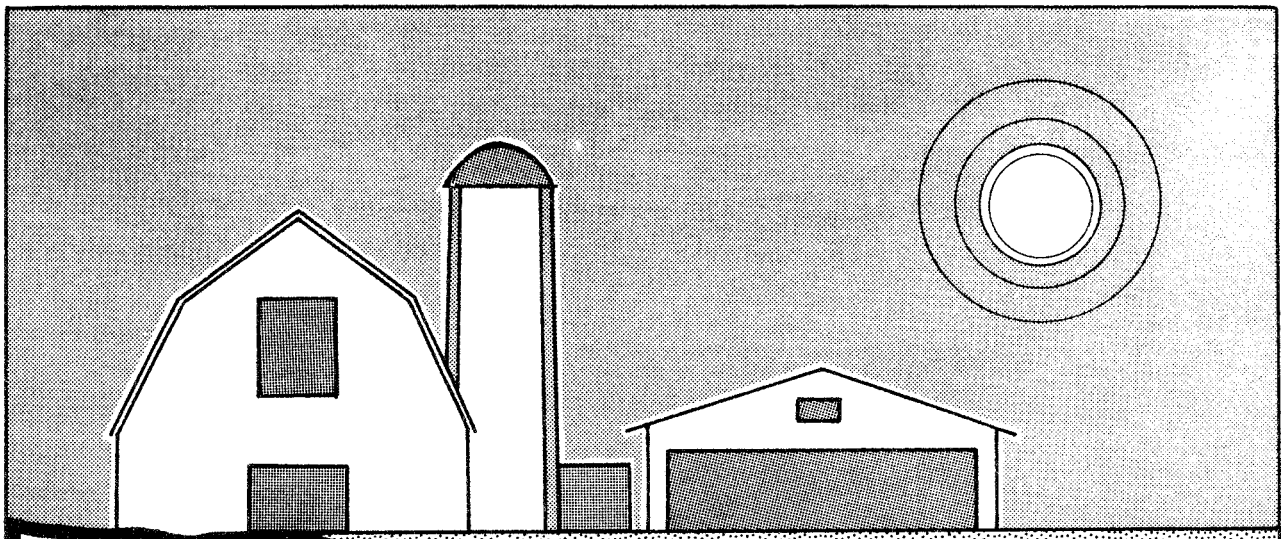
Bulletin No. 29 December 1983



a preliminary investigation and data summary

GROUND-WATER HYDROLOGY OF LAC QUI PARLE COUNTY, MINNESOTA

Minnesota
Department of Natural Resources
Division of Waters

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by
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St. Paul, Minnesota

December 1983

Minnesota
Department of Natural Resources
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I. INTRODUCTION

A. PURPOSE AND SCOPE

The purposes for this publication are:

(1) To describe the general occurrence, extent and thickness of buried glacial outwash aquifers in Lac Qui Parle County with emphasis on the southwest portion of the County;

(2) To tabulate and furnish the public with ground-water data gathered by the Division of Waters for Lac Qui Parle County; and

(3) To provide preliminary interpretations of these data so that available ground-water information can be used for decision-making on the local and regional level.

Background

Periods of below-normal precipitation during the mid-1970's and 1980 have resulted in increased development of ground water for irrigation. All active irrigation well permits in Lac Qui Parle County have been issued since the mid-1970's. Most of this water is pumped from glacial-drift aquifers by high-capacity wells. These wells are pumped from 300 to 1200 gallons per minute (gpm). In addition, several municipalities obtain their water from wells completed in these glacial drift aquifers. Further increases in development of ground water may result in additional conflicts between users. This report presents and interprets existing ground-water data for Lac Qui Parle County. It is hoped that the report will result in a better understanding of the ground-water resources of the county.

Lac Qui Parle County was chosen for study because there are many high-capacity wells in operation, there has been an increase in conflicts between water users and there is a general lack of ground-water data. In response to the increased demand and because data were not adequate, test drilling was conducted and observation wells were installed as part of the study effort.

B. LOCATION AND PHYSICAL SETTING

Lac Qui Parle County is located in west-central Minnesota (Figure 1). The county covers an area of approximately 496,000 acres or 775 square miles.

The relief of Lac Qui Parle County is mainly gently rolling. Land-surface elevations range from about 1000 to about 1400 feet above sea level. The east edge of the county is bounded by the Minnesota River Valley, which is cut to depths of 100 to 150 feet below the surrounding topography. The southwestern part of the county is on the slope of the Coteau des Prairies, a prominent plateau in the southwestern part of the state. This area reaches elevations of 1400 feet above sea level.

Streams and rivers in Lac Qui Parle County drain northeastward to the Minnesota River. The major rivers are the Yellow Bank and Lac Qui Parle Rivers (Thiel, 1944).

Lac Qui Parle County has a continental climate. Summers are generally hot and humid and winters are very cold. Climatological data collected by the National Weather Service have been reviewed for the years 1941 to 1980 for the Dawson and Madison weather stations, with the exception of a few years when no data was collected. The average yearly mean temperature at the Madison station is reported to be 44.3°F for this period. The average yearly precipitation for this period at Madison and Dawson is 25.47 and 24.52 inches, respectively. The severe drought mentioned earlier is reflected in the 1976 average precipitation figures and shows 9.41 inches for the Madison station and 10.70 inches for the Dawson station. The average precipitation for 1980 was 15.44 and 14.32 inches, respectively for Madison and Dawson which is well below the average yearly precipitation for that area. National Weather Service figures show that from 1941 to 1980 at Madison and Dawson, 16.89 and 16.47 inches fell, respectively during the May-September growing season, which is 66-67 percent of the average yearly precipitation for these areas.

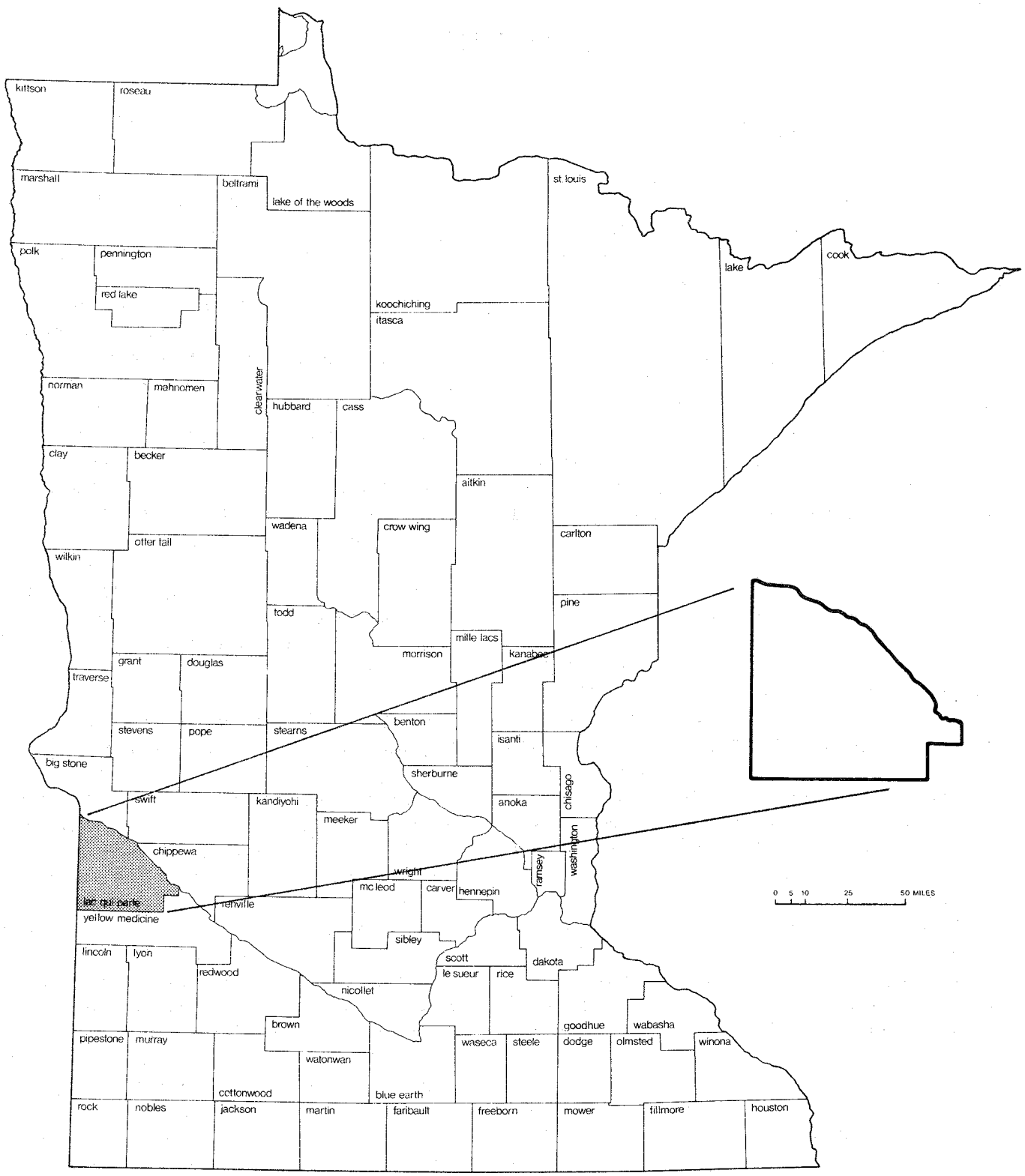


FIGURE 1. Location of Lac Qui Parle County, Minnesota.

C. PREVIOUS INVESTIGATIONS

There is a limited amount of data available on the ground-water resources of Lac Qui Parle County. The Minnesota Geological Survey published *The Geology and Underground Waters of Southern Minnesota* (Thiel, 1944). More recently, the U.S. Geological Survey in cooperation with the Department of Natural Resources, Division of Waters, completed hydrological reconnaissance studies which included the watershed units in Lac Qui Parle County. These cooperative studies are Hydrologic Investigation Atlas 213 *Water Resources of the Big Stone Lake Watershed, West-Central Minnesota* (1966) and Hydrologic Investigation Atlas 269 *Water Resources of the Lac Qui Parle River Watershed, Southwestern Minnesota* (1968).

D. METHOD OF INVESTIGATION

Most of the data used in this report were compiled from existing reports and files. Well log data were obtained from the Division's permit and well log files and from the Minnesota Geological Survey's Subsurface Geology Data Base.

Limited drilling was conducted by the Division through a private contractor. Geologic data obtained from drilling were used to locate two buried glacial outwash aquifers in the southwestern corner of the county. Water-use conflicts have arisen in these areas in the past several years. Six (6) observation wells were constructed and seven (7) test holes drilled in key locations in these two areas. Altogether a total of nine (9) observation wells and eleven (11) test holes were drilled throughout the county.

All irrigation wells were field located by Division staff. Depths to water in these wells and Division observation wells were measured in November, 1980.

II. GROUND-WATER GEOLOGY

The geology of Lac Qui Parle County consists of crystalline and sedimentary bedrock (see Map 2) which is overlain by glacial drift. Bedrock units include Precambrian crystalline rocks and younger Cretaceous sandstones and shales. The contact between the Cretaceous rocks and the underlying Precambrian rocks includes a weathered zone in the Precambrian rock. This weathered zone was formed during Early Cretaceous time (Austin, 1972).

A. PRECAMBRIAN BEDROCK

Precambrian crystalline bedrock underlies the entire county and crops out at a number of locations in the Minnesota River Valley, and less frequently in the upland area. Where the surface of this rock has been protected from erosion, a weathered zone (regolith) of white, gritty clay remains. The Precambrian bedrock surface is very irregular and ranges from 100 to 400 feet below the land surface (Thiel, 1944).

The Precambrian crystalline rocks yield little water. The weathered zone (regolith) of the Precambrian surface is not a dependable aquifer, although a few wells have been completed there (Cotter and Bidwell, 1968).

B. CRETACEOUS BEDROCK

Cretaceous sedimentary bedrock covers the Precambrian bedrock and is in turn covered by glacial drift throughout most of the county. It has been partially eroded away along the Minnesota and Lac Qui Parle Rivers. The Cretaceous is absent near Providence and in a few other areas within the county (see Map 2). The bedrock consists of layers of thick shales, some sandstones and minor limestones (Austin, 1972). Due to the irregularity of the upper and lower surfaces, the total thickness of the Cretaceous beds vary greatly. These beds can reach a thickness of more than 200 feet in the county.

The shales and sandstones generally have low water yielding capabilities. In scattered areas throughout the county some Cretaceous sandstones may yield up to 100 gallons per minute. This water can be relatively soft and low in iron, however, it may be high in sodium, chloride, boron, and total dissolved salts (Cotter and Bidwell, 1968).

C. GLACIAL DEPOSITS

Most of the present day landscape in Lac Qui Parle County is the result of glacial erosion and deposition which occurred approximately 10,000 years ago. Older glacial deposits are probably present in the subsurface, but were not documented during this study. The total thickness of these glacial deposits range from about 100 to 300 feet (Thiel, 1944). These deposits can be divided into glacial till and glacial outwash.

Glacial till, which blankets most of the county, is a mixture of clay, silt, sand, gravel and rocks deposited directly by the advance or retreat of a glacier (see Map 4). Glacial till has a low water yielding capability and is not considered a source for groundwater supply.

Glacial outwash consists of layers of silt, sand and gravel deposited by glacial meltwater. Outwash that is exposed on the land surface is referred to as surficial glacial outwash. There are large areas of surficial outwash in the southwestern and southeastern parts of the county. There are also large surficial outwash terraces along the Minnesota River Valley (see Map 4). Glacial outwash not exposed on the land surface, but covered by till, is referred to as buried glacial outwash. Buried glacial outwash is present throughout the county, however, the areal extent and thickness of buried outwash cannot be clearly defined. Two large areas of buried outwash are located in the southwestern part of the county and another area exists in the northeastern part of the county. Test drilling conducted for this study has better defined the limits of the buried deposits in southwestern Lac Qui Parle County. The inferred extent of buried glacial outwash in Lac Qui Parle County is shown on Map 3. Surficial and buried glacial outwash aquifers are capable of yielding several hundred gallons, to over a thousand gallons of water per minute from properly constructed wells (Cotter and Bidwell, 1968).

D. ALLUVIAL DEPOSITS

Alluvial deposits (alluvium) consists of sand and gravel, locally interbedded with silt, clays and organic material deposited by streams or other bodies of running water on adjacent flood plains (Kanivetsky, 1979). See Map 4 for its distribution in Lac Qui Parle County.

Alluvial deposits are capable of yielding several hundred to over a thousand gallons of water per minute, although wells constructed in these deposits are more susceptible to surface contamination.

III. MAP DESCRIPTIONS

A. MAP 1 – Location of Wells and Test Holes with Lithologic Logs.

Logs of wells and test holes for the county were obtained from Division of Waters and Minnesota Geological Survey files. Selected well logs were used to develop cross-sections which show thickness and character of the glacial deposits, particularly in the southwestern corner of the county (Appendix C). Sufficient reliable data were not available to construct representative cross-sections throughout the county.

B. MAP 2 – Generalized Bedrock Map.

Lac Qui Parle County is underlain by Precambrian crystalline rock. These rocks crop out at a number of locations in the Minnesota River Valley, and less frequently on the upland area. This bedrock surface is unconformably overlain by younger Cretaceous sedimentary bedrock consisting of layers of thick shales, some sandstones and minor limestone (Austin, 1972). A long period of weathering resulted in the development of a thick regolith of white, gritty clay on the Precambrian rock surface beneath the Cretaceous strata.

C. MAP 3 – Inferred Extent of Buried Glacial Outwash Aquifers.

Map 3 shows the inferred extent of known buried glacial outwash aquifers in Lac Qui Parle County. These buried glacial outwash deposits occur in a stratigraphically complex sequence of glacial drift. The sand and gravel bodies that make up the buried aquifers are interbedded with silt, clay and glacial till. The buried glacial outwash complex can be further divided into separate aquifers, many of which are hydraulically connected. Most wells finished in the buried glacial outwash produce water under confined (artesian) conditions.

The two most identifiable aquifer units are shown in Figures 2 and 3 and described below:

Aquifer A, south of Marietta, is a buried outwash deposit (see Figure 2). The aquifer consists of medium to coarse sand, and gravel. Finer sand is found in areas where the aquifer appears to be pinching out. New data indicate that the aquifer pinches out or thins to the west and northwest. Drilling indicates the aquifer may be somewhat thicker to the east and southeast, but the extent was not documented. Additional test drilling is needed to further define the aquifer extent. The top of the aquifer lies at an approximate elevation of 1000 feet above mean sea level. The distance from land surface to the top of the aquifer is generally about 150 feet. The thickness of the aquifer ranges from 40 to 70 feet in several Division test holes. Forty to fifty feet, however, is probably more representative of the thickness of the aquifer.

Aquifer B, also south of Marietta, is shown in Figure 3. Like Aquifer A, Aquifer B is a buried glacial outwash aquifer. It lies stratigraphically above Aquifer A. The extent and characteristics of this aquifer are not well known. Available evidence indicates that it is less extensive and capable of producing lesser amounts of water than Aquifer A. Test drilling and existing well logs of the area indicate the aquifer is not as extensive toward the southeast and northwest as previously thought. Additional test drilling is needed to accurately define its limits. The thickest sections of the aquifer appear to be in the east-central portion of Manfred Township and western Freeland Township. The top of the aquifer lies at an elevation of about 1100 feet above mean sea level. The distance from land surface to the top of the aquifer varies from 30 to 85 feet. The thickness of the aquifer cannot be defined with available data, but is at least 55 feet thick in several Division test holes.

Aquifer test data from the area indicate there may be a hydraulic connection between Aquifers A and B. Additional aquifer tests will be necessary to determine the relationships between Aquifers A and B.

D. MAP 4 – Surficial Materials Map.

Map 4 shows the extent of surficial deposits of glacial outwash, glacial till and alluvial material (alluvium). Some of the boundaries shown on this map are slightly modified from an existing map (Kanivetsky, 1979). The saturated thickness of the surficial aquifers (glacial outwash and alluvium) are not described because sufficient data are not available.

Recently two irrigation wells were completed in the surficial outwash in Hantho Township. Numerous domestic wells produce water from the surficial outwash.

Figure 2. DEEP BURIED GLACIAL OUTWASH AQUIFER A, SOUTH of MARIETTA.
INFERRED AREAL EXTENT.

