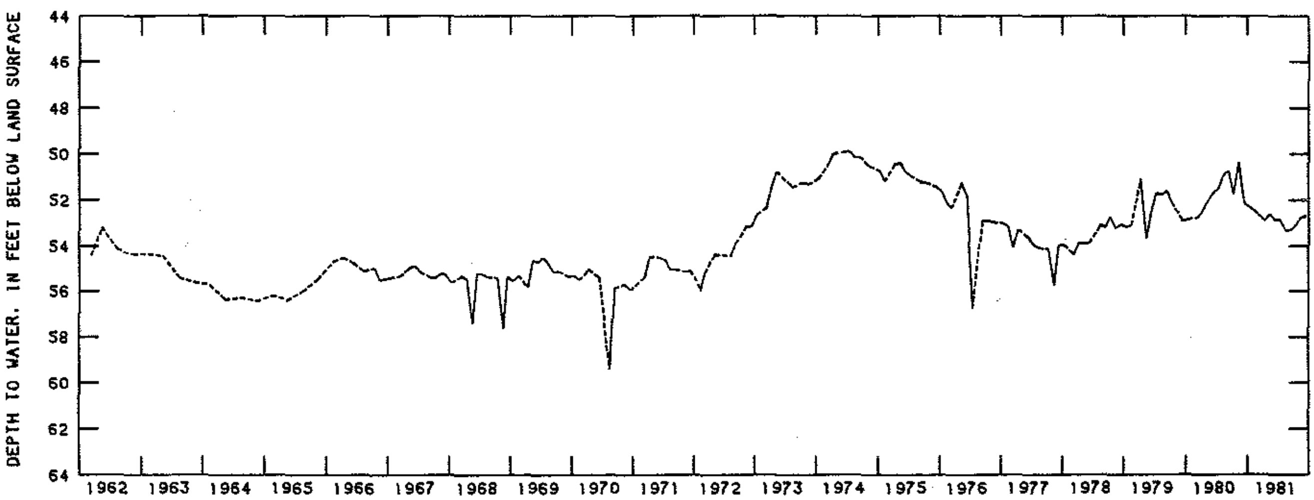


RA-03/22E/21-0005

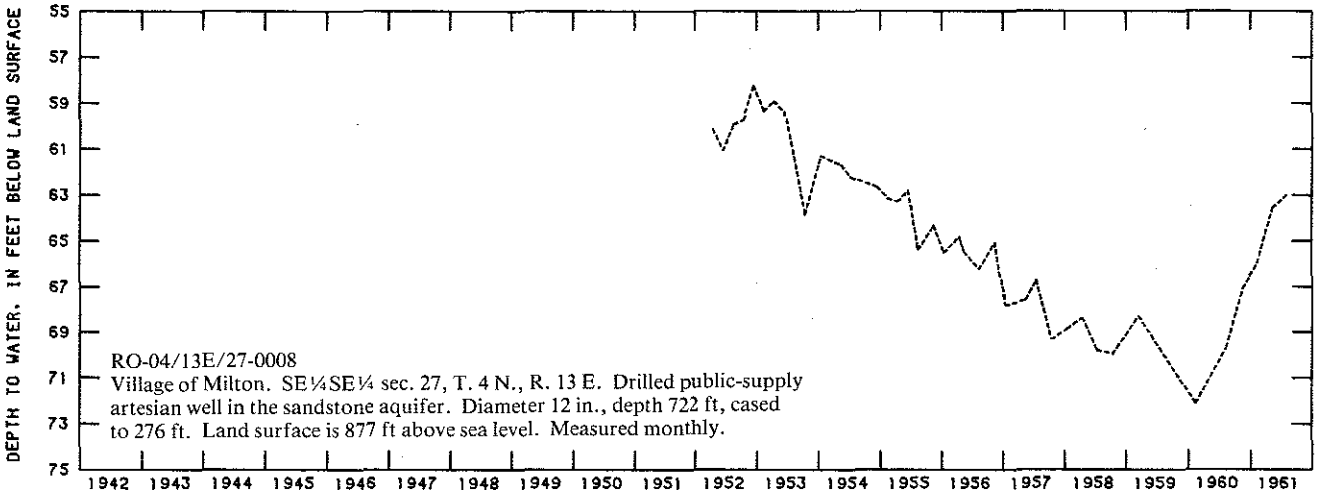


RI-10/01E/26-0023

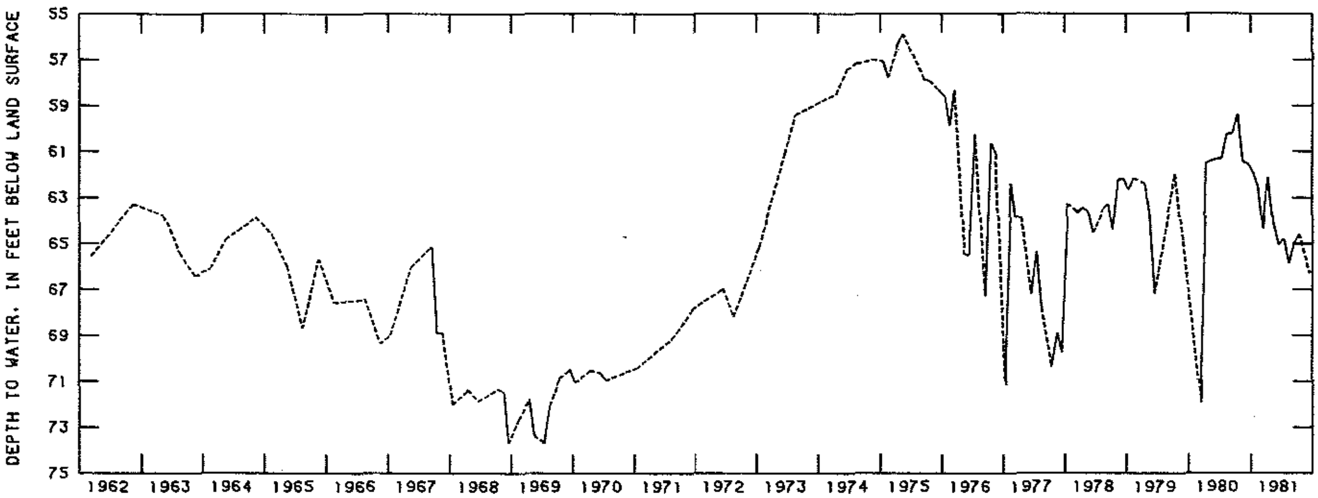




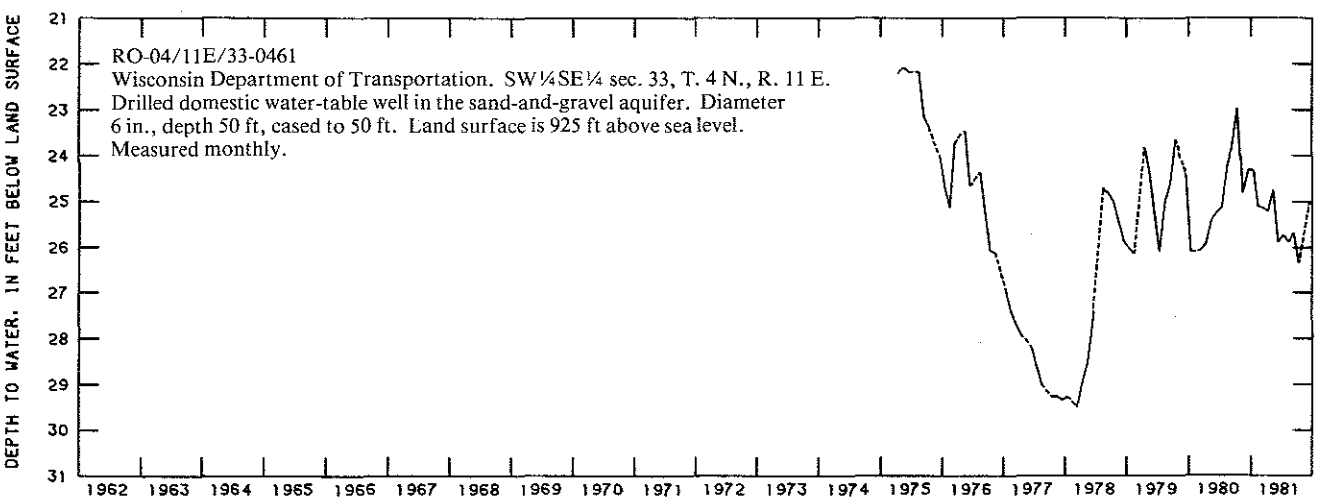
RO-02/12E/02-0003



RO-04/13E/27-0008
Village of Milton. SE¼SE¼ sec. 27, T. 4 N., R. 13 E. Drilled public-supply artesian well in the sandstone aquifer. Diameter 12 in., depth 722 ft, cased to 276 ft. Land surface is 877 ft above sea level. Measured monthly.

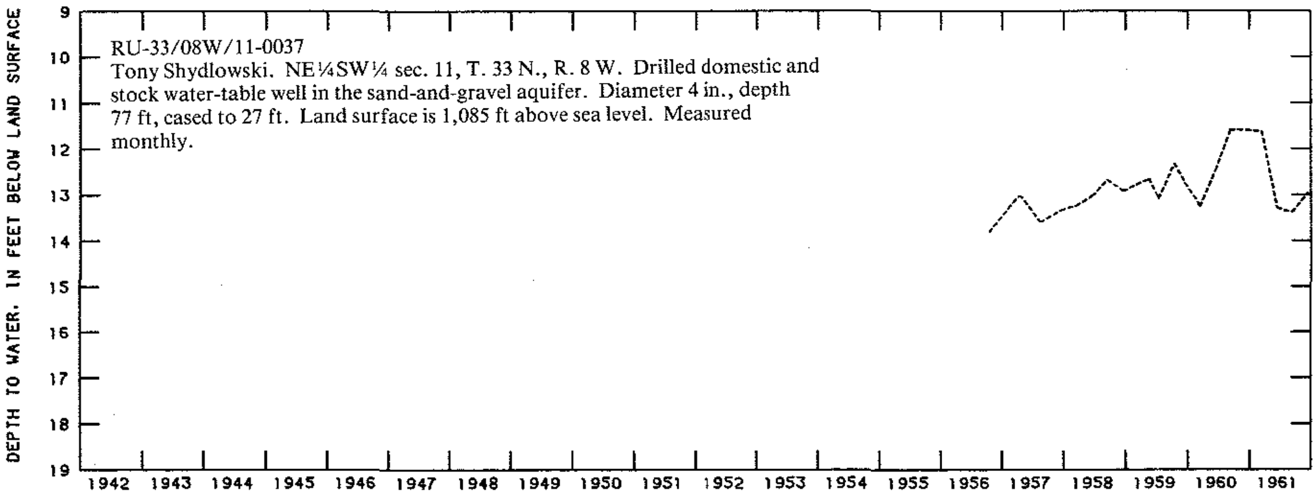


RO-04/13E/27-0008

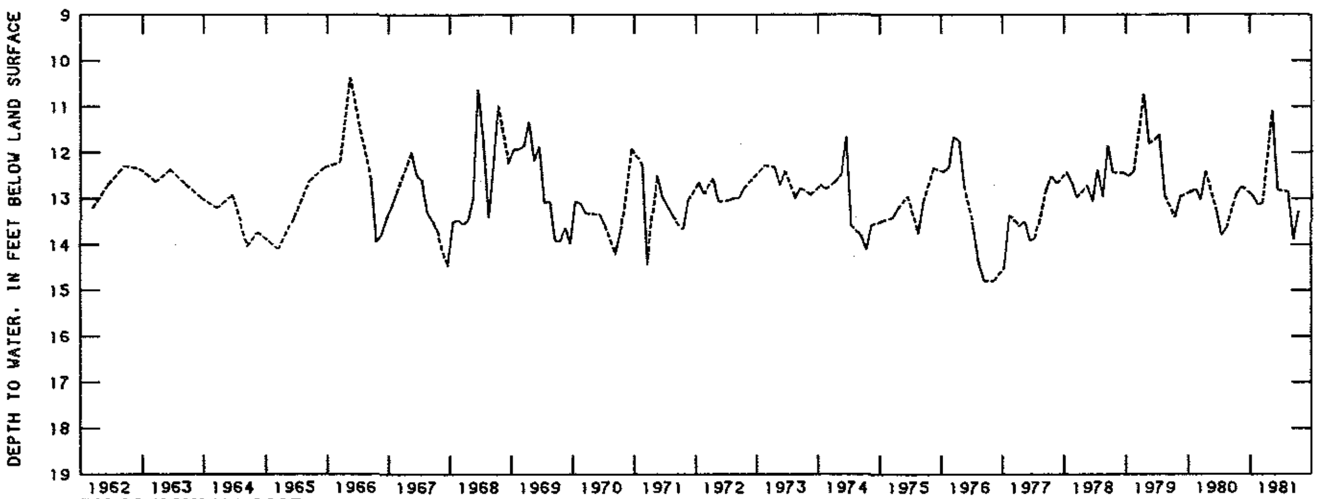


RO-04/11E/33-0461
Wisconsin Department of Transportation. SW¼SE¼ sec. 33, T. 4 N., R. 11 E. Drilled domestic water-table well in the sand-and-gravel aquifer. Diameter 6 in., depth 50 ft, cased to 50 ft. Land surface is 925 ft above sea level. Measured monthly.

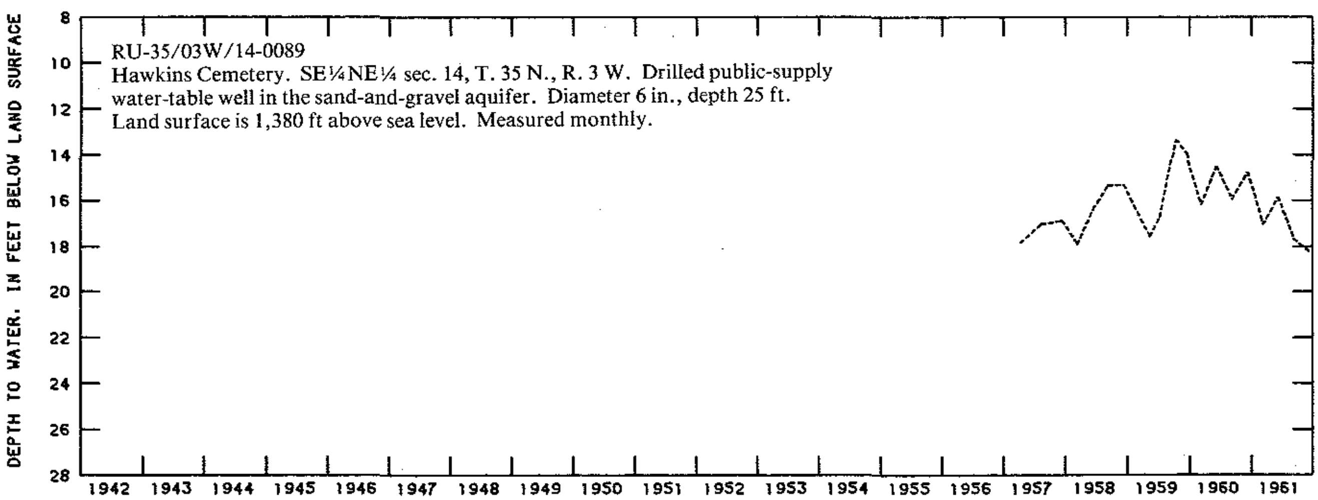
RO-04/11E/33-0461



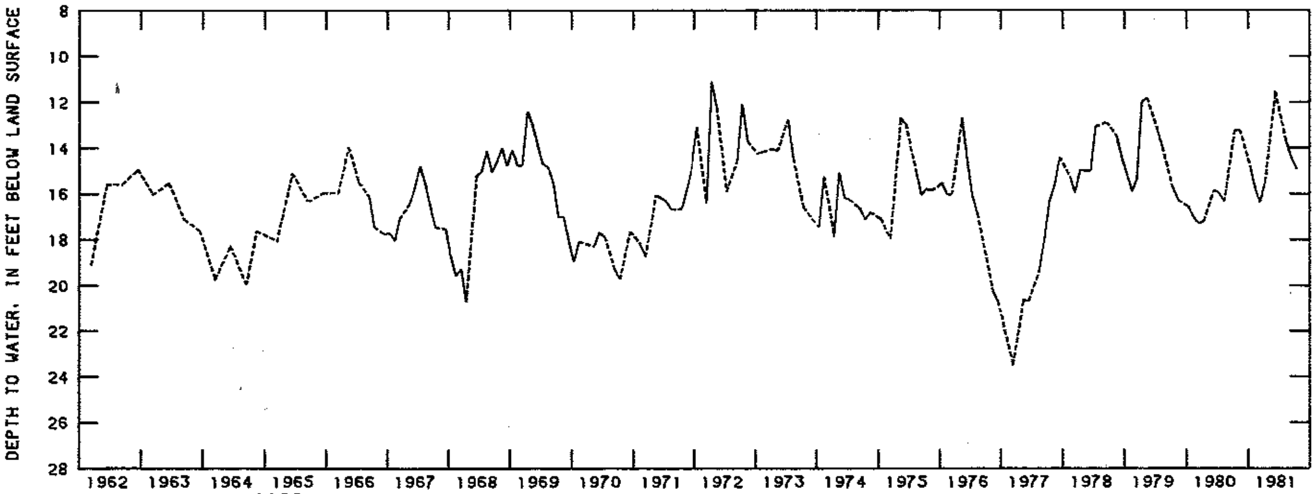
RU-33/08W/11-0037
Tony Shydlowski. NE¼SW¼ sec. 11, T. 33 N., R. 8 W. Drilled domestic and stock water-table well in the sand-and-gravel aquifer. Diameter 4 in., depth 77 ft, cased to 27 ft. Land surface is 1,085 ft above sea level. Measured monthly.



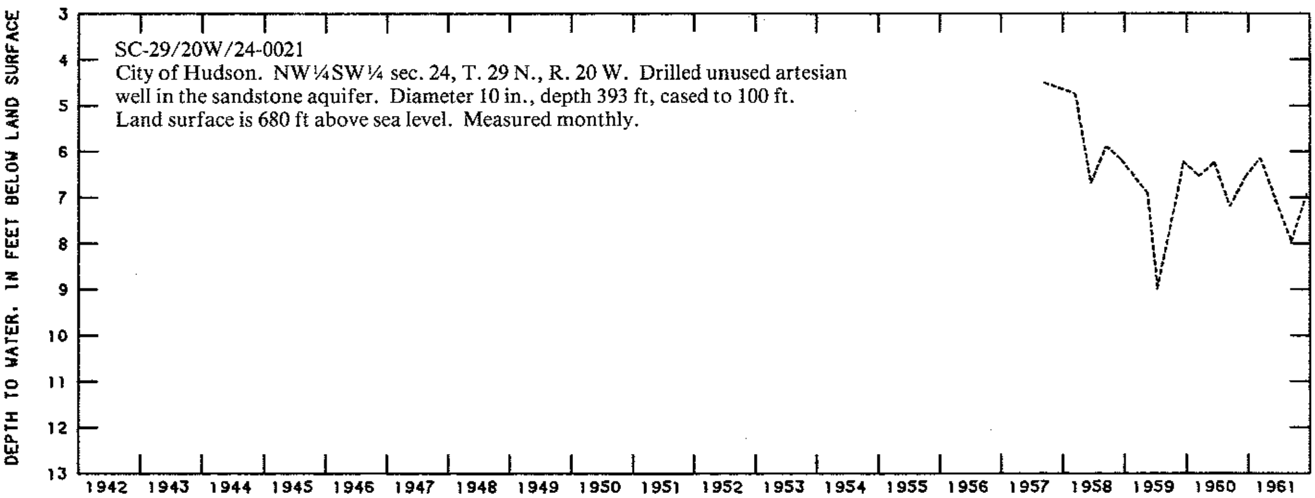
RU-33/08W/11-0037

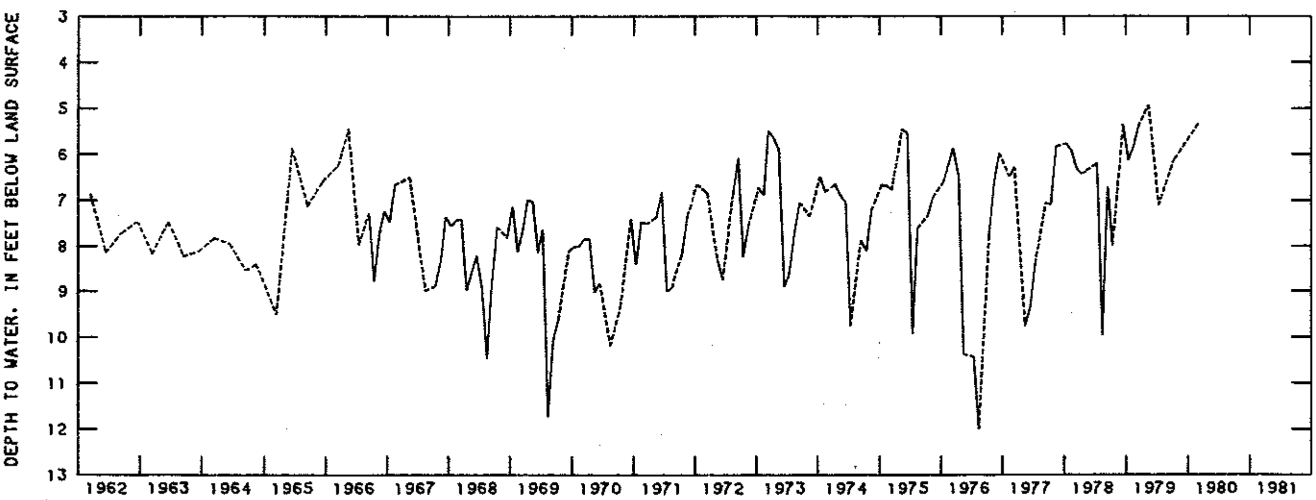


RU-35/03W/14-0089
Hawkins Cemetery. SE¼NE¼ sec. 14, T. 35 N., R. 3 W. Drilled public-supply water-table well in the sand-and-gravel aquifer. Diameter 6 in., depth 25 ft. Land surface is 1,380 ft above sea level. Measured monthly.

