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A SUMMARY OF CURRENT HYDROGEOLOGIC CONDITIONS IN THE DOLTON AQUIFER

by

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CONTENTS

FIGURES

INTRODUCTION

At the request of the Hanson Rural Water System (Hanson RWS) the South Dakota Geological Survey (SDGS) conducted an aquifer test by concurrently pumping Hanson RWS wells 78-5 (which is currently not being used for production) and 78-6. The purpose of this test was to determine if well 78-5 could be pumped in combination with well 78-6 to provide enough water to meet the rural water system's present water needs in the event the main production well (79-2) needs to be shut down. Also, existing hydrologic data were reviewed to evaluate the potential of the Dolton aquifer to supply a satisfactory quantity and quality of water in the future.

The Dolton aquifer is a buried confined aquifer of glacial origin which provides water for the Hanson RWS, the TM Rural Water System (TM RWS) and many private wells in the area. This outwash aquifer consists of sand and gravel with an average thickness of 21 feet and is buried under approximately 130 to 140 feet of till. While further delineation of the areal extent of the aquifer is currently in progress, the known size of the aquifer is approximately 82 square miles (fig. 1).

The Hanson RWS began serving water in 1982 and the TM RWS began serving water in 1985. Data from the Division of Water Rights, South Dakota Department of Water and Natural Resources, files show that the Hanson RWS pumped 421 acre-feet of water and the TM RWS pumped 576 acre-feet of water from the Dolton aquifer in 1988.

In order to evaluate the potential for short and long term water development in the Dolton aquifer, water-level decline in the aquifer and water quality of the aquifer must be considered.

WATER-LEVEL DECLINE IN THE DOLTON AQUIFER

In general, water-level decline will occur near any production well, especially in a confined aquifer such as the Dolton aquifer. Continued pumping will usually expand the cone of depression in the aquifer until recharge areas are intercepted causing the rate of water-level decline to be significantly reduced or stopped entirely. In the Dolton aquifer, the cone of depression has extended throughout the entire area of the aquifer for which water-level records are available and water levels are continuing to decline. This response indicates that the cone of depression has not intercepted sources of recharge equal to or greater than the discharge from this aquifer. Figure 1 shows the water-level decline for various periods and the remaining head on the Dolton aquifer. It should be noted that most of the observation wells in figure 1 were not installed until after the Hanson RWS began pumping water and thus, total water level decline in the aquifer since the Hanson RWS began pumping water is greater than that shown for these wells.

Two other points should also be noted regarding declining water levels: (1) since the areal extent of the aquifer is currently being defined, the aquifer may be larger than it is presently considered to be, and (2) discharge from the aquifer has not been constant during this period because the two rural water systems have increased their withdrawals from the aquifer. The

