EXECUTIVE SUMMARY

Hydrogeology and Computer Simulation of the Sundre Aquifer System

Ward and McHenry Counties, North Dakota

By
Steve W. Pusc

North Dakota Ground-Water Studies
Number 92 - Part II
North Dakota State Water Commission
Vernon Fahy, State Engineer

Prepared by the
North Dakota State Water Commission
In Cooperation with the
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The Sundre aquifer system is a sequence of water bearing sands and gravels which occupy portions of a buried bedrock valley in Ward and McHenry Counties (figures 1 and 2). Width of the Sundre aquifer ranges from 1 to 2 miles (figure 2). Thickness varies from 30 feet just southeast of Minot to 250 feet thick in the Souris River valley (figures 3 and 4). Length of the Sundre aquifer is approximately 18 miles (figure 2).

In the Souris River floodplain, the Sundre aquifer is overlain by water bearing sands and gravels of the Souris Valley aquifer (figure 3). In the upland areas adjacent to the Souris River valley, the Sundre aquifer is overlain and confined by a thick layer of glacial till (figure 4). Bedrock underlying the area consists of consolidated silt, clay and sandstone units of the Fort Union Formation (figures 3 and 4).

Well yields from the Sundre aquifer range from 2–5 gpm from small diameter domestic wells to 2800 gpm from well D of the Minot well field. Presently, the city of Minot has five large capacity wells which draw ground water from the Sundre aquifer system. Average water use since 1976 has been 2.1 million gallons per day (mg/d). Water use in 1985 was 2.6 mg/d.

Prior to development, water–level fluctuations and ground–water movement in the Sundre aquifer system were controlled by the stage of the Souris River, precipitation, and evapotranspiration. Lowest ground–water levels were in the late fall in response to evapotranspiration and low river stage. During this time period the Souris River valley acted as a regional discharge area and all ground–water movement in the Sundre aquifer was directed toward the river valley (figure 5). Ground–water levels generally rose in the spring in response to precipitation (snow melt) and high Souris river stage. During this time period the Souris River valley acted as a regional recharge area and all ground–water movement in the Sundre aquifer was directed away from the river valley (figure 5).