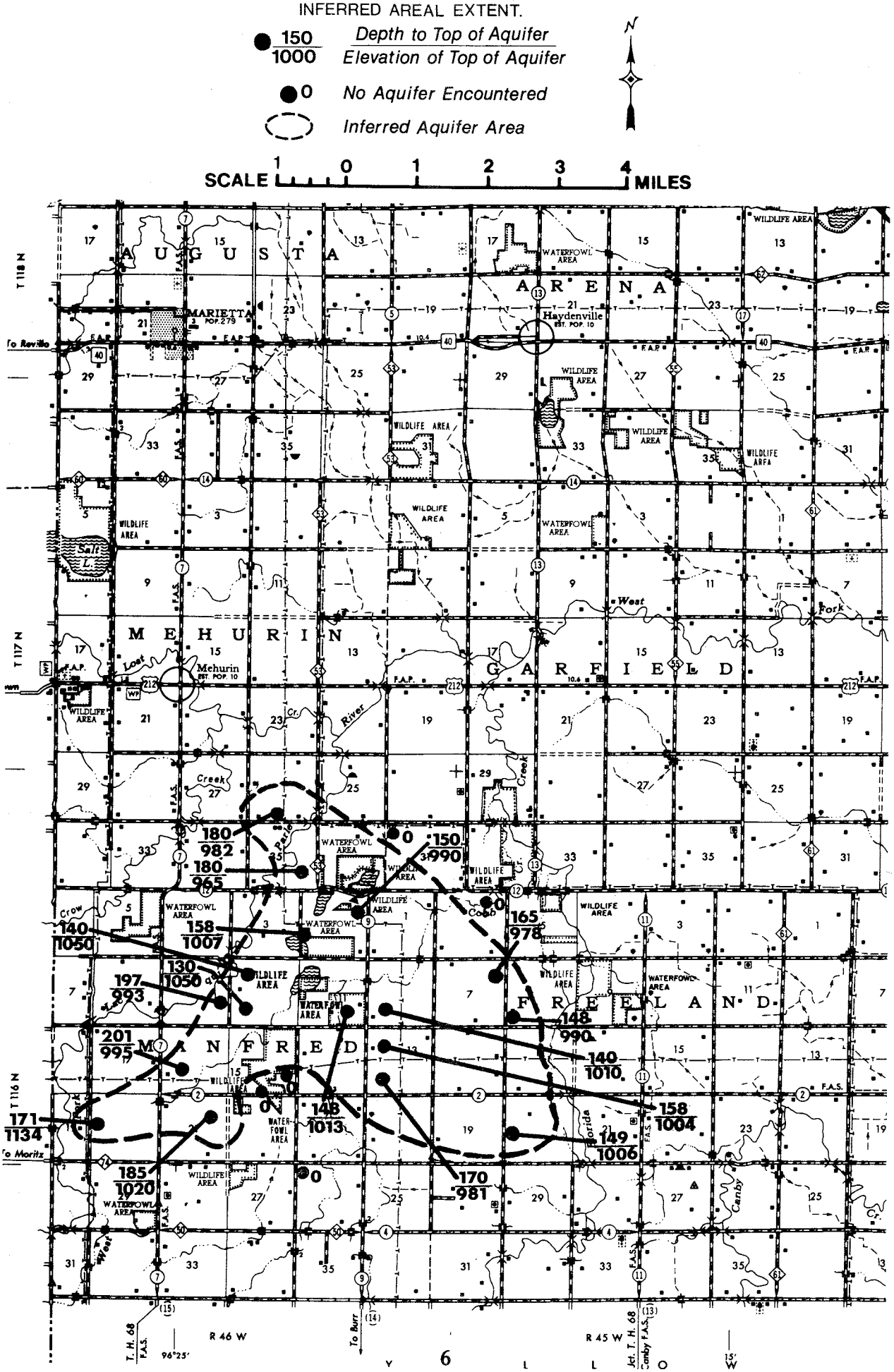
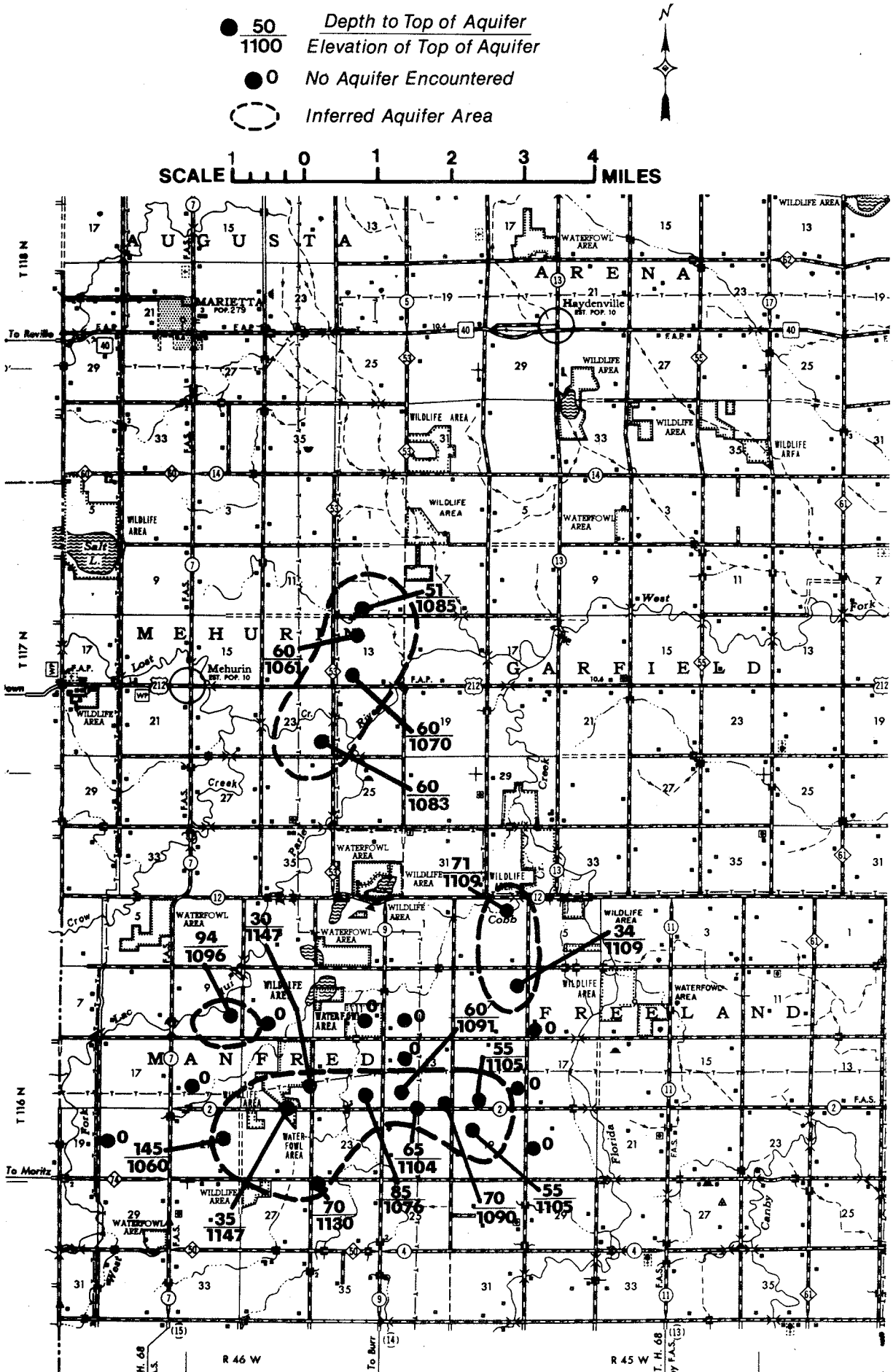


Figure 3. SHALLOW BURIED GLACIAL OUTWASH AQUIFER B, SOUTH of MARIETTA. INFERRED AREAL EXTENT.



E. MAP 5 – Map of Potentiometric Levels in Deep Buried Glacial Outwash Aquifer A.

Ground water in Aquifer A occurs under confined (artesian) conditions. The aquifer is sandwiched between relatively less permeable layers and the water in it is under pressure greater than atmospheric. When a well is drilled through the upper confining layer into Aquifer A, water rises up in the well to a level above the top of the aquifer. This level is referred to as the potentiometric level or surface and is defined as an imaginary surface representing the static head of ground water. When the potentiometric surface is above the land surface, as in several irrigation and domestic wells in southwestern Lac Qui Parle County, flowing wells occur. The concepts of a confined (artesian) aquifer are illustrated in Figure 4.

Depths to water in irrigation and observation wells were measured by Division staff during November, 1980. Measurements were made in November because it was assumed that water levels had recovered from changes produced from summer withdrawals. Data from the measurements in Aquifer A were used to construct a map showing the potentiometric surface at each well, there were insufficient data points to justify doing the same for Aquifer B. Not enough data points were available to construct a contour map showing the potentiometric surface throughout Aquifer A. Field data indicate potentiometric levels in Aquifer A range from 23 feet below to 10 feet above land surface, while the limited data available for Aquifer B indicate potentiometric levels 13 to 26 feet below land surface. Hydrographs constructed from field measurements revealed that water levels in Aquifer A and Aquifer B had at the time of measurement recovered to, or nearly to, pre-irrigation season pumping elevations.

F. MAP 6 – Location of Permitted Irrigation Wells.

Map 6 shows the locations of permitted irrigation wells in Lac Qui Parle County as of early 1982. The majority of these wells were located in the field by Division staff during the fall of 1980. Some of these locations were compared with Minnesota Geological Survey data to confirm locations. Map 6 shows the distribution of irrigation wells by aquifer type.

G. MAP 7 – Aquifer Test and Observation Well Locations.

As of January, 1982, there were eleven aquifer test analyses available for Lac Qui Parle County. A summary of these tests is shown in Table 1. The test data were obtained from the U.S. Geological Survey, Division of Waters, and private companies. All but one of the tests were conducted on wells completed in buried glacial outwash under confined (artesian) conditions, one well displayed a water table condition. Transmissivities range from less than 1500 to over 23,000 ft.^{2}/day with storage coefficients in the 10^{-3} to 10^{-5} range.

Map 7 shows a total of sixteen possible observation wells in the county, eight are being measured by the Lac Qui Parle County Soil and Water Conservation District. Prior to this, a maximum of twelve observation wells had been measured.

Eleven of these sixteen observation wells were used for this study, nine having been installed through the Division of Waters in the spring of 1980 and two having been installed by private individuals as part of the Division's permit application process. Five of the Division's nine wells were installed in Aquifer A and one was installed in Aquifer B. Of the two private observation wells, one was installed in Aquifer A and one in Aquifer B.

Data on the construction, geology and water levels of ten of these observation wells are tabulated in Appendix A. The well hydrographs are shown in Appendix B.

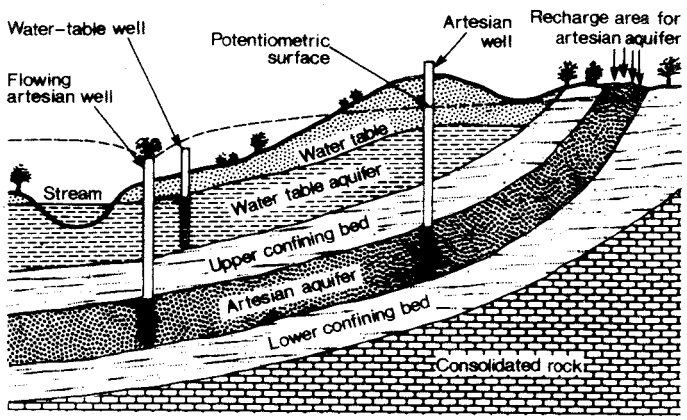
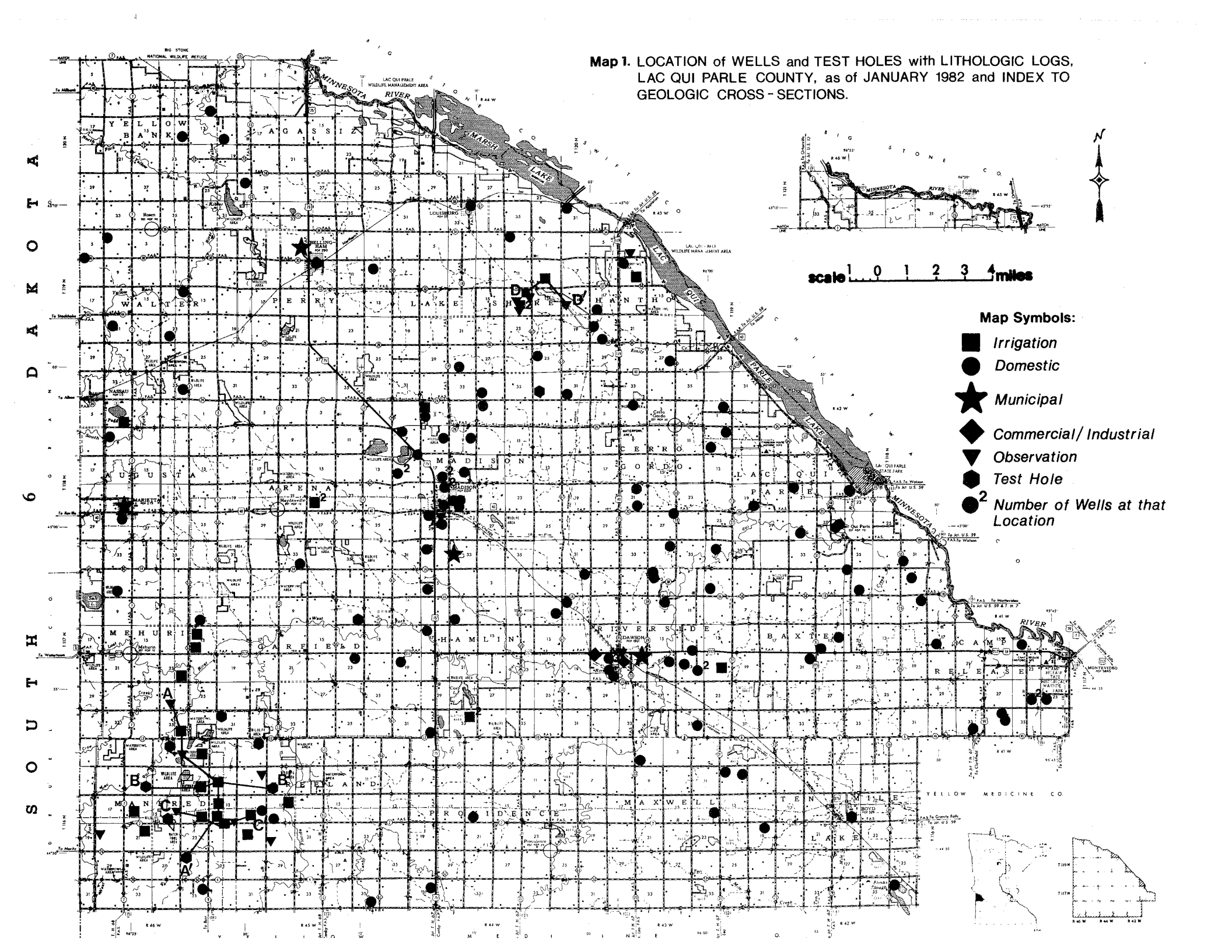


FIGURE 4. Subsurface and ground water phase of the hydrologic cycle.

Map 1. LOCATION of WELLS and TEST HOLES with LITHOLOGIC LOGS, LAC QUI PARLE COUNTY, as of JANUARY 1982 and INDEX TO GEOLOGIC CROSS - SECTIONS.



Map Symbols:

- Irrigation
- Domestic
- Municipal
- Commercial/ Industrial
- Observation
- Test Hole
- Number of Wells at that Location

Map 2. GENERALIZED BEDROCK MAP

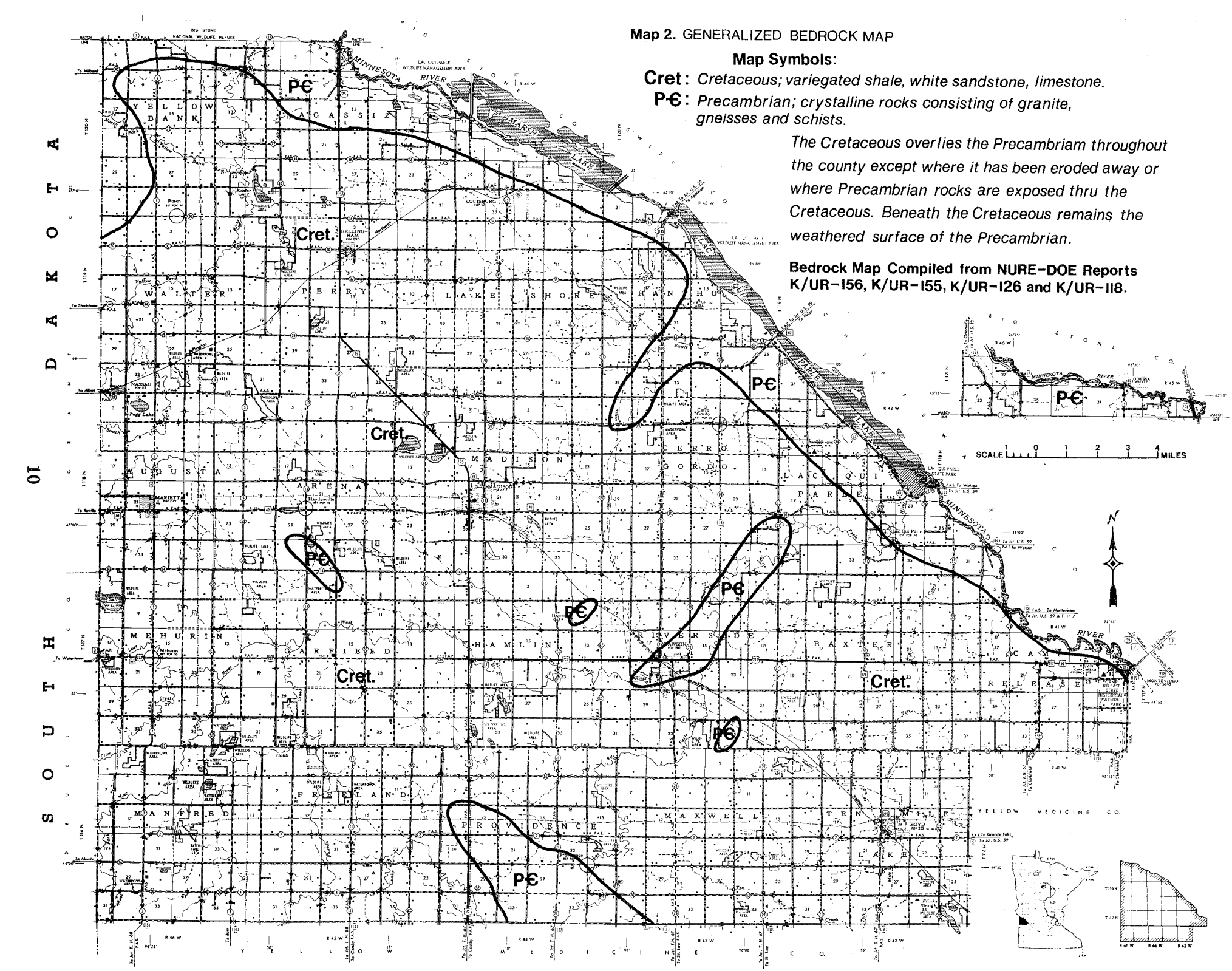
Map Symbols:

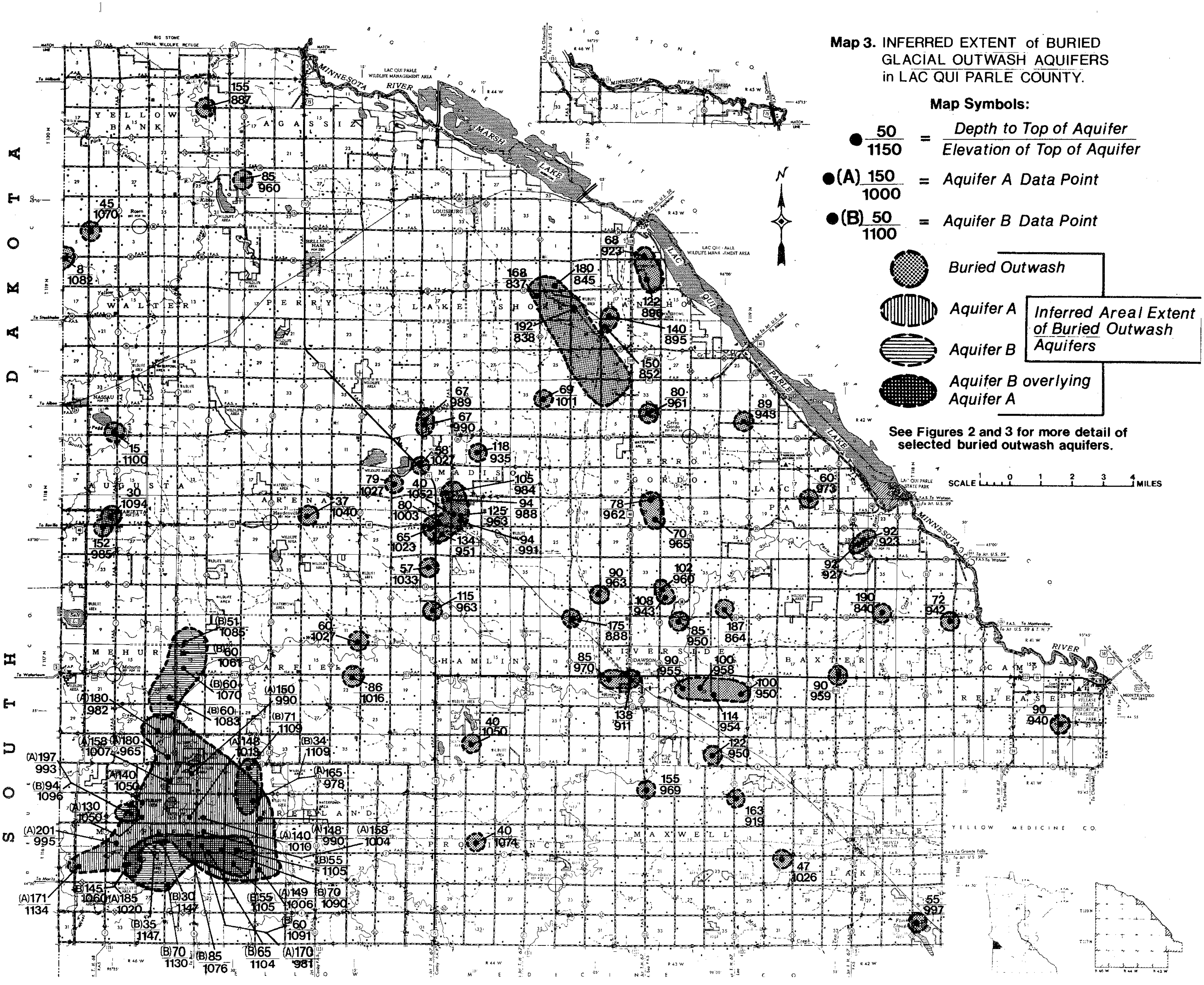
Cret: *Cretaceous; variegated shale, white sandstone, limestone.*

P-€: *Precambrian; crystalline rocks consisting of granite, gneisses and schists.*

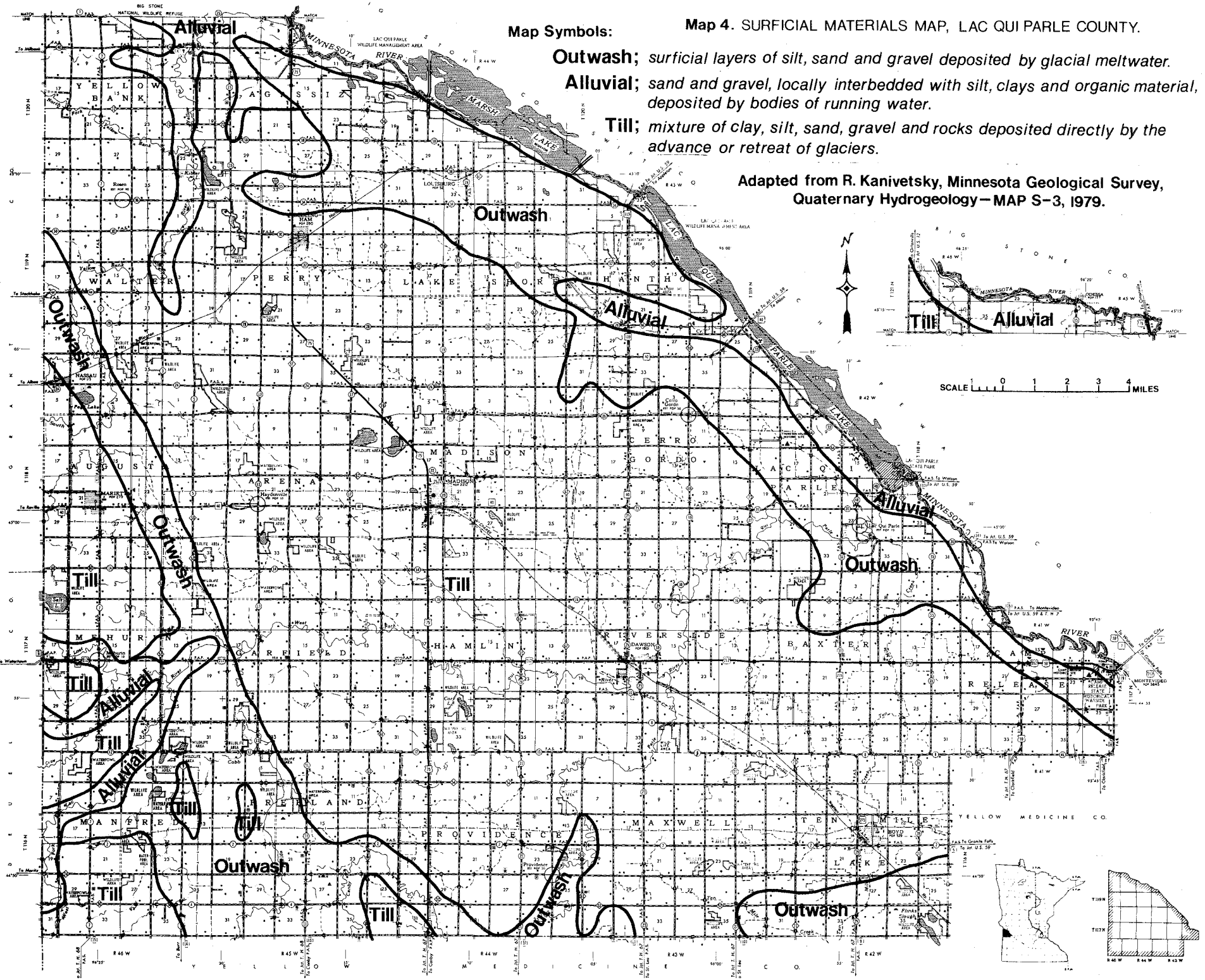
The Cretaceous overlies the Precambriam throughout the county except where it has been eroded away or where Precambrian rocks are exposed thru the Cretaceous. Beneath the Cretaceous remains the weathered surface of the Precambrian.