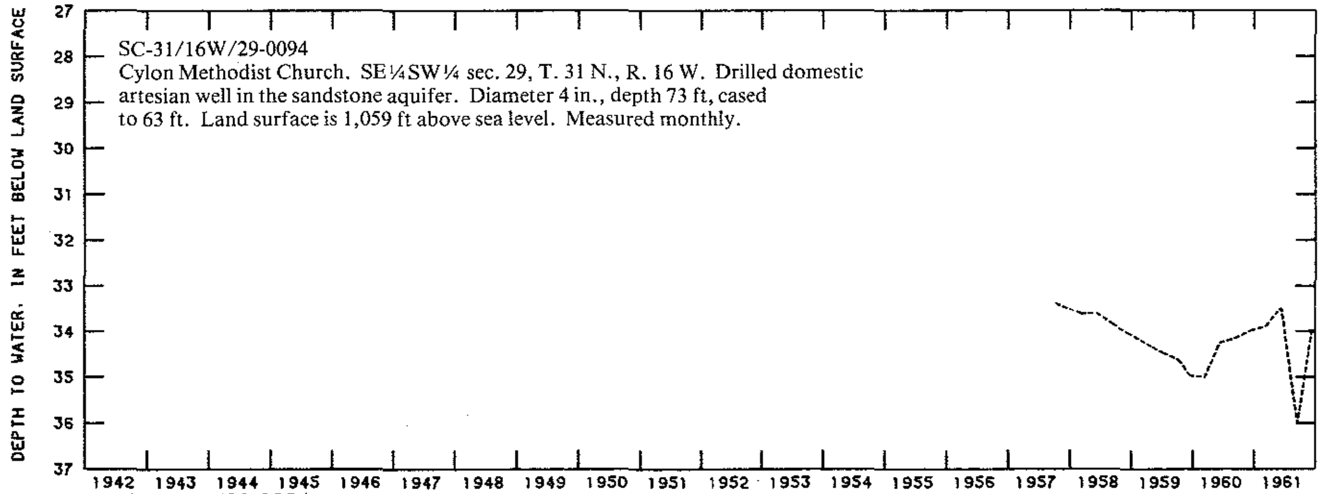


RU-35/03W/14-0089

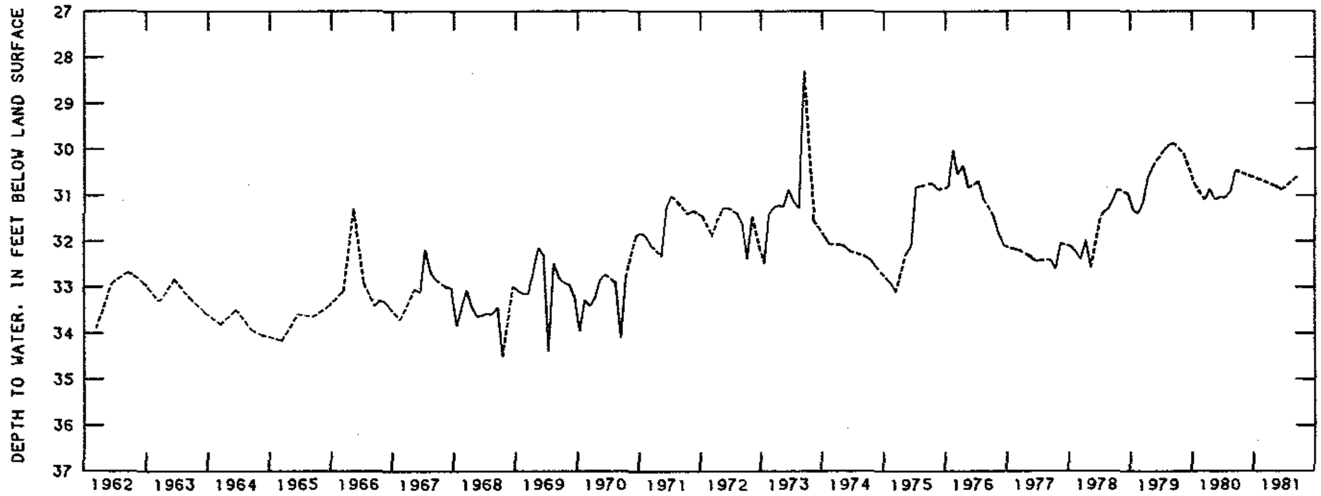


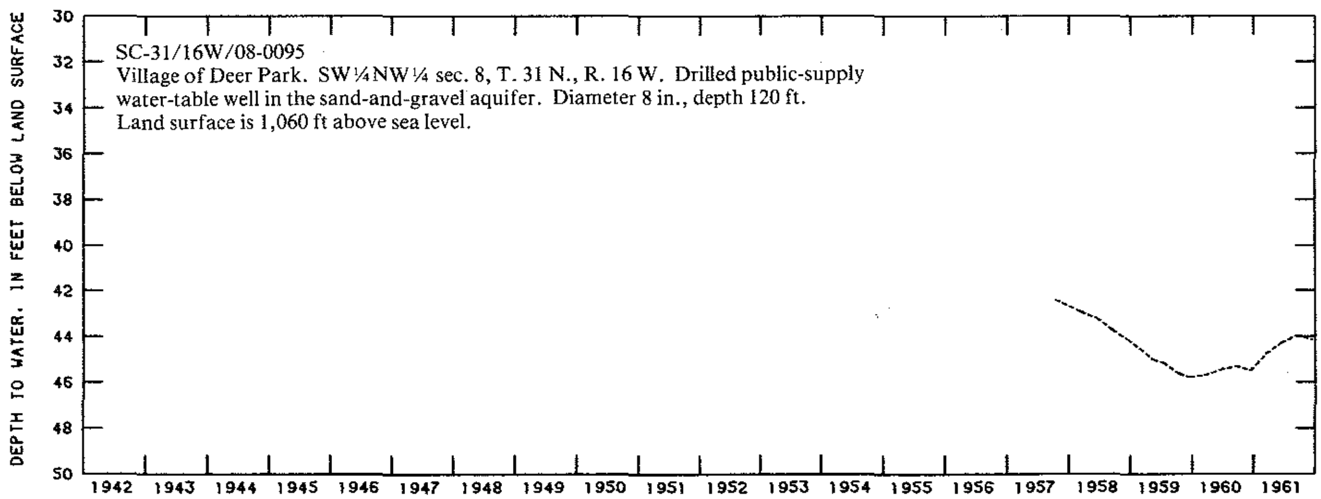


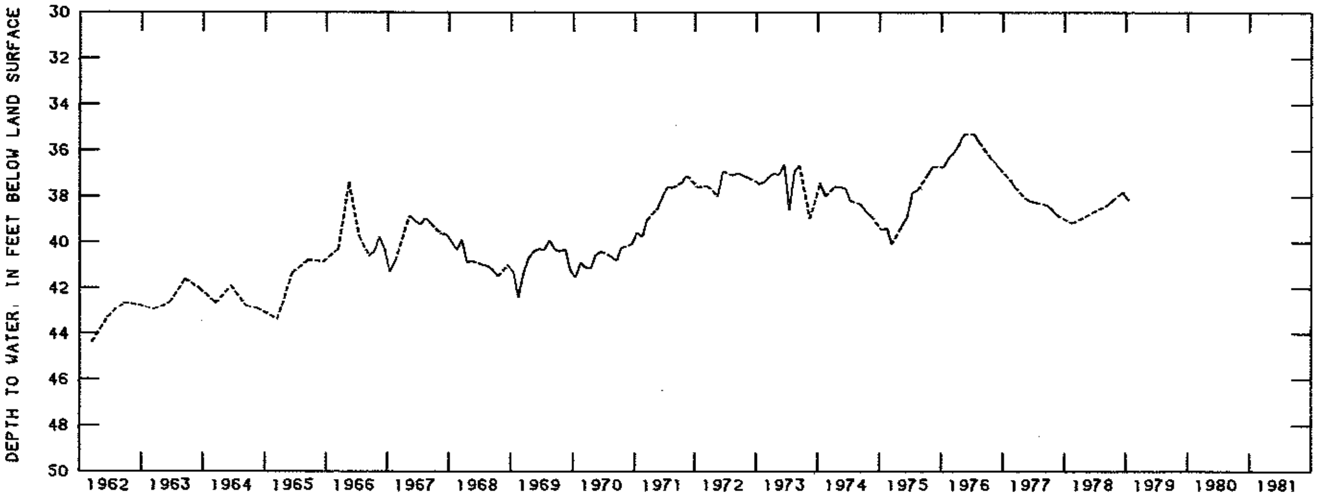
SC-29/20W/24-0021



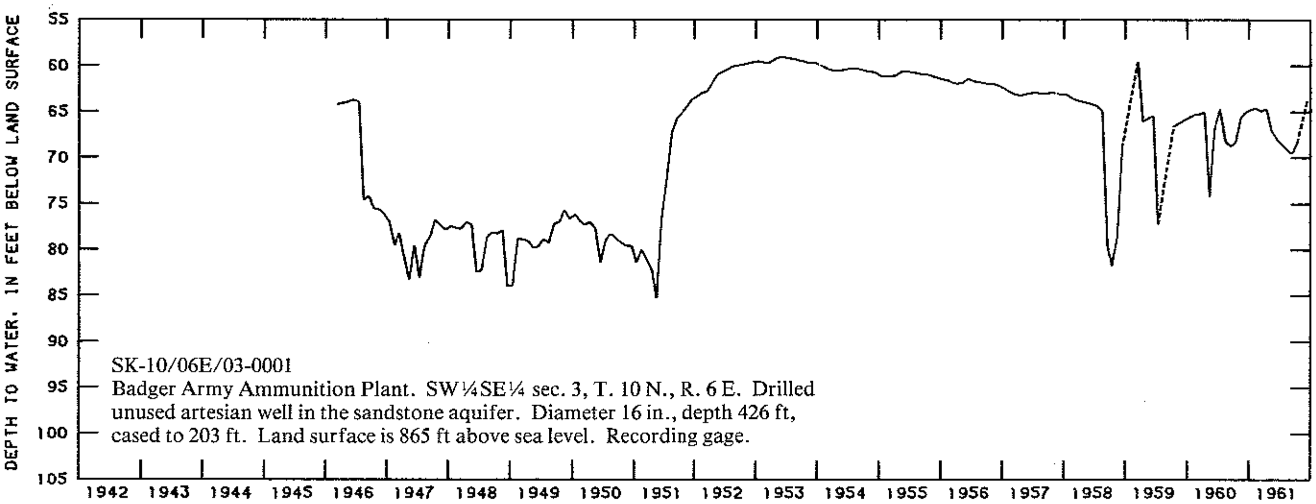
SC-31/16W/29-0094

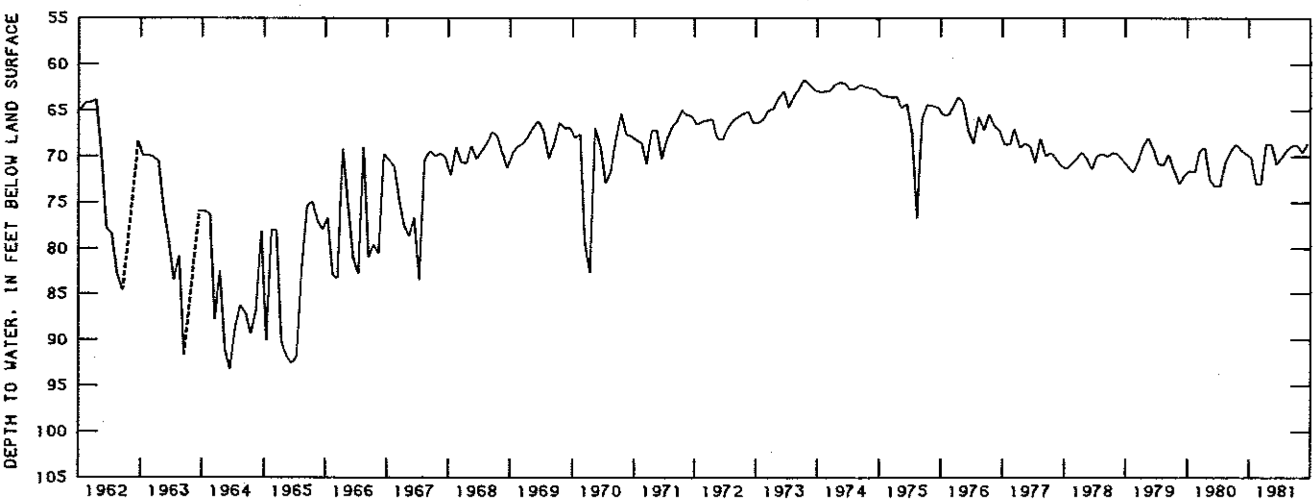




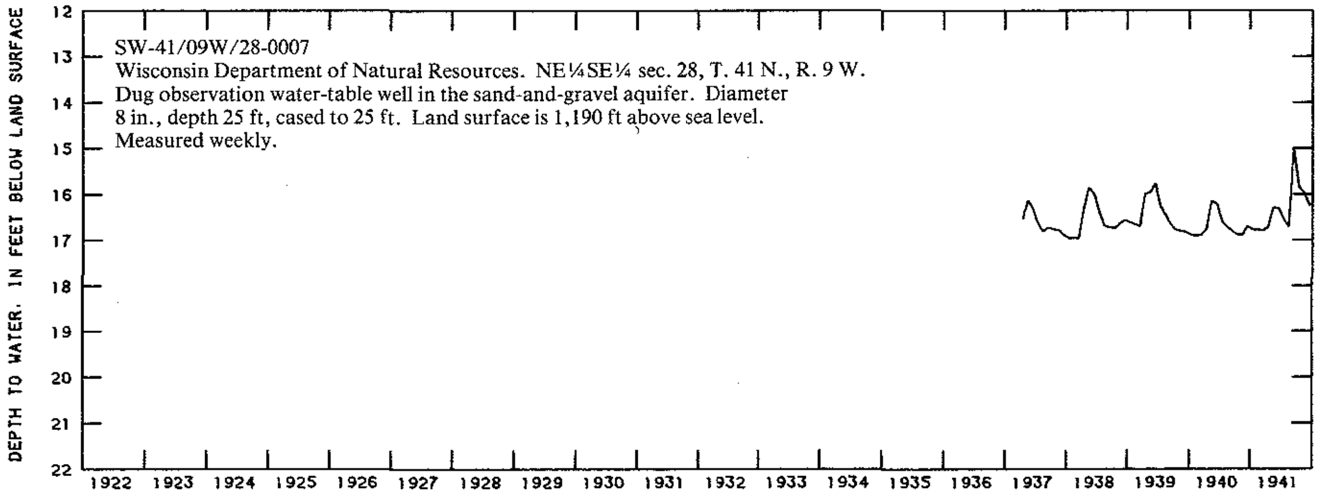


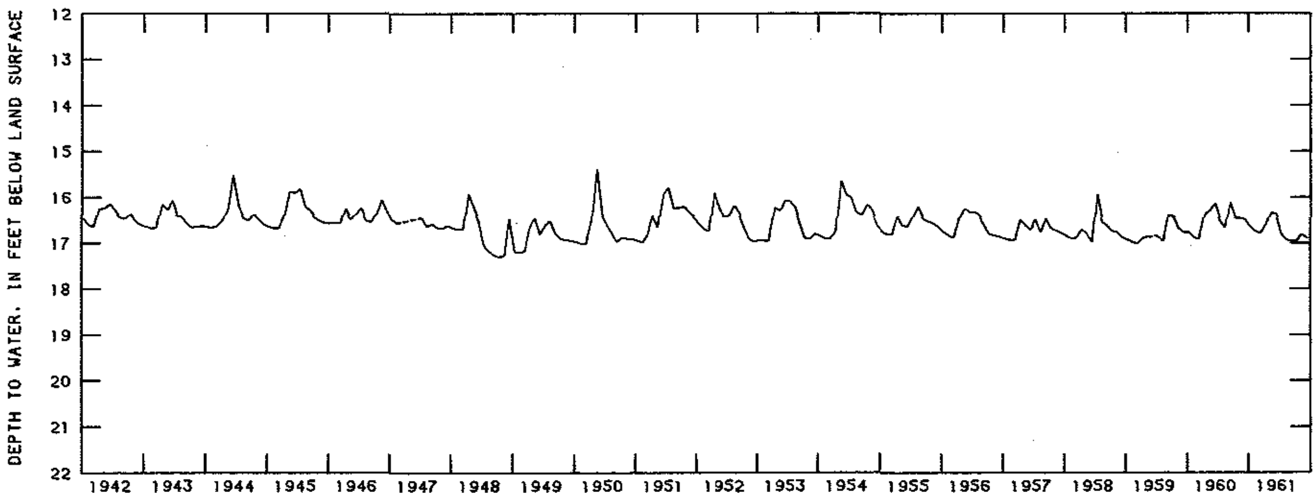
SC-31/16W/08-0095

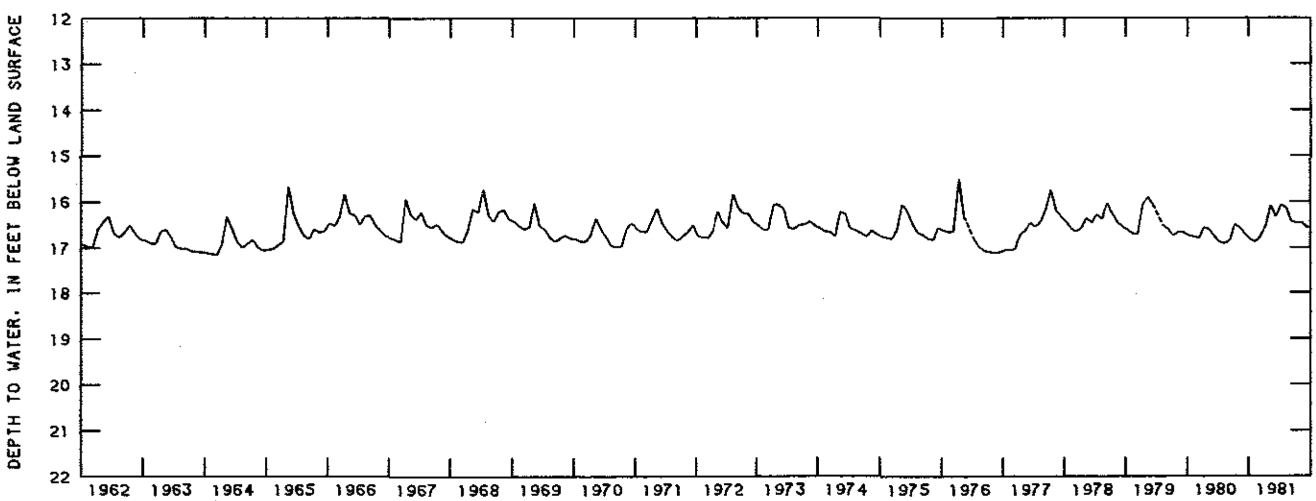




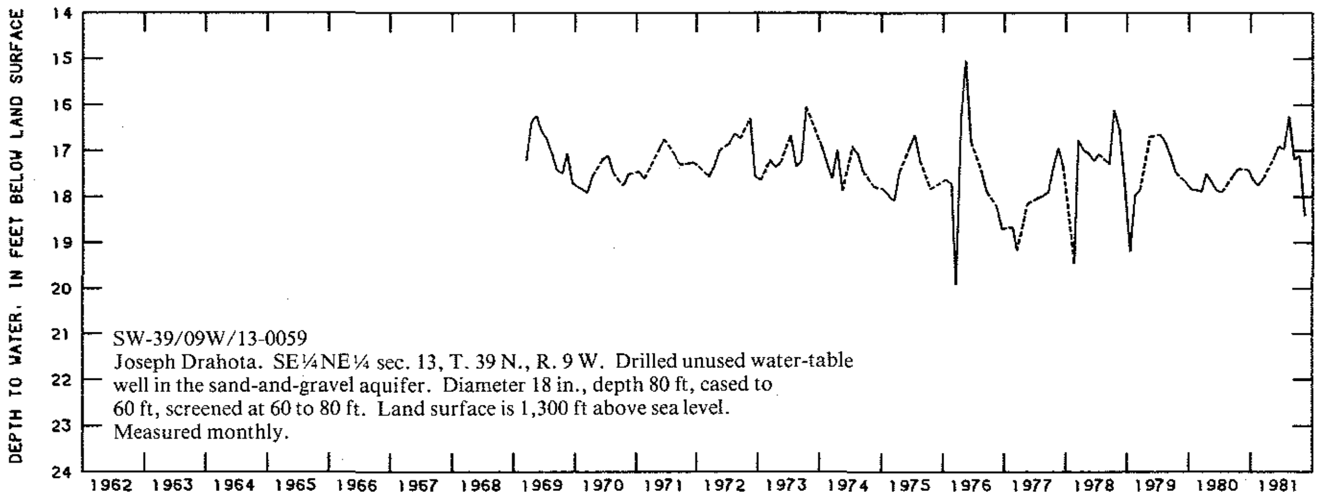
SK-10/06E/03-0001





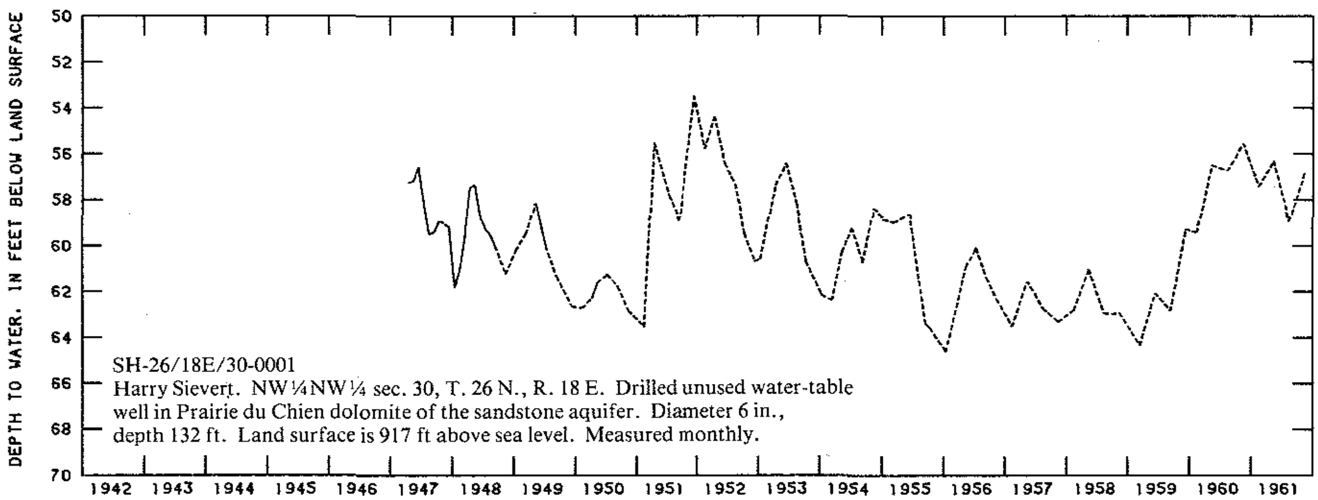


SW-41/09W/28-0007

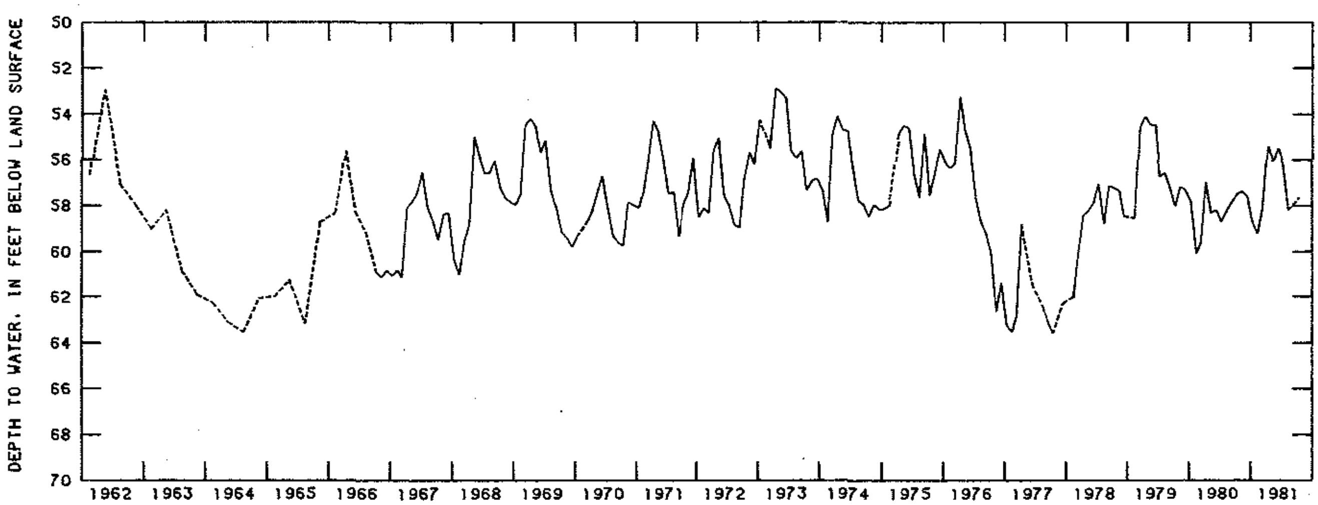


SW-39/09W/13-0059
Joseph Drahota. SE¼NE¼ sec. 13, T. 39 N., R. 9 W. Drilled unused water-table well in the sand-and-gravel aquifer. Diameter 18 in., depth 80 ft, cased to 60 ft, screened at 60 to 80 ft. Land surface is 1,300 ft above sea level. Measured monthly.