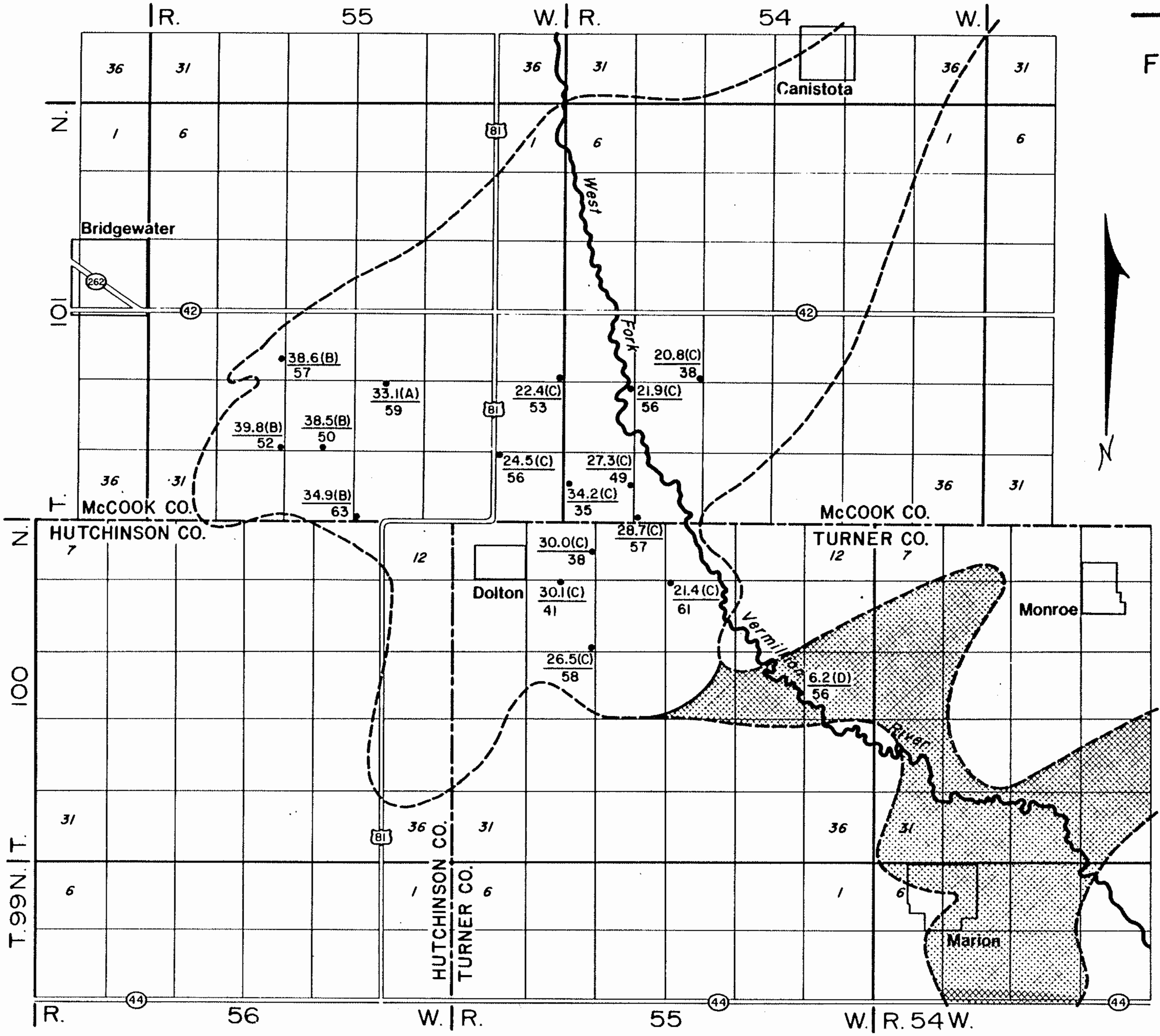


Figure 1. Water-level decline in the Dolton aquifer and remaining head above the top of the aquifer.

22.4(C) / 53 • Observation well. Upper number is water-level decline, in feet. Letter A, B, C or D indicates period of record (see chart below). Lower number is head above top of the Dolton aquifer, in feet, on 6/1/89.

Period of record

A-8/21/78 - 6/1/89
B-8/28/79 - 6/1/89
C-11/2,3,4/83 - 6/1/89
D-4/29/87 - 6/1/89

Area which is tentatively considered part of the Dolton aquifer.

Approximate aquifer boundary.

0 1 2 3 4 5 MI.
SCALE

combined withdrawal was 865 and 997 acre feet in 1987 and 1988, respectively. This increased withdrawal from the aquifer has had some impact on the water-level decline, but the rate of water-level decline appears to be greater than would be expected if it were due only to pumping-rate increases. Although the quantity of water pumped from the aquifer is only a small percentage of the water available in the aquifer, water-level decline is having an impact on wells in the area and is the primary reason for reduced production from the Hanson RWS wells, as discussed in the section below.

AQUIFER TESTS USING HANSON RURAL WATER SYSTEM PRODUCTION WELLS

Well 79-2

Well 79-2 is the main production well for the Hanson RWS. An aquifer test was conducted in 1979 by pumping well 79-2 for 72 hours at a pumping rate of 598 gallons per minute (gpm). The static water level in the well before the test was approximately 57 feet below land surface and at the end of the test was approximately 110 feet below land surface, which is about 29 feet above the top of the aquifer (fig. 2). Another test was conducted in 1987 by pumping this well for 16.9 hours at a rate of 510 to 520 gpm. The water level in the well was about 96 feet below land surface before the start of the test and about 134 feet below land surface at the end of the test. Thus, at the end of the test the water level was about 4 feet below the top of the aquifer (fig. 2). This is despite the fact that (1) the pumping rate for this test was about 83 gpm less than the pumping rate in 1979 and (2) the duration of this test was only 16.9 hours as compared to 72 hours in 1979.

Well 78-6

A 24 hour aquifer test was conducted in 1981 using well 78-6 at a pumping rate of approximately 560 gpm. The water level in the well before the test was 54 feet below land surface and at the end of the test was 117 feet below land surface (20 feet above the top of the aquifer; fig. 3). Another test was conducted in 1987 using this well for about 14 hours at a rate which varied from about 500 gpm to 350 gpm. The water level in well 78-6 was about 91 feet below land surface before the start of the test and about 154 feet below land surface at the end of the test. Thus, at the end of the test the water level was about 17 feet below the top of the aquifer (fig. 3).