Bedrock Map Compiled from NURE-DOE Reports K/UR-156, K/UR-155, K/UR-126 and K/UR-118.





Map 3. INFERRED EXTENT of BURIED GLACIAL OUTWASH AQUIFERS in LAC QUI PARLE COUNTY.



Map Symbols:

Outwash; *surficial layers of silt, sand and gravel deposited by glacial meltwater.*

Alluvial; *sand and gravel, locally interbedded with silt, clays and organic material, deposited by bodies of running water.*

Till; *mixture of clay, silt, sand, gravel and rocks deposited directly by the advance or retreat of glaciers.*

Map 4. SURFICIAL MATERIALS MAP, LAC QUI PARLE COUNTY.

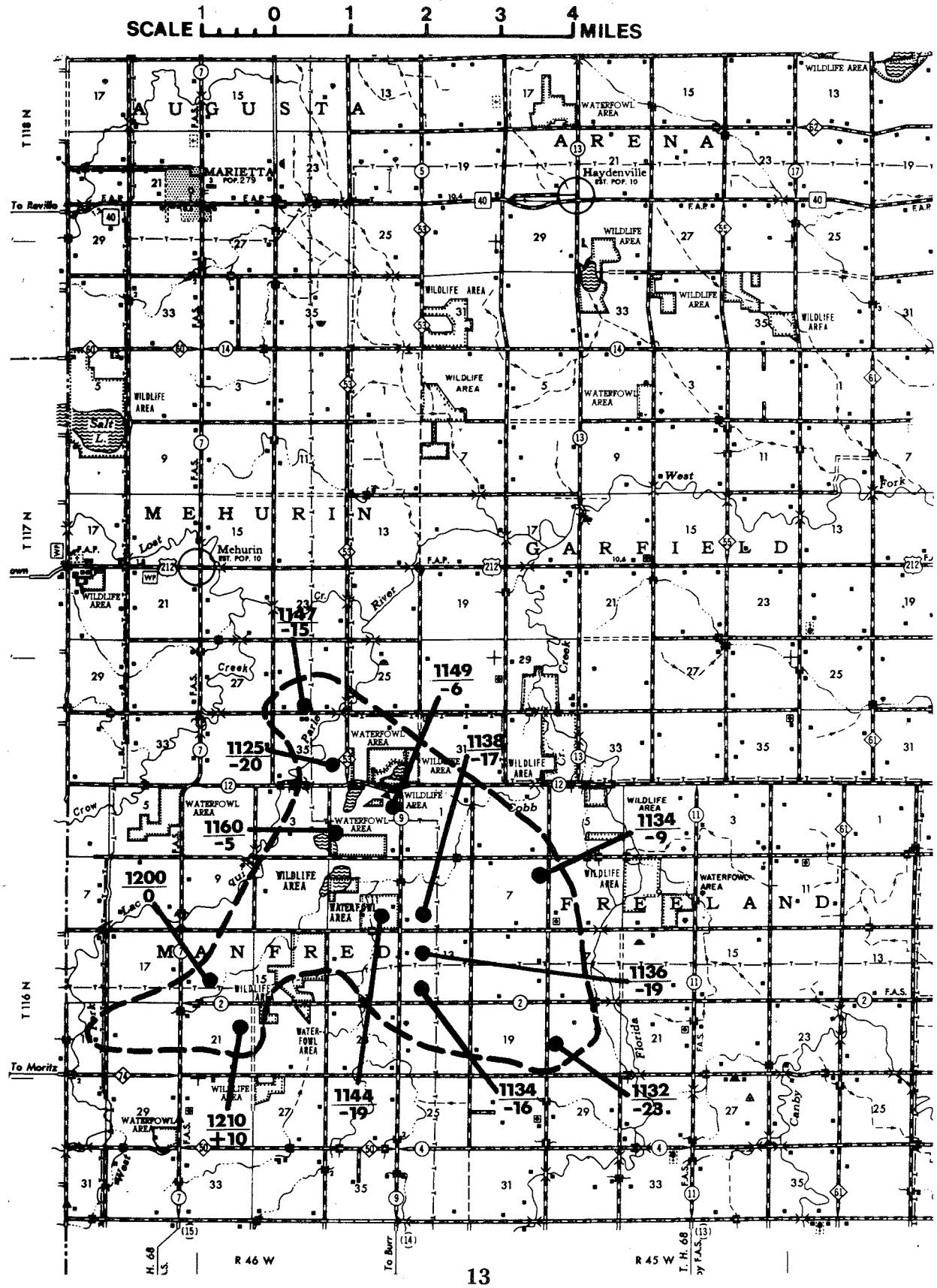
Adapted from R. Kanivetsky, Minnesota Geological Survey, Quaternary Hydrogeology—MAP S-3, 1979.

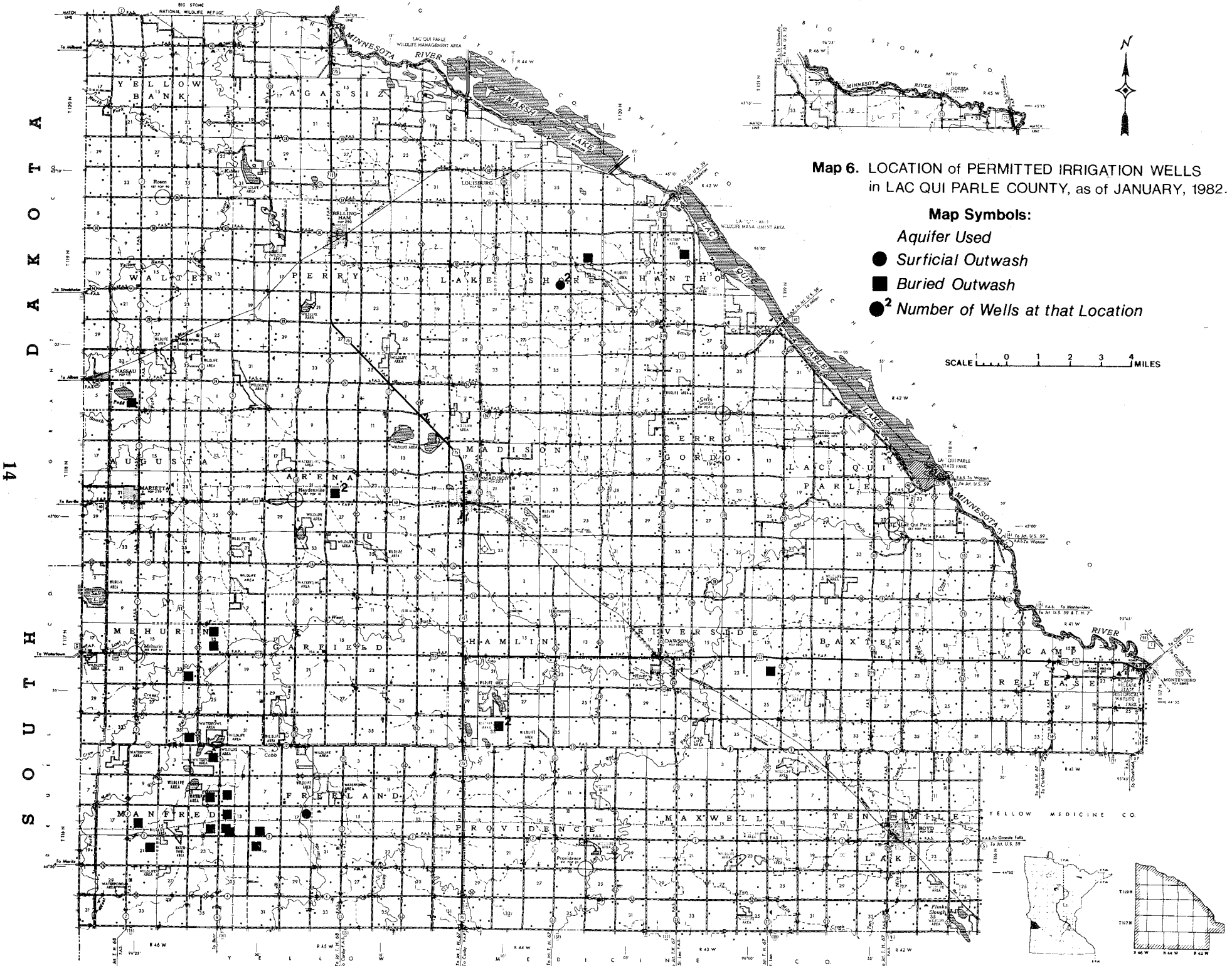
Map 5. POTENTIOMETRIC LEVELS in DEEP BURIED GLACIAL OUTWASH AQUIFER A, FALL of 1980

Map Symbols:

1140 / 12 — *Elevation of Potentiometric Level / Distance of Potentiometric Level Above (+) or Below (−) Land Surface*

Inferred Aquifer Area





Map 6. LOCATION of PERMITTED IRRIGATION WELLS in LAC QUI PARLE COUNTY, as of JANUARY, 1982.

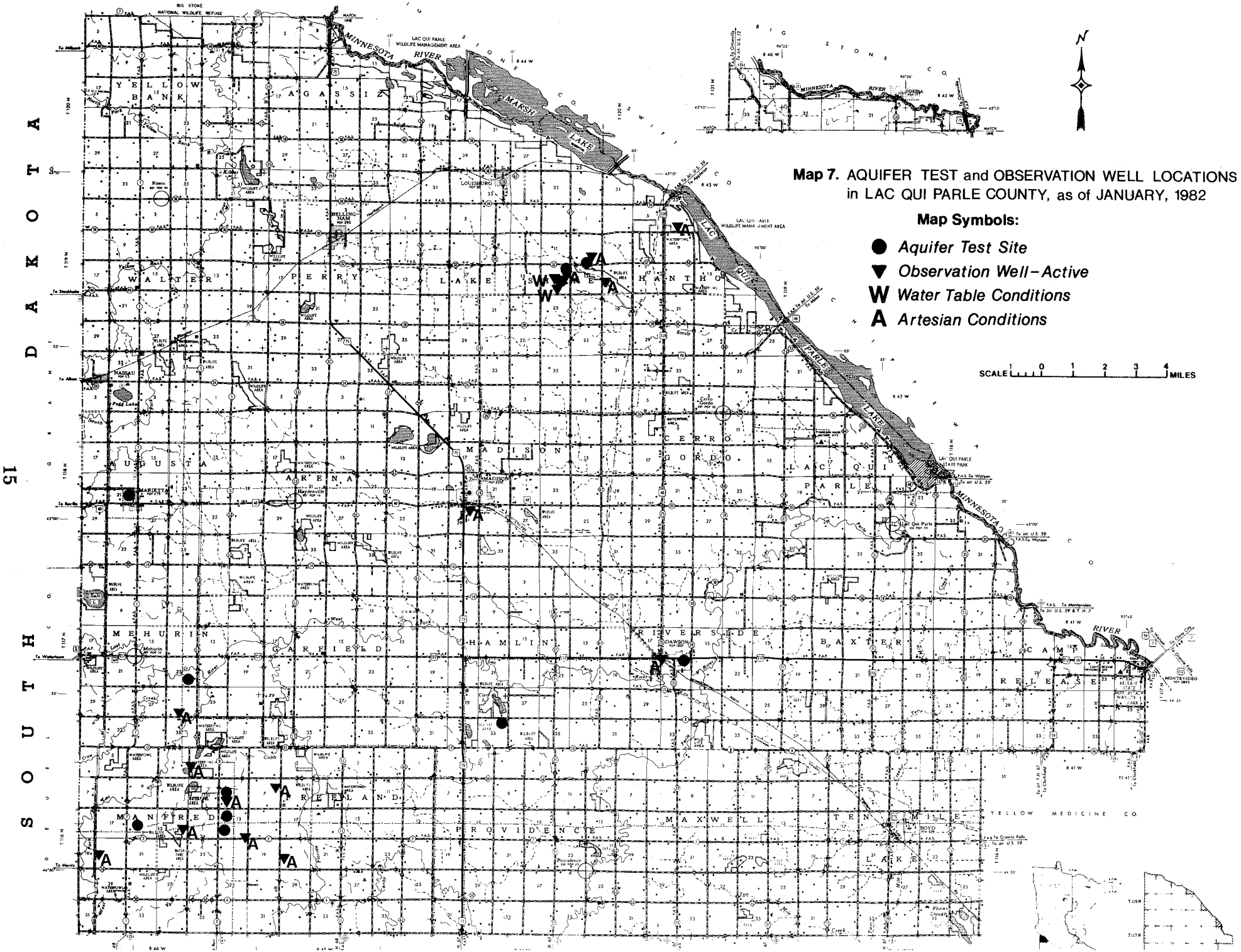
Map Symbols:

Aquifer Used

● *Surficial Outwash*

■ *Buried Outwash*

●^{2} *Number of Wells at that Location*



Map 7. AQUIFER TEST and OBSERVATION WELL LOCATIONS in LAC QUI PARLE COUNTY, as of JANUARY, 1982

Map Symbols:

- ● *Aquifer Test Site*
- ▼ *Observation Well–Active*
- **W** *Water Table Conditions*
- **A** *Artesian Conditions*

TABLE 1.
SUMMARY OF AQUIFER TESTS IN LAC QUI PARLE COUNTY

a — gpd/ft
b — ft^2/day
Qowb — Quaternary Outwash Buried
WT — Water Table
A — Artesian

TEST NO.	LOCATION T.R. SEC.	DATE	DURATION (HOURS)	DISCHARGE gpm	TRANSMISSIVITY DRAWDOWN/RECOVERY	STORAGE COEFFICIENT	AQUIFER/ CONDITION	WELL DEPTH	CONDUCTED BY
1.	116.46.12 cab	3/78	150.6	1,310	119,000/177,300 a 15,900/ 23,700 b	0.000303	Qowb/A	200′	DNR
2.	116.46.13 bca	9/77	27	1,000	80,600/ 94,750 a 10,800/ 12,675 b	0.000414	Qowb/A	208′	Private
3.	117.44.33 aac	6/76	10.5	323	12,775/ 16,175 a 1,700/ 2,165 b	0.000174	Qowb/A	75′	DNR and USGS
4.	118.46.21 dbd	7/65	3.75	150	11,080/ 12,075 a 1,490/ 1,615 b	0.000110	Qowb/A	70′	USGS
5.	117.46.23 dac	2/78	23	665	61,900/ 80,700 a 8,300/ 10,800 b	0.000073	Qowb/A	104′	Private
6.	117.43.21 aab	10/75	24	160	32,500/ 31,400 a 4,350/ 4,200 b	----	Qowb/A	180′	Private
7.	116.46.13 cbd	6/78	24	620	71,200/ 90,900 a 9,500/ 12,150 b	0.0000102	Qowb/A	163′	DNR
8.	116.46.16 caa	5/79	25	800	14,600/ 10,560 a 1,950/ 1,400 b	0.000046	Qowb/A	222′	DNR
9.	119.44.14 aaa	10/80	25	1,500	18,429/ 21,703 a 2,500/ 2,900 b	0.00105	Qowb/A	196′	DNR
10.	119.44.12 dcd	8/81	24	600	19,500/ 18,500 a 2,600/ 2,500 b	0.0002	Qowb/A	200′	DNR
11.	119.44.14 dab	10/81	24 5	800 1,000	Too variable for use.	Too variable for use	Qowb/WT	93′	DNR

IV. WATER USE

A. GENERAL DISCUSSION

A water appropriation permit must be obtained from the Commissioner of Natural Resources by any person, corporation or political subdivision of the State who wishes to use surface or ground water in quantities exceeding 10,000 gallons per day or 1,000,000 gallons per year. Domestic uses serving under twenty-five people are exempted.*

Appropriation permit holders are required to submit annual pumpage reports from surface and ground-water sources to the Division of Waters. These reports were used to produce the water use tables shown in this report. Total reported water use for 1979 through 1981 from municipal and irrigation wells is shown in Tables 2 and 3, respectively.

B. MUNICIPAL WELLS

According to a survey conducted by the Division of Waters, there are five municipalities in Lac Qui Parle County that obtain ground water from a total of eleven wells; eight active and three standby. The figures in Table 2 do not accurately reflect total municipal water use because all municipalities did not report their appropriation. Actual water use is somewhat greater.

C. IRRIGATION WELLS

Table 3 shows the number of permitted irrigation wells by township in Lac Qui Parle County. There are a total of 26 permitted irrigation wells in Lac Qui Parle County, of which 16 (or more than half) of these wells are located in the southwest corner of the county. Eight of the irrigation wells appear to penetrate Aquifer A and seven appear to penetrate Aquifer B. All of the irrigation wells were constructed during or after the mid-1970's drought years. Actual water use was somewhat greater because all appropriation was not reported.

All except two of the irrigation wells withdraw ground water from buried glacial outwash that is under confined (artesian) conditions. The large increase in the use of buried outwash aquifers, particularly in the southwestern part of the county, prompted the Division to install an observation well monitoring network. Nine new observation wells were installed for this purpose in 1980 through the Division's drilling program.

*Details of water appropriation rules and permit procedures can be obtained from

Minnesota Department of Natural Resources
Division of Waters
Box 32, Centennial Office Building
St. Paul, MN 55155
(612) 296-4800

TABLE 2.
REPORTED GROUND-WATER USE ESTIMATES FOR MUNICIPAL WELLS, LAC QUI PARLE COUNTY

MUNICIPALITY	NO. OF ACTIVE WELLS*	WATER USE (GALLONS) 1979	1980	1981
Bellingham	2	NR	NR	NR
Boyd PN 66-5790	1	NR	NR	NR
Dawson PN 78-4387	3	147,900,000	136,700,000(2)	129,100,000(2)
Madison PN 66-5784	1[2]	NR	NR	NR
Marietta PN 79-4298	1[1]	10,900,000(1)	11,400,000(1)	NR
TOTAL	**8[3]**	**158,800,000**	**148,100,000**	**129,100,000**

* — Determined from Municipal Well Survey MN DNR — DOW 1979.
NR — Water use not reported.
[ ] — Designates number of standby wells.
( ) — No. of wells reported from.