Highest ground–water levels were recorded during extreme flood events of 1969,

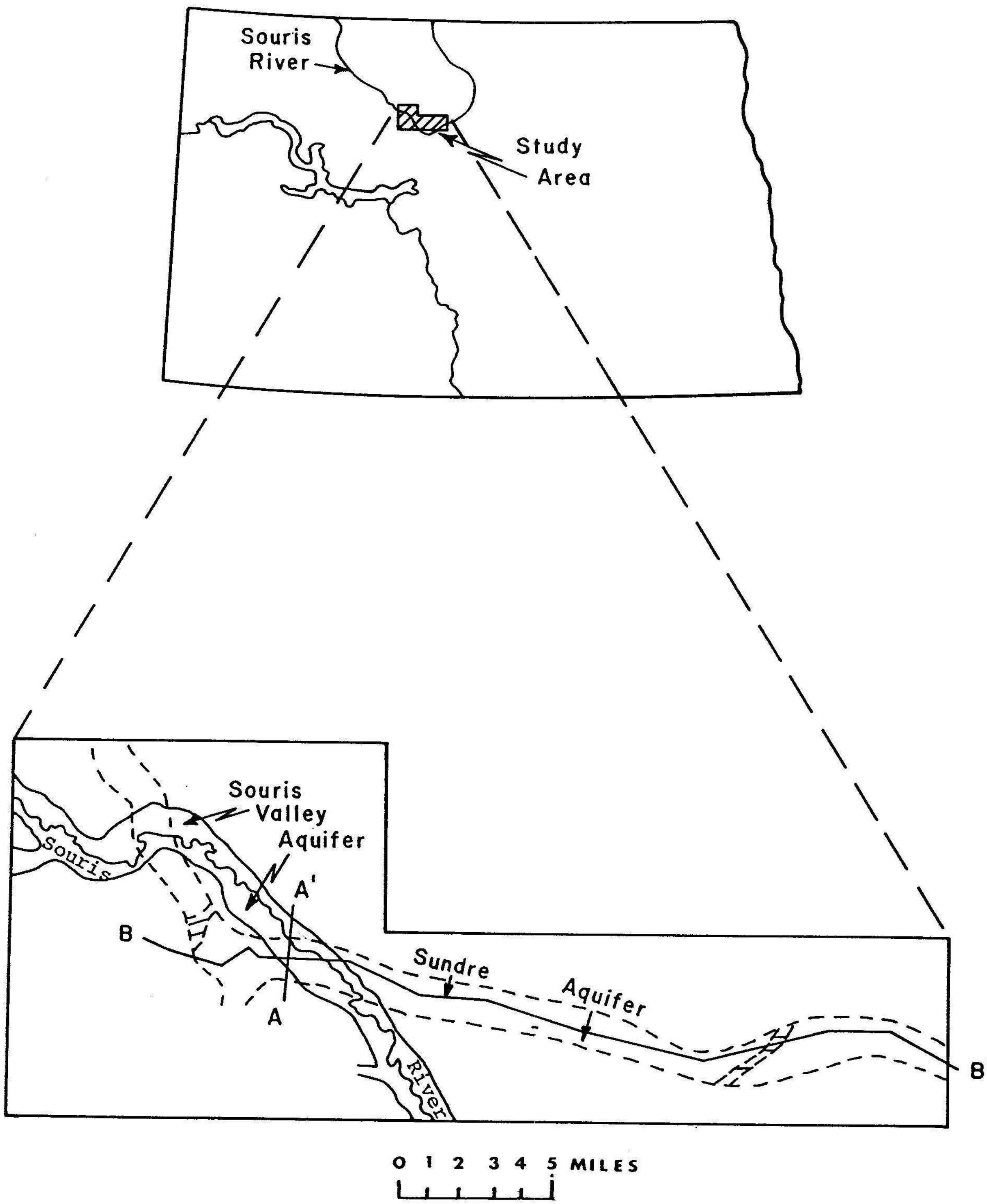


Figure 1

Map showing the location of the Sundre Aquifer system study area .