Well 78-5

Well 78-5, which was installed as a test well, is currently unused. In 1978, a 72 hour aquifer test was conducted using this well. The pumping rate began at 300 gpm and was reduced to 250 gpm after 35 hours. The static water level in the well before the test was approximately 50 feet

Figure 2. Static and pumping water levels in Hanson Rural Water System well 79-2 from 1979 and 1987 aquifer-test data.

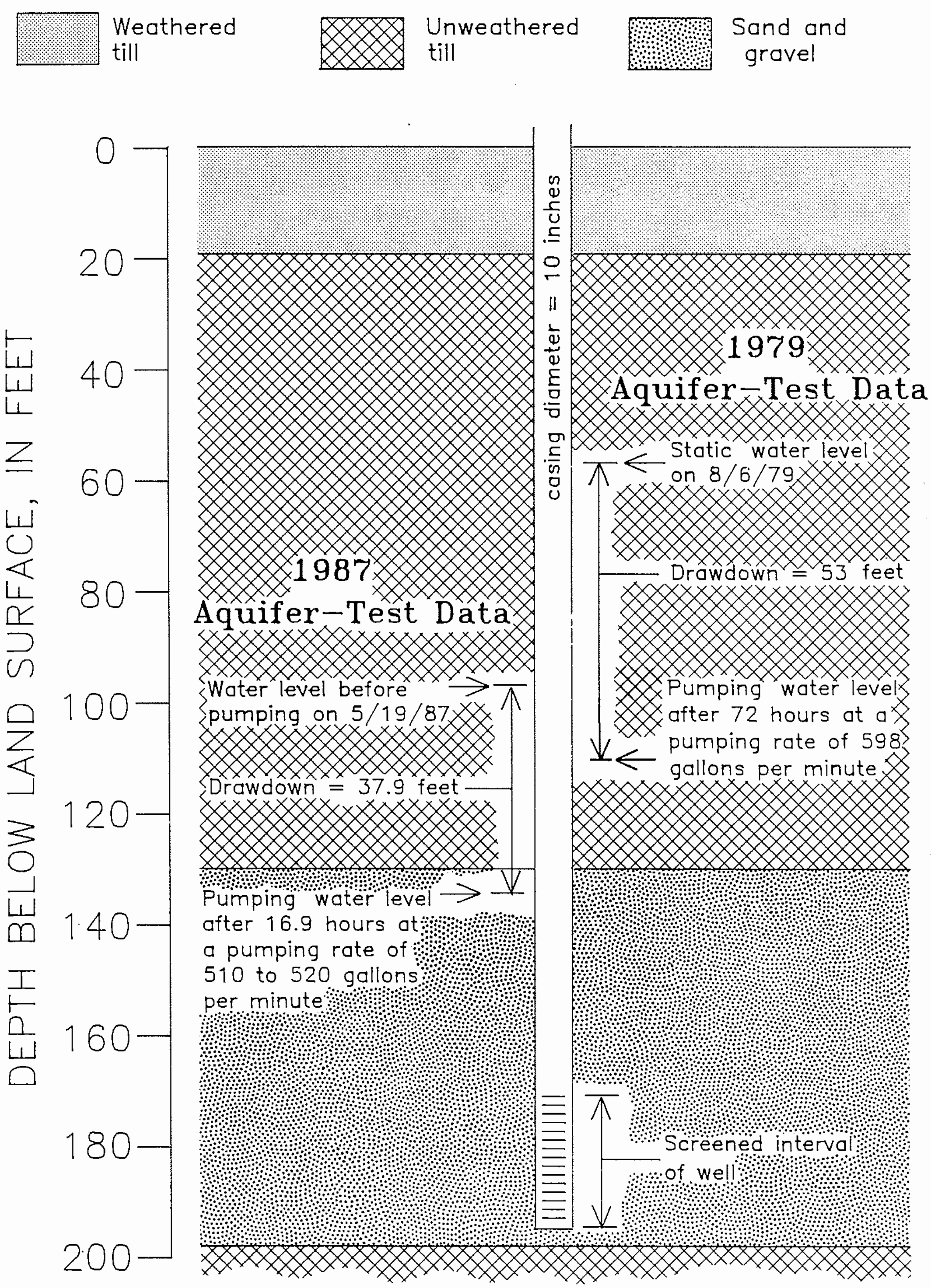
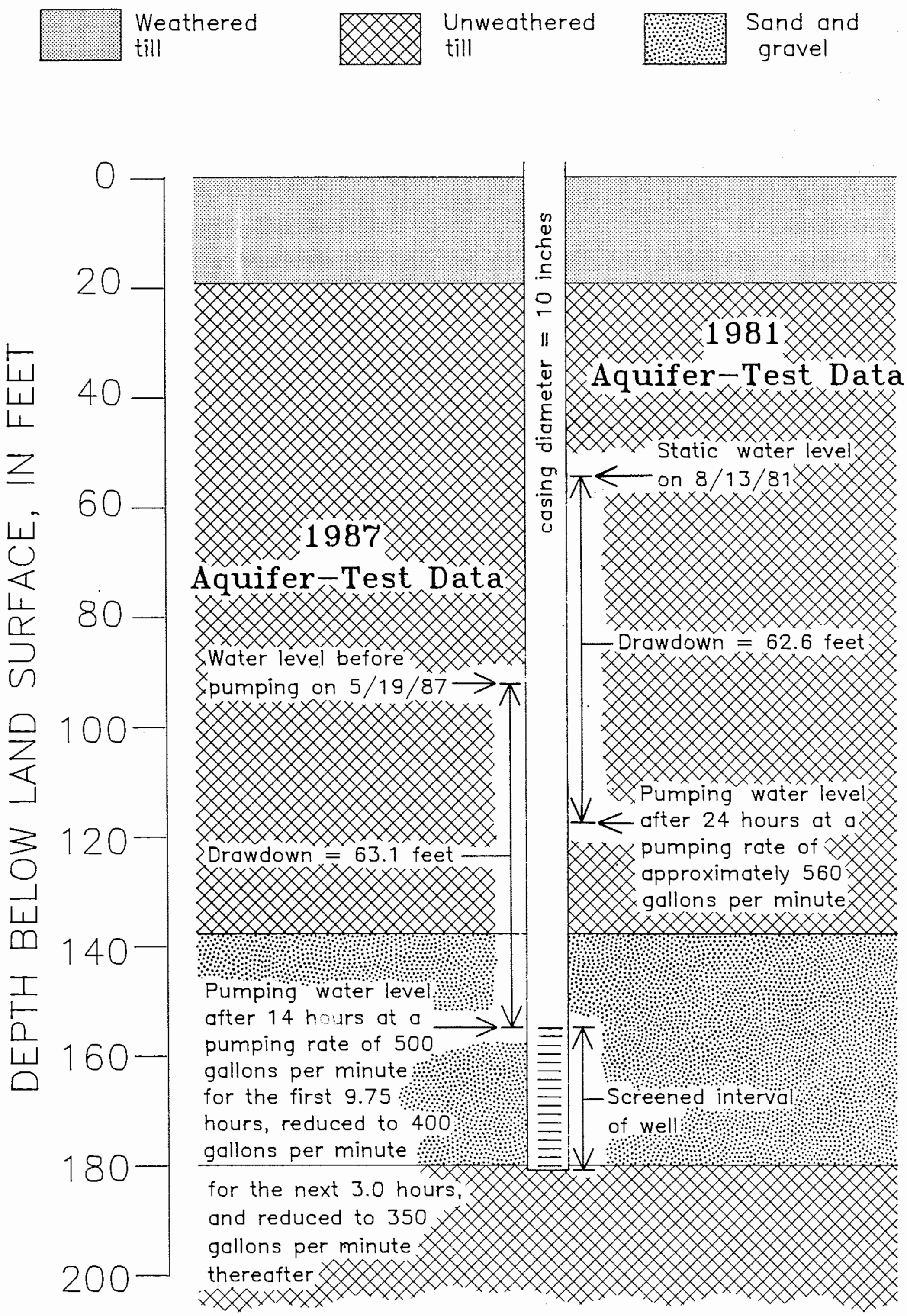