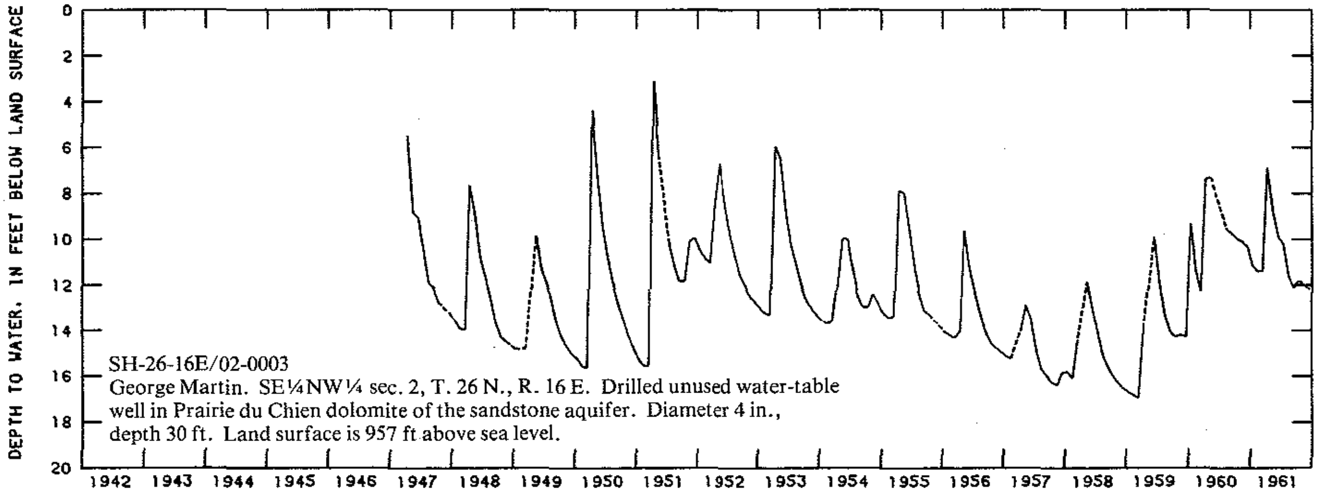
SW-39/09W/13-0059

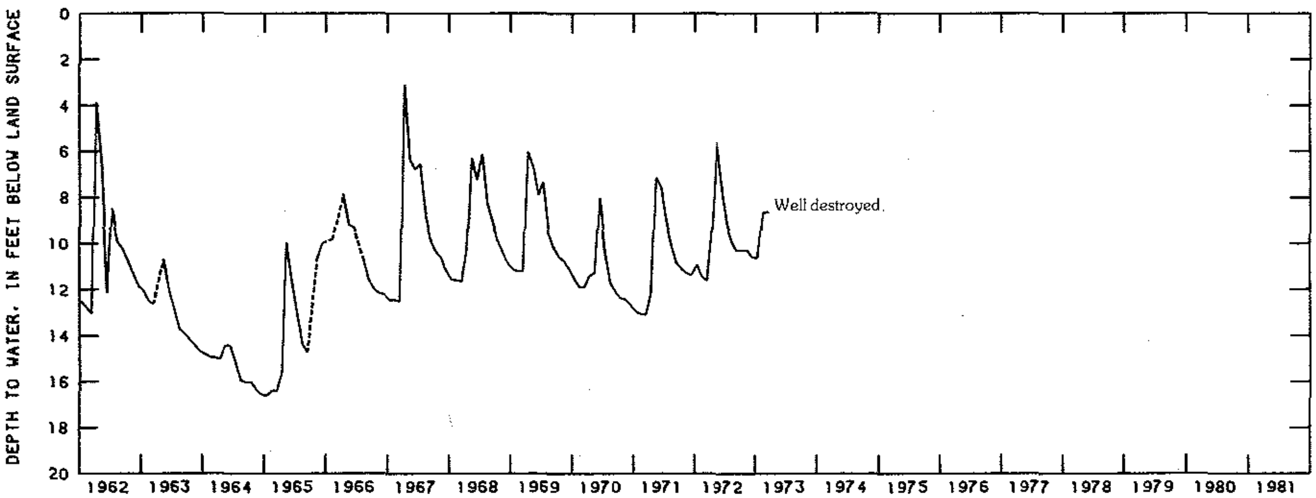


SH-26/18E/30-0001
Harry Sievert. NW¼NW¼ sec. 30, T. 26 N., R. 18 E. Drilled unused water-table well in Prairie du Chien dolomite of the sandstone aquifer. Diameter 6 in., depth 132 ft. Land surface is 917 ft above sea level. Measured monthly.