TABLE 3.
REPORTED GROUND-WATER USE ESTIMATES FOR PERMITTED IRRIGATION, LAC QUI PARLE COUNTY

T-R	TOWNSHIP NAME	NO. OF WELLS*	WATER USE (GALLONS) 1979	1980	1981
116.42	Ten Mile Lake	0	— — —	— — —	— — —
116.43	Maxwell	0	— — —	— — —	— — —
116.44	Providence	0	— — —	— — —	— — —
116.45	Freeland	3	14,500,000(1)	25,800,000(1)	23,400,000(1)
116.46	Manfred	9	156,500,000(8)	217,600,000(9)	261,000,000(9)
117.41	Camp Release	0	— — —	— — —	— — —
117.42	Baxter	0	— — —	— — —	— — —
117.43	Riverside	1	— — —	— — —	— — —
117.44	Hamlin	2	NR	NR	NR
117.45	Garfield	0	— — —	— — —	— — —
117.46	Mehurin	4	52,000,000(4)	105,400,000(3)	31,200,000(1)
118.42	Lac Qui Parle	0	— — —	— — —	— — —
118.43	Cerro Gordo	0	— — —	— — —	— — —
118.44	Madison	0	— — —	— — —	— — —
118.45	Arena	2	6,400,000(2)	24,500,000(2)	25,900,000(2)
118.46	Augusta	1	— — —	13,200,000(1)	14,700,000(1)
119.43	Hantho	1	27,800,000(1)	34,300,000(1)	45,800,000(1)
119.44	Lake Shore South	3	6,300,000(1)	26,100,000(1)	27,000,000(2)
119.45	Perry	0	— — —	— — —	— — —
119.46	Walter	0	— — —	— — —	— — —
120.44	Lake Shore North	0	— — —	— — —	— — —
120-121.45	Agassiz	0	— — —	— — —	— — —
120-121.46	Yellow Bank	0	— — —	— — —	— — —
	TOTAL	**26**	**263,500,000**	**446,900,000**	**429,000,000**

* — MOST DETERMINED BY WINDSHIELD SURVEY DNR-DOW 1980.
(1) — Example, number of wells from which water use was reported.
NR — Water use not reported.
— — — — Indicates no appropriation.

V. CONCLUSION

The projected increase in ground-water withdrawals in Lac Qui Parle County underlines the need for careful monitoring of water levels, pumping rates, and consumptive use. Installation of the observation well network in the county in 1980 and the assistance in monitoring these wells by the Lac Qui Parle County Soil and Water Conservation District have contributed greatly to the knowledge needed for management of withdrawals from these aquifers. The pumping data received yearly by the Division of Waters provides a means of monitoring withdrawal rates and water use for the areas submitting data. These data combined with water level data enable the observation of aquifer response to pumping and provide a means of early identification of potential problems, such as excessive withdrawals. Cooperation in submitting high-capacity well pumping data is important for responsible water resource management.

Along with improvement of data collection, it is important that the geologic framework and hydraulic relationships between aquifers be determined. Any future work must include further determination of hydraulic boundaries of buried outwash aquifers; the hydrologic relationship between buried and surficial aquifers; and an assessment of the impacts of ground-water withdrawals on surface water supplies, i.e., stream and river flows and lake levels.

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APPENDIX A

Location, Construction, Geologic and Water Level Data for Observation Wells in Lac Qui Parle County.

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MINNESOTA DEPARTMENT OF NATURAL RESOURCES - DIVISION OF WATERS
OBSERVATION WELL DATA BASE - LAC QUI PARLE

WELL NAME : RICHARD JIBBEN #78-1 OBSERVER: SWCD
DNR WELL NO.: 37000
UNIQUE NO. :

COUNTY : LAC QUI PARLE
CITY : CANBY

TOWNSHIP : 116 TOPOGRAPHIC
RANGE : 46 SETTING : UNKNOWN
SECTION : 13
1/4 SECTION
FLS : SESESE
USGS : DDD

ELEVATION : 1156.9 FT. ABOVE SEA LEVEL METHOD DRILLED : HYDRAULIC OR MUD ROTARY
DEPTH : 85 FT. DIAMETER : 1.5 IN.
COMPLETED : 06/ /78 SCREEN LENGTH : 3 FT.
TYPE : ARTESIAN CASING DEPTH : 82 FT.
CASING MATERIAL: STEEL
MEASURING POINT: 1.59 TOP OF CASING ABOVE LSD

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GEOLOGIC LOG

DEPTH INTERVAL (IN FEET)		LITHOLOGY	LITH ABBR	STRATIGRAPHY
0	70	CLAY	CLAY	PLEISTOCENE
70	85	SAND	SAND	

PERIOD OF MONITORING
BEGIN : 06/16/80
END : 09/15/81
FREQ OF MEAS: MONTHLY
METHOD OF MEASUREMENT : STEEL TAPE

AQUIFER : QUATERNARY BURIED OUTWASH

REMARKS :

COUNTY: LAC QUI PARLE TOWNSHIP: 116 RANGE: 46 SECTION: 13
DNR OBSERVATION WELL NUMBER : 37000
MEASUREMENTS ARE IN FEET BELOW LAND SURFACE DATUM.
WATER LEVELS FOR YEAR 1980 NUMBER OF READINGS 7

JUN 16 9.98 SEP 16 21.31 DEC 23 13.03
JUL 16 21.01 OCT 15 15.89
AUG 15 28.83 NOV 15 14.17

WATER LEVELS FOR YEAR 1981 NUMBER OF READINGS 9

JAN 15 12.80 APR 16 11.90 JUL 15 27.68
FEB 13 12.50 MAY 15 13.33 AUG 14 35.63
MAR 18 12.37 JUN 15 13.37 SEP 15 30.57

****
MINNESOTA DEPARTMENT OF NATURAL RESOURCES - DIVISION OF WATERS
OBSERVATION WELL DATA BASE - LAC QUI PARLE

WELL NAME : DNR #80-4 OBSERVER: SWCD
DNR WELL NO.: 37001
UNIQUE NO. : 225951

COUNTY : LAC QUI PARLE
CITY : CANBY

TOWNSHIP : 116
RANGE : 45
SECTION : 20
1/4 SECTION
PLS : NENWSW
USGS : CBA

TOPOGRAPHIC
SETTING : UNKNOWN

ELEVATION : 1157.0 FT. ABOVE SEA LEVEL
DEPTH : 210 FT.
COMPLETED : 04/30/80
TYPE : ARTESIAN

METHOD DRILLED : HYDRAULIC OR MUD ROTARY
DIAMETER : 2 IN.
SCREEN LENGTH : 3 FT.
CASING DEPTH : 207 FT.
CASING MATERIAL: STEEL
MEASURING POINT: 3.43 TOP OF CASING ABOVE LSD

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GEOLOGIC LOG

DEPTH INTERVAL (IN FEET)		LITHOLOGY	LITH ABBR	STRATIGRAPHY
0	5	SAND FINE BROWN SOFT	SAND	PLEISTOCENE
5	10	SAND MEDIUM-COARSE BROWN SOFT	SAND	
10	16	SAND MEDIUM-COARSE BLACK SOFT	SAND	
16	32	CLAY SANDY GRAY MEDIUM	CLAY	
32	45	CLAY GRAVELLY GRAY MEDIUM	CLAY	
45	105	CLAY SANDY GRAY MEDIUM	CLAY	
105	116	CLAY SANDY WITH GREEN CLAY LENS	CLAY	
116	120	SAND FINE-MEDIUM GRAY SOFT	SAND	
120	149	CLAY SANDY WITH PEBBLES MEDIUM	CLAY	
149	155	SAND FINE BROWN SOFT	SAND	
155	160	SAND AND GRAVEL BROWN SOFT	SAND	
160	190	GRAVEL BROWN MEDIUM	GRVL	
190	200	SAND MEDIUM BROWN SOFT	SAND	
200	205	CLAY GRAVELLY BROWN-GRAY MEDIUM	CLAY	
205	218	GRAVEL BROWN MEDIUM	GRVL	
218	220	CLAY SANDY GRAY MEDIUM	CLAY	

PERIOD OF MONITORING
BEGIN : 06/16/80
END : 09/15/81
FREQ OF MEAS: MONTHLY
METHOD OF MEASUREMENT : STEEL TAPE

AQUIFER : QUATERNARY BURIED OUTWASH

REMARKS : ARVID HALSTENSON.

COUNTY: LAC QUI PARLE TOWNSHIP: 116 RANGE: 45 SECTION: 20
DNR OBSERVATION WELL NUMBER : 37001
MEASUREMENTS ARE IN FEET BELOW LAND SURFACE DATUM.
WATER LEVELS FOR YEAR 1980 NUMBER OF READINGS 7

JUN 16	22.89	SEP 16	31.79	DEC 23	22.51
JUL 16	37.38	OCT 15	24.35		
AUG 15	38.24	NOV 15	22.84		

WATER LEVELS FOR YEAR 1981 NUMBER OF READINGS 9

JAN 15	22.57	APR 16	22.25	JUL 15	40.77
FEB 13	22.55	MAY 15	26.10	AUG 14	39.57
MAR 18	22.38	JUN 15	26.01	SEP 15	40.43

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MINNESOTA DEPARTMENT OF NATURAL RESOURCES - DIVISION OF WATERS
OBSERVATION WELL DATA BASE - LAC QUI PARLE

WELL NAME    : DNR  #80-7                          OBSERVER: SWCD
DNR WELL NO.: 37002
UNIQUE NO.   : 225954

COUNTY       : LAC QUI PARLE
CITY         : CANBY

TOWNSHIP     : 116                          TOPOGRAPHIC
RANGE        :  46                          SETTING        : UNKNOWN
SECTION      :   2
1/4 SECTION
  PLS        : SWNWSW
  USGS       : CBC

ELEVATION    : 1161.1 FT. ABOVE SEA LEVEL   METHOD DRILLED : HYDRAULIC OR MUD ROTARY
DEPTH        :  210   FT.                   DIAMETER       :     2 IN.
COMPLETED    : 05/06/80                     SCREEN LENGTH  :     3 FT.
TYPE         : ARTESIAN                     CASING DEPTH   :   207 FT.
                                            CASING MATERIAL: STEEL
                                            MEASURING POINT:  2.65 TOP OF CASING ABOVE LSD

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                              GEOLOGIC LOG

 DEPTH
INTERVAL                                                          LITH
(IN FEET)   LITHOLOGY                                             ABBR  STRATIGRAPHY

   0   40   SAND MEDIUM-COARSE BROWN SOFT                         SAND  PLEISTOCENE
  40   45   GRAVEL GRAY MEDIUM                                    GRVL
  45   50   CLAY GRAVELLY GRAY MEDIUM                             CLAY
  50  165   CLAY GRAY MEDIUM-HARD                                 CLAY
 165  225   SAND AND GRAVEL BROWN SOFT                            SAND
 225        CLAY SANDY GRAY MEDIUM                                CLAY

PERIOD OF
MONITORING
  BEGIN        : 06/16/80
  END          : 09/15/81
FREQ OF MEAS: MONTHLY
METHOD OF MEASUREMENT : STEEL TAPE

AQUIFER      : QUATERNARY BURIED OUTWASH

REMARKS      : UNITED STATES FISH AND WILDLIFE SERVICE FARRELL WPA.

COUNTY: LAC QUI PARLE    TOWNSHIP: 116    RANGE: 46    SECTION:  2
DNR OBSERVATION WELL NUMBER :  37002
MEASUREMENTS ARE IN FEET BELOW LAND SURFACE DATUM.
WATER LEVELS FOR YEAR 1980               NUMBER OF READINGS   7

JUN 16  20.63     SEP 16  26.49     DEC 23  20.10
JUL 16  33.91     OCT 15  19.91
AUG 15  34.04     NOV 15  20.15


WATER LEVELS FOR YEAR 1981               NUMBER OF READINGS   9

JAN 15  20.33     APR 16  19.63     JUL 15  35.43
FEB 13  20.37     MAY 15  27.41     AUG 14  36.90
MAR 18  20.26     JUN 15  23.01     SEP 15  35.63
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MINNESOTA DEPARTMENT OF NATURAL RESOURCES - DIVISION OF WATERS
OBSERVATION WELL DATA BASE - LAC QUI PARLE

WELL NAME : DNR #80-8 OBSERVER: SWCD
DNR WELL NO.: 37003
UNIQUE NO. : 225955

COUNTY : LAC QUI PARLE
CITY : MARIETTA

TOWNSHIP : 117 TOPOGRAPHIC
RANGE : 46 SETTING : UNKNOWN
SECTION : 26
1/4 SECTION
PLS : SESESW
USGS : CDD

ELEVATION : 1158.0 FT. ABOVE SEA LEVEL METHOD DRILLED : HYDRAULIC OR MUD ROTARY
DEPTH : 189 FT. DIAMETER : 2 IN.
COMPLETED : 05/07/80 SCREEN LENGTH : 3 FT.
TYPE : ARTESIAN CASING DEPTH : 186 FT.
CASING MATERIAL: STEEL
MEASURING POINT: 3.15 TOP OF CASING ABOVE LSD

==========

GEOLOGIC LOG

DEPTH INTERVAL (IN FEET)		LITHOLOGY	LITH ABBR	STRATIGRAPHY
0	13	SILT FINE SANDY BROWN SOFT	SILT	PLEISTOCENE
13	21	CLAY WITH SAND BROWN MEDIUM-HARD	CLAY	
21	25	GRAVEL BROWN MEDIUM	GRVL	
25	42	CLAY GRAY HARD	CLAY	
42	43	SAND COARSE BROWN SOFT	SAND	
43	58	CLAY SANDY GRAY HARD	CLAY	
58	62	SAND COARSE WITH GRAVEL BROWN HARD	SAND	
62	79	CLAY SANDY GRAY MEDIUM	CLAY	
79	80	CLAY SANDY WITH GRAVEL GRAY HARD	CLAY	
80	92	CLAY SANDY GRAY MEDIUM	CLAY	
92	93	SAND MEDIUM-COARSE BROWN DIRTY SOFT	SAND	
93	95	CLAY SANDY GRAY MEDIUM	CLAY	
95	115	CLAY SILTY GRAY-GREEN SOFT	CLAY	
115	158	CLAY SANDY GRAY-GREEN MEDIUM	CLAY	
158	176	CLAY WITH SAND FINE BROWN SOFT	CLAY	
176	195	SAND FINE-MEDIUM BROWN SOFT	SAND	
195	196	BOULDER VERY HARD	BLDR	
196	200	SHALE CLAYEY SANDY WITH WOOD CHIPS GRAY MED	SHLE	CRETACEOUS
200	225	SHALE CLAYEY SANDY GRAY MEDIUM	SHLE	

PERIOD OF
MONITORING
BEGIN : 06/16/80
END : 09/15/81
FREQ OF MEAS: MONTHLY
METHOD OF MEASUREMENT : STEEL TAPE

AQUIFER : QUATERNARY BURIED OUTWASH

REMARKS : MENHURIN TOWNSHIP HALL.

COUNTY: LAC QUI PARLE TOWNSHIP: 117 RANGE: 46 SECTION: 26
DNR OBSERVATION WELL NUMBER : 37003
MEASUREMENTS ARE IN FEET BELOW LAND SURFACE DATUM.
WATER LEVELS FOR YEAR 1980 NUMBER OF READINGS 7

JUN 16 15.08 SEP 16 20.41 DEC 23 14.74
JUL 16 24.62 OCT 15 16.10
AUG 15 24.11 NOV 15 15.02

WATER LEVELS FOR YEAR 1981 NUMBER OF READINGS 9

JAN 15 14.87 APR 16 14.73 JUL 15 26.28
FEB 13 14.87 MAY 15 18.33 AUG 14 25.98
MAR 18 14.70 JUN 15 17.53 SEP 15 27.05

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MINNESOTA DEPARTMENT OF NATURAL RESOURCES - DIVISION OF WATERS
OBSERVATION WELL DATA BASE - LAC QUI PARLE

WELL NAME : DNR #80-11 OBSERVER: SWCD
DNR WELL NO.: 37004
UNIQUE NO. : 225958

COUNTY : LAC QUI PARLE
CITY : CANBY

TOWNSHIP : 116 TOPOGRAPHIC
RANGE : 45 SETTING : UNKNOWN
SECTION : 7
1/4 SECTION
PLS : NESENE
USGS : ADA

ELEVATION : 1144.1 FT. ABOVE SEA LEVEL METHOD DRILLED : HYDRAULIC OR MUD ROTARY
DEPTH : 203 FT. DIAMETER : 2 IN.
COMPLETED : 05/09/80 SCREEN LENGTH : 3 FT.
TYPE : ARTESIAN CASING DEPTH : 200 FT.
CASING MATERIAL: STEEL
MEASURING POINT: 3.08 TOP OF CASING ABOVE LSD

==========

GEOLOGIC LOG

DEPTH INTERVAL (IN FEET)		LITHOLOGY	LITH ABBR	STRATIGRAPHY
0	24	CLAY BROWN MEDIUM	CLAY	PLEISTOCENE
24	30	GRAVEL BROWN MEDIUM	GRVL	
30	34	CLAY GRAVELLY BROWN MEDIUM	CLAY	
34	41	GRAVEL BROWN MEDIUM	GRVL	
41	75	CLAY GRITTY GRAY MEDIUM	CLAY	
75	80	CLAY GREEN-BROWN-GRAY	CLAY	
80	152	CLAY GRITTY GRAY MEDIUM	CLAY	
152	156	SAND FINE-MEDIUM BROWN SOFT	SAND	
156	160	CLAY SANDY BROWN MEDIUM	CLAY	
160	165	CLAY GRITTY GRAY MEDIUM-HARD	CLAY	
165	195	SAND FINE-MEDIUM BROWN SOFT	SAND	
195	203	SAND MEDIUM-COARSE BROWN SOFT	SAND	
203	208	SAND COARSE TO GRAVEL BROWN SOFT	SAND	
208	225	CLAY GRITTY GRAY MEDIUM	CLAY	

PERIOD OF
MONITORING
BEGIN : 06/16/80
END : 09/15/81
FREQ OF MEAS: MONTHLY
METHOD OF MEASUREMENT : STEEL TAPE

AQUIFER : QUATERNARY BURIED OUTWASH

REMARKS : OVIE CARLSON.

COUNTY: LAC QUI PARLE TOWNSHIP: 116 RANGE: 45 SECTION: 7
DNR OBSERVATION WELL NUMBER : 37004
MEASUREMENTS ARE IN FEET BELOW LAND SURFACE DATUM.
WATER LEVELS FOR YEAR 1980 NUMBER OF READINGS 7

JUN 16 9.21 SEP 16 17.72 DEC 23 8.85
JUL 16 24.40 OCT 15 10.46
AUG 15 25.30 NOV 15 9.15

WATER LEVELS FOR YEAR 1981 NUMBER OF READINGS 9

JAN 15 8.91 APR 16 8.60 JUL 15 27.55
FEB 13 8.90 MAY 15 13.27 AUG 14 26.84
MAR 18 8.76 JUN 15 12.12 SEP 15 27.16

****
MINNESOTA DEPARTMENT OF NATURAL RESOURCES - DIVISION OF WATERS
OBSERVATION WELL DATA BASE - LAC QUI PARLE

WELL NAME : DNR #80-12 OBSERVER: SWCD
DNR WELL NO.: 37005
UNIQUE NO. : 225959

COUNTY : LAC QUI PARLE
CITY : CANBY

TOWNSHIP : 116 TOPOGRAPHIC
RANGE : 46 SETTING : UNKNOWN
SECTION : 20
1/4 SECTION
PLS : SWSWNW
USGS : BCC

ELEVATION : 1305.1 FT. ABOVE SEA LEVEL METHOD DRILLED : HYDRAULIC OR MUD ROTARY
DEPTH : 189 FT. DIAMETER : 2 IN.
COMPLETED : 05/14/80 SCREEN LENGTH : 3 FT.
TYPE : ARTESIAN CASING DEPTH : 186 FT.
CASING MATERIAL: STEEL
MEASURING POINT: 3.46 TOP OF CASING ABOVE LSD

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DEPTH INTERVAL (IN FEET)		GEOLOGIC LOG LITHOLOGY	LITH ABBR	STRATIGRAPHY
0	35	CLAY BROWN MEDIUM	CLAY	PLEISTOCENE
35	45	CLAY GRAY MEDIUM	CLAY	
45	77	CLAY GRITTY WITH GRAVEL GRAY MEDIUM	CLAY	
77	79	GRAVEL DIRTY GRAY MEDIUM-HARD	GRVL	
79	105	CLAY GRITTY GRAY MEDIUM-HARD	CLAY	
105	106	SAND FINE-MEDIUM DIRTY BROWN SOFT	SAND	
106	115	CLAY STICKY GRAY HARD	CLAY	
115	116	SAND COARSE DIRTY BROWN SOFT	SAND	
116	137	CLAY GRAY MEDIUM	CLAY	
137	138	SAND FINE-MEDIUM DIRTY BROWN SOFT	SAND	
138	171	CLAY WITH GRAVEL BITS GRAY MEDIUM	CLAY	
171	196	GRAVEL BROWN HARD	GRVL	
196	230	CLAY GRAY MEDIUM-HARD	CLAY	
230	257	CLAY WITH GRAVEL BITS GRAY MEDIUM-HARD	CLAY	
257	278	CLAY WITH SAND GRAY MEDIUM	CLAY	
278	290	SANDSTONE FINE-MEDIUM GRAY SOFT-MEDIUM	SNDS	CRETACEOUS
290	305	SHALE SILTY GRAY HARD	SHLE	
305	322	SHALE SILTY W/SAND LENSES GRAY-GREEN MED-HARD	SHLE	
322	325	SILTSTONE SANDY GRAY-GREEN MEDIUM	SLSN	
325	360	SHALE SILTY GRAY-GREEN HARD	SHLE	
360	380	SHALE GRAY-GREEN HARD	SHLE	
380	385	SHALE SILTY GRAY-GREEN HARD	SHLE	
385	455	SHALE GRAY-GREEN HARD	SHLE	
455	460	SHALE SILTY DARK GREEN DRILLED EASIER MEDIUM	SHLE	
460	485	SHALE DARK GREEN HARD	SHLE	
485	505	REGOLITH CLAYEY W/ANG QUARTZ TURQUOISE-BLUE	REGO	PRE-CRETACEOUS

PERIOD OF MONITORING
BEGIN : 06/16/80
END : 09/15/81
FREQ OF MEAS: MONTHLY
METHOD OF MEASUREMENT : STEEL TAPE

AQUIFER : QUATERNARY BURIED OUTWASH

REMARKS : GARY THEISEN.