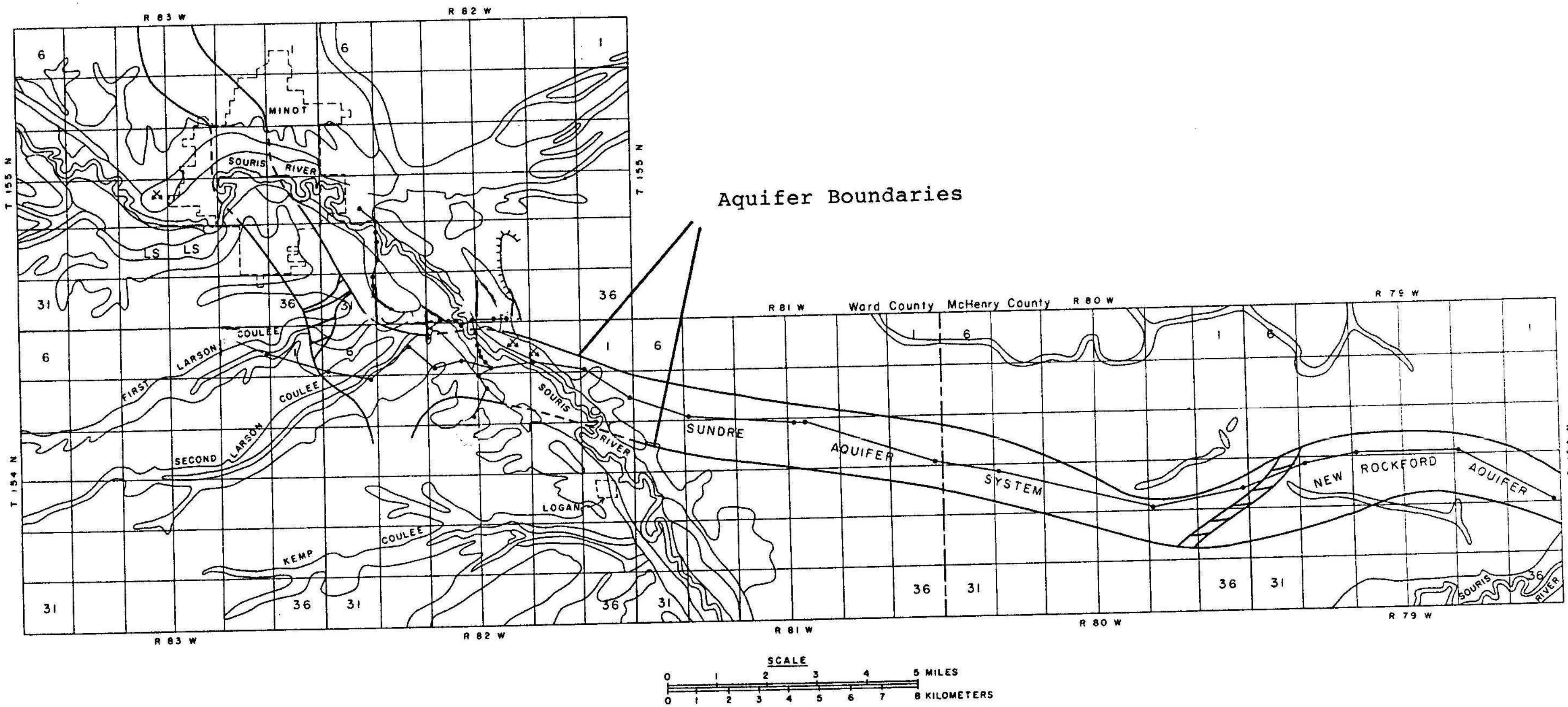


Figure 2. Map showing boundaries of the Sundre Aquifer System

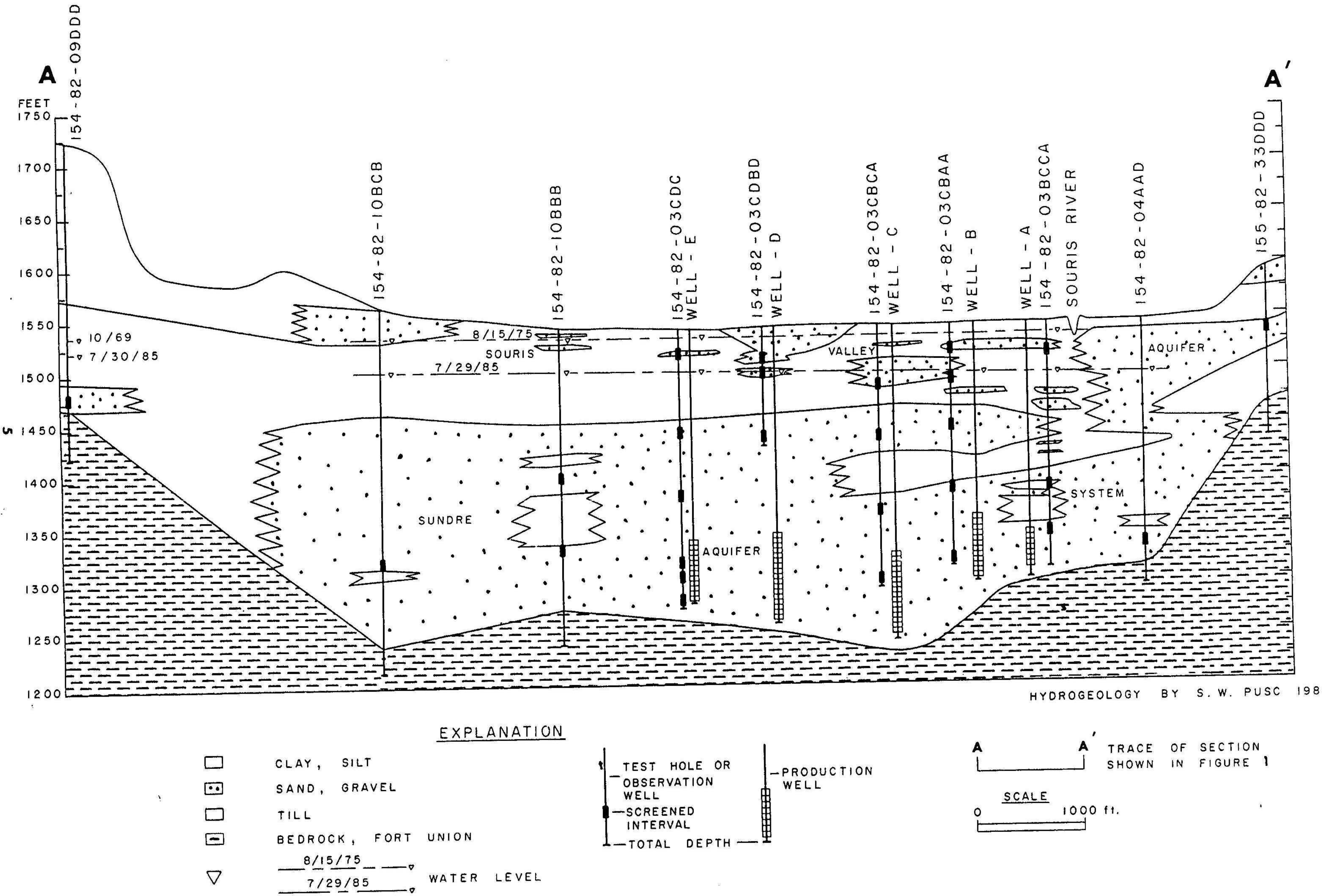


FIGURE 3.—Hydrogeologic section A-A′ showing the Souris Valley aquifer and Sundre aquifer in the vicinity of Minot's Sundre well field.