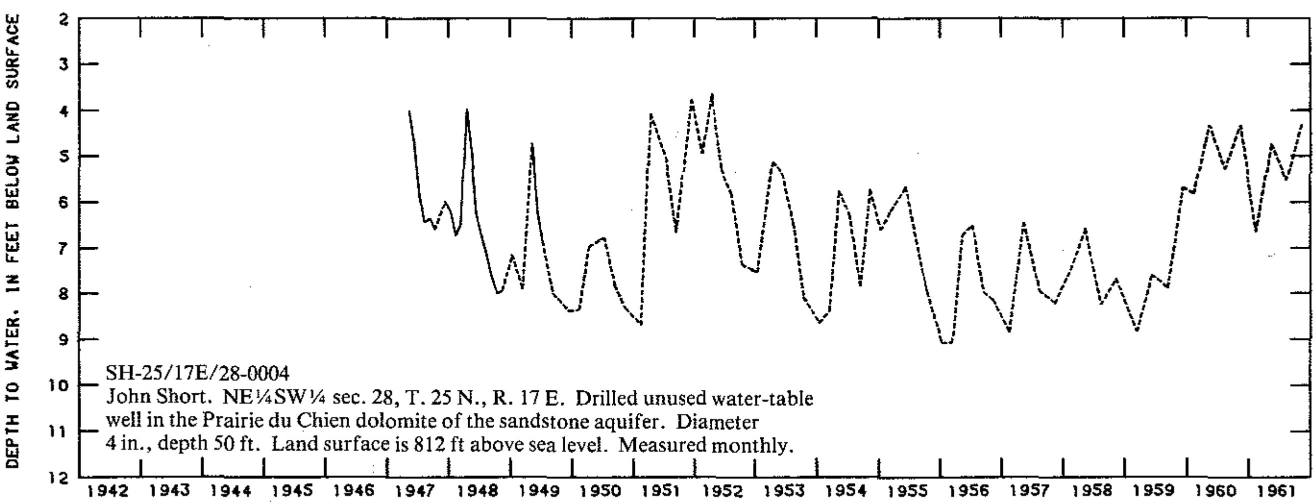


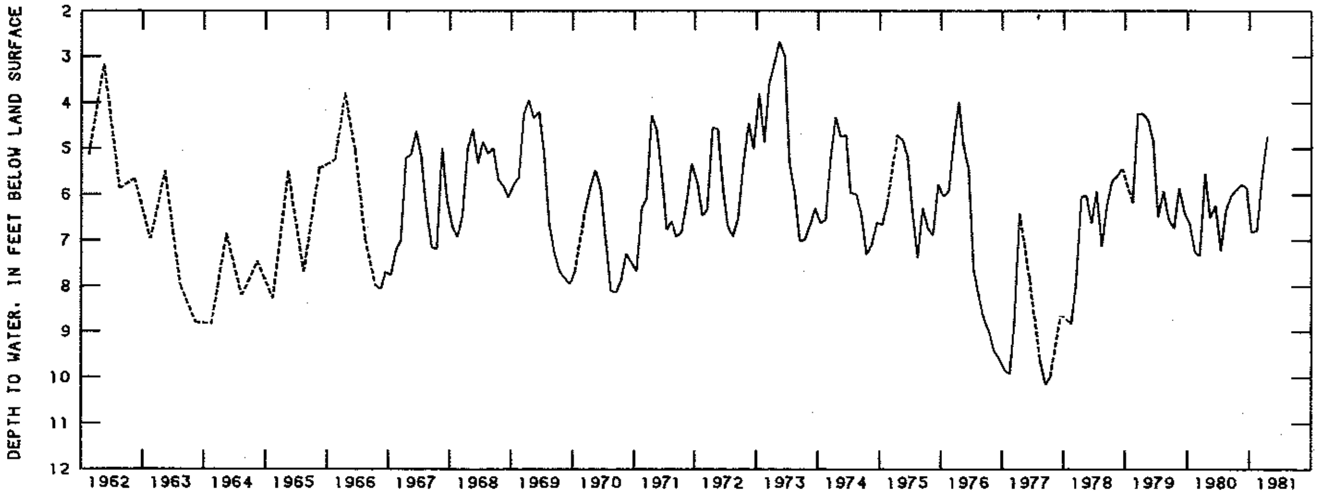
SH-26/18E/30-0001



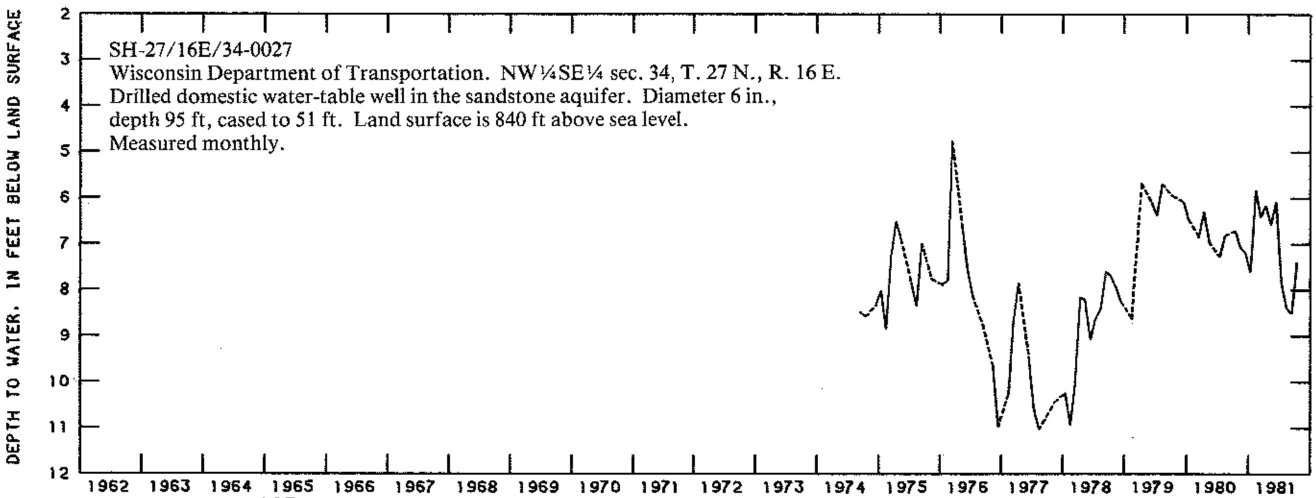


SH-26/16E/02-0003

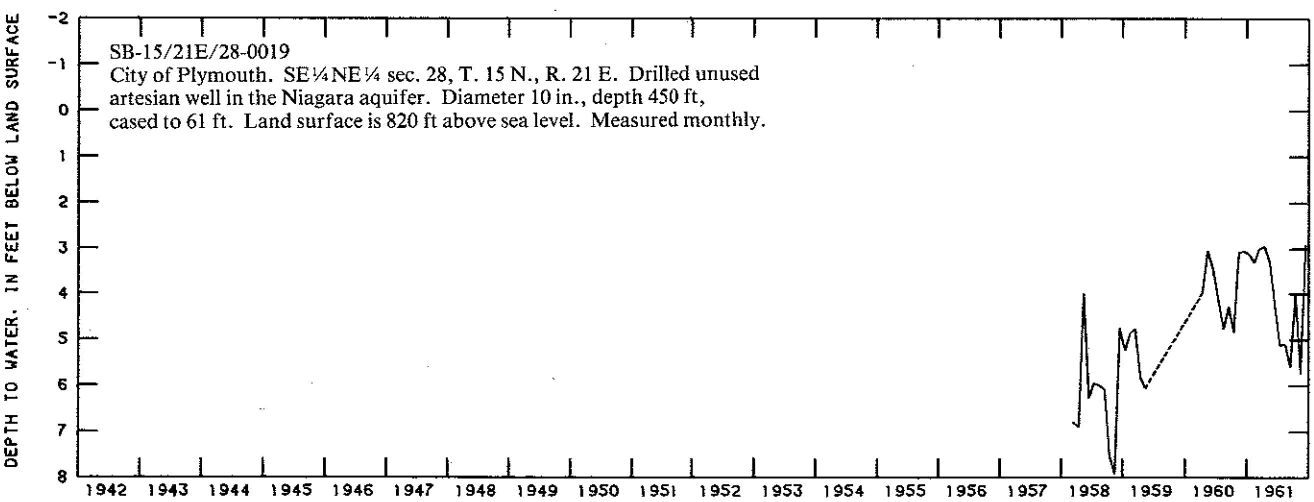


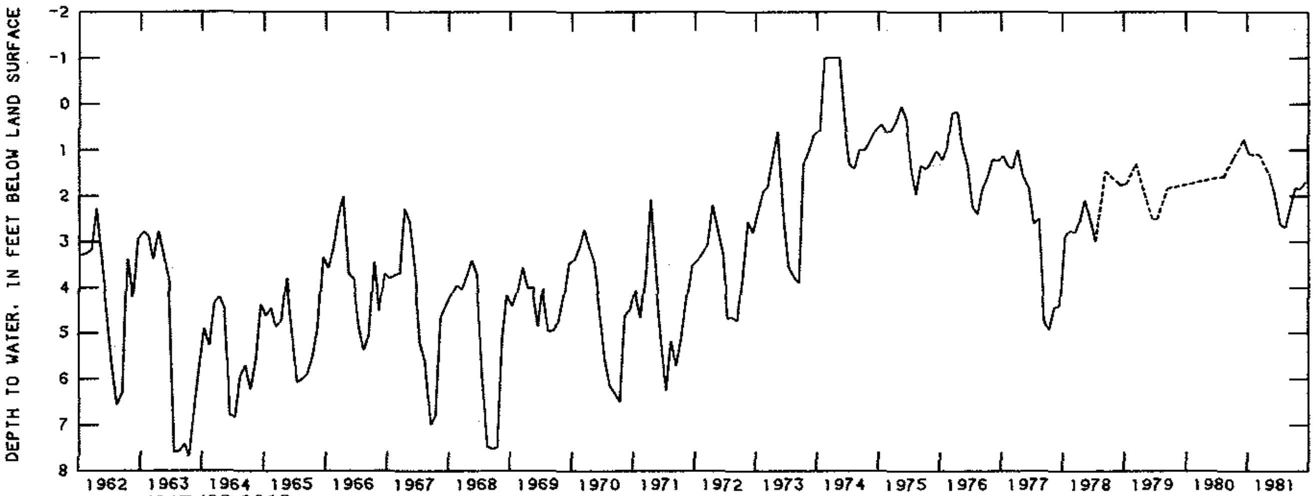


SH-25/17E/28-0004

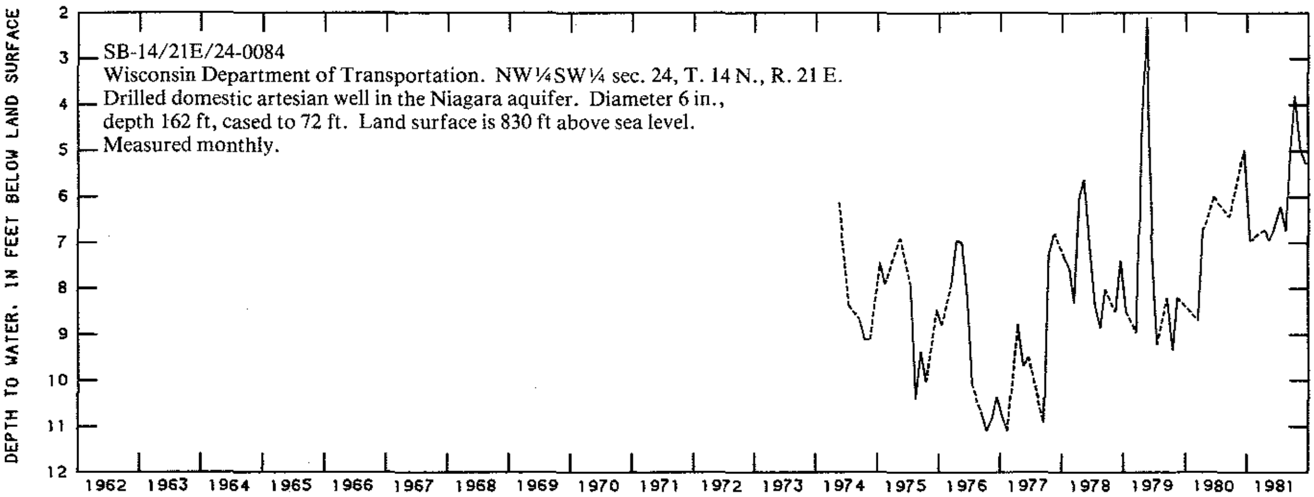


SH-27/16E/34-0027

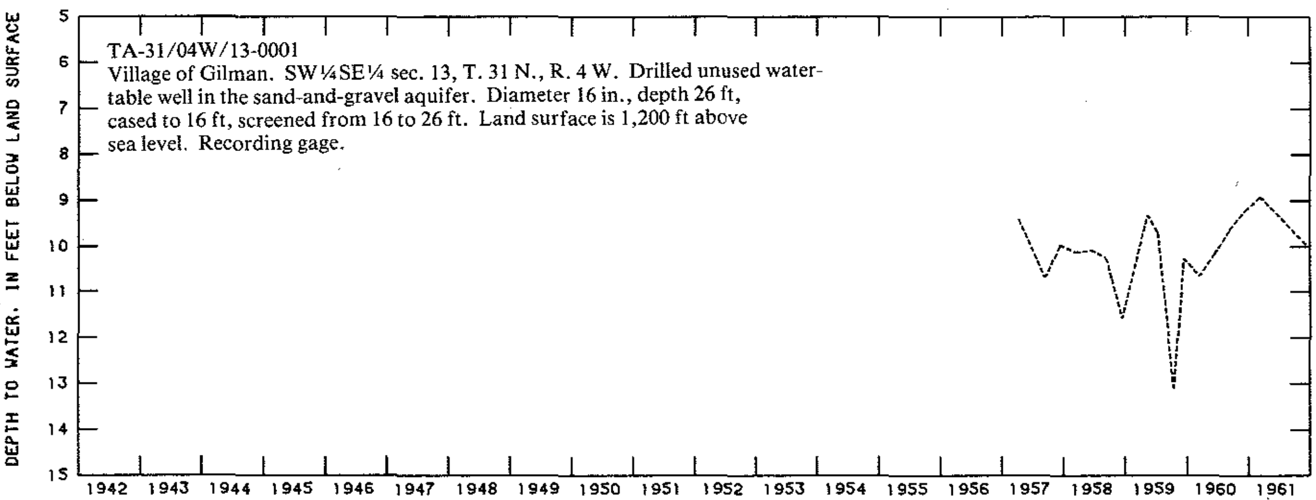


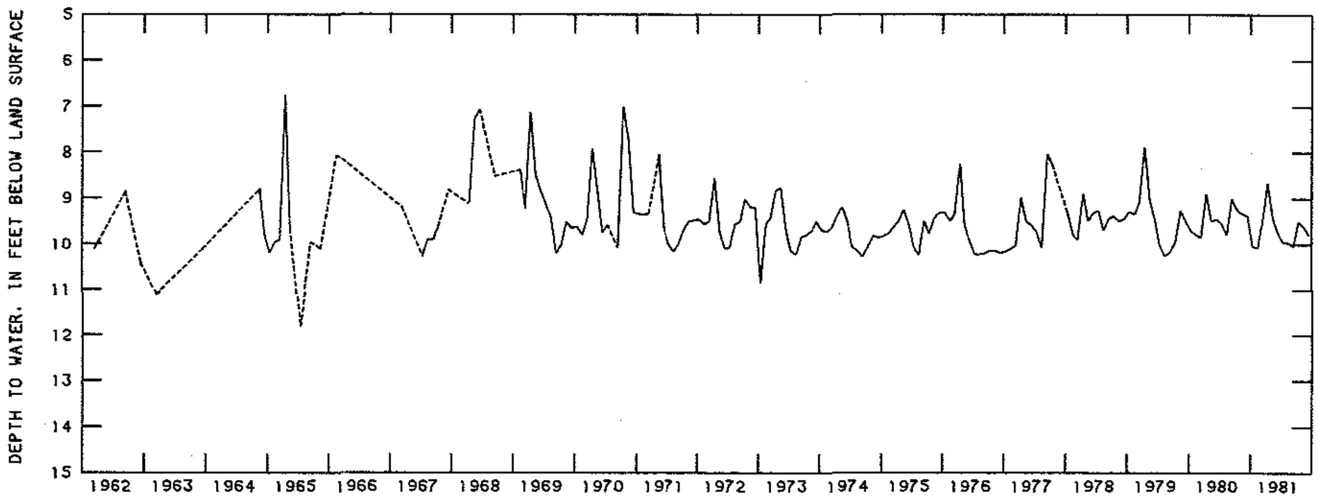


SB-15/21E/28-0019

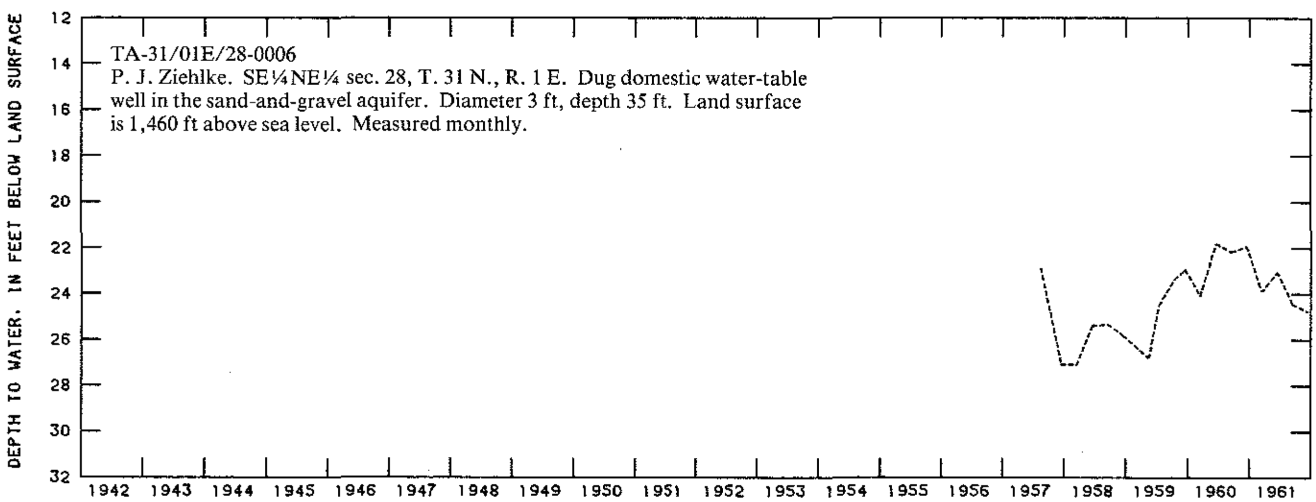


SB-14/21E/24-0084

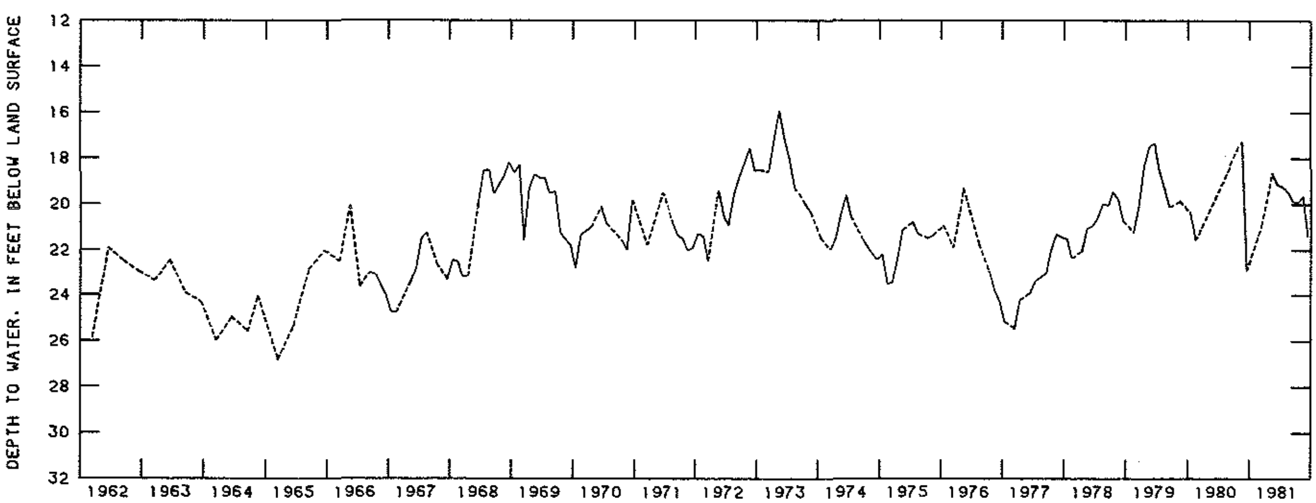




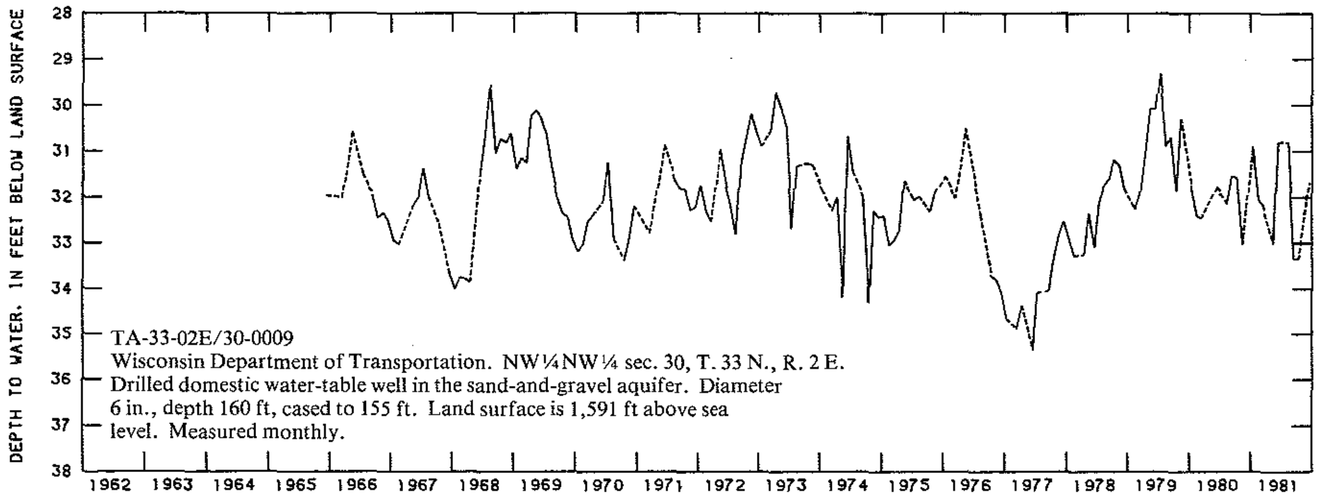
TA-31/04W/13-0001



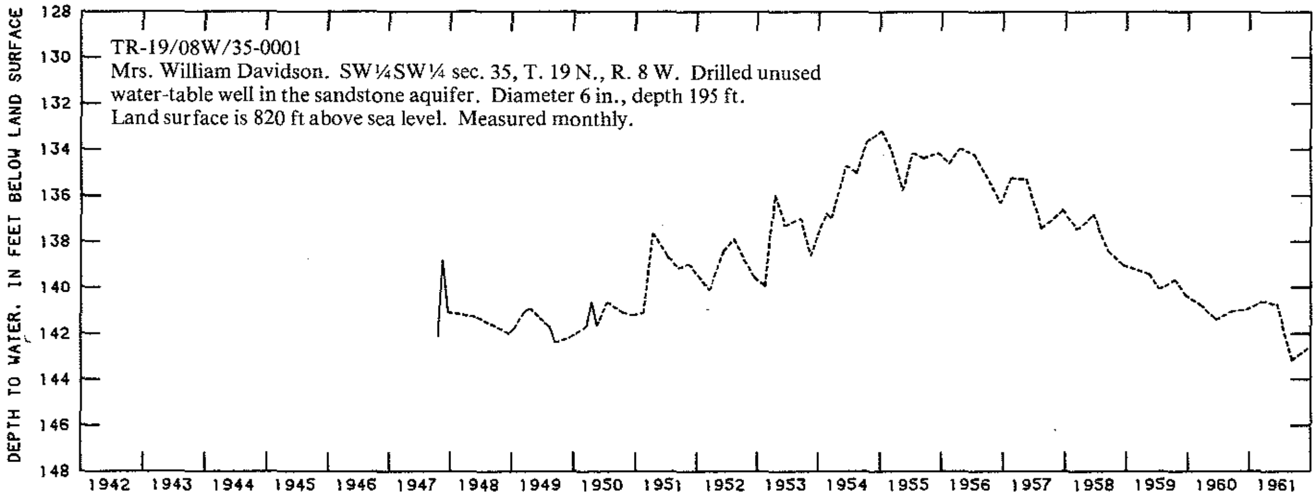
TA-31/01E/28-0006
P. J. Ziehlke. SE¼NE¼ sec. 28, T. 31 N., R. 1 E. Dug domestic water-table well in the sand-and-gravel aquifer. Diameter 3 ft, depth 35 ft. Land surface is 1,460 ft above sea level. Measured monthly.