COUNTY: LAC QUI PARLE TOWNSHIP: 116 RANGE: 46 SECTION: 20
DNR OBSERVATION WELL NUMBER : 37005
MEASUREMENTS ARE IN FEET BELOW LAND SURFACE DATUM.
WATER LEVELS FOR YEAR 1980 NUMBER OF READINGS 7

JUN 16 55.76 SEP 16 59.11 DEC 23 73.99
JUL 16 55.96 OCT 15 72.22
AUG 15 56.49 NOV 15 74.26

WATER LEVELS FOR YEAR 1981 NUMBER OF READINGS 9

JAN 15 74.14 APR 16 73.93 JUL 15 74.83
FEB 13 74.16 MAY 15 73.97 AUG 14 75.49
MAR 18 74.07 JUN 15 74.27 SEP 15 76.07

****
MINNESOTA DEPARTMENT OF NATURAL RESOURCES - DIVISION OF WATERS
OBSERVATION WELL DATA BASE - LAC QUI PARLE

WELL NAME : DNR #80-13 OBSERVER: SWCD
DNR WELL NO.: 37006
UNIQUE NO. : 225960

COUNTY : LAC QUI PARLE
CITY : CANBY

TOWNSHIP : 116 TOPOGRAPHIC
RANGE : 46 SETTING : UNKNOWN
SECTION : 15
1/4 SECTION
PLS : SESENE
USGS : ADD

ELEVATION : 1179.0 FT. ABOVE SEA LEVEL METHOD DRILLED : HYDRAULIC OR MUD ROTARY
DEPTH : 70 FT. DIAMETER : 2 IN.
COMPLETED : 05/14/80 SCREEN LENGTH : 3 FT.
TYPE : ARTESIAN CASING DEPTH : 67 FT.
CASING MATERIAL: STEEL
MEASURING POINT: 2.76 TOP OF CASING ABOVE LSD

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GEOLOGIC LOG

DEPTH INTERVAL (IN FEET)		LITHOLOGY	LITH ABBR	STRATIGRAPHY
0	5	SAND FINE-MEDIUM BROWN SOFT	SAND	PLEISTOCENE
5	12	SAND MEDIUM-COARSE BROWN SOFT	SAND	
12	18	CLAY GRITTY BROWN MEDIUM	CLAY	
18	25	CLAY GRAY MEDIUM	CLAY	
25	30	CLAY GRAVELLY GRAY MEDIUM	CLAY	
30	41	SAND COARSE WITH GRAVEL BROWN MEDIUM	SAND	
41	45	SAND WITH CLAY LENSES BROWN-GRAY MEDIUM	SAND	
45	50	SAND MEDIUM-COARSE BROWN SOFT	SAND	
50	78	SAND COARSE WITH GRAVEL BROWN SOFT	SAND	
78	105	CLAY GRITTY STICKY GRAY HARD	CLAY	
105	195	CLAY SANDY W/SAND LENSES AT 159-160' GRAY SOFT	CLAY	
195	225	CLAY STICKY GRAY MEDIUM-HARD	CLAY	

PERIOD OF
MONITORING
BEGIN : 06/16/80
END : 09/15/81
FREQ OF MEAS: MONTHLY
METHOD OF MEASUREMENT : STEEL TAPE

AQUIFER : QUATERNARY BURIED OUTWASH

REMARKS : UNITED STATES FISH AND WILDLIFE SERVICE PEARSON WPA.

COUNTY: LAC QUI PARLE TOWNSHIP: 116 RANGE: 46 SECTION: 15
DNR OBSERVATION WELL NUMBER : 37006
MEASUREMENTS ARE IN FEET BELOW LAND SURFACE DATUM.
WATER LEVELS FOR YEAR 1980 NUMBER OF READINGS 7

JUN 16	10.48	SEP 16	13.30	DEC 23	13.29
JUL 16	12.11	OCT 15	13.46		
AUG 15	13.03	NOV 15	12.81		

WATER LEVELS FOR YEAR 1981 NUMBER OF READINGS 9

JAN 15	13.73	APR 16	11.58	JUL 15	13.29
FEB 13	13.87	MAY 15	12.20	AUG 14	14.04
MAR 18	12.13	JUN 15	11.17	SEP 15	14.65

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MINNESOTA DEPARTMENT OF NATURAL RESOURCES - DIVISION OF WATERS
OBSERVATION WELL DATA BASE - LAC QUI PARLE

WELL NAME    : DNR  #80-16                          OBSERVER: SWCD
DNR WELL NO.: 37007
UNIQUE NO.   : 225963

COUNTY       : LAC QUI PARLE
CITY         : DAWSON

TOWNSHIP     : 117                        TOPOGRAPHIC
RANGE        :  43                        SETTING        : UNKNOWN
SECTION      :  21
1/4 SECTION
  PLS        : NWNWNW
  USGS       : BBB

ELEVATION    : 1048.2 FT. ABOVE SEA LEVEL  METHOD DRILLED : HYDRAULIC OR MUD ROTARY
DEPTH        :  143   FT.                  DIAMETER       :     2 IN.
COMPLETED    : 05/19/80                    SCREEN LENGTH  :     3 FT.
TYPE         : ARTESIAN                    CASING DEPTH   :   140 FT.
                                           CASING MATERIAL: STEEL
                                           MEASURING POINT:  2.89 TOP OF CASING ABOVE LSD

==========================================================================

 DEPTH                          GEOLOGIC LOG
INTERVAL                                                        LITH
(IN FEET)   LITHOLOGY                                           ABBR  STRATIGRAPHY

   0    1   TOPSOIL BLACK SOFT                                  SOIL  PLEISTOCENE
   1    5   SAND SILTY LIGHT BROWN SOFT                         SAND
   5   10   SAND FINE-MEDIUM BROWN SOFT                         SAND
  10   14   SAND MEDIUM-COARSE BROWN SOFT                       SAND
  14   73   CLAY SLIGHTLY GRITTY GRAY MEDIUM-HARD               CLAY
  73   80   SAND MEDIUM BROWN SOFT                              SAND
  80  102   GRAVEL WITH CLAY LENSES BROWN MEDIUM                GRVL
 102  109   CLAY GRAY MEDIUM                                    CLAY
 109  110   CLAY SANDY BROWN-YELLOW MEDIUM                      CLAY
 110  123   SAND CLAYEY BROWN-YELLOW MEDIUM                     SAND
 123  125   CLAY GRITTY LIGHT GRAY MEDIUM                       CLAY
 125  138   GRAVEL CLAYEY LIGHT BROWN HARD                      GRVL
 138  147   GRAVEL LIGHT BROWN MEDIUM                           GRVL
 147  150   CLAY SANDY GRAY MEDIUM                              CLAY
 150  158   SHALE SILTY HARD                                    SHLE  CRETACEOUS
 158  165   REGOLITH KAOLIN CLAY GRITTY WHITE MEDIUM-HARD       REGO  PRE-CRETACEOUS
 165  175   REGO. SILTY SAND GRITTY GRY-WHT & GRN MED HARD      REGO
 175  200   REGO. KAOLIN CLAY GRITTY GRAY-WHITE MED-HARD        REGO
 200  230   REGO. CLAYEY SAND W/QTZ FELD GRY-WHT MED-HARD       REGO
 230        GNEISS GRANITIC PINK-WHITE-BLACK                    GNIS  PRECAMBRIAN

PERIOD OF
MONITORING
  BEGIN      : 06/16/80
  END        : 09/15/81
FREQ OF MEAS: MONTHLY
METHOD OF MEASUREMENT : STEEL TAPE

AQUIFER      : QUATERNARY BURIED OUTWASH

REMARKS      : CITY OF DAWSON.

COUNTY: LAC QUI PARLE    TOWNSHIP: 117    RANGE: 43    SECTION: 21
DNR OBSERVATION WELL NUMBER :  37007
MEASUREMENTS ARE IN FEET BELOW LAND SURFACE DATUM.
WATER LEVELS FOR YEAR 1980                NUMBER OF READINGS   7

JUN 16  46.00     SEP 16  47.56     DEC 23  47.60
JUL 16  47.53     OCT 15  47.49
AUG 15  47.58     NOV 15  47.68


WATER LEVELS FOR YEAR 1981                NUMBER OF READINGS   9

JAN 15  48.36     APR 16  48.41     JUL 15  49.60
FEB 13  48.80     MAY 15  48.45     AUG 14  49.35
MAR 18  48.41     JUN 15  47.76     SEP 15  42.88
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MINNESOTA DEPARTMENT OF NATURAL RESOURCES - DIVISION OF WATERS
OBSERVATION WELL DATA BASE - LAC QUI PARLE

WELL NAME    : DNR  #80-17                          OBSERVER: SWCD
DNR WELL NO.: 37008
UNIQUE NO.   : 225964

COUNTY       : LAC QUI PARLE
CITY         : MADISON

TOWNSHIP     : 118                        TOPOGRAPHIC
RANGE        :  44                        SETTING        : UNKNOWN
SECTION      :  29
1/4 SECTION
  PLS        : NESWNE
  USGS       : ACA

ELEVATION    : 1083.1 FT. ABOVE SEA LEVEL  METHOD DRILLED : HYDRAULIC OR MUD ROTARY
DEPTH        : 146    FT.                  DIAMETER       :     2 IN.
COMPLETED    : 05/20/80                    SCREEN LENGTH  :     3 FT.
TYPE         : ARTESIAN                    CASING DEPTH   :   143 FT.
                                           CASING MATERIAL: STEEL
                                           MEASURING POINT:  3.74 TOP OF CASING ABOVE LSD

======================================================================

 DEPTH
INTERVAL                          GEOLOGIC LOG                          LITH
(IN FEET)   LITHOLOGY                                                   ABBR  STRATIGRAPHY

   0    9   CLAY SANDY GRAVELLY DARK BROWN MEDIUM                       CLAY  PLEISTOCENE
   9   23   CLAY GRITTY LIGHT BROWN MEDIUM                              CLAY
  23   42   CLAY GRITTY GRAY MEDIUM                                     CLAY
  42   50   CLAY FINE SANDY GRAY MEDIUM                                 CLAY
  50   57   CLAY STICKY GRAY MEDIUM                                     CLAY
  57   70   CLAY SANDY WITH BOULDER @ 57-58' GRAY MEDIUM                CLAY
  70  134   CLAY WITH PEBBLES GRAY HARD                                 CLAY
 134  137   SAND MEDIUM BROWN SOFT                                      SAND
 137  145   SAND WITH CLAY LENSES BROWN-GRAY MEDIUM                     SAND
 145  152   GRAVEL WITH BOULDERS BROWN-GRAY HARD                        GRVL
 152  195   CLAY STICKY GRAY HARD                                       CLAY  CRETACEOUS
 195  240   SHALE STICKY GRAY HARD                                      SHLE
 240  250   SHALE GRADING TO LIMESTONE DK BROWN MED-HARD                SHLE
 250  260   LIMESTONE SHALY DARK BROWN MEDIUM-HARD                      LMSN
 260  290   SHALE CHALKY STICKY DARK BROWN MEDIUM-HARD                  SHLE
 290  295   SHALE STICKY BLACK MEDIUM-HARD                              SHLE
 295  310   REGOLITH STICKY W/QUARTZ WHITE MEDIUM-HARD                  REGO  PRE-CRETACEOUS
 310  430   GRANITE DECOMPOSED WHITE-GREEN HARD                         GRAN  PRECAMBRIAN
 430  432   GRANITE CHIPS WHITE BLACK AND PINK                          GRAN

PERIOD OF
MONITORING
  BEGIN      : 06/16/80
  END        : 09/15/81
FREQ OF MEAS: MONTHLY
METHOD OF MEASUREMENT : STEEL TAPE

AQUIFER      : QUATERNARY BURIED OUTWASH

REMARKS      : LAC QUI PARLE COUNTY FAIRGROUNDS.

COUNTY: LAC QUI PARLE    TOWNSHIP: 118    RANGE: 44    SECTION: 29
DNR OBSERVATION WELL NUMBER :  37008
MEASUREMENTS ARE IN FEET BELOW LAND SURFACE DATUM.
WATER LEVELS FOR YEAR 1980              NUMBER OF READINGS   7

JUN 16  30.03     SEP 16  33.15     DEC 23  33.35
JUL 16  32.21     OCT 15  33.37
AUG 15  32.98     NOV 15  33.77


WATER LEVELS FOR YEAR 1981              NUMBER OF READINGS   9

JAN 15  33.58     APR 16  33.92     JUL 15  35.92
FEB 13  33.62     MAY 15  36.40     AUG 14  36.48
MAR 18  33.66     JUN 15  34.96     SEP 15  36.46
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MINNESOTA DEPARTMENT OF NATURAL RESOURCES - DIVISION OF WATERS
OBSERVATION WELL DATA BASE - LAC QUI PARLE

WELL NAME : DNR #80-20 OBSERVER: SWCD
DNR WELL NO.: 37009
UNIQUE NO. : 225967

COUNTY : LAC QUI PARLE
CITY : APPLETON

TOWNSHIP : 119 TOPOGRAPHIC
RANGE : 43 SETTING : UNKNOWN
SECTION : 4
1/4 SECTION
PLS : SESESW
USGS : CDD

ELEVATION : 990.9 FT. ABOVE SEA LEVEL METHOD DRILLED : HYDRAULIC OR MUD ROTARY
DEPTH : 189 FT. DIAMETER : 2 IN.
COMPLETED : 05/27/80 SCREEN LENGTH : 3 FT.
TYPE : ARTESIAN CASING DEPTH : 186 FT.
CASING MATERIAL: STEEL
MEASURING POINT: 3.51 TOP OF CASING ABOVE LSD

==========

GEOLOGIC LOG

DEPTH INTERVAL (IN FEET)		LITHOLOGY	LITH ABBR	STRATIGRAPHY
0	16	SILT SANDY BROWN SOFT	SILT	PLEISTOCENE
16	20	SAND FINE BROWN SOFT	SAND	
20	40	SAND COARSE TO GRAVEL BROWN SOFT	SAND	
40	68	CLAY STICKY GRAY MEDIUM-HARD	CLAY	
68	95	GRAVEL BROWN SOFT	GRVL	
95	100	SAND COARSE BROWN SOFT	SAND	
100	170	SAND MEDIUM BROWN SOFT BOULDER @ 166-167'	SAND	
170	180	SAND COARSE TO GRAVEL BROWN-GRAY MEDIUM	SAND	
180	197	GRAVEL BROWN-GRAY MEDIUM	GRVL	
197	265	CLAY STICKY GRAY MEDIUM-HARD	CLAY	
265	270	SHALE SILTY CARBONACEOUS GRAY-WHITE MEDIUM	SHLE	CRETACEOUS
270	275	SHALE STICKY GRAY-WHITE MEDIUM	SHLE	
275	280	SHALE MIXED W/REGOLITH STICKY GRAY-WHITE MED	SHLE	
280	357	REGOLITH KAOLIN CLAY QRTZ FELD WHITE W/PINK	REGO	PRE-CRETACEOUS
357	358	GRANITE WHITE BLACK AND PINK VERY HARD	GRAN	PRECAMBRIAN

PERIOD OF MONITORING
BEGIN : 06/16/80
END : 09/15/81
FREQ OF MEAS: MONTHLY
METHOD OF MEASUREMENT : STEEL TAPE

AQUIFER : QUATERNARY BURIED OUTWASH

REMARKS : UNITED STATES FISH AND WILDLIFE SERVICE HEGLAND WPA.

COUNTY: LAC QUI PARLE TOWNSHIP: 119 RANGE: 43 SECTION: 4
DNR OBSERVATION WELL NUMBER : 37009
MEASUREMENTS ARE IN FEET BELOW LAND SURFACE DATUM.
WATER LEVELS FOR YEAR 1980 NUMBER OF READINGS 7

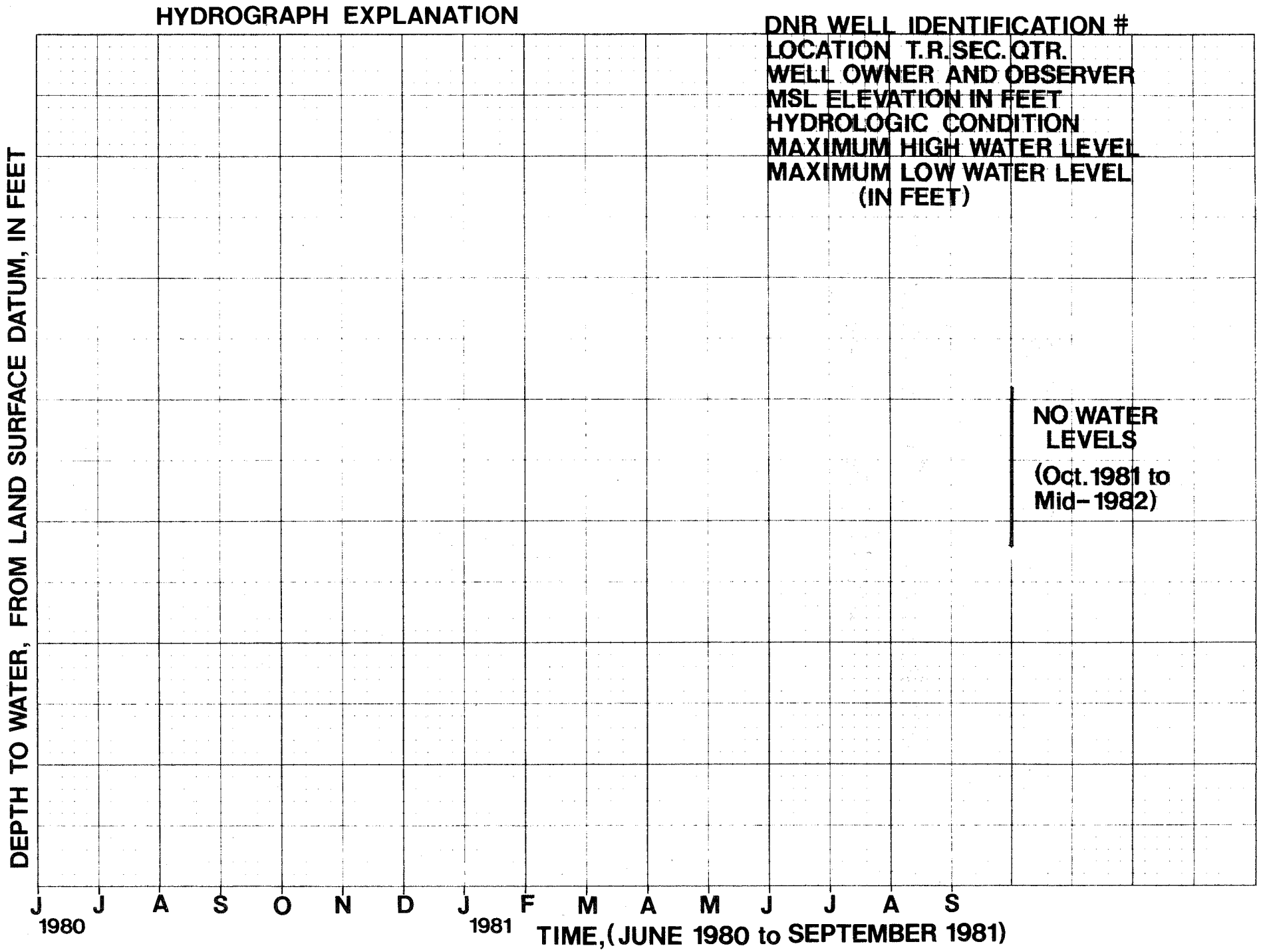
JUN 16 25.27 SEP 16 26.06 DEC 23 25.38
JUL 16 26.88 OCT 15 25.93
AUG 15 29.37 NOV 15 25.86