Figure 3. Static and pumping water levels in Hanson Rural Water System well 78-6 from 1981 and 1987 aquifer-test data.



below land surface and at the end of the test the water level was approximately 140 feet below land surface, which is 4 feet below the top of the aquifer (fig. 4).

Combined Test with Wells 78-5 and 78-6

In 1989, an aquifer test was conducted by concurrently pumping wells 78-5 and 78-6. The purpose of this test was to determine if these two wells could be pumped at a combined, sustainable rate of at least 375 gpm. According to Francis "Buzz" Mason, the manager of the Hanson RWS, wells 78-5 and 78-6 would need to produce 375 gpm if for any reason the main production well (79-2) is shut down. While a test duration of 48 to 72 hours is generally preferred, the duration of this test had to be limited to 9.5 hours due to the water demands of the Hanson RWS at the time.

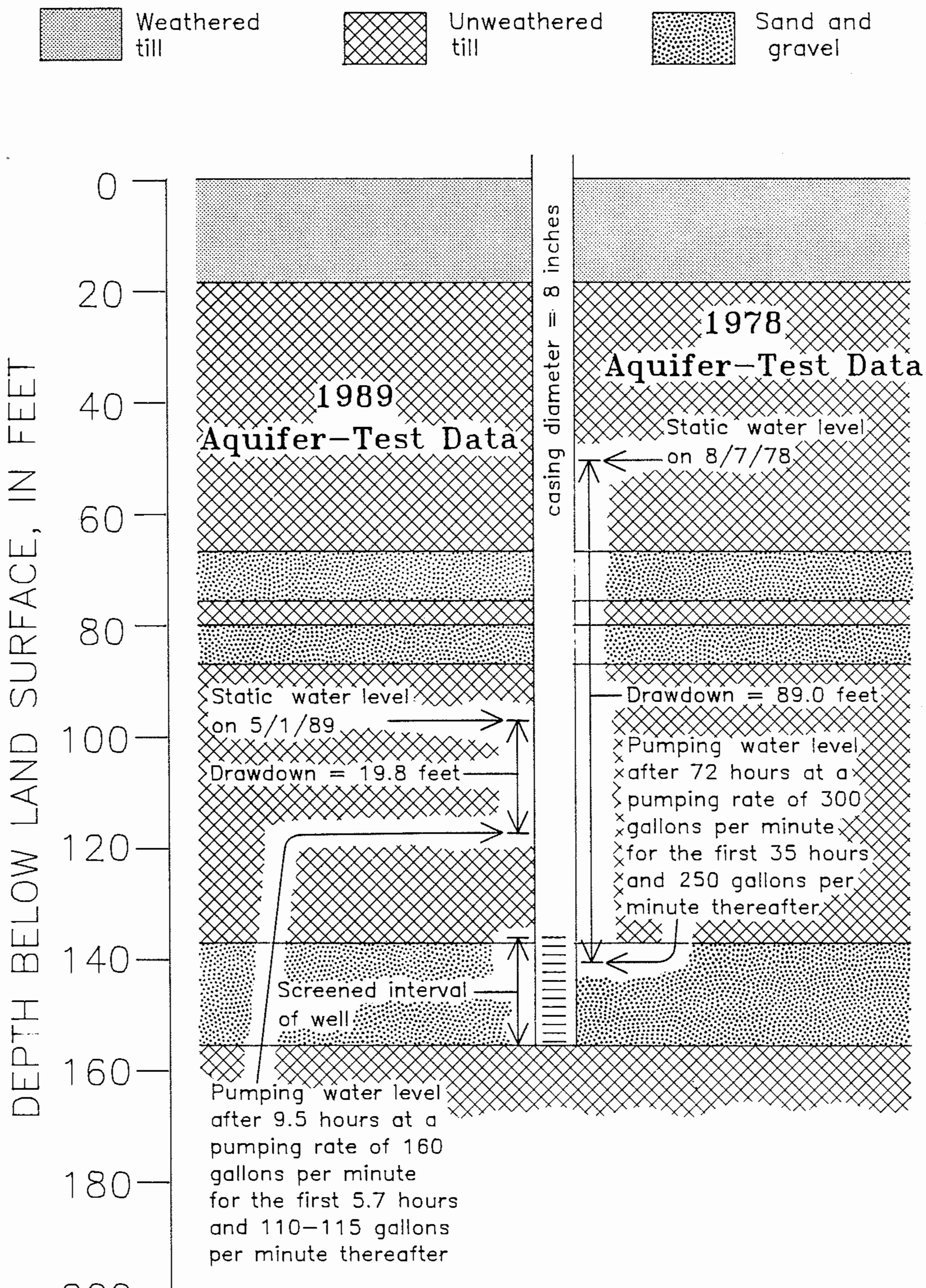
The static water levels of wells 78-5 and 78-6 were about 97 and 100 feet below land surface, respectively. Well 78-5 was pumped at a rate of 160 gpm for 180 minutes while well 78-6 remained off. Well 78-6 was then turned on, and about 20 minutes later an increase in the rate of drawdown in well 78-5 occurred, which was most likely due to the pumping of well 78-6 (fig. 5). At about 340 minutes into the test the pumping rate in well 78-5 was reduced to 110-115 gpm (fig. 5) and at about 390 minutes into the testing period the pumping rate in well 78-6 was stabilized at 300 gpm (fig. 5). The pumping rates from wells 78-5 and 78-6 yielded a combined rate of 410-415 gpm from about 390 minutes until 570 minutes into the test period, at which point the test was concluded. At the conclusion of the test, the water level in well 78-5 appeared to have stabilized at about 117 feet below land surface. The water level in well 78-6 was at about 132 feet below land surface and was dropping at a rate of about 1 foot every 3 hours at the conclusion of the test.