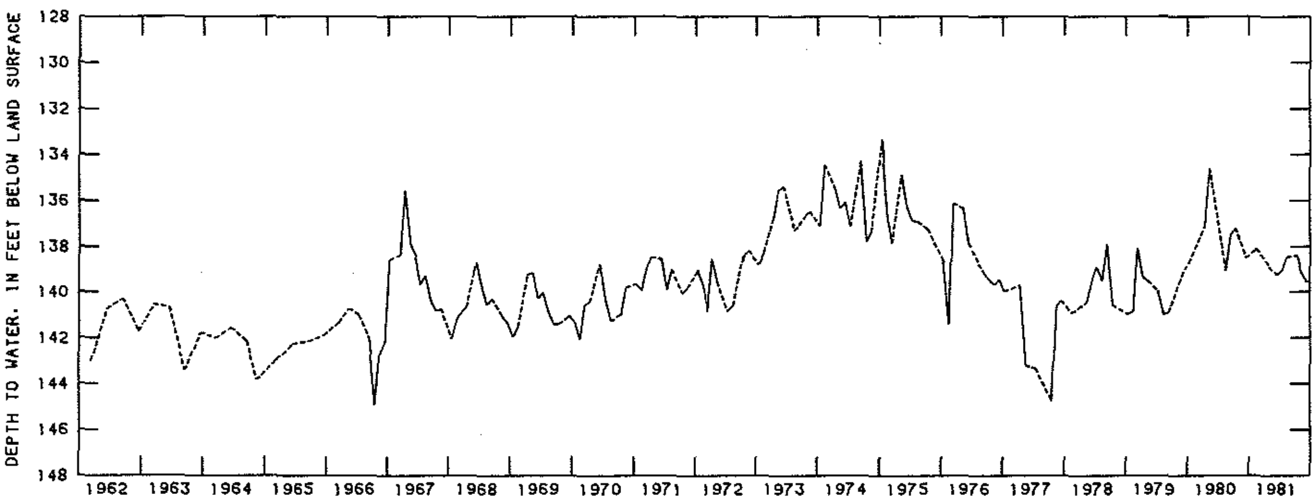


TA-31/01E/28-0006

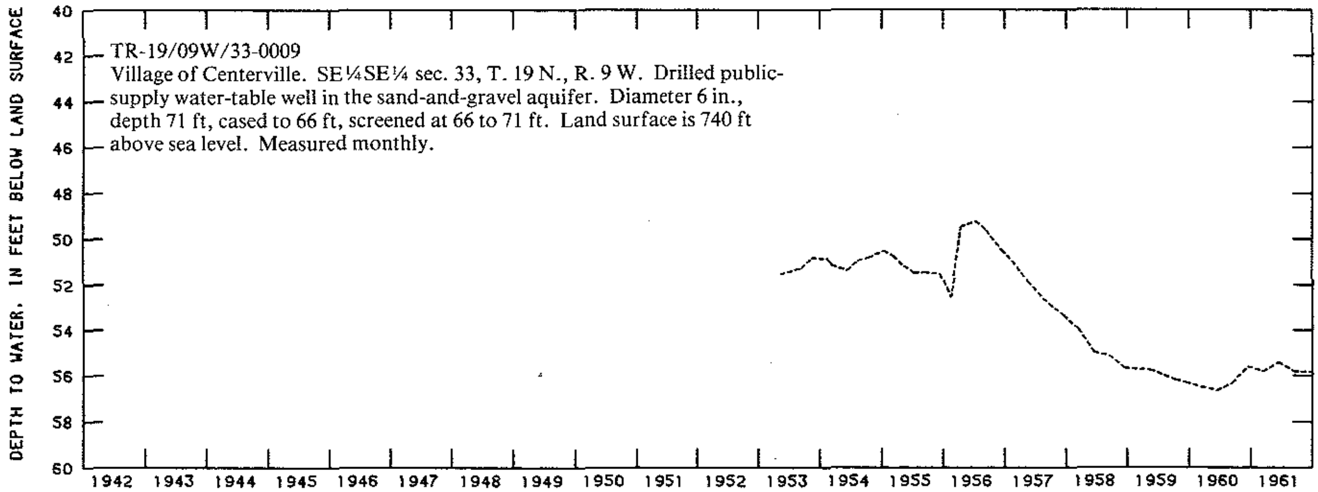


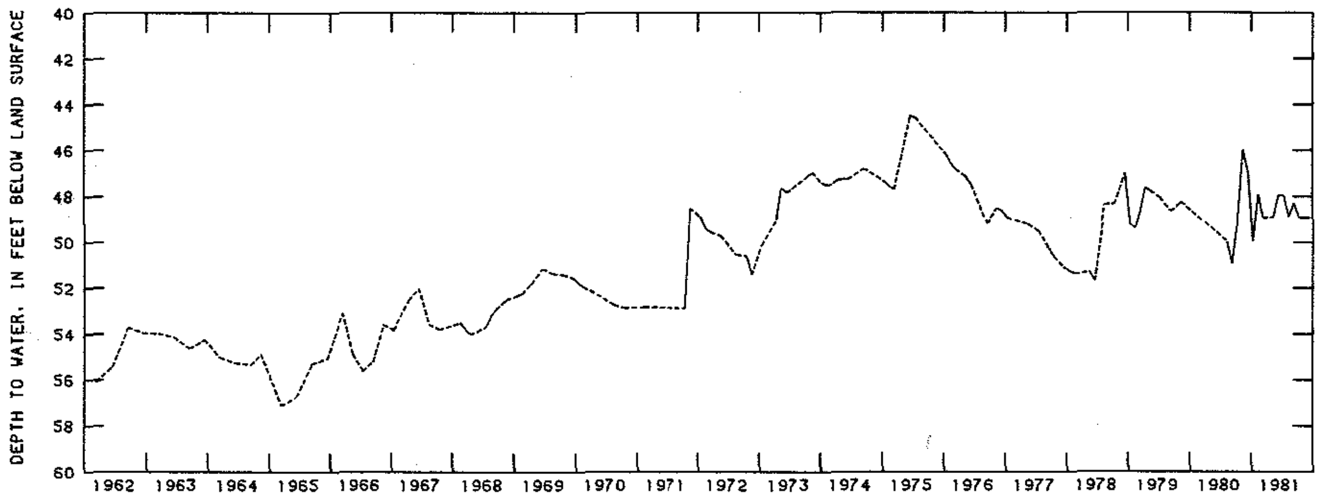
TA-33-02E/30-0009



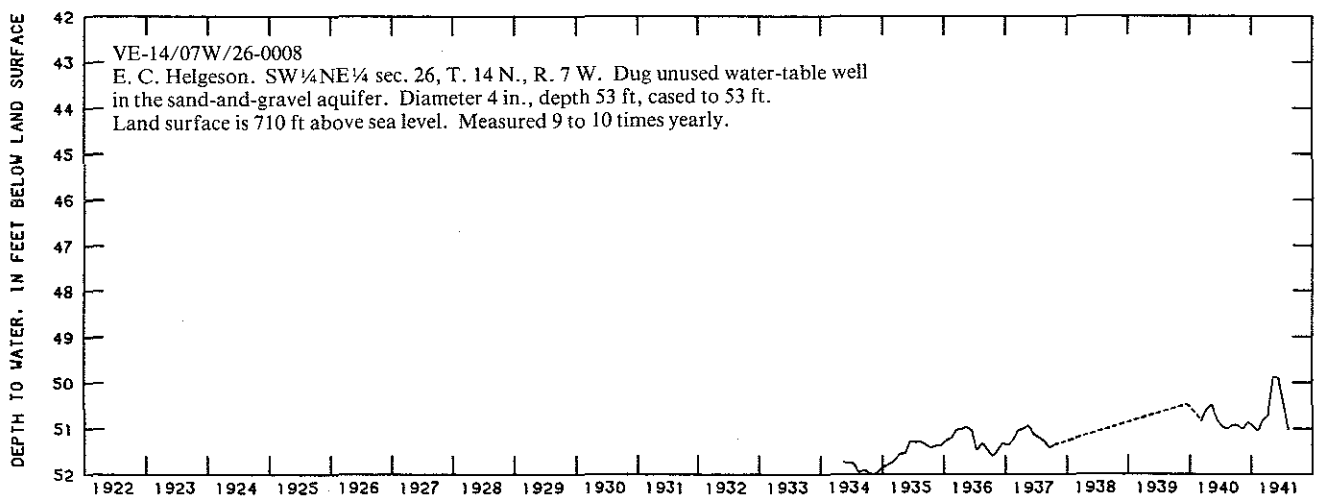


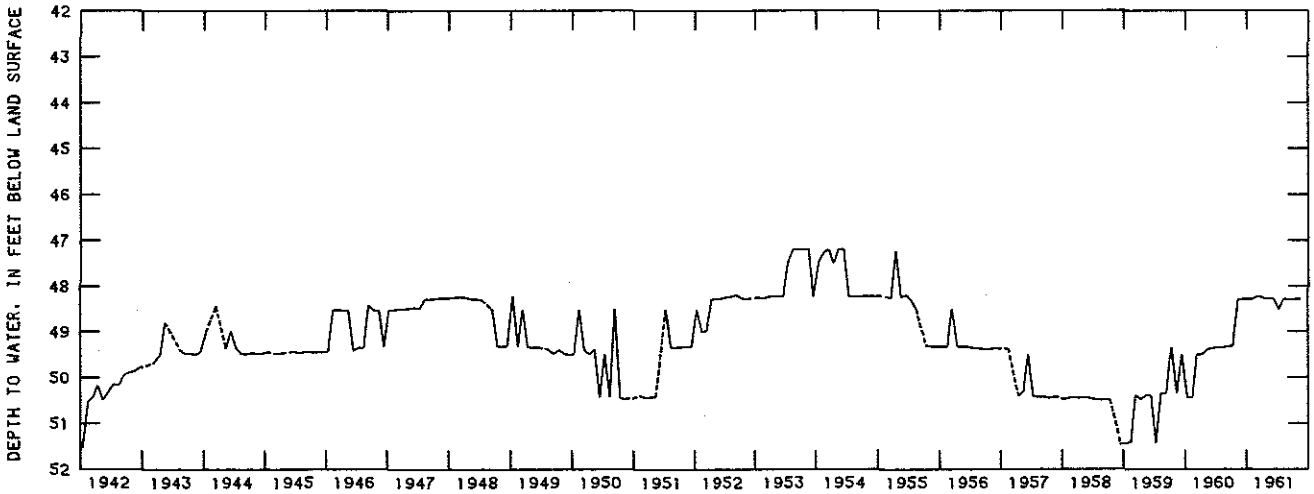
TR-19/08W/35-0001

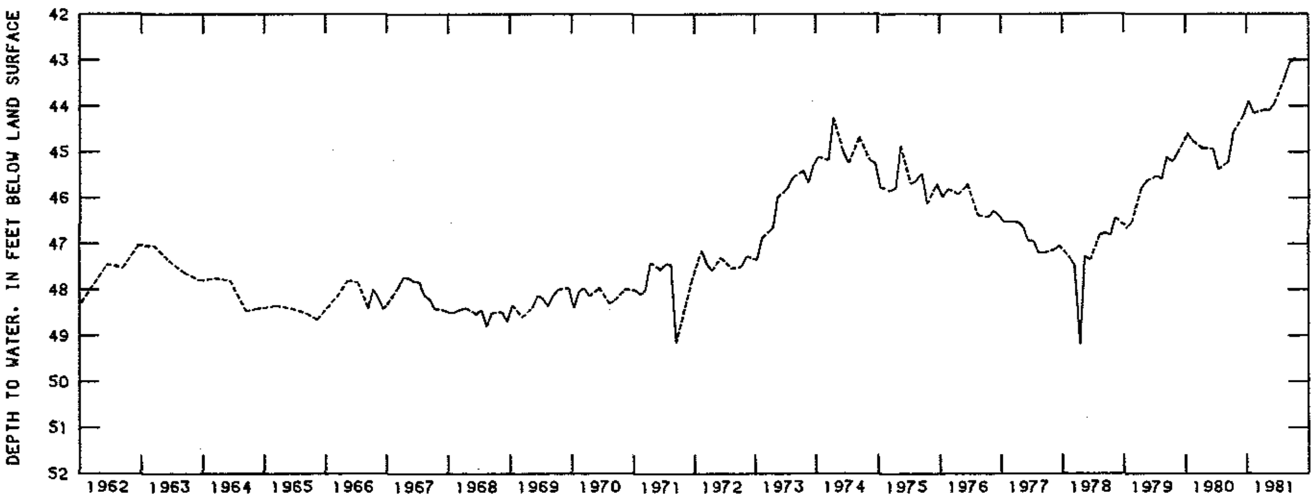




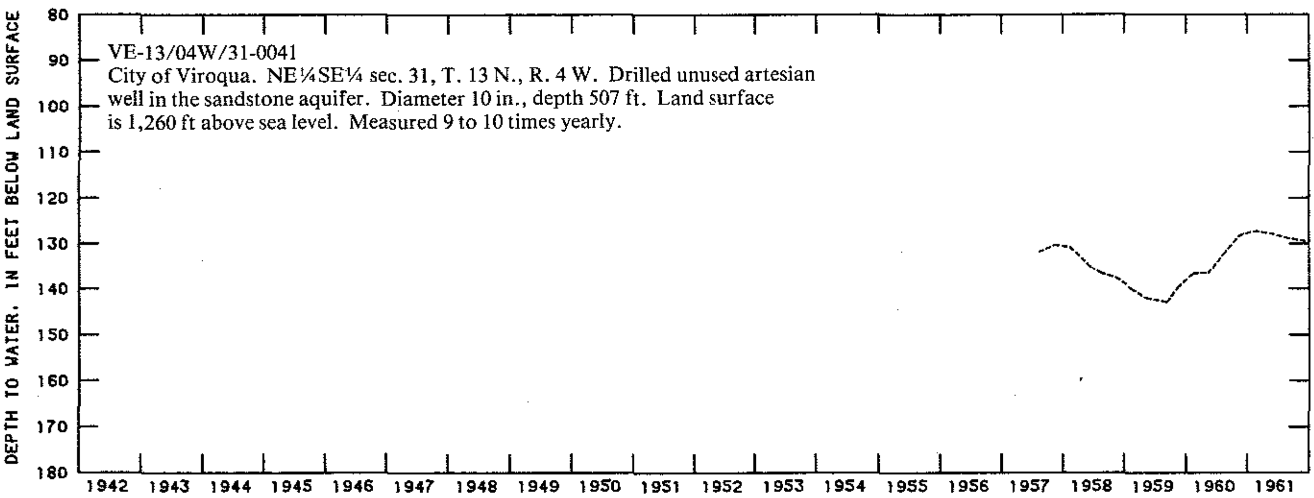
TR-19/09W/33-0009

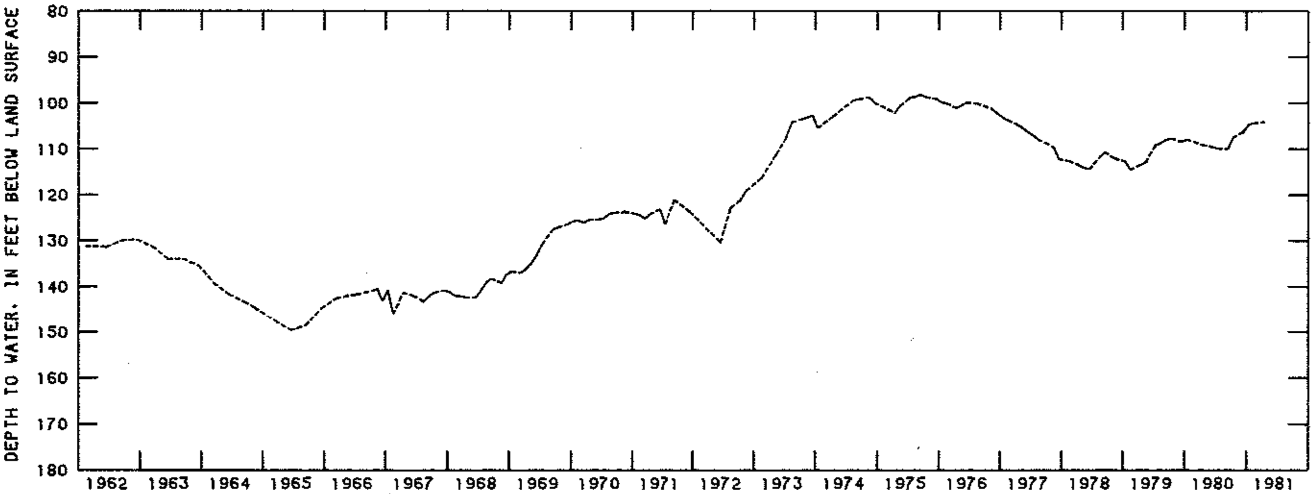




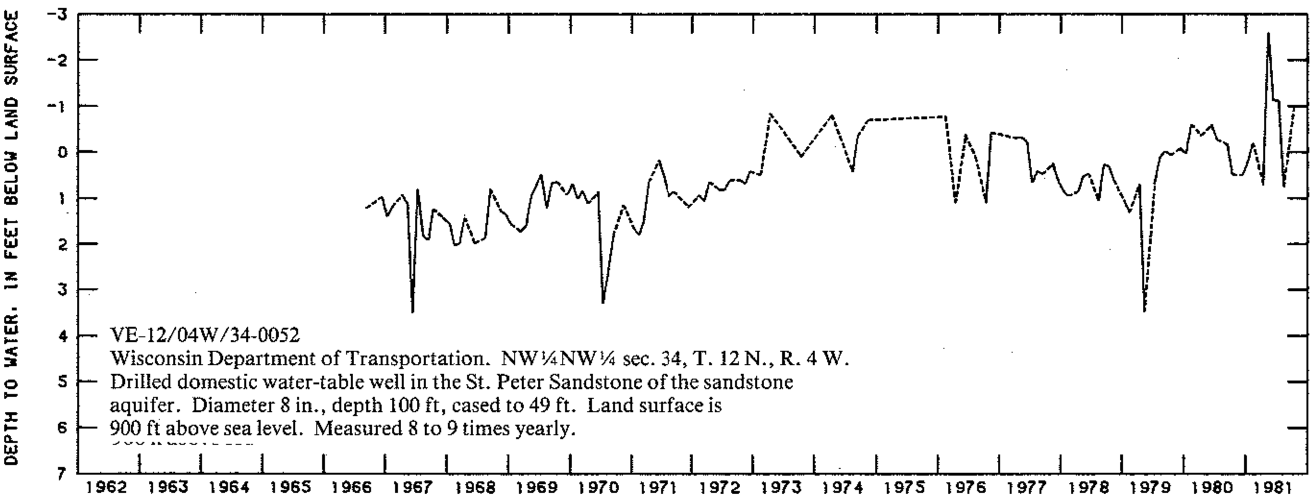


VE-14/07W/26-0008

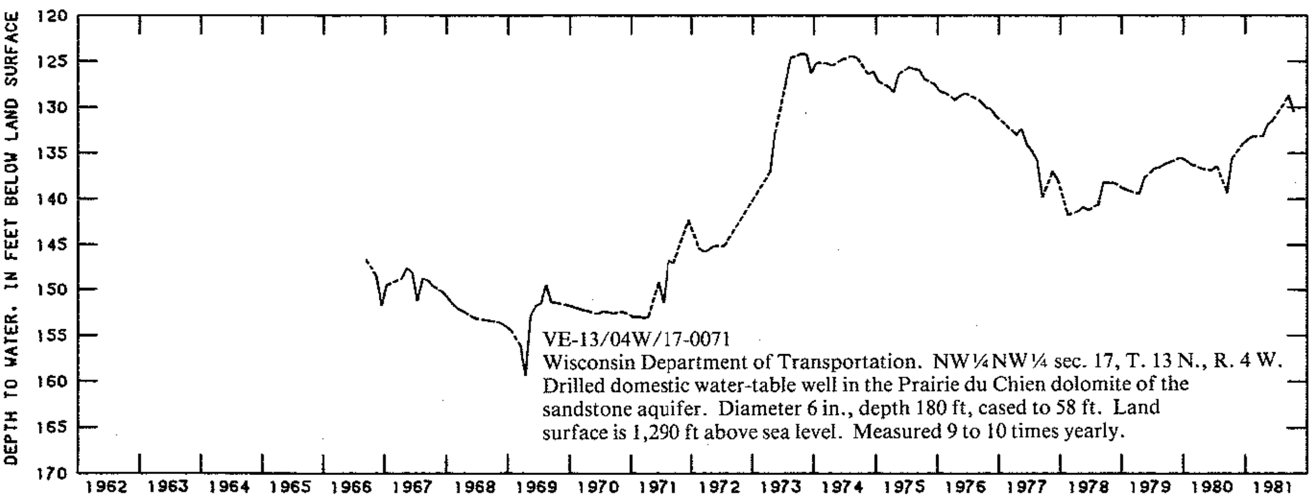




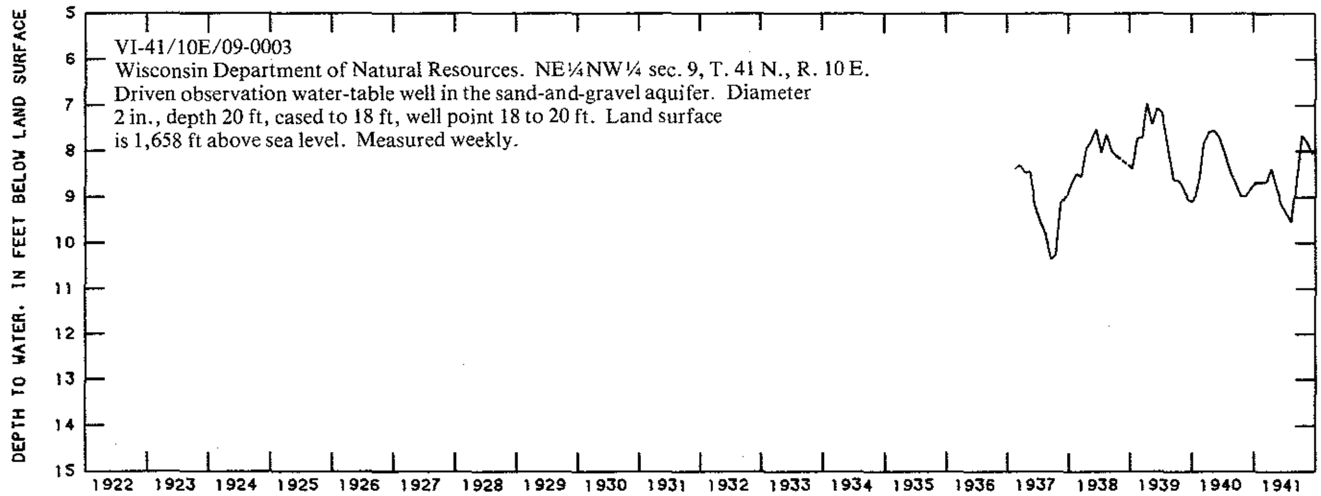
VE-13/04W/31-0041

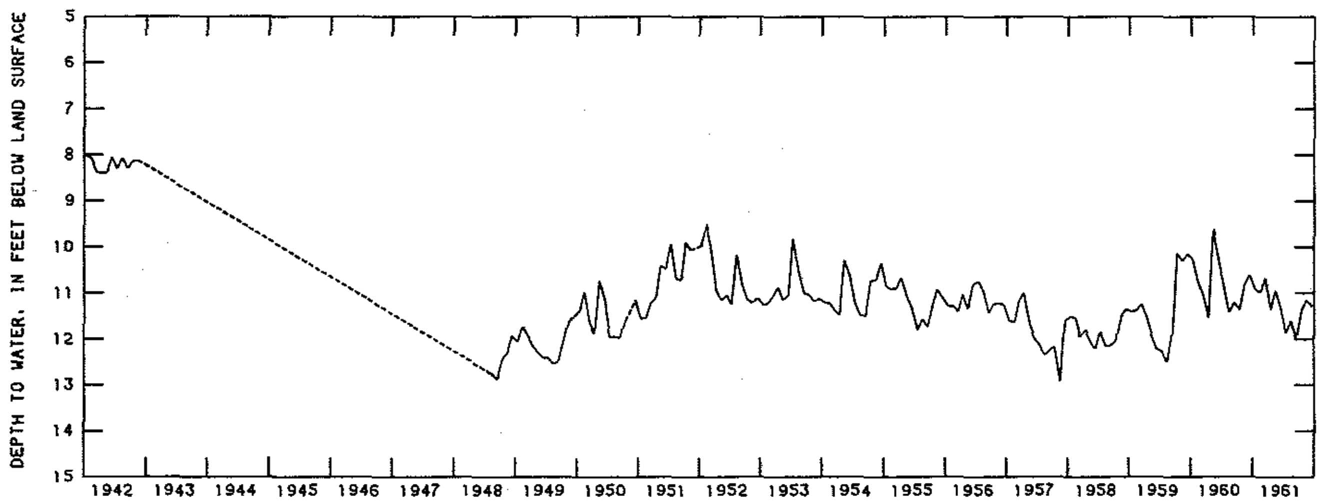


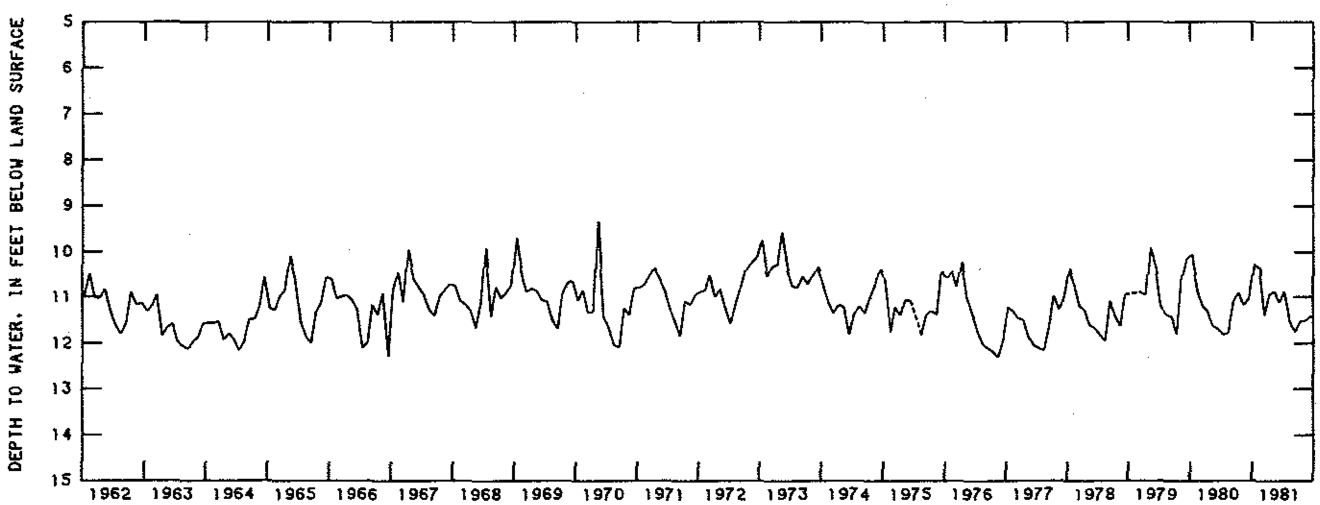
VE-12/04W/34-0052



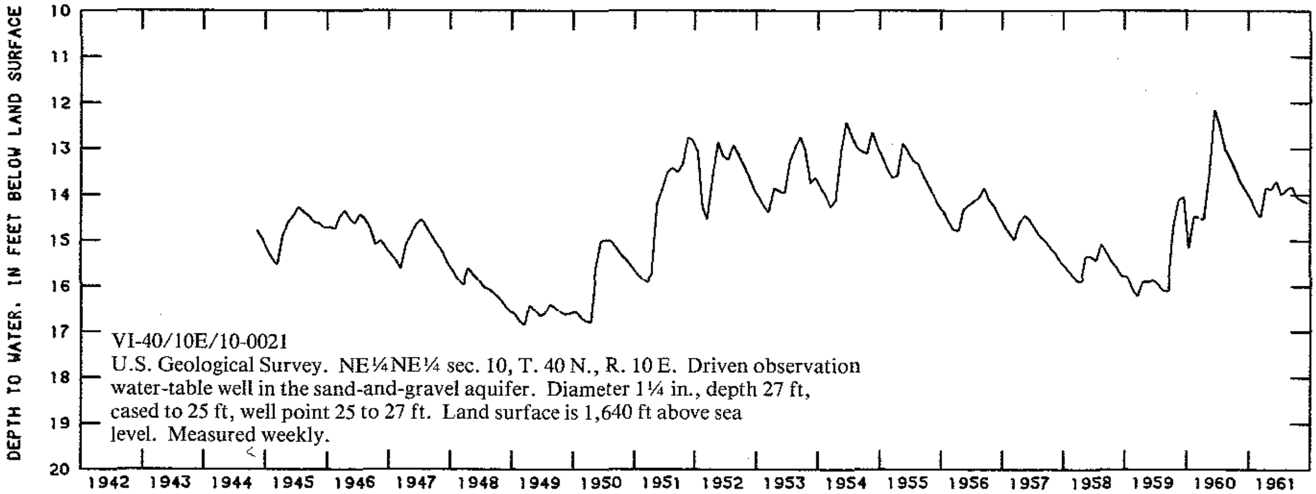
VE-13/04W/17-0071



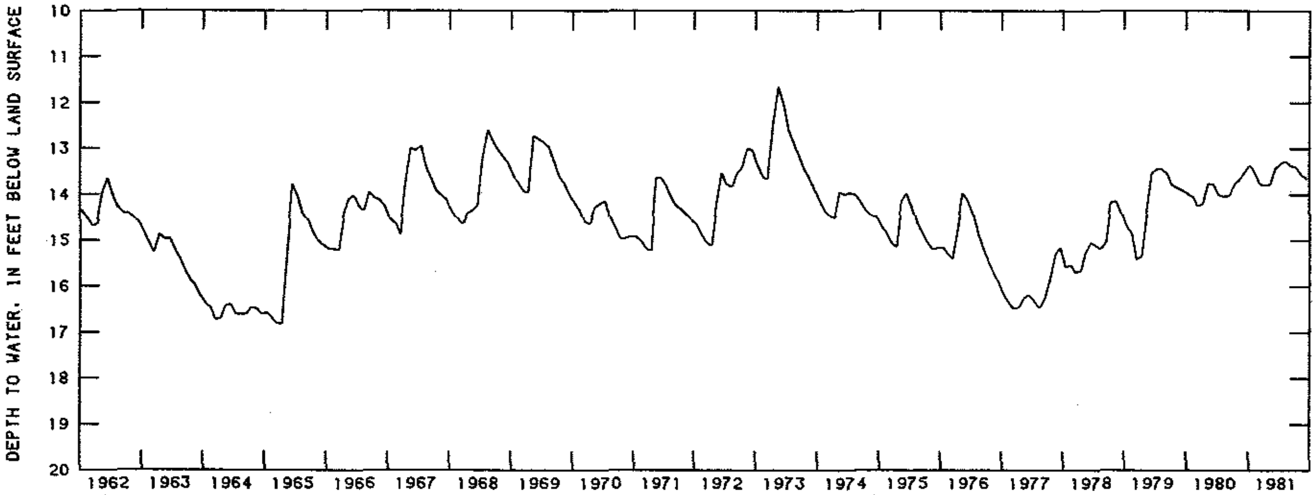




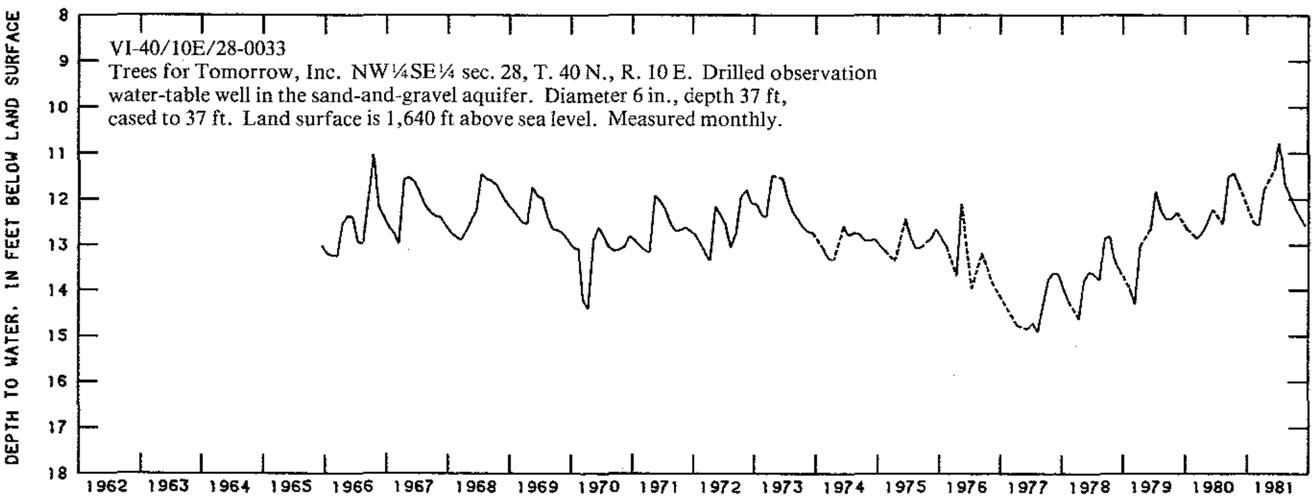
VI-41/10E/09-0003



VI-40/10E/10-0021
U.S. Geological Survey. NE¼NE¼ sec. 10, T. 40 N., R. 10 E. Driven observation water-table well in the sand-and-gravel aquifer. Diameter 1¼ in., depth 27 ft, cased to 25 ft, well point 25 to 27 ft. Land surface is 1,640 ft above sea level. Measured weekly.

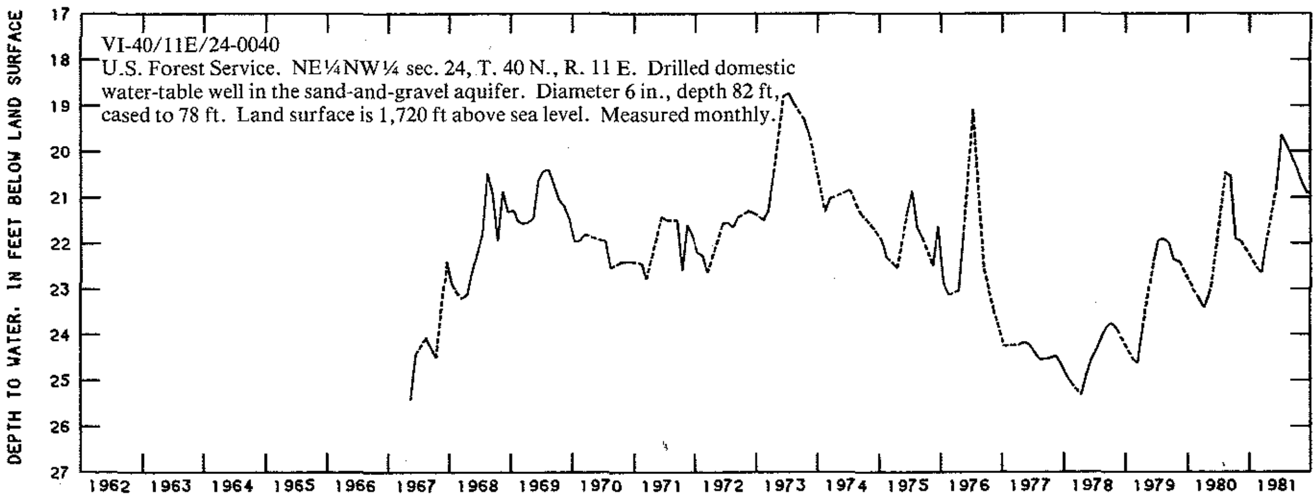


VI-40/10E/10-0021

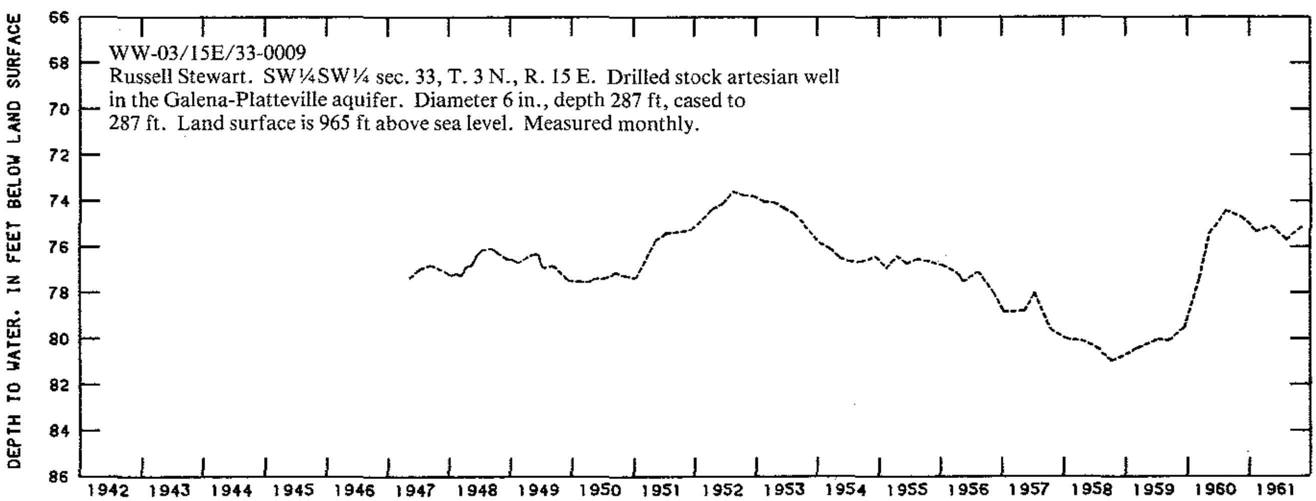


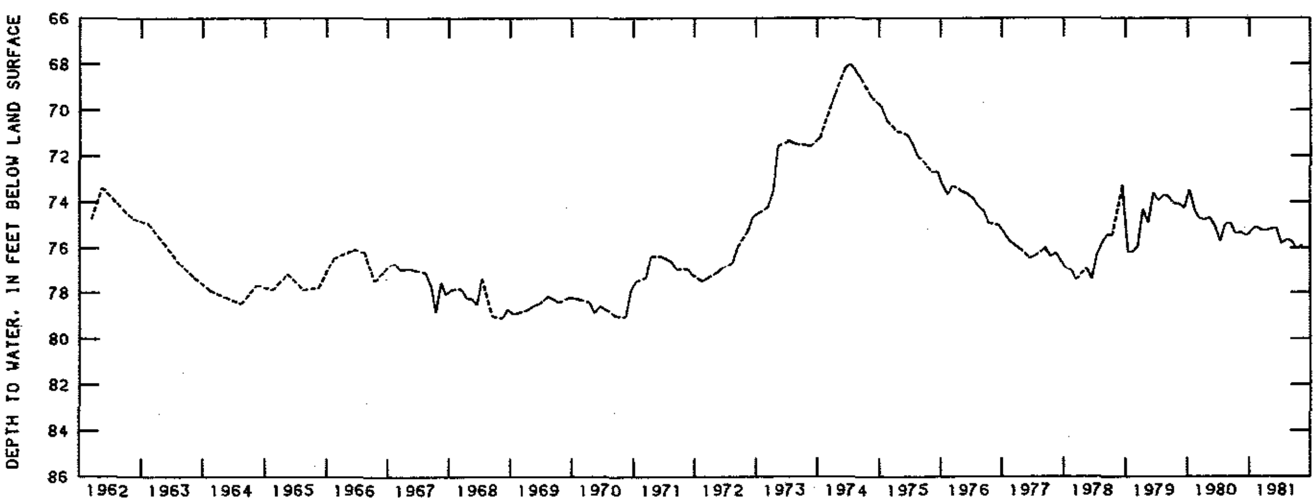
VI-40/10E/28-0033
Trees for Tomorrow, Inc. NW¼SE¼ sec. 28, T. 40 N., R. 10 E. Drilled observation water-table well in the sand-and-gravel aquifer. Diameter 6 in., depth 37 ft, cased to 37 ft. Land surface is 1,640 ft above sea level. Measured monthly.