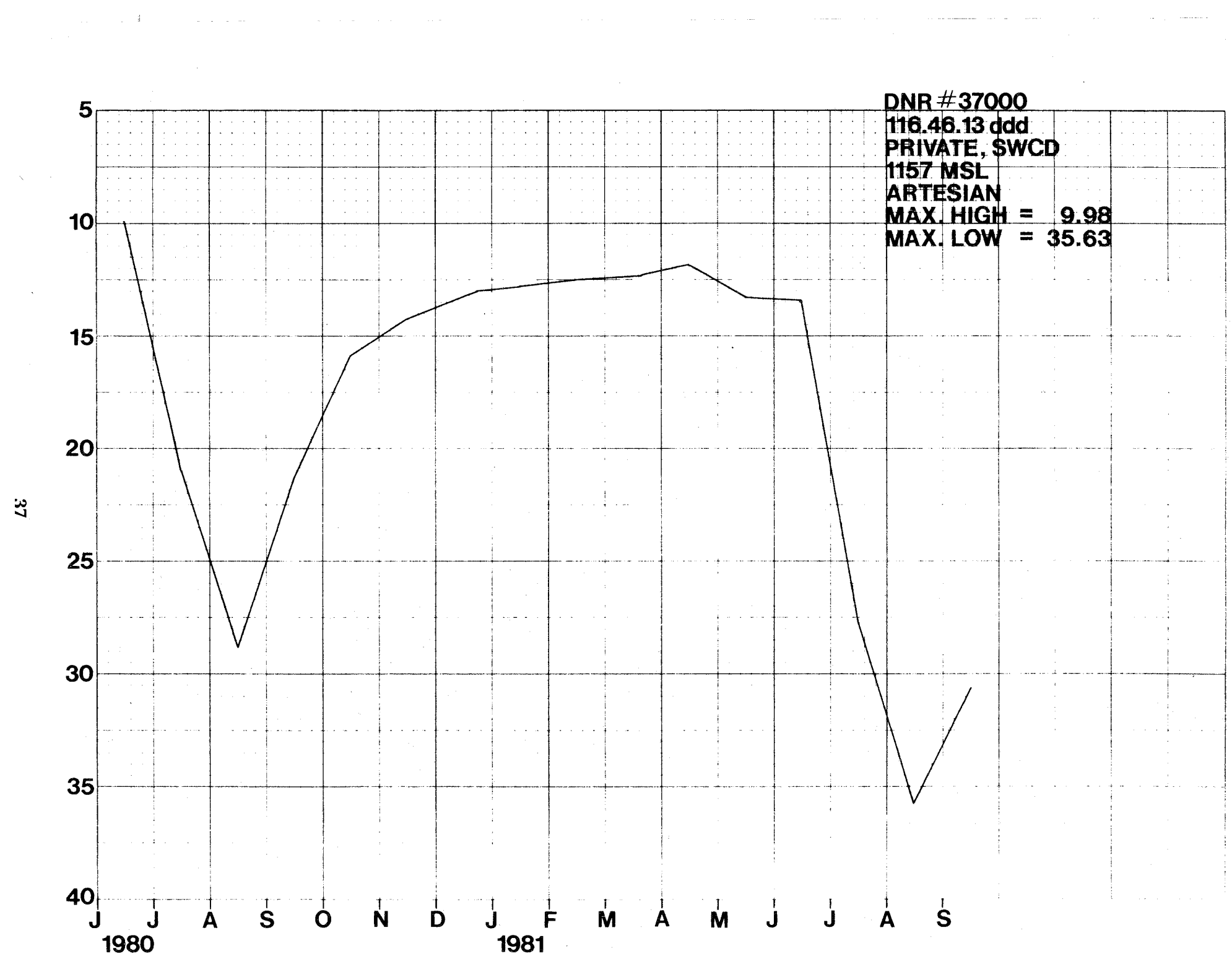
WATER LEVELS FOR YEAR 1981 NUMBER OF READINGS 9

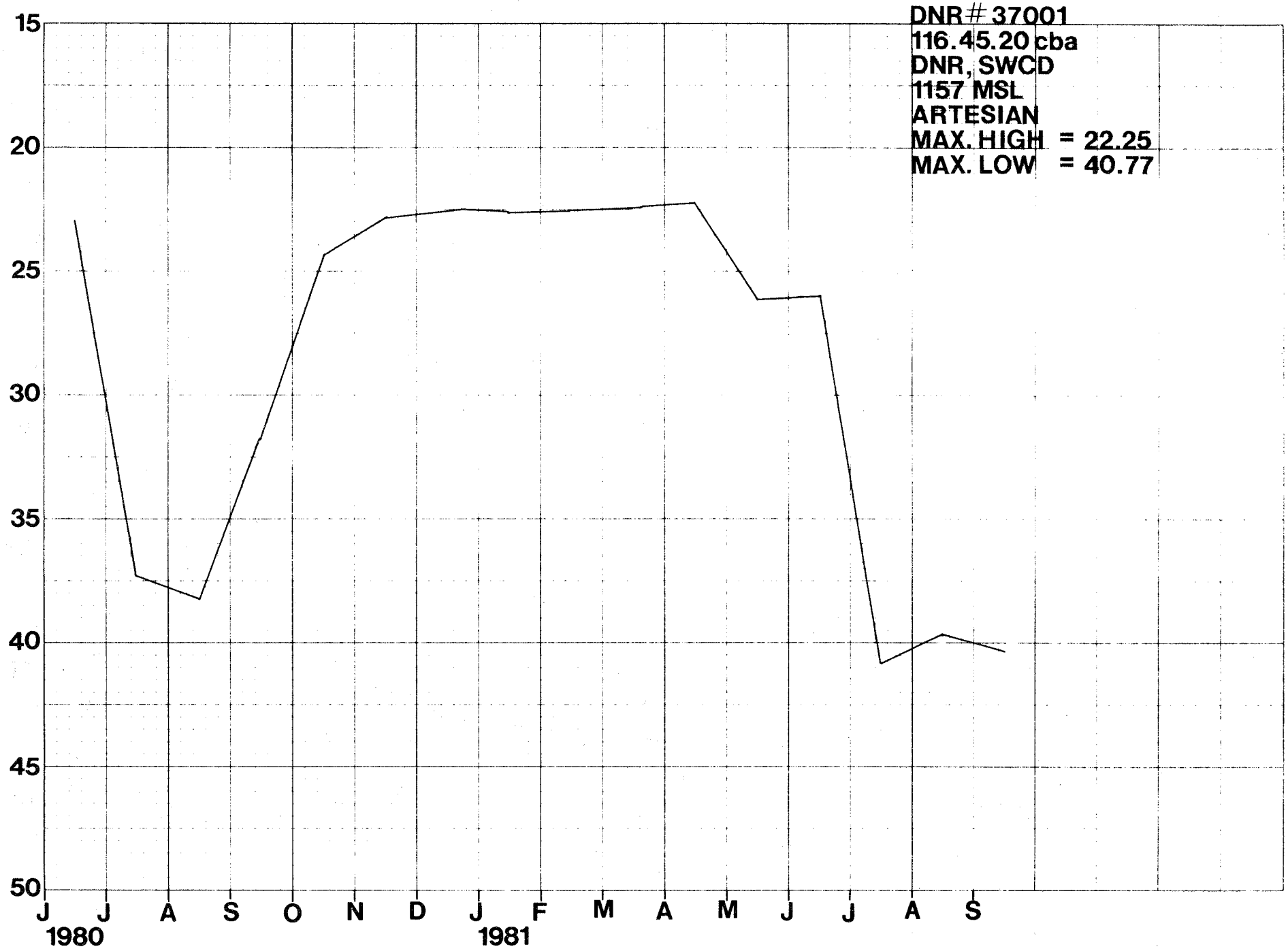
JAN 15 25.65 APR 16 25.53 JUL 15 25.77
FEB 13 25.57 MAY 15 27.16 AUG 14 27.34
MAR 18 26.39 JUN 15 25.94 SEP 15 28.15

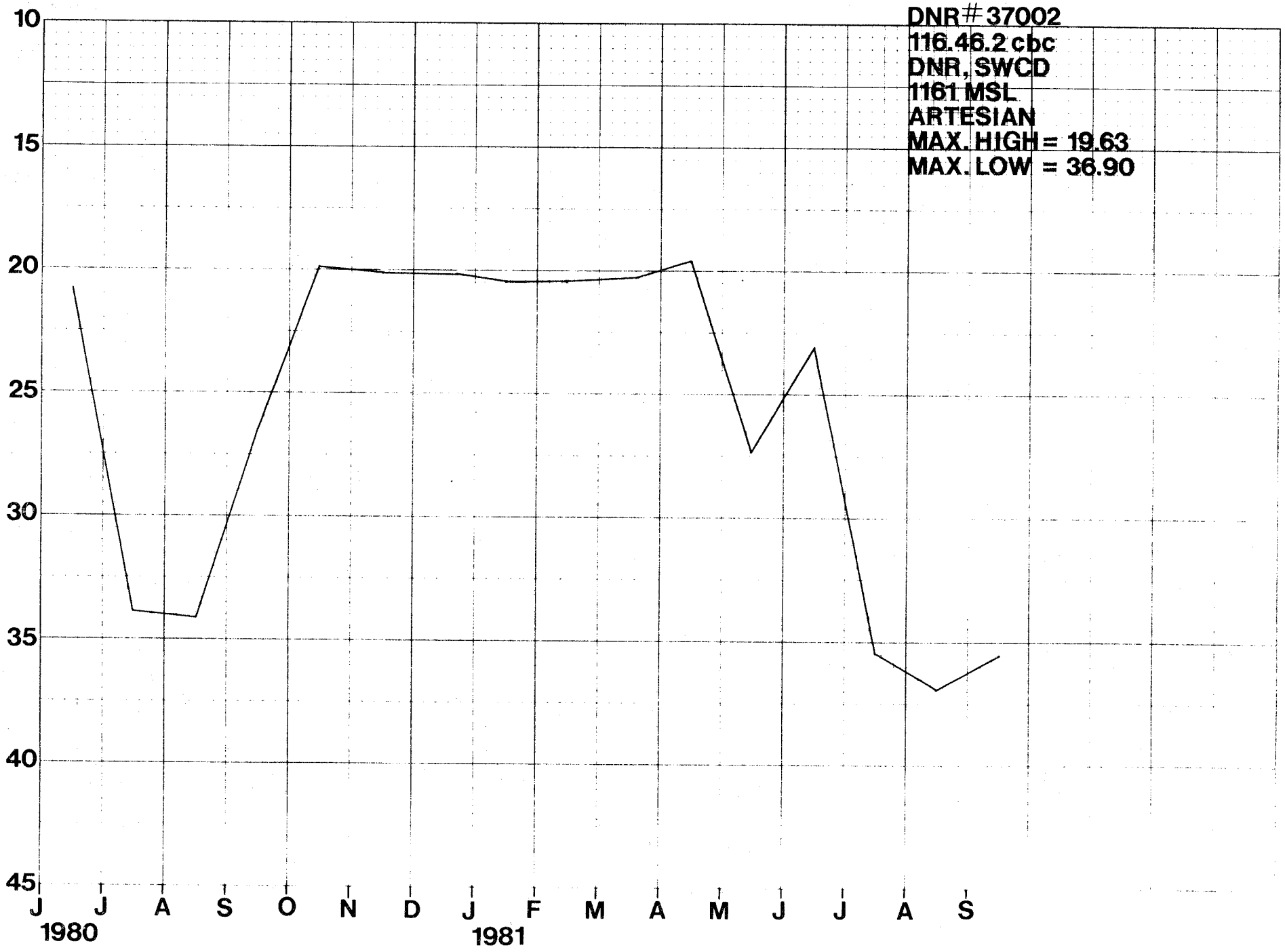
APPENDIX B

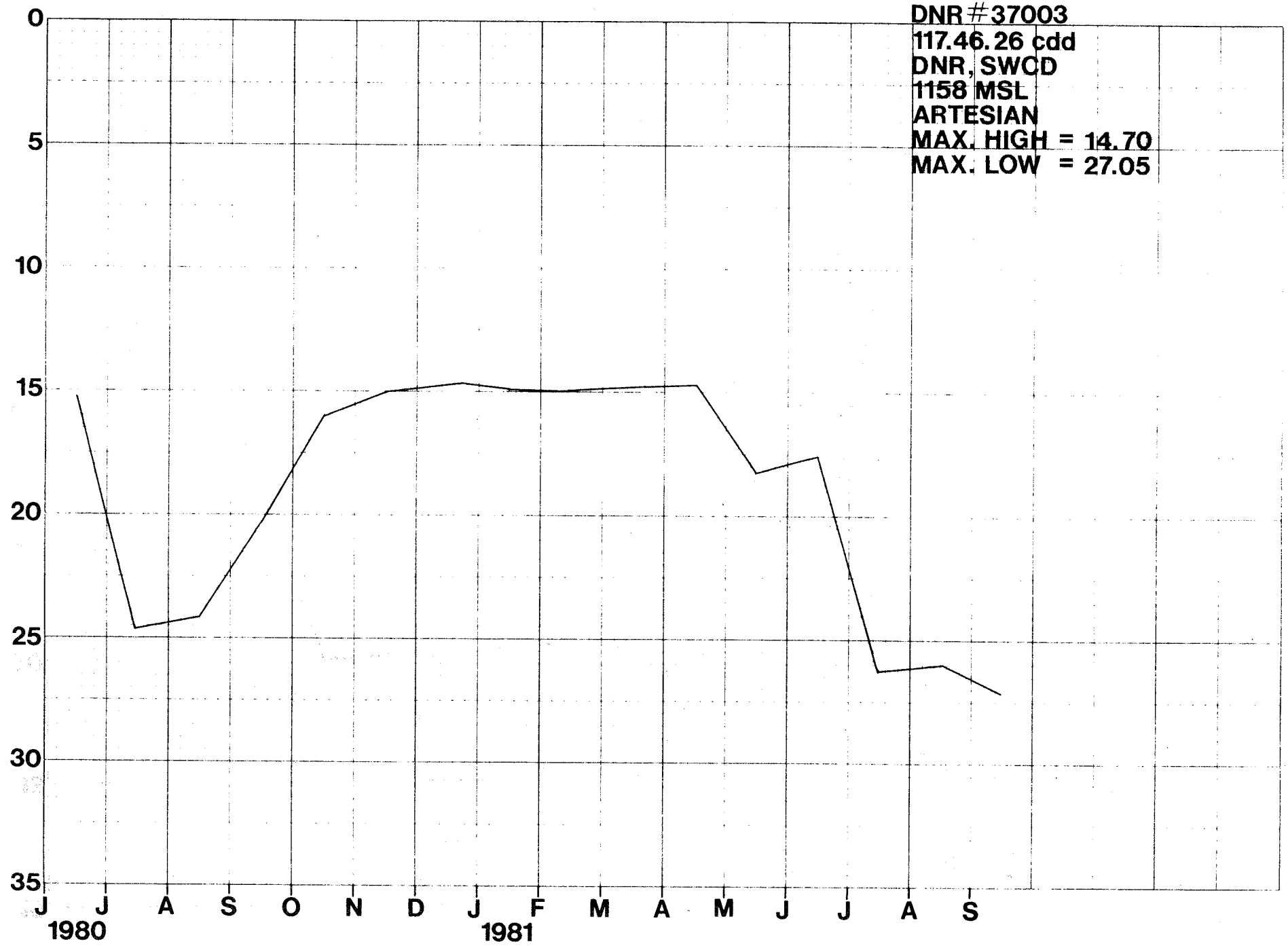
Hydrographs for Observation Wells in Lac Qui Parle County.

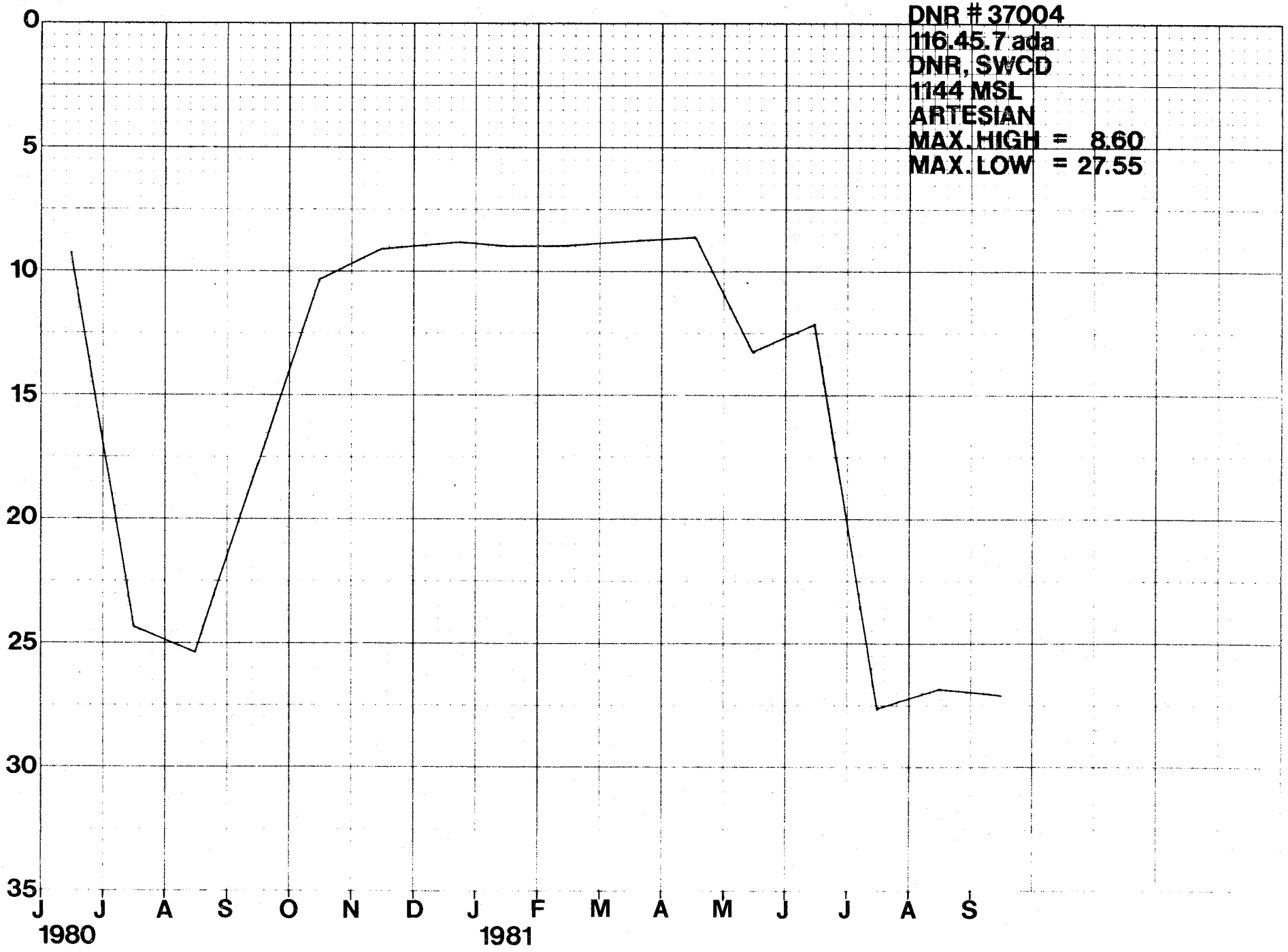

HYDROGRAPH EXPLANATION
DNR WELL IDENTIFICATION #
LOCATION T.R.SEC. QTR.
WELL OWNER AND OBSERVER
MSL ELEVATION IN FEET
HYDROLOGIC CONDITION
MAXIMUM HIGH WATER LEVEL
MAXIMUM LOW WATER LEVEL
(IN FEET)
NO WATER LEVELS
(Oct. 1981 to Mid-1982)
DEPTH TO WATER, FROM LAND SURFACE DATUM, IN FEET
J J A S O N D J F M A M J J A S
1980
1981
TIME, (JUNE 1980 to SEPTEMBER 1981)