The top of the screen in well 78-5 is 135 feet below land surface and the top of the aquifer is 136 feet below land surface. The top of the screen in well 78-6 is 154 feet below land surface, the top of the aquifer is 137 feet below land surface, and the pump is reportedly at about 150 feet below land surface.

Results from this test indicate that the required yield of 375 gpm can be obtained by pumping wells 78-5 and 78-6 concurrently if the pumping rate of well 78-5 does not exceed 110 gpm and the pumping rate of well 78-6 does not exceed 300 gpm. Based on the depth to the top of the screens discussed above and the hydrograph shown in figure 5, these two wells should be able to maintain a combined production of 375 gpm for at least 24 hours of continuous pumping without water levels reaching the top of either screen.

The above statement about a combined, sustainable production of 375 gpm from wells 78-5 and 78-6 for at least 24 hours is valid if the potentiometric surface of the Dolton aquifer remains near its present level. However, if the water levels continue to decline in the Dolton aquifer, the pumping capacity of these two wells will be reduced. In the future, additional production wells may have to be constructed to the east or southeast of the present well field to maintain required pumping rates.

Figure 4. Static and pumping water levels in Hanson Rural Water System well 78-5 from 1978 and 1989 aquifer-test data.



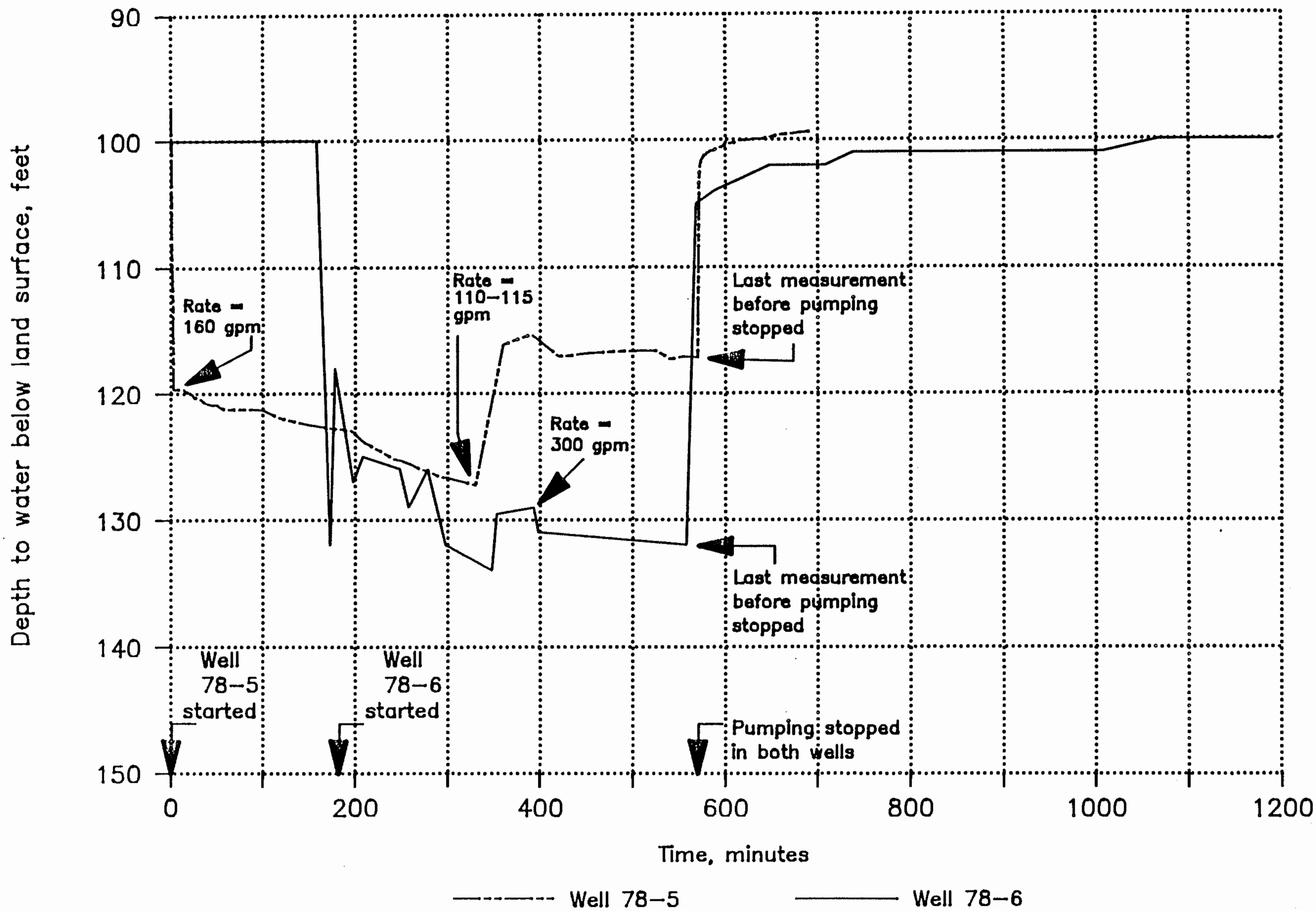


Figure 5. Hydrograph of wells 78–5 and 78–6 during a 1989 aquifer test.

WATER QUALITY IN THE DOLTON AQUIFER

The Dolton aquifer has water-quality characteristics not common to other glacial aquifers. It consists of a zone of good-quality water approximately 15 square miles in size near the center of the aquifer surrounded by poorer-quality water (fig. 6). This zone of good-quality water is characterized by total dissolved solids (TDS) concentrations less than 1,000 milligrams per liter (mg/L) and contains areas with TDS concentrations less than 600 mg/L. In the area of poorer-quality water, TDS concentrations can exceed 3,000 mg/L. Both the Hanson RWS and the TM RWS have developed their well fields in the zone of good-quality water and both well fields are less than a mile away from the area of poorer-quality water.