VI-40/10E/28-0033

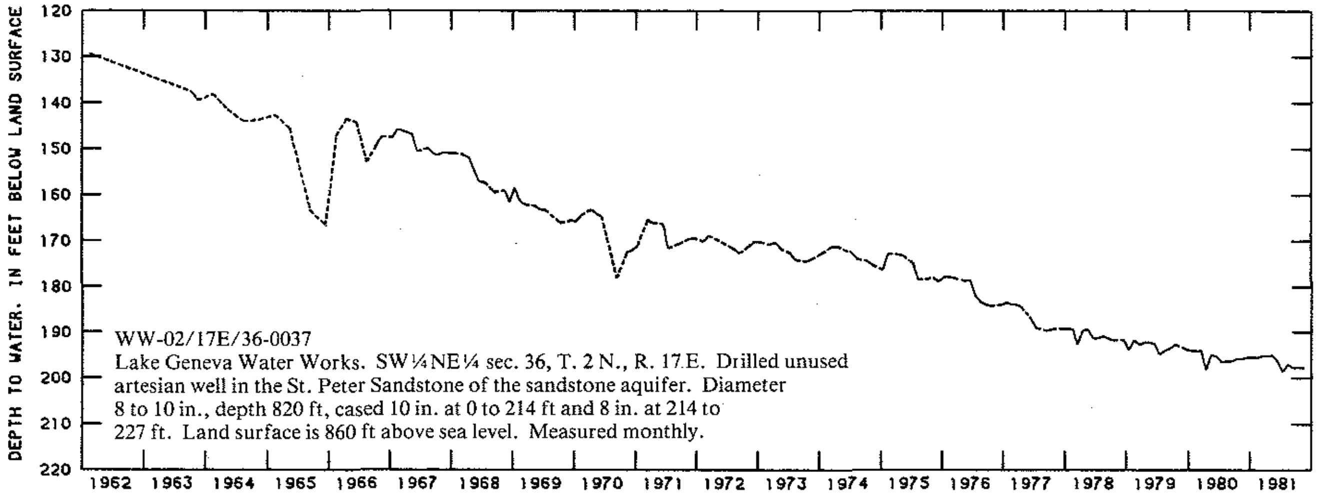


VI-40/11E/24-0040

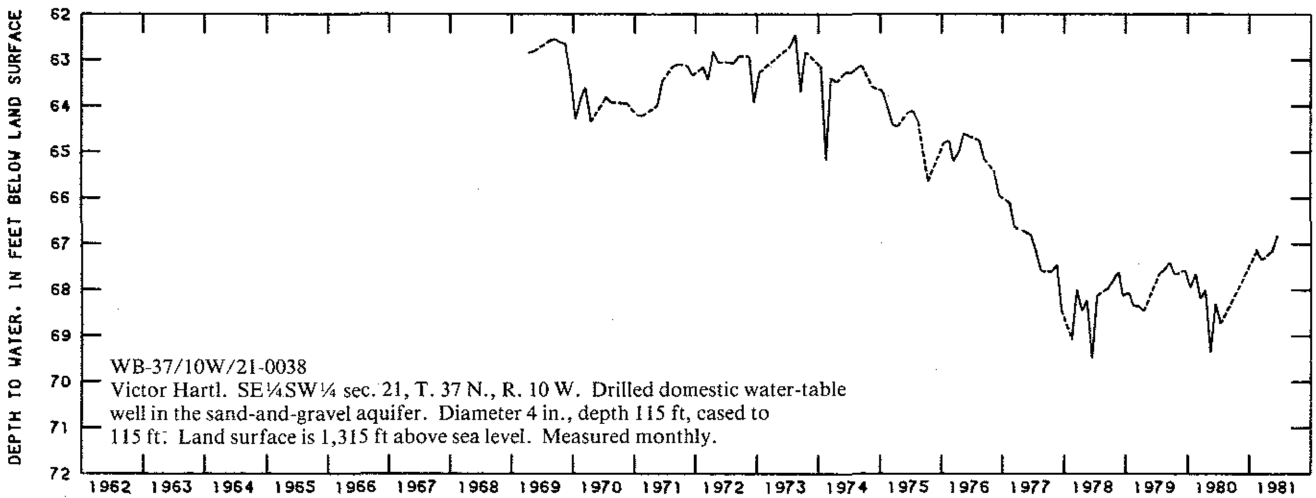




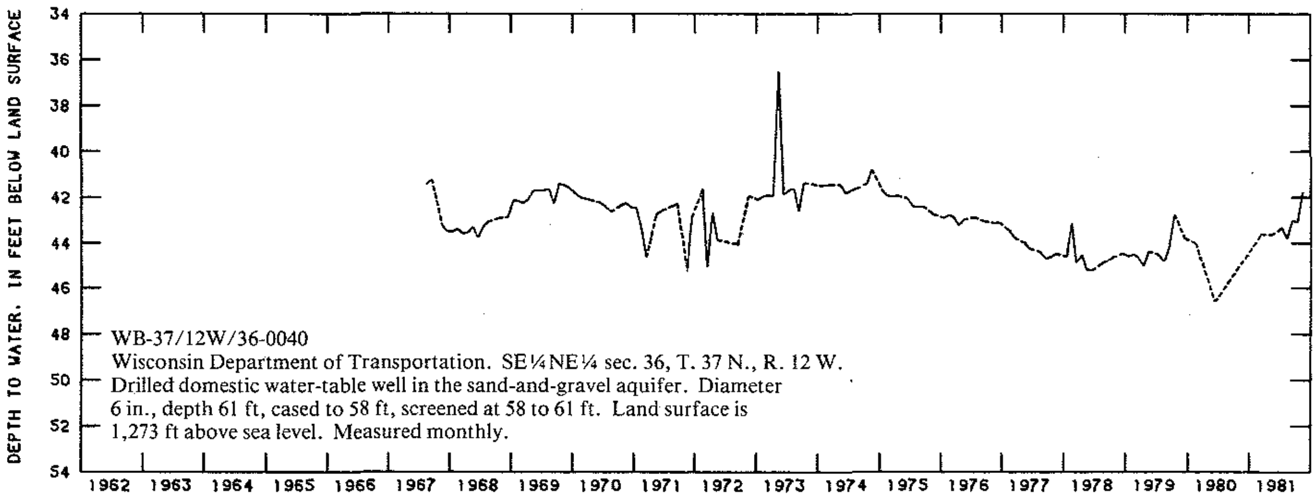
WW-03/15E/33-0009



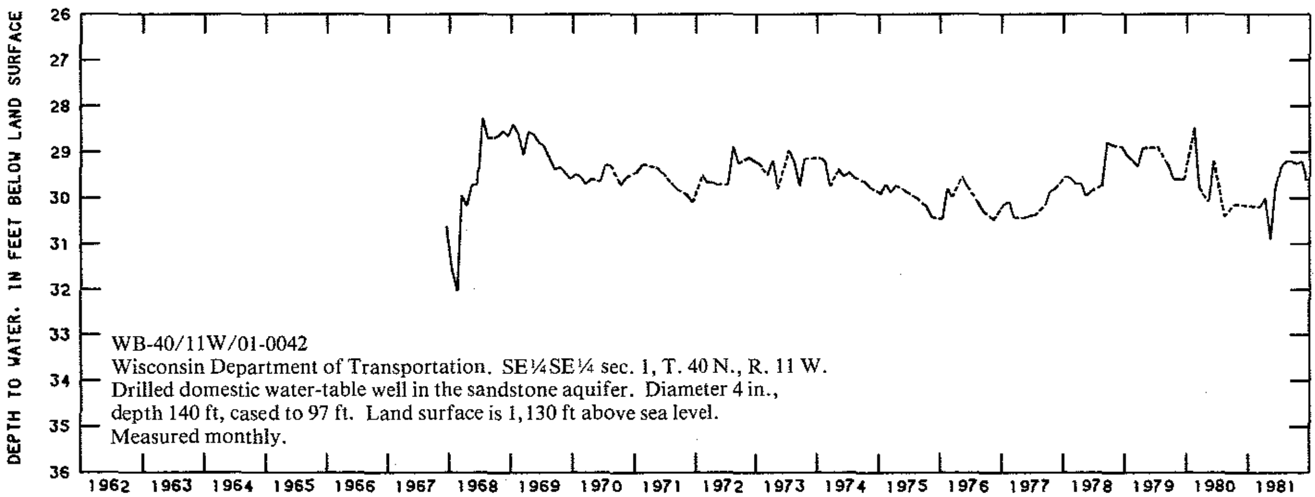
WW-02/17E/36-0037



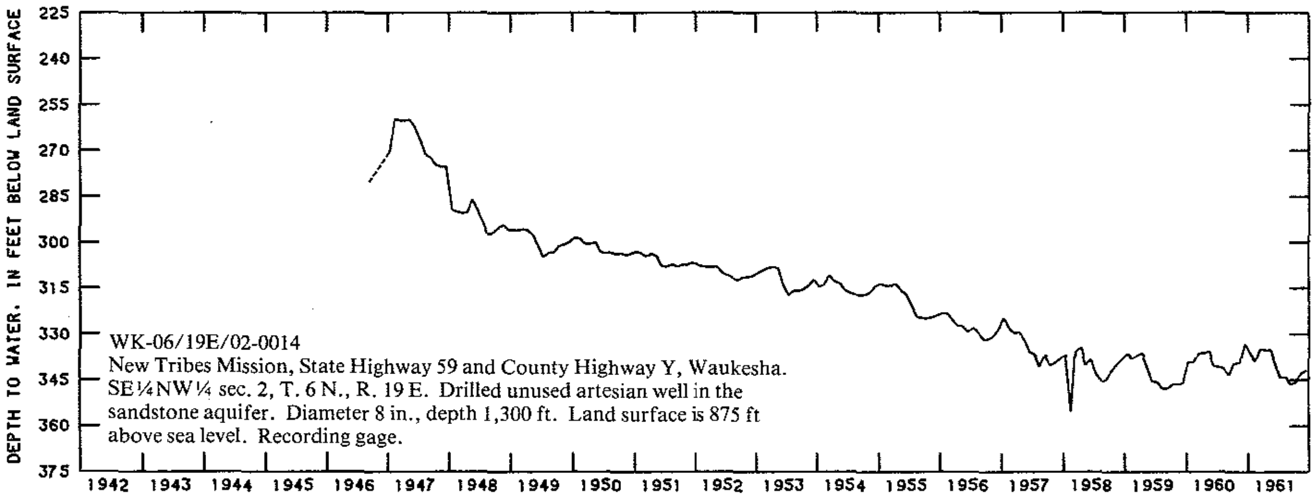
WB-37/10W/21-0038

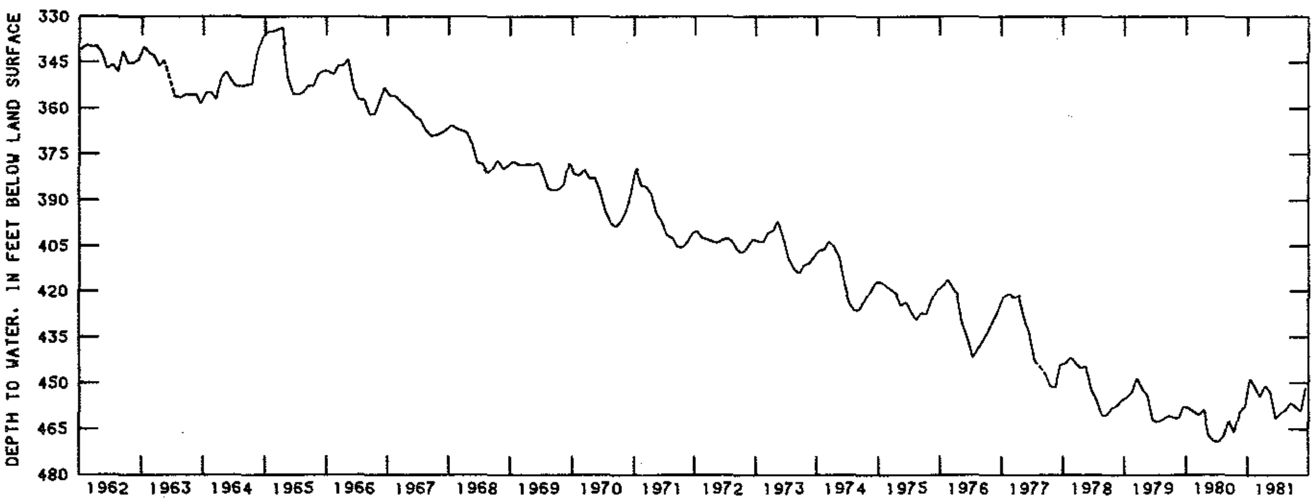


WB-37/12W/36-0040

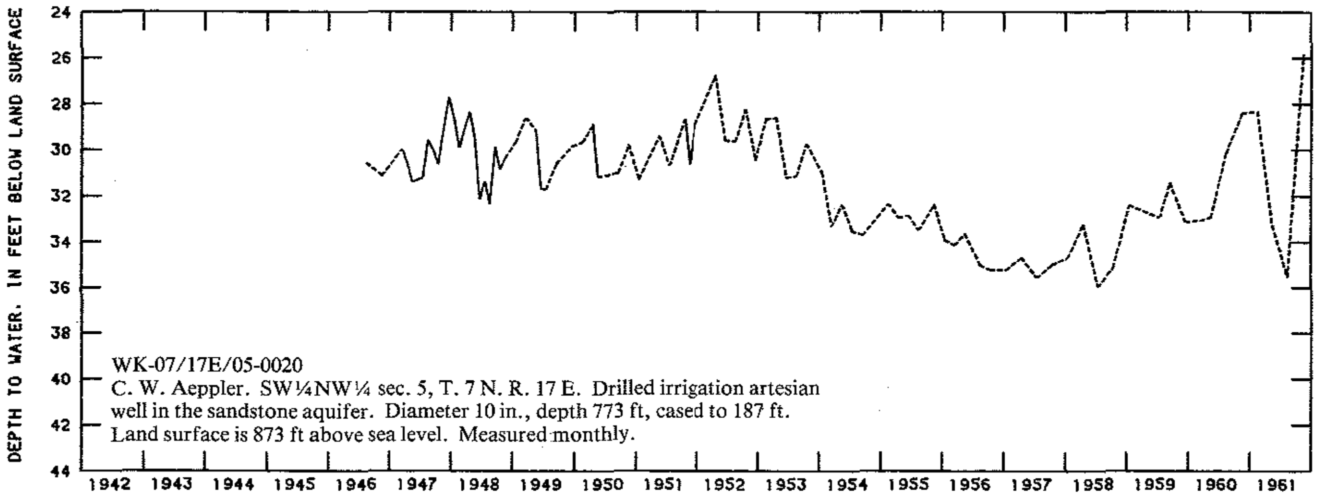


WB-40/11W/01-0042

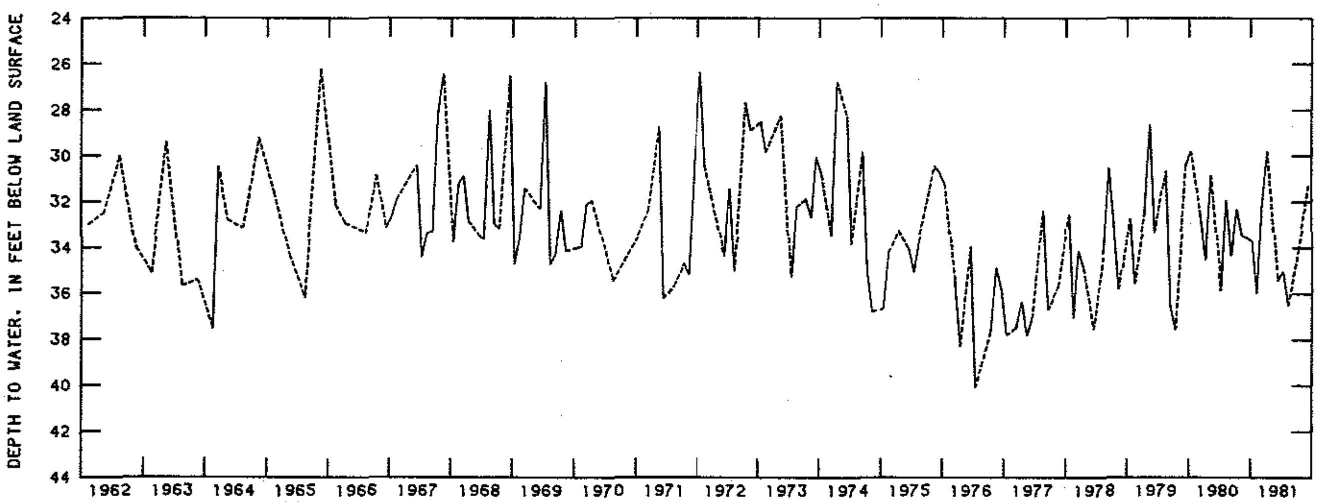




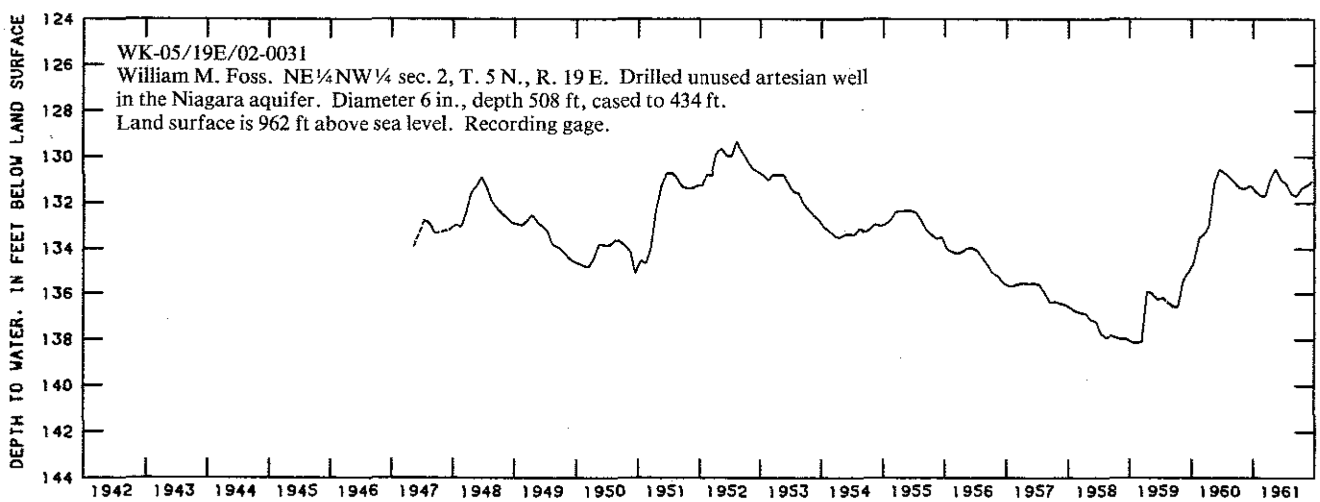
WK-06/19E/02-0014



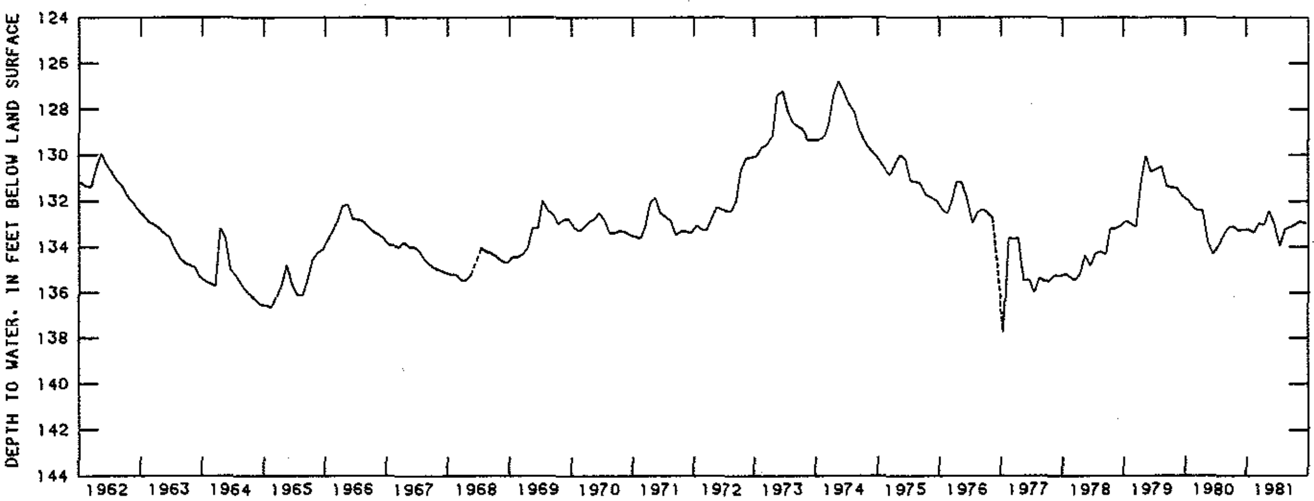
WK-07/17E/05-0020
C. W. Aeppler. SW¼NW¼ sec. 5, T. 7 N. R. 17 E. Drilled irrigation artesian well in the sandstone aquifer. Diameter 10 in., depth 773 ft, cased to 187 ft. Land surface is 873 ft above sea level. Measured monthly.



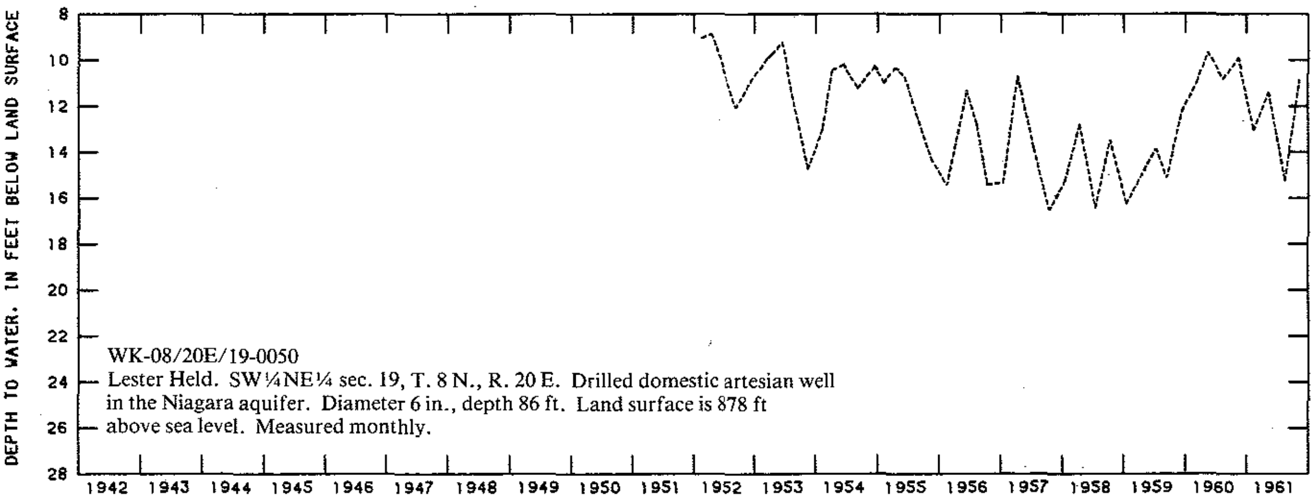
WK-07/17E/05-0020

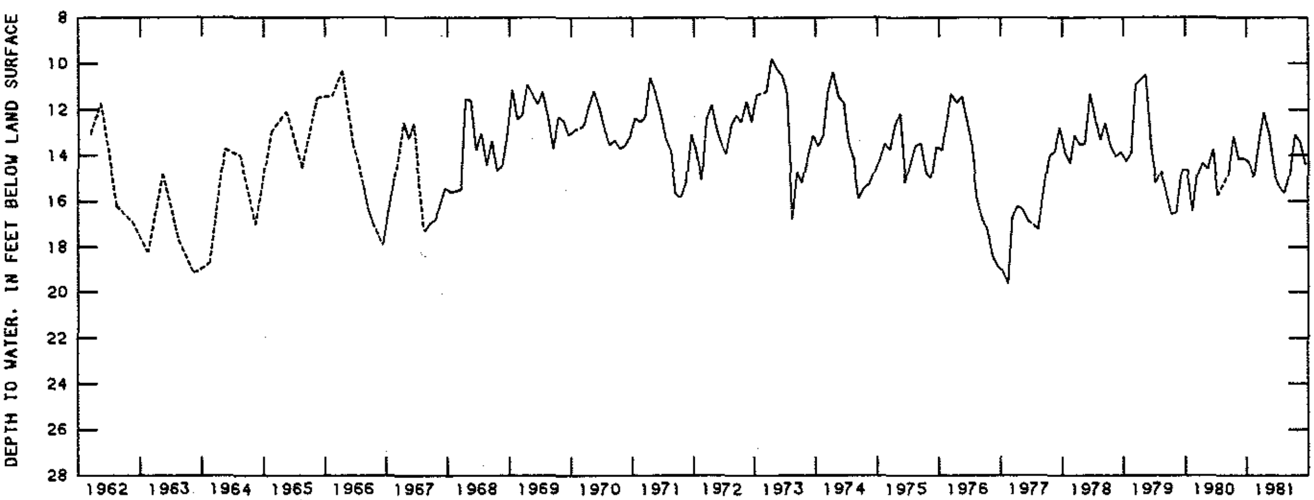


WK-05/19E/02-0031
William M. Foss. NE¼NW¼ sec. 2, T. 5 N., R. 19 E. Drilled unused artesian well in the Niagara aquifer. Diameter 6 in., depth 508 ft, cased to 434 ft. Land surface is 962 ft above sea level. Recording gage.