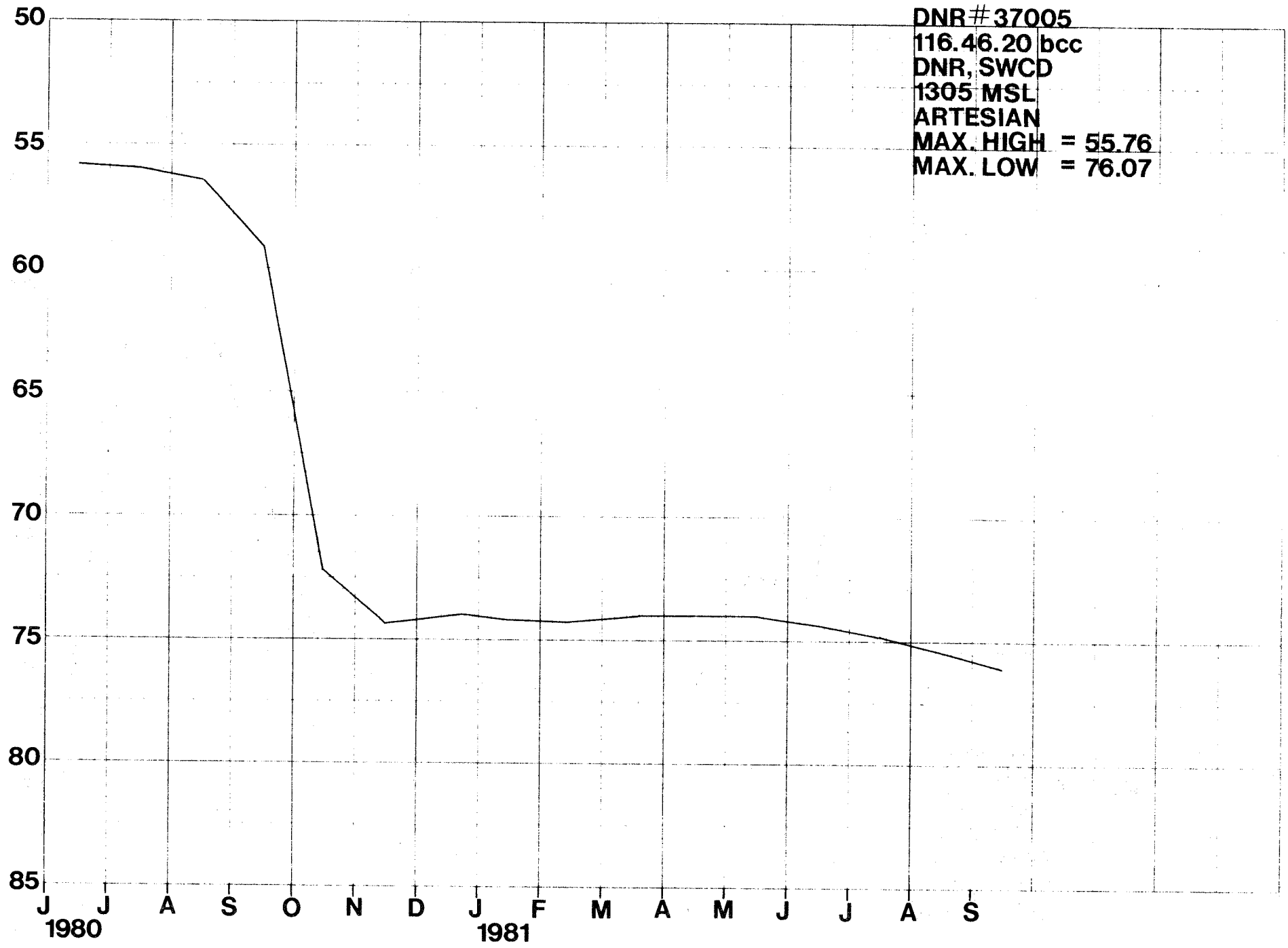

DNR #37000
116.46.13 ddd
PRIVATE, SWCD
1157 MSL
ARTESIAN
MAX. HIGH = 9.98
MAX. LOW = 35.63
5
10
15
20
25
30
35
40
J J A S O N D J F M A M J J A S
1980
1981

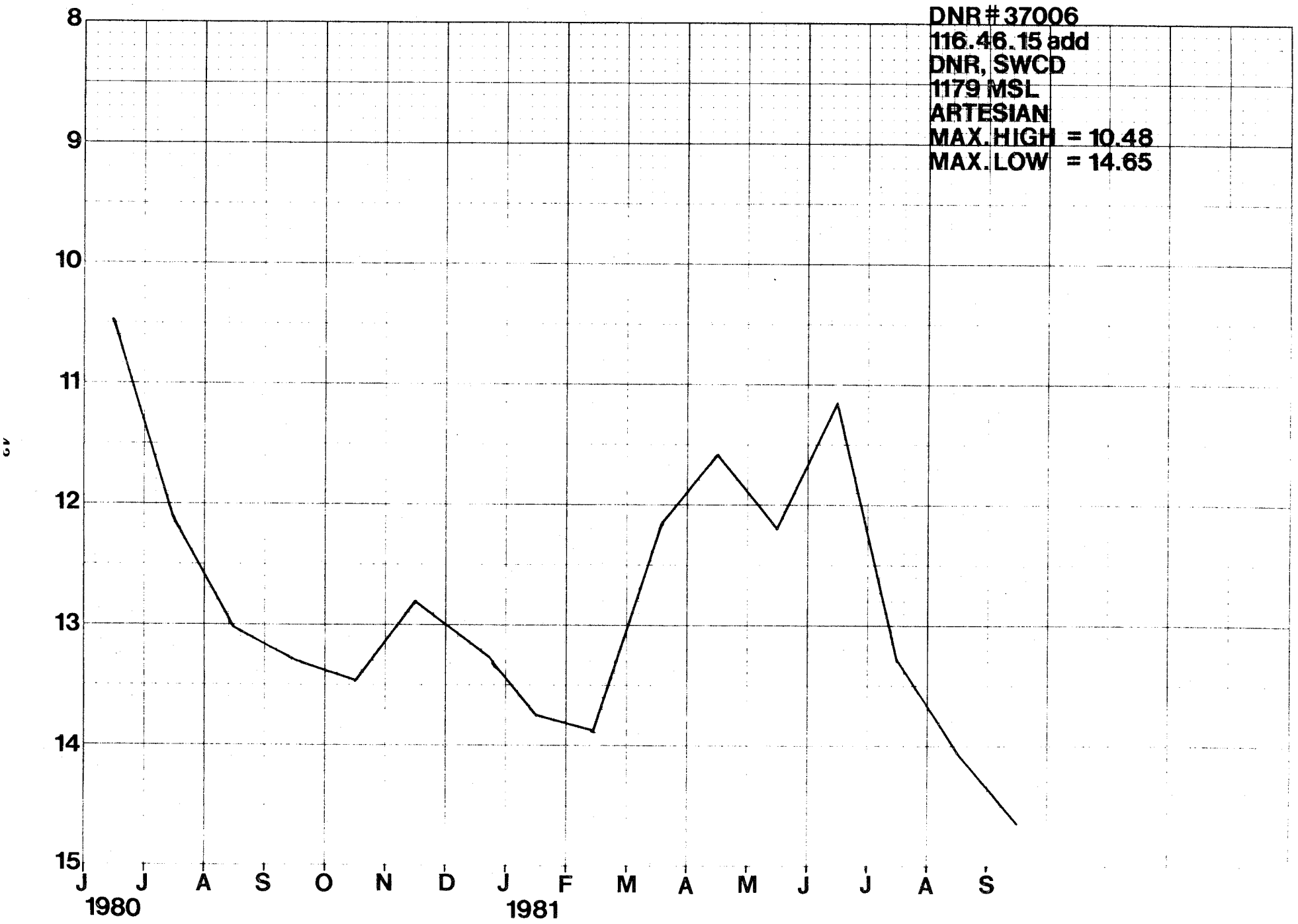

DNR# 37001
116.45.20 cba
DNR, SWCD
1157 MSL
ARTESIAN
MAX. HIGH = 22.25
MAX. LOW = 40.77
15
20
25
30
35
40
45
50
J
J
A
S
O
N
D
J
F
M
A
M
J
J
A
S
1980
1981

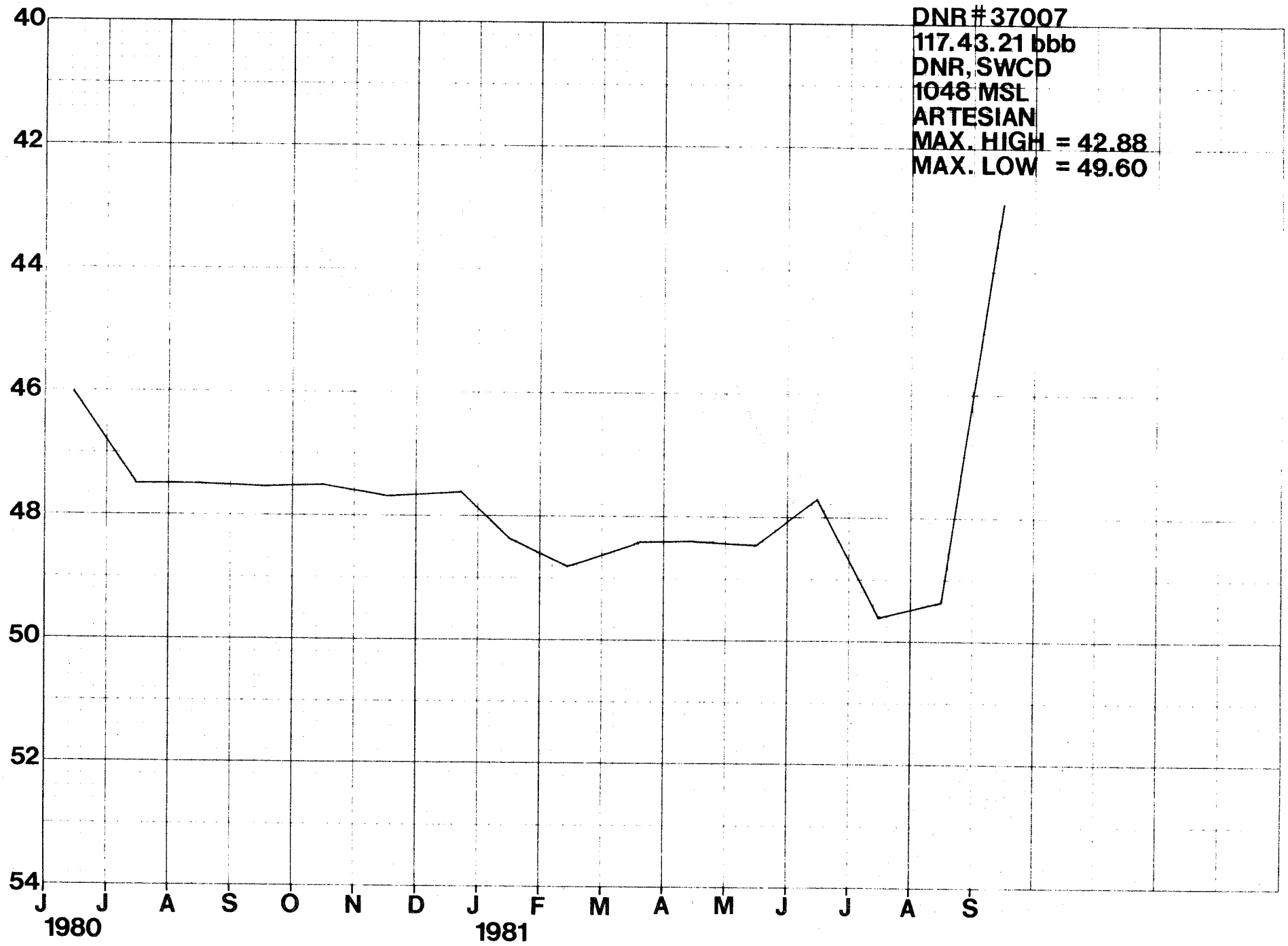

DNR # 37002
116.46.2 cbc
DNR, SWCD
1161 MSL
ARTESIAN
MAX. HIGH = 19.63
MAX. LOW = 36.90
10
15
20
25
30
35
40
45
J
J
A
S
O
N
D
J
F
M
A
M
J
J
A
S
1980
1981

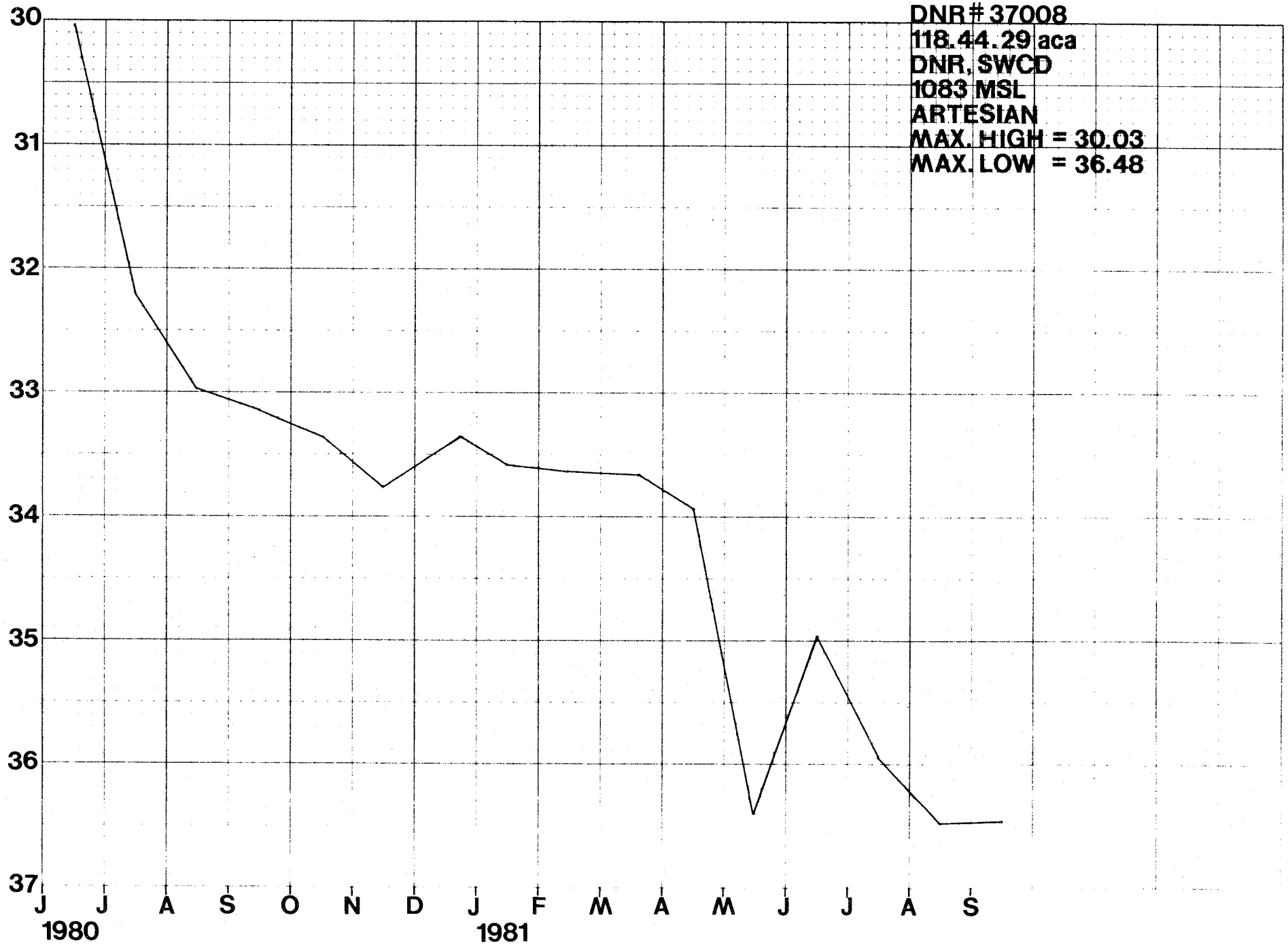

DNR # 37003
117.46.26 cdd
DNR, SWCD
1158 MSL
ARTESIAN
MAX. HIGH = 14.70
MAX. LOW = 27.05
0
5
10
15
20
25
30
35
J J A S O N D J F M A M J J A S
1980
1981

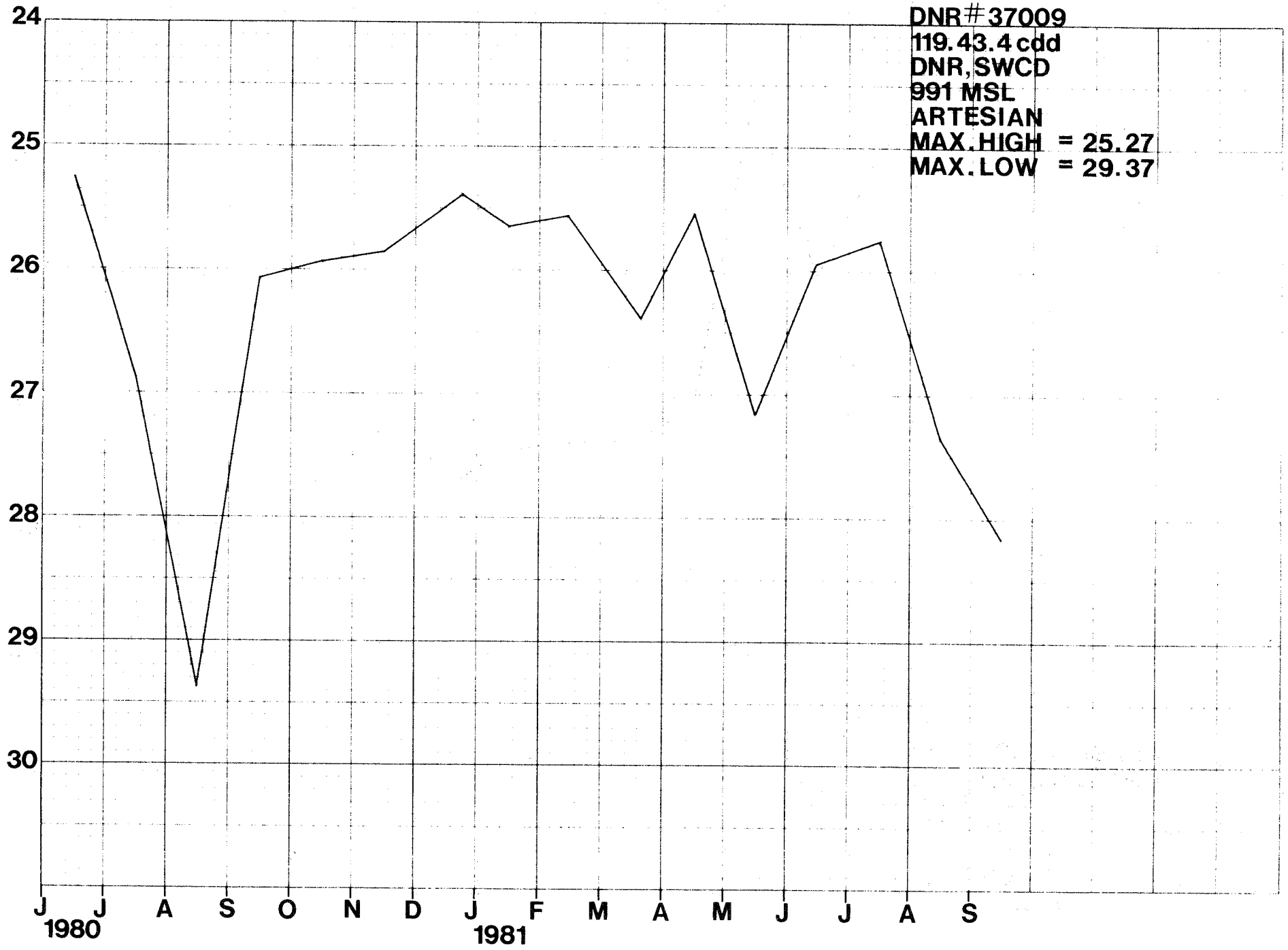

DNR # 37004
116.45.7 ada
DNR, SWCD
1144 MSL
ARTESIAN
MAX. HIGH = 8.60
MAX. LOW = 27.55
0
5
10
15
20
25
30
35
J J A S O N D J F M A M J J A S
1980
1981


DNR#37005
116.46.20 bcc
DNR, SWCD
1305 MSL
ARTESIAN
MAX. HIGH = 55.76
MAX. LOW = 76.07
50
55
60
65
70
75
80
85
J J A S O N D J F M A M J J A S
1980
1981


DNR # 37006
116.46.15 add
DNR, SWCD
1179 MSL
ARTESIAN
MAX. HIGH = 10.48
MAX. LOW = 14.65
8
9
10
11
12
13
14
15
J J A S O N D J F M A M J J A S
1980
1981

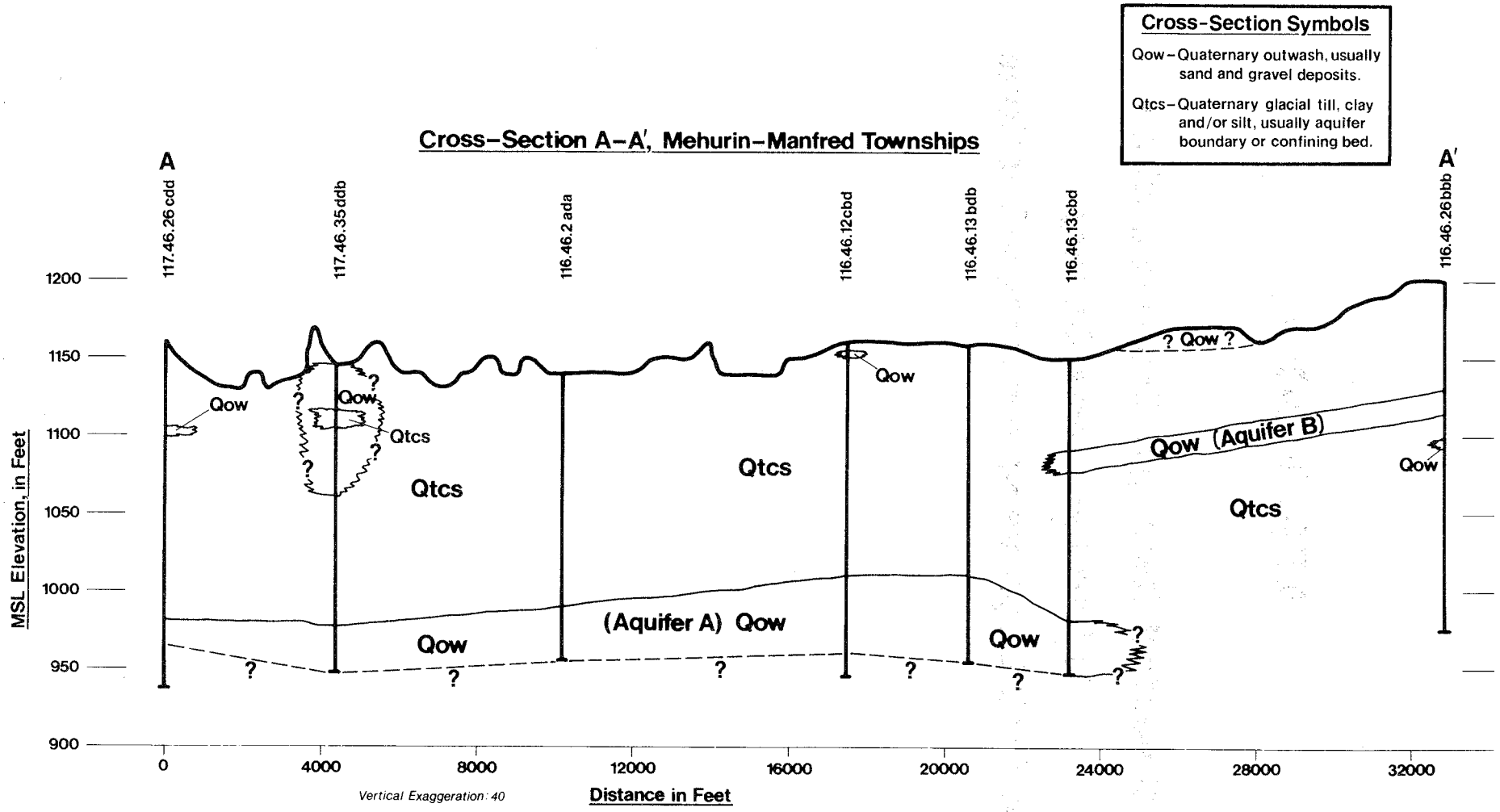

DNR # 37007
117.43.21 bbb
DNR, SWCD
1048 MSL
ARTESIAN
MAX. HIGH = 42.88
MAX. LOW = 49.60
40
42
44
46
48
50
52
54
J J A S O N D J F M A M J J A S
1980
1981