Water-quality analyses from the Hanson RWS and the TM RWS well fields between 1983 and 1988 indicate that TDS, sulfate, and hardness concentrations are increasing in the well fields. In Hanson RWS well 79-2, from 1983 to 1988 the TDS increased from 590 to 828 mg/L, the sulfate increased from less than 12 to 136 mg/L, and the hardness increased from 101 to 124 mg/L. In TM RWS well no. 1, from 1983 to 1988 the TDS increased from 537 to 639 mg/L and the hardness increased from 72.4 to 100 mg/L. Also in TM RWS well no. 1, from 1983 to 1986 the sulfate increased from less than 12 to 19.4 mg/L.

As the Hanson RWS and the TM RWS continue to pump from the Dolton aquifer, poorer-quality water is induced into the zone of good-quality water. Therefore, degradation of water quality in the well fields of both rural-water systems is likely to continue.

CONCLUSIONS

1. Hanson RWS production wells 78-5 and 78-6 can be pumped together to meet the required production of 375 gpm for at least 24 hours if well 79-2 is shut down, provided the individual pumping rates in wells 78-5 and 78-6 do not exceed 110 gpm and 300 gpm, respectively. However, this combined pumping rate probably will be reduced if the potentiometric surface of the aquifer declines significantly from its current level.

2. Withdrawal of water has lowered water levels (head pressure) in the wells penetrating the Dolton aquifer in this area. The decrease in pumping capacity of the Hanson RWS wells is attributed mainly to lowering of the water level in the aquifer. Water-level decline in the aquifer will probably continue and thus, additional production wells will have to be installed in the future by the Hanson RWS to maintain current production rates. Also, water-level decline will have a similar impact on other wells in the Dolton aquifer.

3. The areal extent of the Dolton aquifer is currently being defined. Continuous decline of water levels in the extent of the aquifer that has been monitored indicates that the cone of depression created by the combined pumping wells in the aquifer has not intercepted sources of recharge equal to or greater than withdrawals.