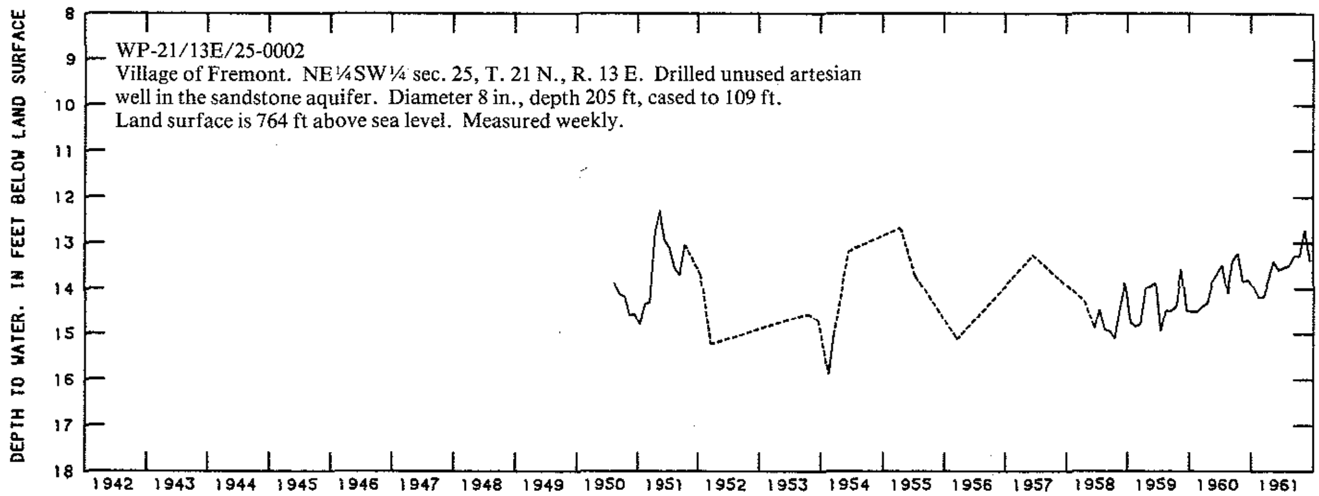


WK-05/19E/02-0031

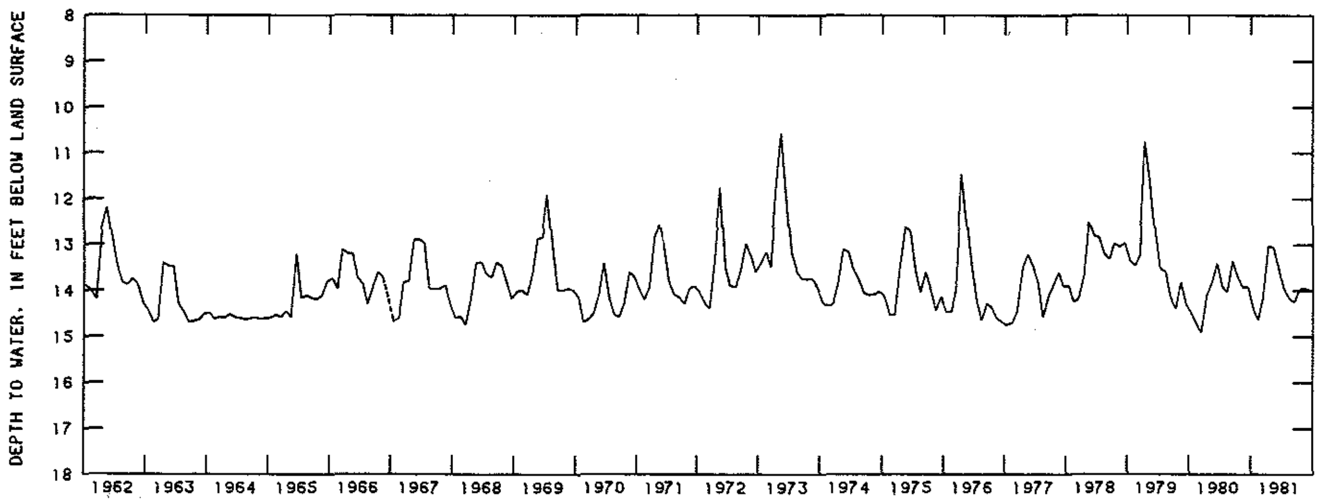




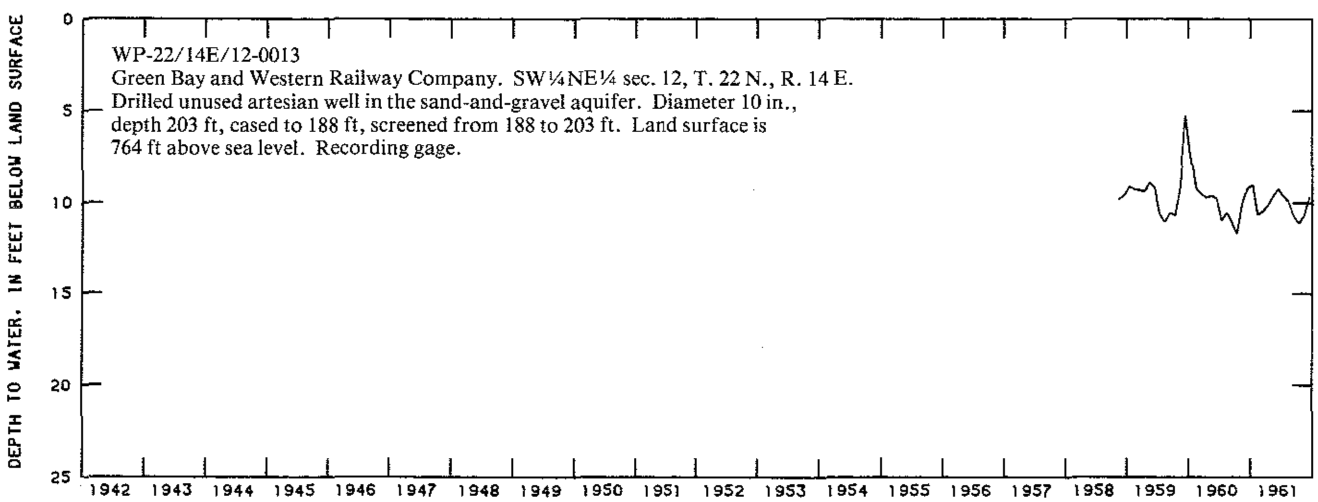
WK-08/20E/19-0050



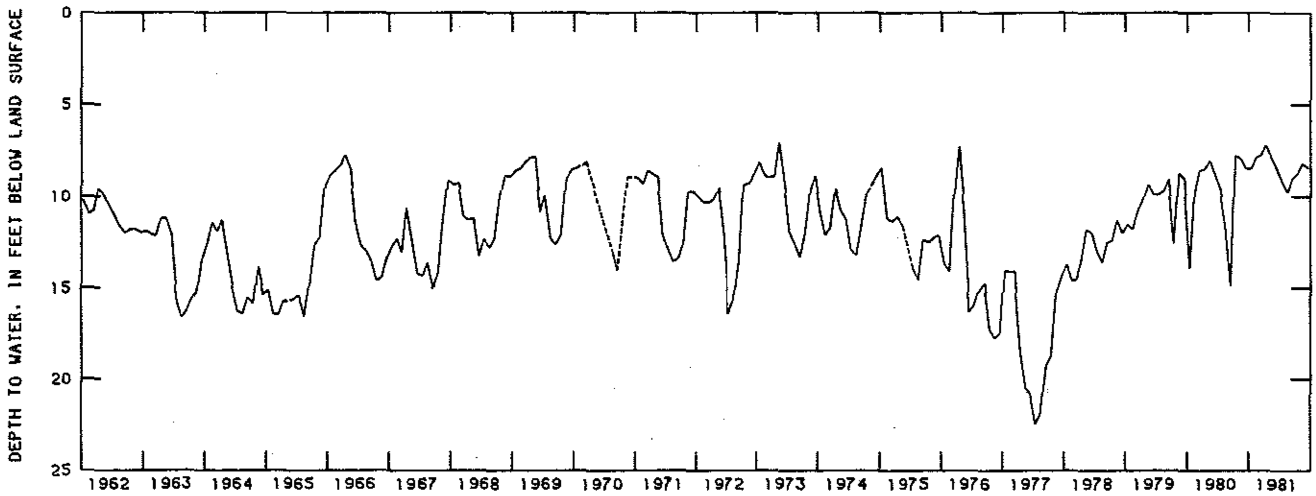
WP-21/13E/25-0002
Village of Fremont. NE¼SW¼ sec. 25, T. 21 N., R. 13 E. Drilled unused artesian well in the sandstone aquifer. Diameter 8 in., depth 205 ft, cased to 109 ft. Land surface is 764 ft above sea level. Measured weekly.



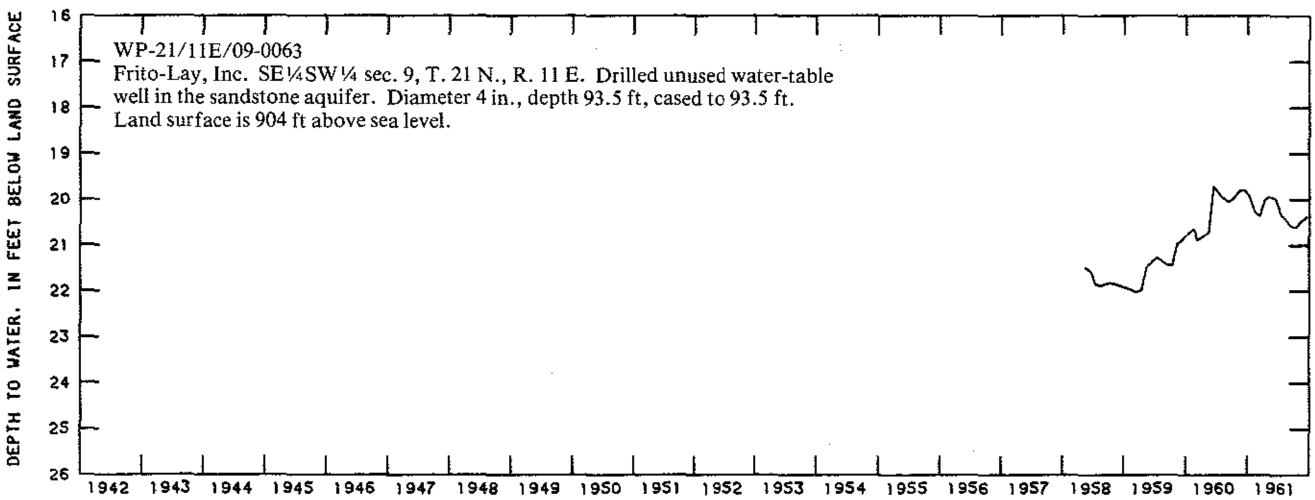
WP-21/13E/25-0002

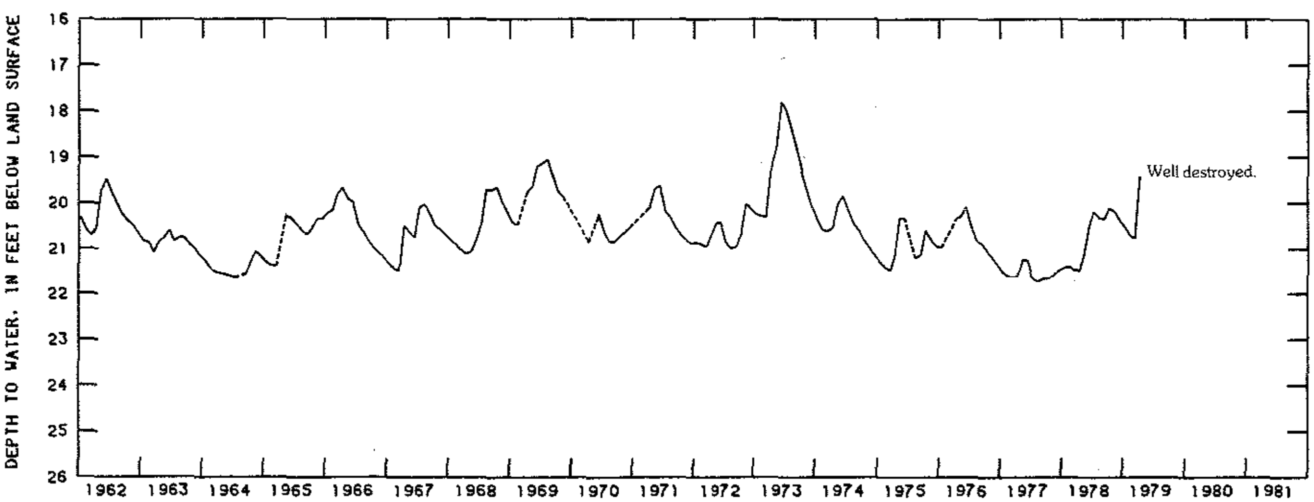


WP-22/14E/12-0013
Green Bay and Western Railway Company. SW¼NE¼ sec. 12, T. 22 N., R. 14 E. Drilled unused artesian well in the sand-and-gravel aquifer. Diameter 10 in., depth 203 ft, cased to 188 ft, screened from 188 to 203 ft. Land surface is 764 ft above sea level. Recording gage.