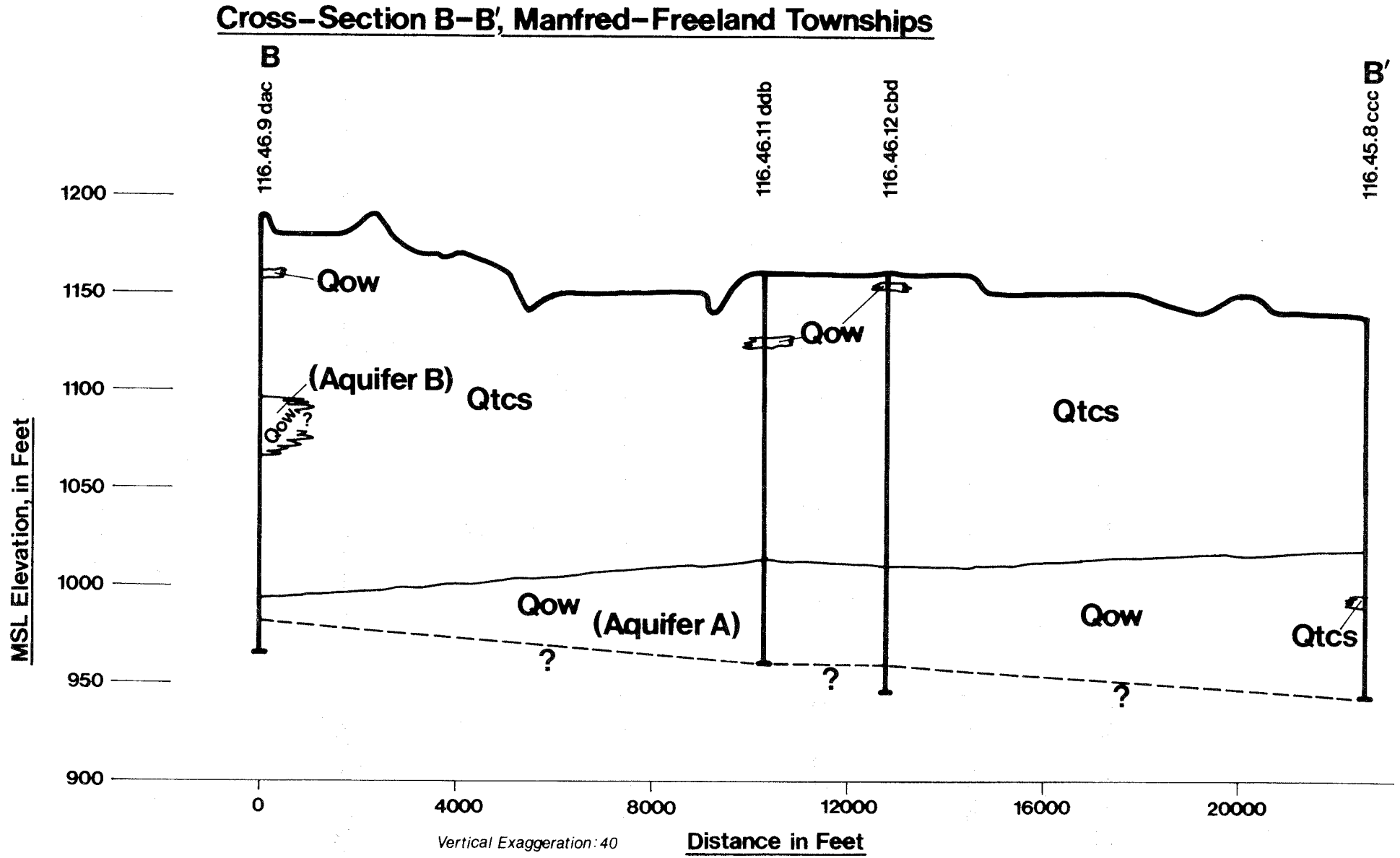

DNR # 37008
118.44.29 aca
DNR, SWCD
1083 MSL
ARTESIAN
MAX. HIGH = 30.03
MAX. LOW = 36.48
30
31
32
33
34
35
36
37
J J A S O N D J F M A M J J A S
1980
1981


DNR#37009
119.43.4 cdd
DNR, SWCD
991 MSL
ARTESIAN
MAX. HIGH = 25.27
MAX. LOW = 29.37
24
25
26
27
28
29
30
J
J
A
S
O
N
D
J
F
M
A
M
J
J
A
S
1980
1981

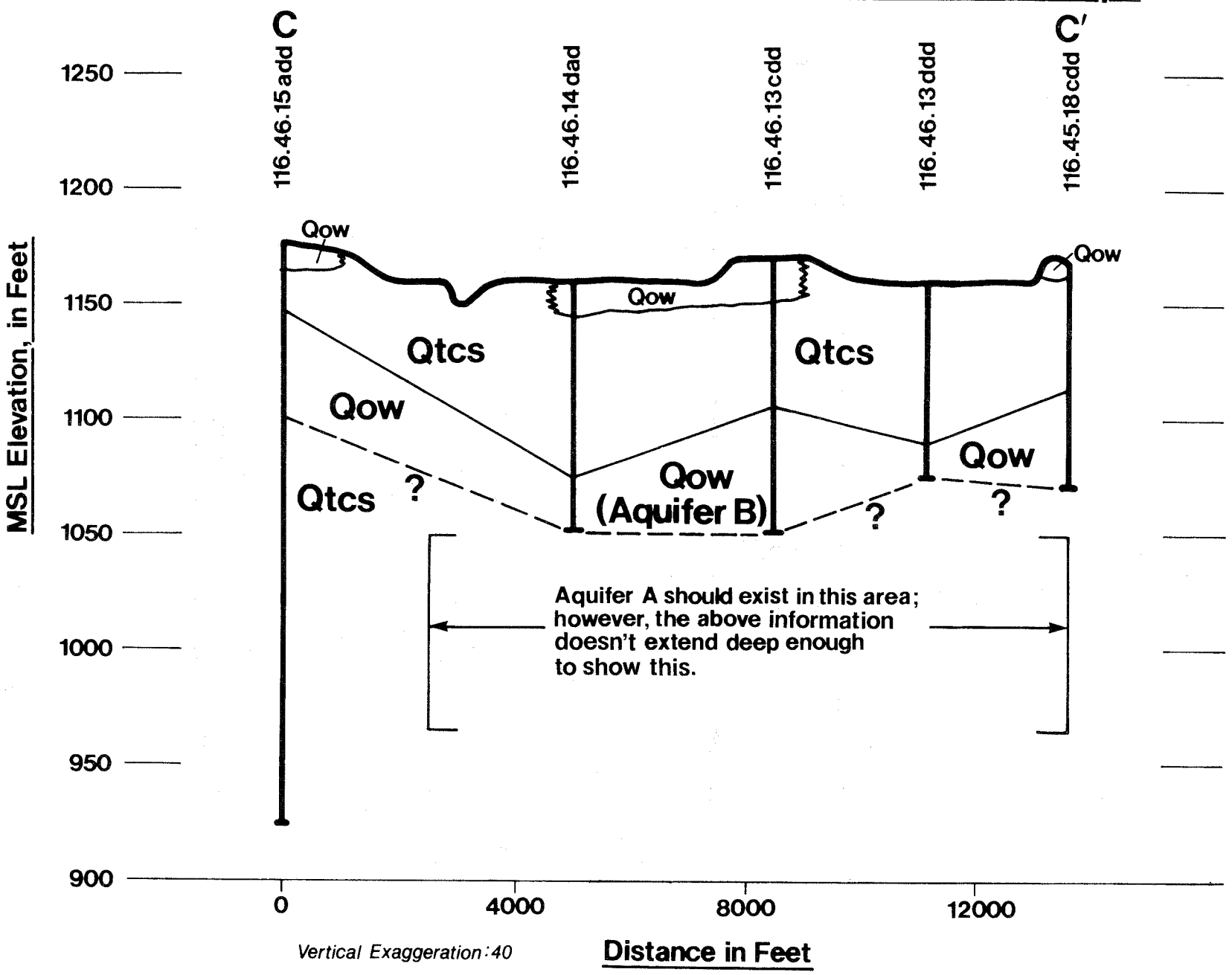
APPENDIX C

Selected Geologic Cross-Sections in Lac Qui Parle County and Well Logs used for Cross-Sections.

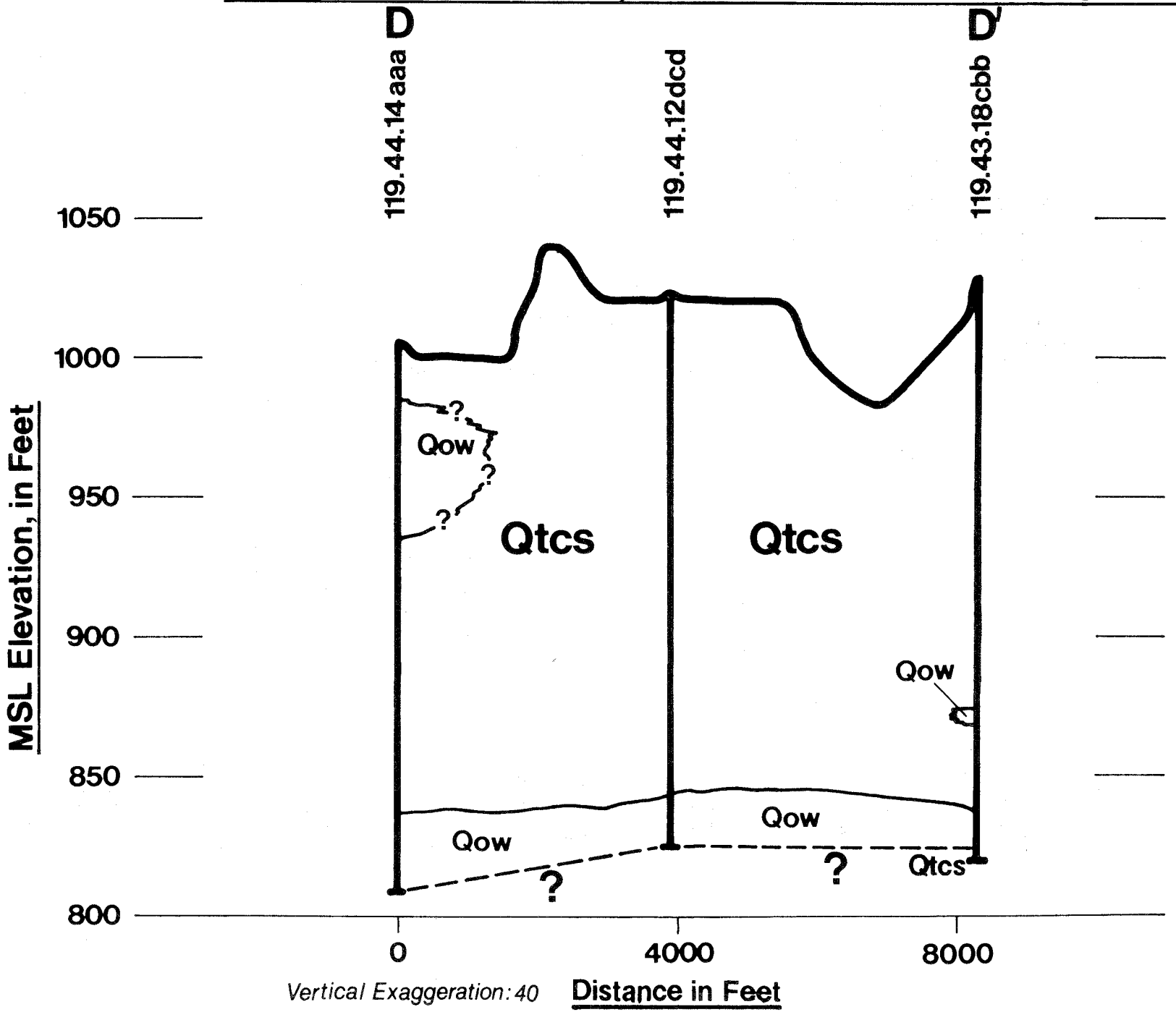

Cross-Section Symbols
Qow – Quaternary outwash, usually sand and gravel deposits.
Qtcs – Quaternary glacial till, clay and/or silt, usually aquifer boundary or confining bed.
Cross-Section A–A′, Mehurin–Manfred Townships
A
A′
117.46.26 cdd
117.46.35 ddb
116.46.2 ada
116.46.12 cbd
116.46.13 bdb
116.46.13 cbd
116.46.26 bbb
MSL Elevation, in Feet
1200
1150
1100
1050
1000
950
900
Qow
Qtcs
(Aquifer A) Qow
Qow (Aquifer B)
? Qow ?
0
4000
8000
12000
16000
20000
24000
28000
32000
Vertical Exaggeration: 40
Distance in Feet


Cross-Section B-B', Manfred-Freeland Townships
B
B'
116.46.9 dac
116.46.11 ddb
116.46.12 cbd
116.45.8 ccc
1200
1150
1100
1050
1000
950
900
MSL Elevation, in Feet
Qow
(Aquifer B)
Qtcs
Qow
Qtcs
Qow
(Aquifer A)
Qow
Qtcs
?
?
?
0
4000
8000
12000
16000
20000
Vertical Exaggeration: 40
Distance in Feet

Cross-Section C-C', Manfred-Freeland Townships



Cross-Section D-D', Lake Shore-Hantho Townships



CROSS-SECTION A-A' MEHURIN-MANFRED TOWNSHIPS

117.46.26 cdd

INTERVAL	DESCRIPTION
0-13	Sandy silt, fine, brown
13-21	Clay, w/sand, brown
21-25	Gravel, brown
25-42	Clay, grey
42-43	Sand, coarse, brown
43-58	Sandy clay, grey
58-62	Sand, coarse w/gravel
62-95	Sandy clay, grey
95-115	Silty clay, grey-green
115-158	Sandy clay, grey-green
158-180	Clay w/sand, fine, brown
180-196	Sand, fine-medium w /boulders, brown
196-200	Clay, sticky w/sand & wood chips, grey
200-225	Clay, sticky w/sand, grey

117.46.35 ddb

INTERVAL	DESCRIPTION
0-2	Topsoil
2-29	Sand, brown
29-40	Clay, grey w/sand
40-85	Sand, fine, dirty, grey
85-168	Clay, blue-grey
168-180	Sand, coarse, w/clay
180-198	Sand, fine to coarse, grey

116.46.2 ada

INTERVAL	DESCRIPTION
0-3	Topsoil
3-60	Clay, soft
60-150	Clay, hard
150-185	Sand, fine

116.46.12 cbd

INTERVAL	DESCRIPTION
0-2	Topsoil
2-6	Clay, yellow
6-8	Sand
8-15	Clay, yellow
15-27	Clay, grey
27-28	Sand, grey
28-75	Clay, grey
75-140	Clay, grey to yellow
140-195	Sand, medium to coarse, w/coal.
195-215	Clay, grey, w/boulders

116.46.13 bdb

INTERVAL	DESCRIPTION
0-18	Sandy clay
18-148	Clay
148-152	Sand, fine
152-155	Clay, grey
155-158	Sand w/clay
158-208	Sand, medium to coarse, and gravel

116.46.13 cbd

INTERVAL	DESCRIPTION
0-3	Topsoil
3-60	Clay
60-75	Sand, medium
75-170	Clay
170-204	Sand, fine to medium

116.46.26 bbb

INTERVAL	DESCRIPTION
0-17	Sandy clay, brown to grey
17-30	Gravelly clay, grey
30-70	Sandy clay
70-85	Sand, medium to coarse
85-102	Sandy clay, grey
102-107	Sand, medium to coarse
107-110	Sandy clay, grey
110-175	Clay, sticky, grey
175-225	Clay w/sand, sticky, grey

CROSS-SECTION B-B' MANFRED-FREELAND TOWNSHIPS

116.46.9 dac

INTERVAL	DESCRIPTION
0-10	Sandy silt, brown
10-24	Clay, Brown to grey
24-30	Gravelly clay, grey, w/boulders
30-32	Sand, fine, brown
32-65	Gravelly clay, grey
65-88	Sandy clay
88-89	Sand, fine, dirty, brown
89-94	Sandy clay, grey
94-124	Sand, medium to coarse, and gravel, dirty, brown
124-153	Sandy clay, grey
153-197	Clay, grey to yellow
197-208	Sand, fine to medium, brown
208-225	Clay, grey to yellow

116.46.11 ddb

INTERVAL	DESCRIPTION
0-2	Topsoil black
2-20	Clay, brown
20-148	Clay, grey
148-158	Sand, fine, grey
158-180	Sand and gravel, grey

116.46.12 cbd

INTERVAL	DESCRIPTION
0-2	Topsoil
2-6	Clay, yellow
6-8	Sand
8-15	Clay, yellow
15-27	Clay, grey
27-28	Sand, grey
28-75	Clay, grey
75-140	Clay, grey to yellow
140-195	Sand, medium to coarse, w/coal
195-215	Clay, grey w/boulders

116.45.8 ccc

INTERVAL	DESCRIPTION
0-15	Sandy clay, brown
15-35	Clayey gravel, brown to grey
35-50	Sandy clay, grey
50-55	Clay, sticky, black to grey
55-78	Sandy clay, grey to brown
78-120	Sandy clay w/gravel, grey to brown
120-143	Sand, medium, brown
143-148	Sandy clay, grey to brown
148-190	Sand, medium to coarse, and gravel, brown.

CROSS-SECTION C-C' MANFRED-FREELAND TOWNSHIPS

116.46.15 add

INTERVAL	DESCRIPTION
0-12	Sand, fine to coarse, brown
12-18	Clay, gritty, brown
18-25	Clay, grey
25-30	Gravelly clay
30-41	Sand, coarse w/gravel, brown
41-45	Sand w/clay lenses, brown to gre
45-78	Sand, medium to coarse w/gravel, brown
78-105	Clay, gritty, sticky, grey
105-195	Sandy clay, grey
195-225	Clay, sticky, grey

116.46.14 dad

INTERVAL	DESCRIPTION
0-15	Sand and gravel
15-85	Clay, sandy
85-108	Sand and gravel

116.46.13 cdd

INTERVAL	DESCRIPTION
0-2	Topsoil, grey
2-18	Sand, coarse, grey
18-65	Sandy clay, grey
65-119	Sand, medium

116.46.13 ddd

INTERVAL	DESCRIPTION
0-70	Clay
70-85	Sand

116.45.18 cdd

INTERVAL	DESCRIPTION
0-5	Sand, grey
5-55	Clay, blue
55-75	Sand, medium, grey
75-97	Sand, coarse, grey

CROSS-SECTION D-D' LAKE SHORE-HANTHO TOWNSHIPS

119.44.14 aaa

INTERVAL	DESCRIPTION
0-2	Topsoil, black
2-20	Clay, brown
20-70	Sand, grey
70-168	Clay, grey
168-196	Sand and gravel, grey

119.44.12 dcd

INTERVAL	DESCRIPTION
0-18	?
18-180	Clay
180-200	Gravel

119.43.18 cbb

INTERVAL	DESCRIPTION
0-47	Clay, brown
47-72	Clay, grey, smeary
72-99	Sandy clay, grey
99-100	Sand, grey
100-128	Sandy clay, grey
128-130	Sand, grey
130-155	Sandy clay, grey
155-161	Sand, grey
161-172	Sandy clay with sand lenses, grey
172-192	Sand, fine with clay, grey
192-207	Sand and gravel
207-209	Clay, gray, smeary
209-120	Clay, brown, smeary