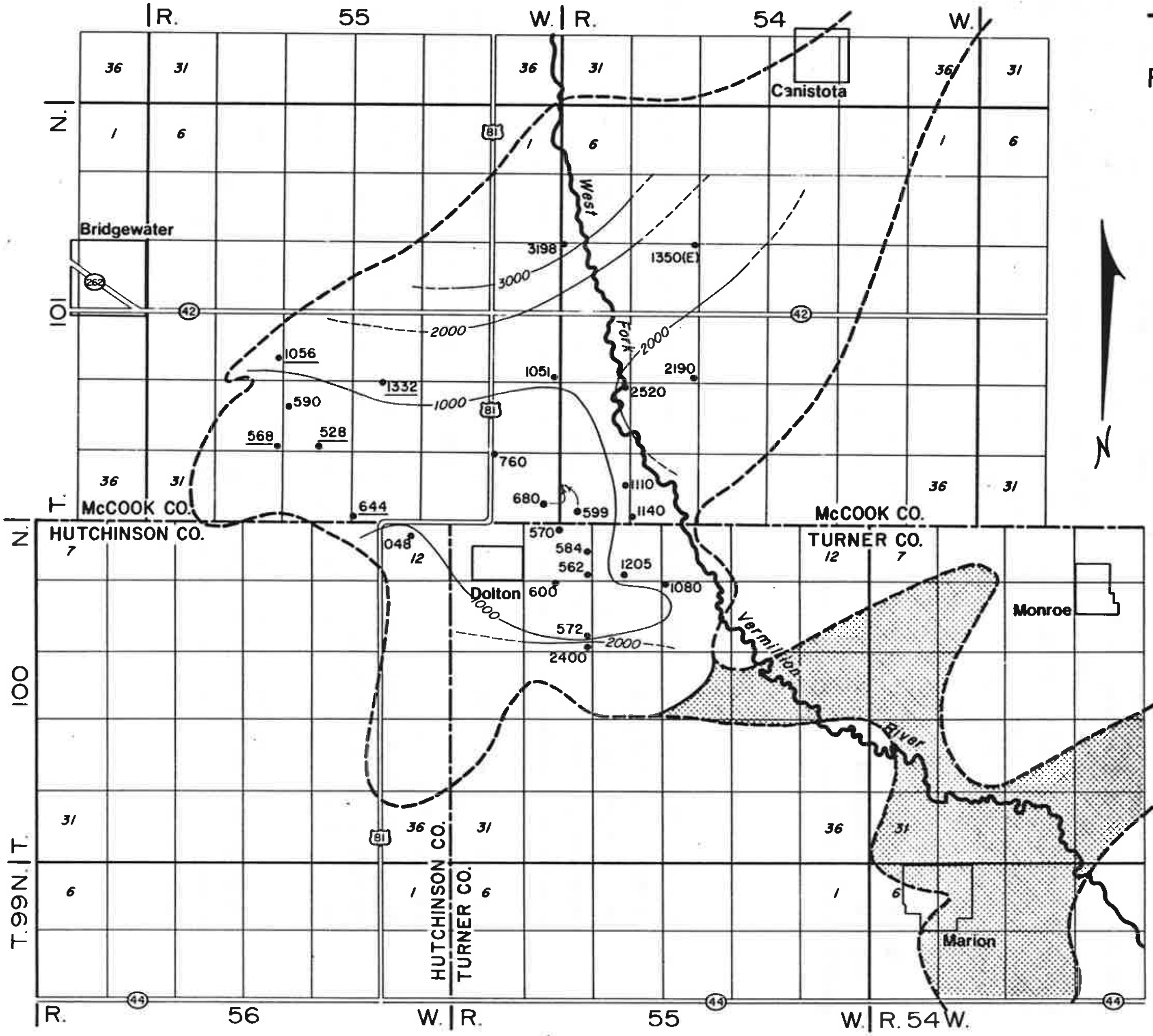


Figure 6. Total dissolved solids concentrations in the Dolton aquifer, 1983-1984.

600 • Well. Number is total dissolved solids (TDS) concentration in parts per million (milligrams per liter). Analytical results are from 1983-84, except underlined numbers which are from 1979-80. The letter E indicates number was estimated from the electrical conductivity.

1000 Line connecting points of equal TDS concentration. Contour interval = 1,000.

Approximate aquifer boundary.

Area which is tentatively considered part of the Dolton aquifer.

0 1 2 3 4 5 Mi.
SCALE

4. Degradation of water quality in the area of the Hanson RWS and TM RWS well fields will likely continue. While the rate of degradation will be gradual, treatment for some of the parameters that continue to increase in concentration may eventually be required.

5. At this time, the Dolton aquifer could physically sustain greater withdrawal rates than it is presently experiencing. However, based on the data and interpretations presented in this report and the fact that the water requirements of the Hanson RWS and the TM RWS continue to increase, the Dolton aquifer will not likely be able to supply a sufficient quantity and quality of water in the long-term future for these rural water systems. Development of alternate or additional sources of water will likely be needed within the next 15 years. Since the development of alternate or additional sources of water will require time, it is recommended that steps be taken to solve this problem in a timely manner.