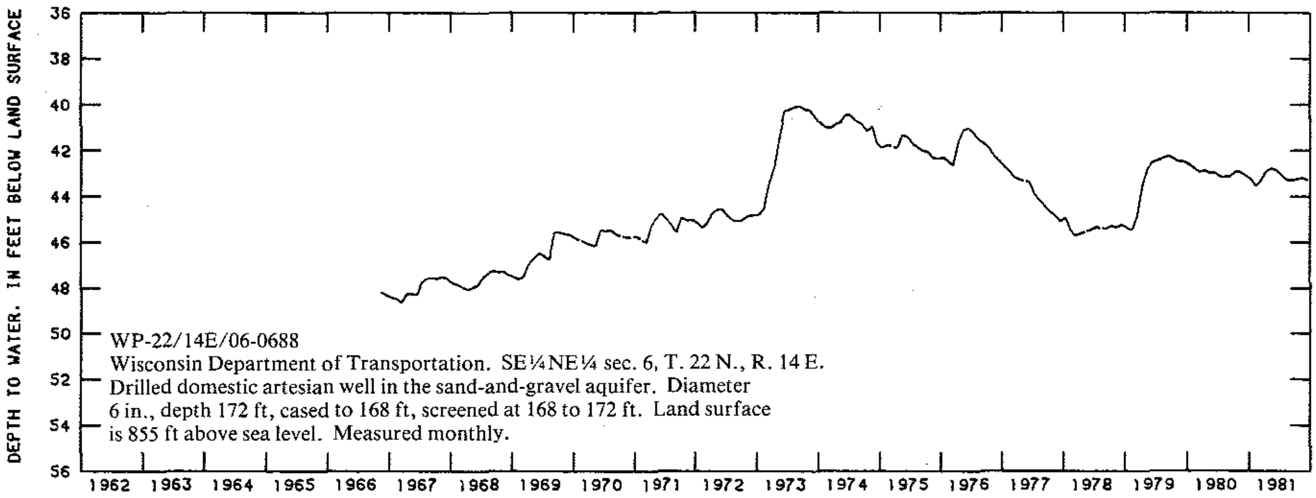


WP-22/14E/12-0013

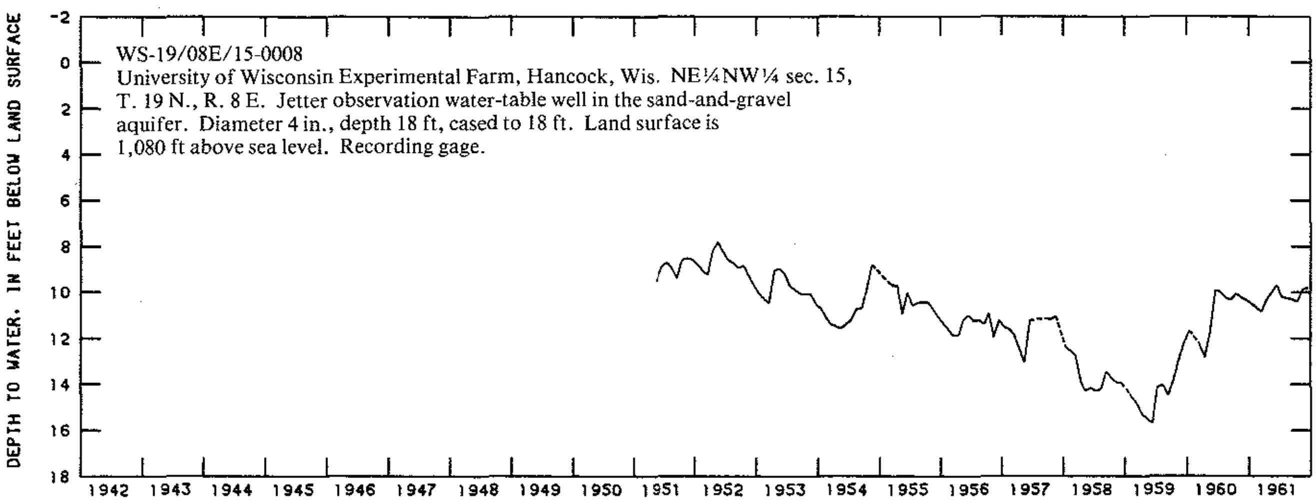


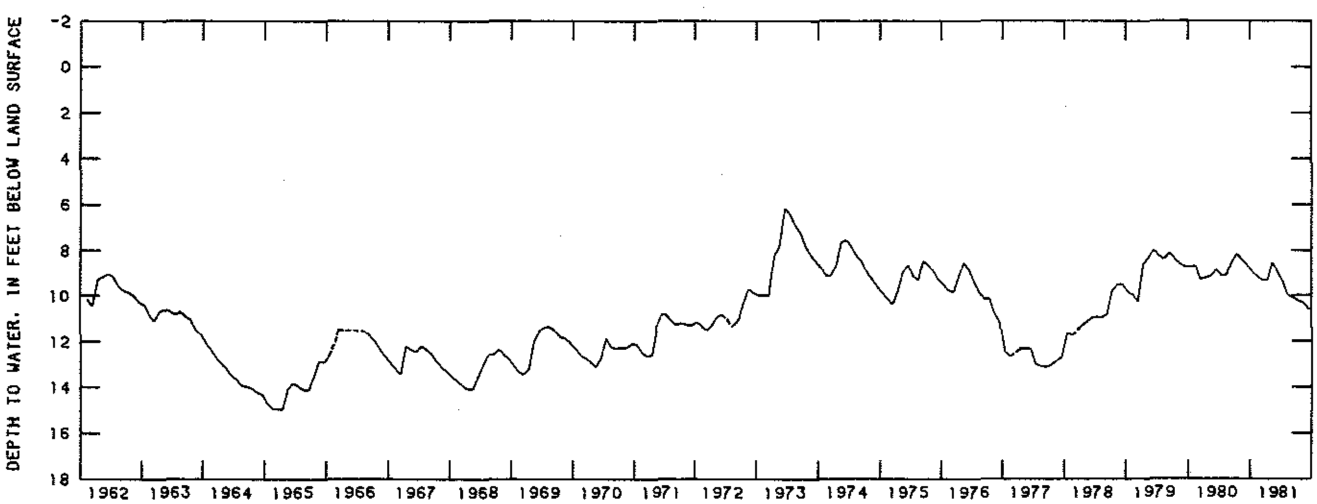


WP-21/11E/09-0063

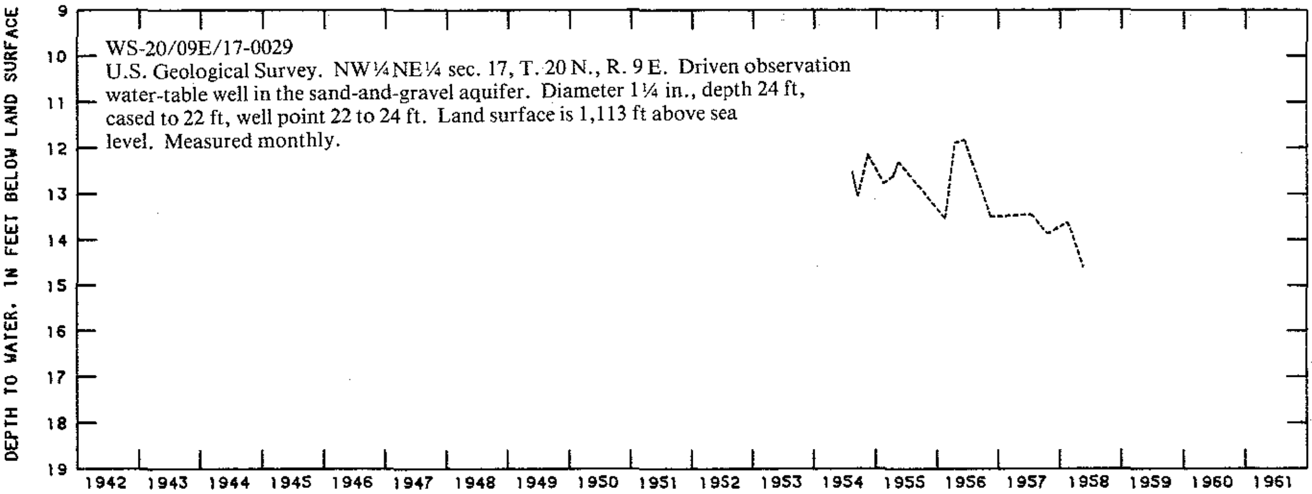


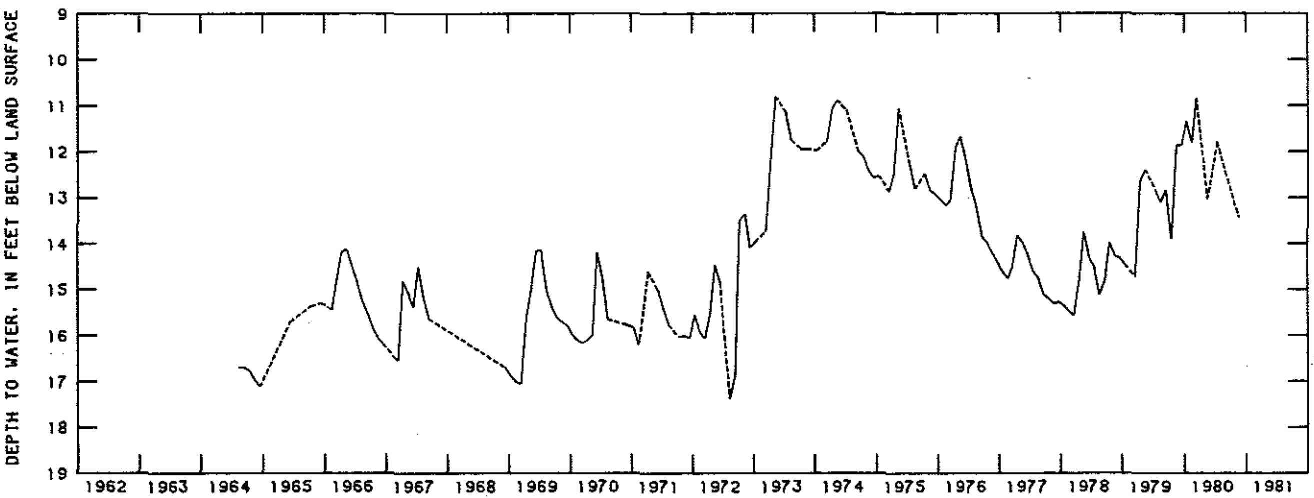
WP-22/14E/06-0688



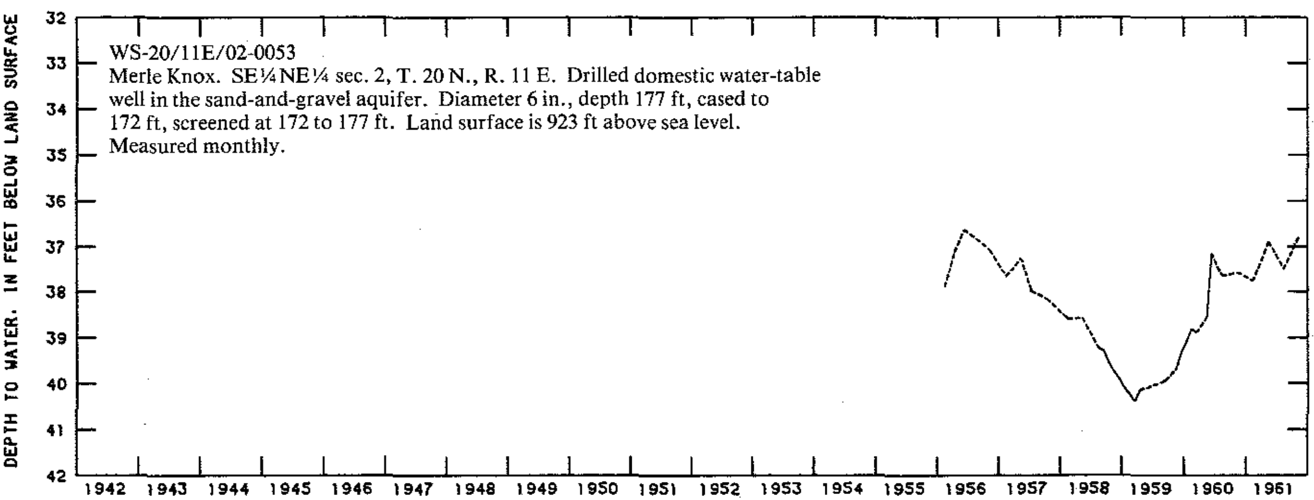


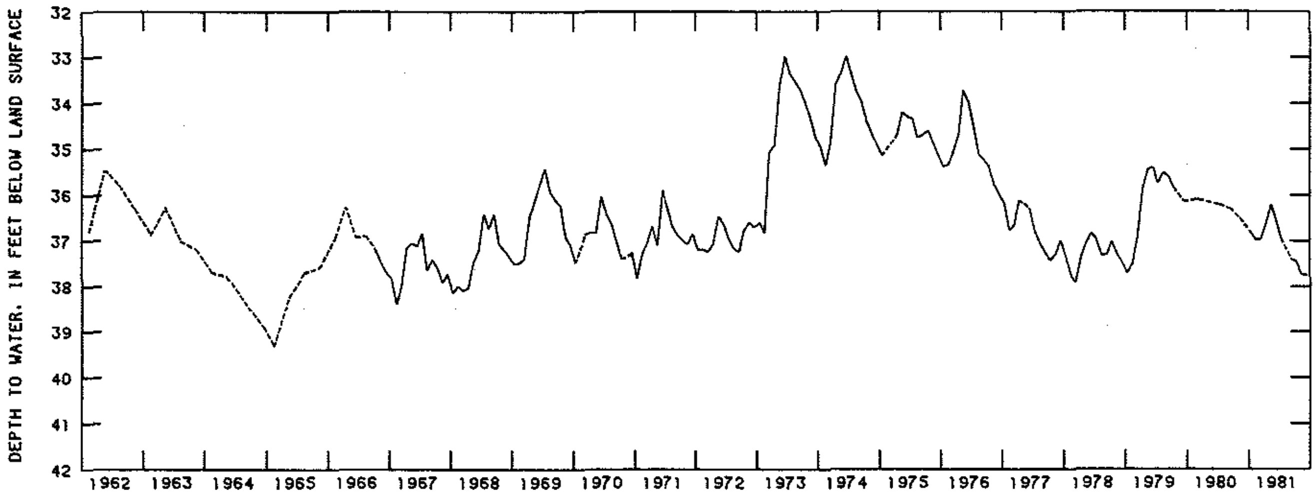
WS-19/08E/15-0008



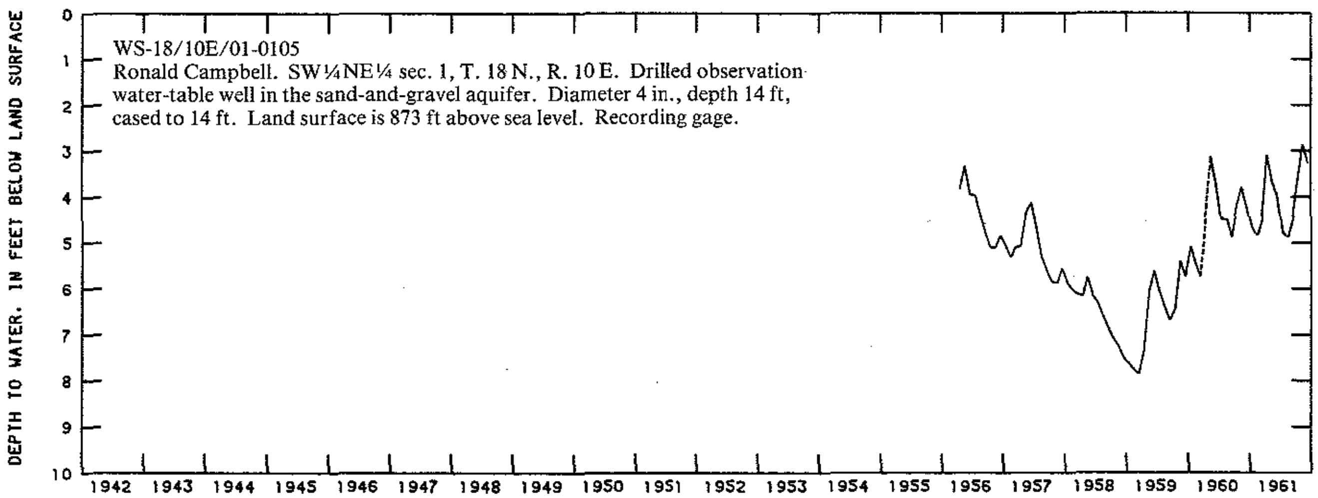


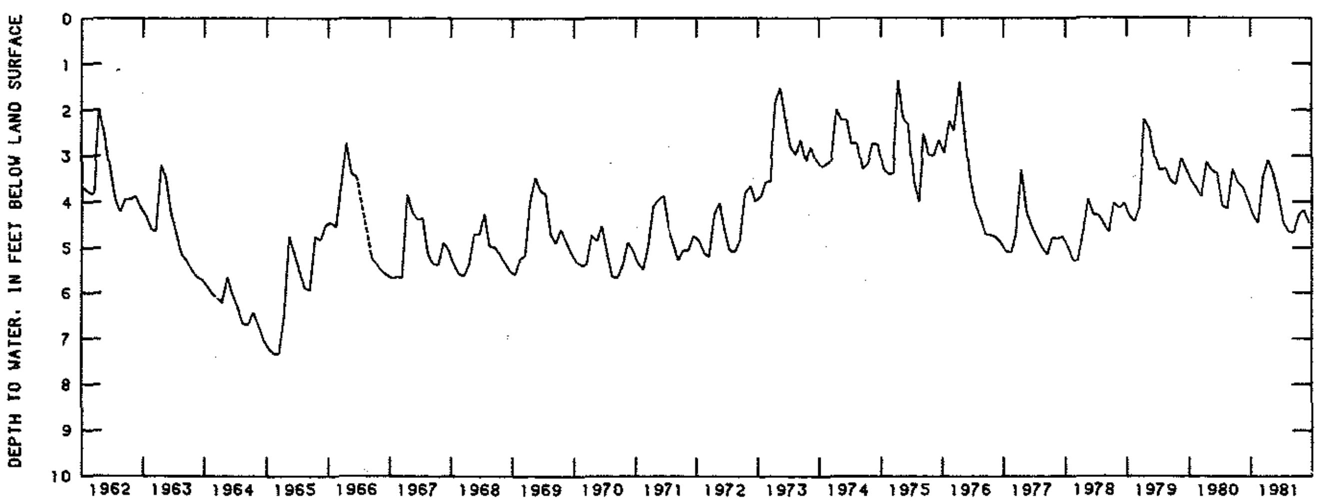
WS-20/09E/17-0029





WS-20/11E/02-0053





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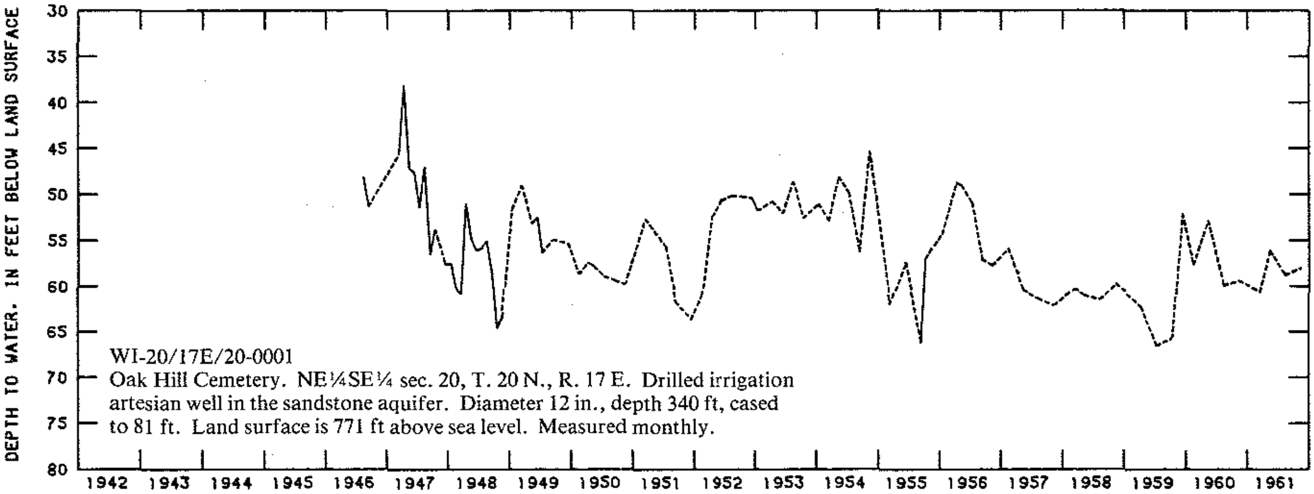

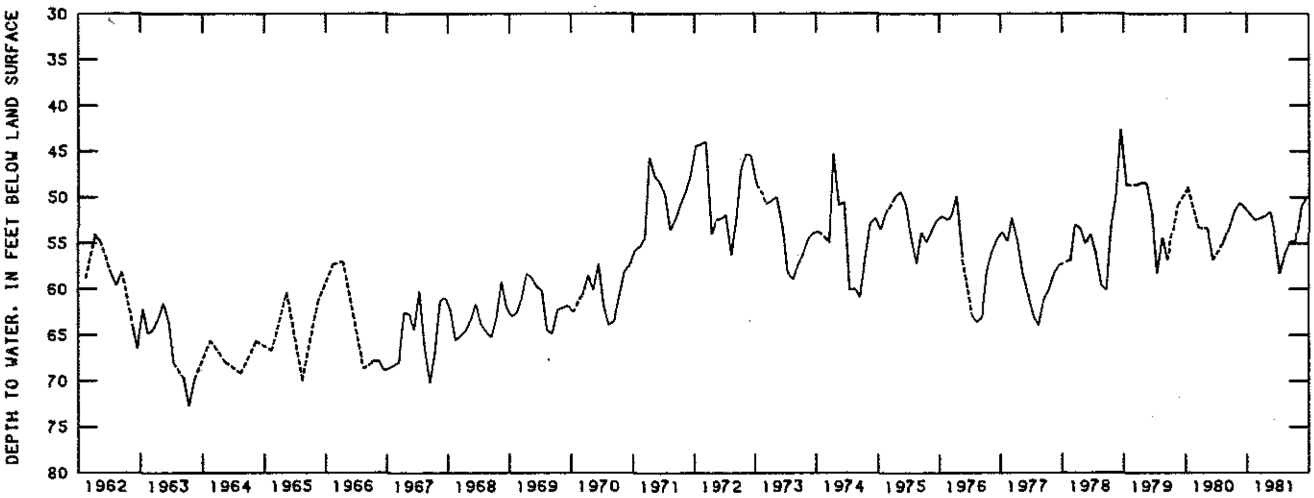

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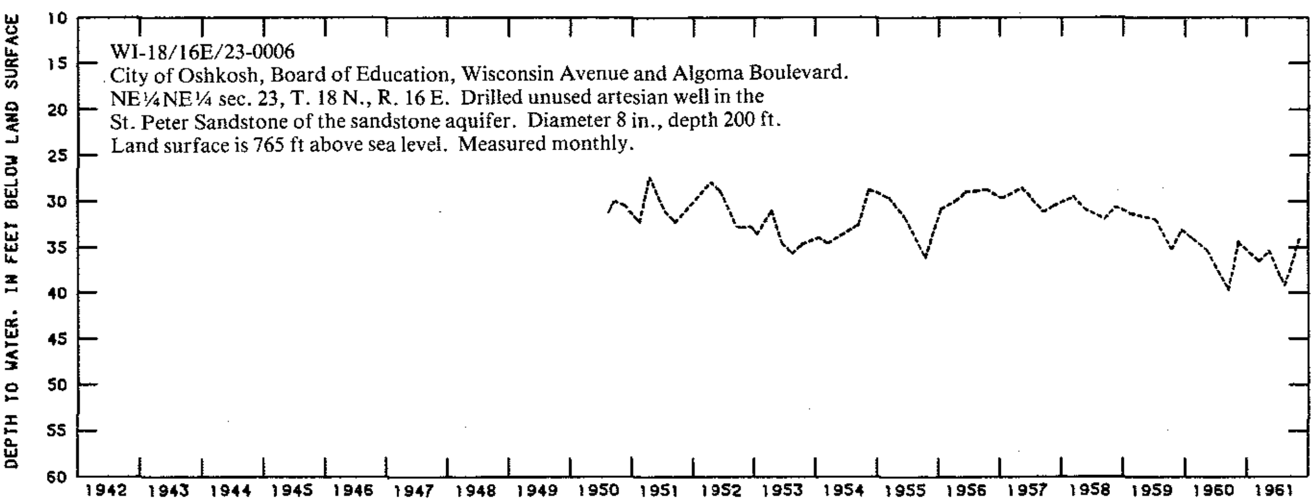

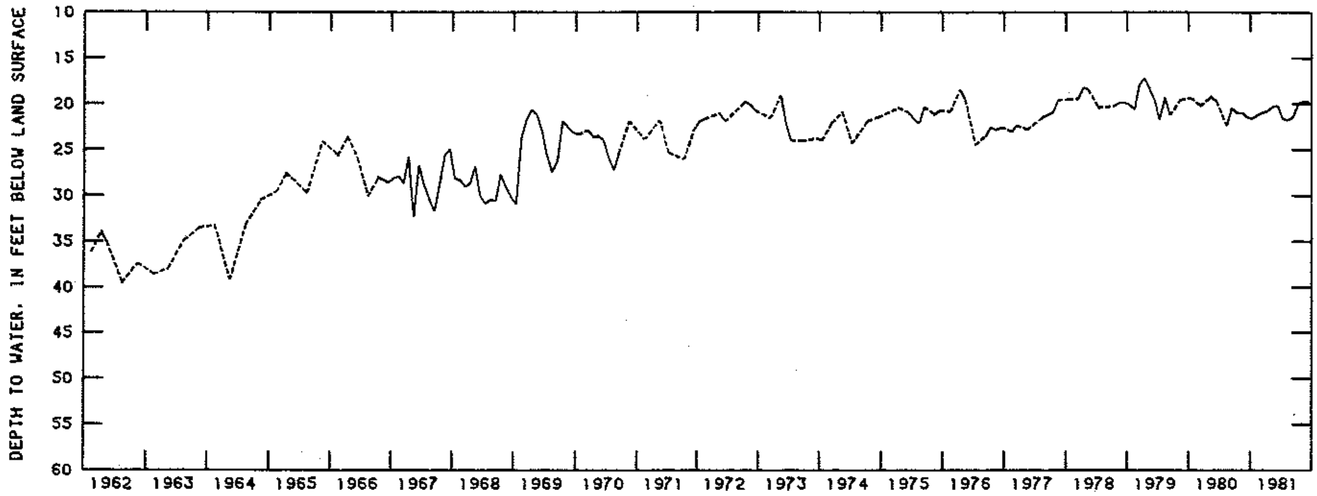

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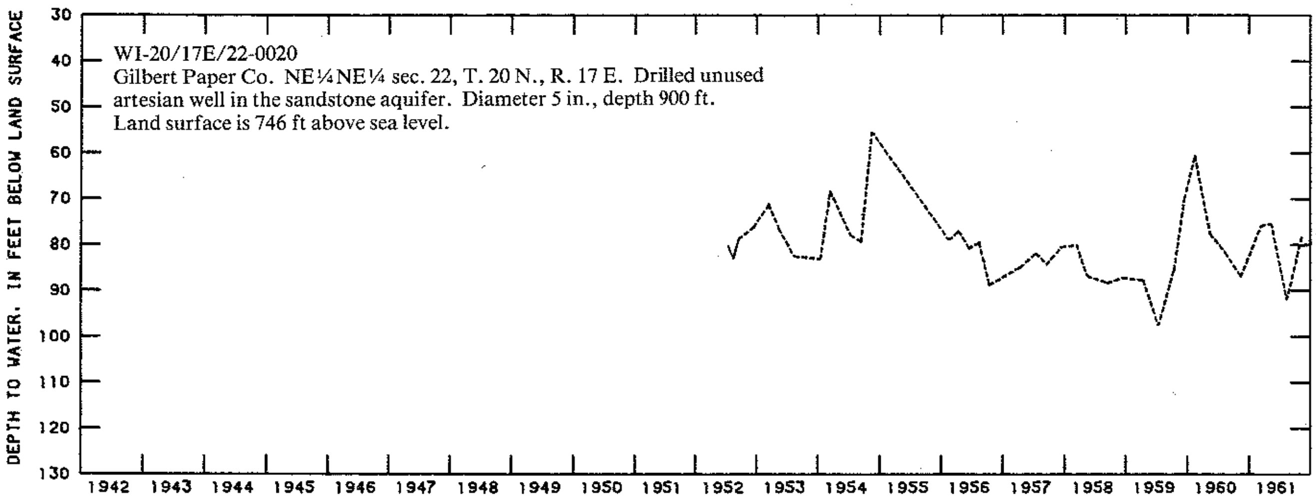

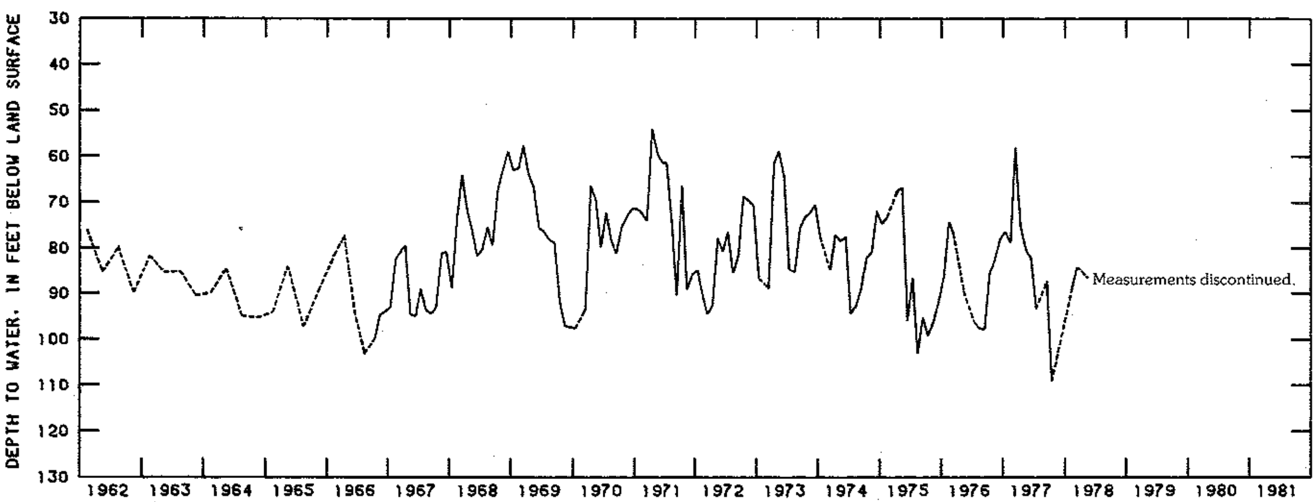

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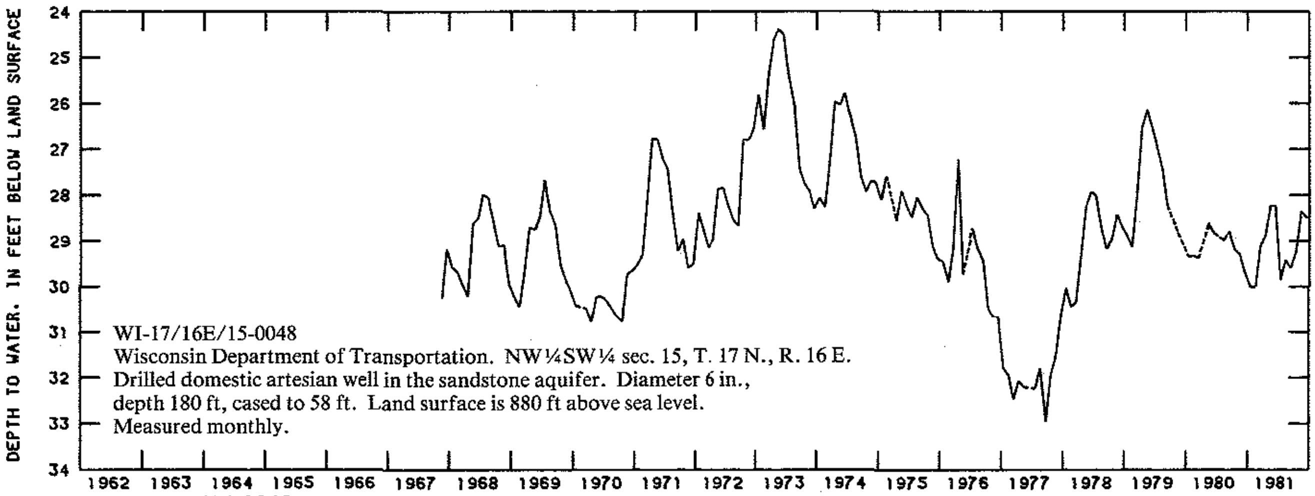

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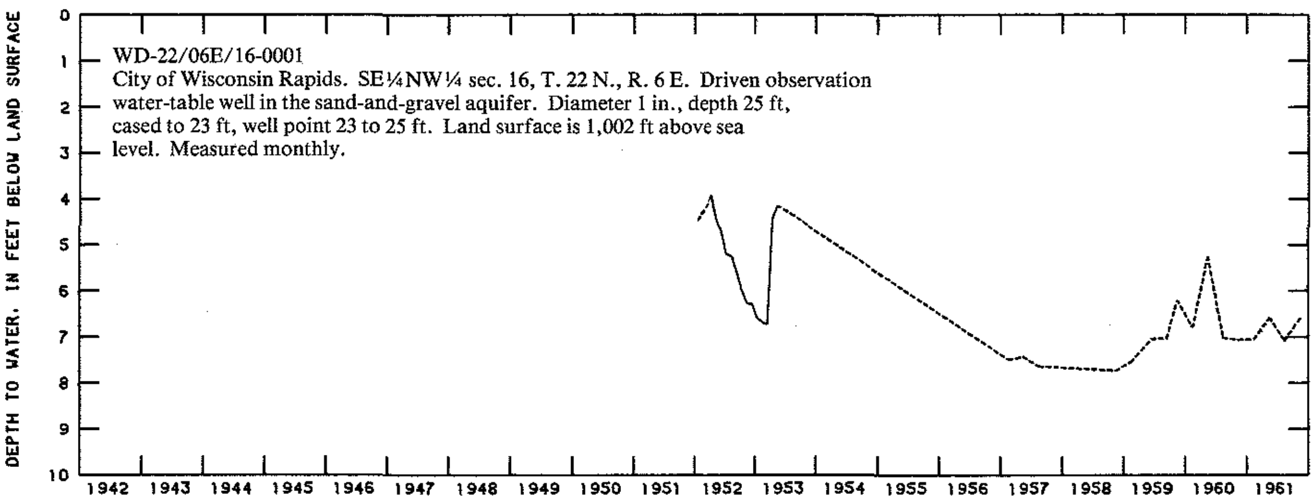

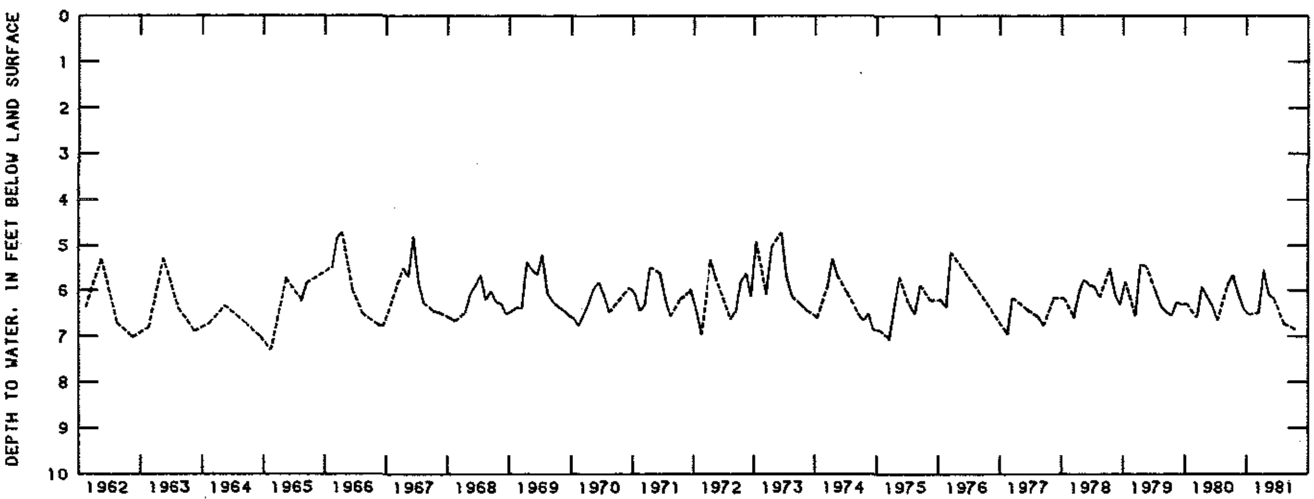

WD-22/06E/16-0001