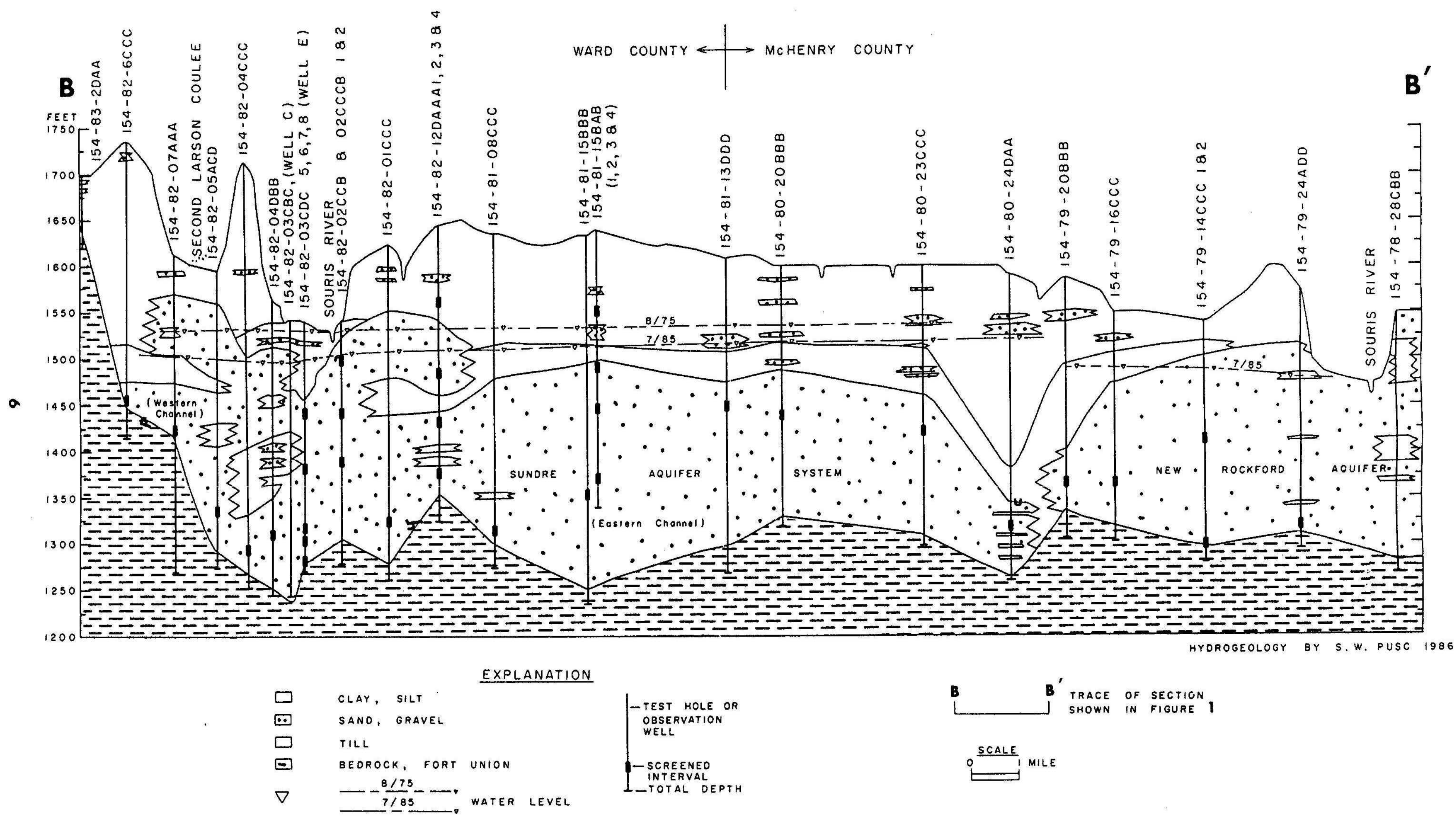
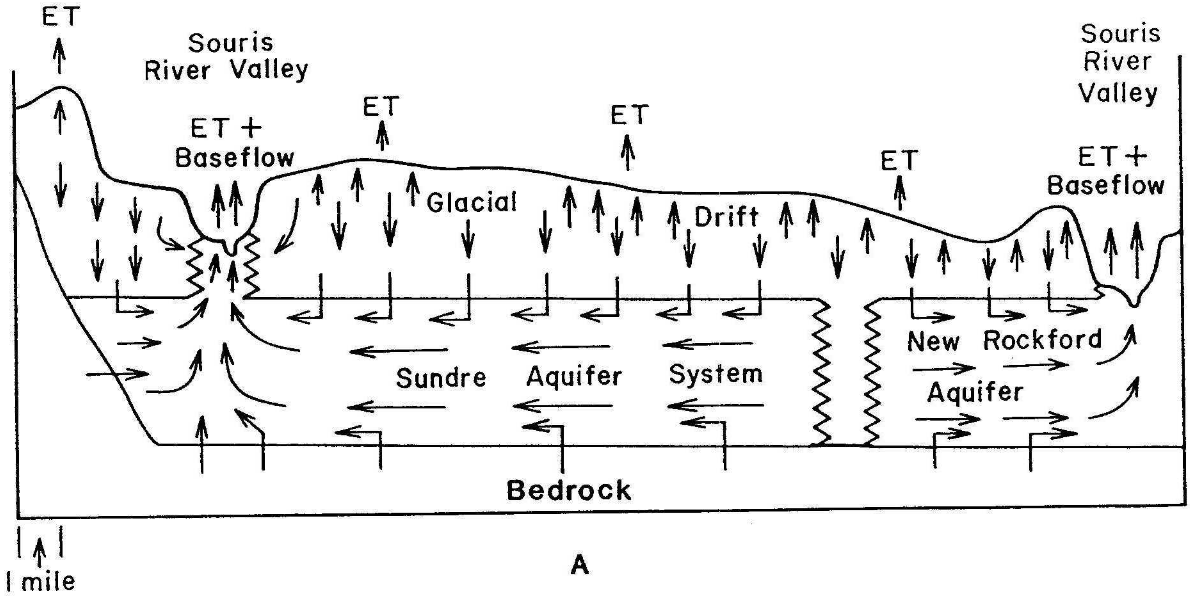
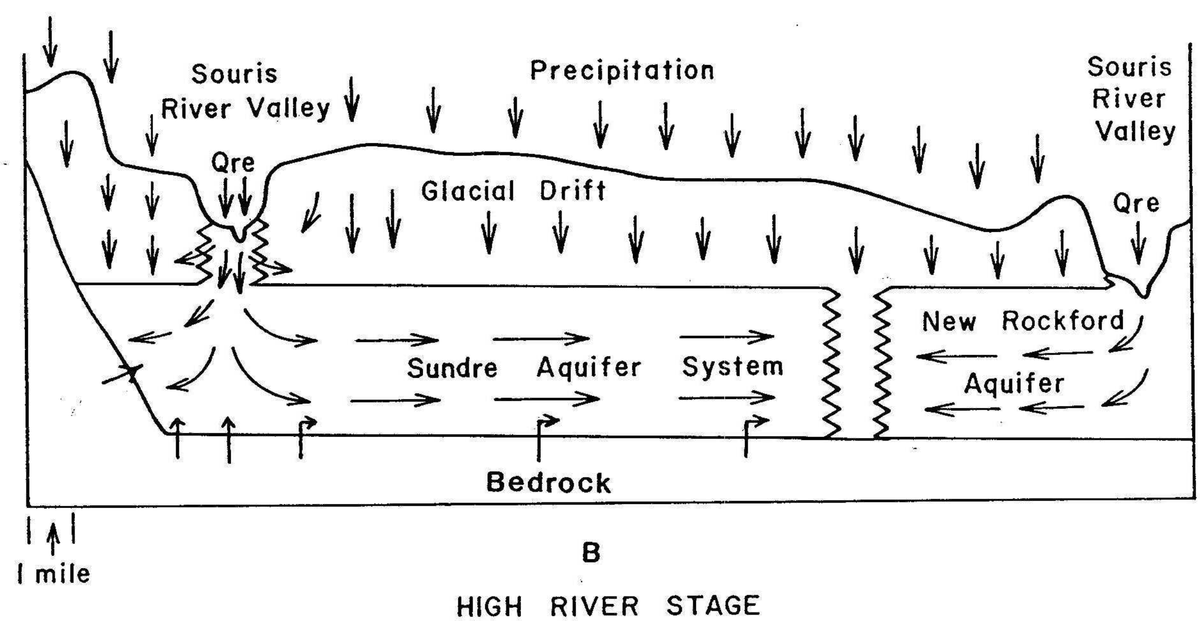


FIGURE 4. Hydrogeologic section B-B′ along the axis of the Sundre Aquifer system and the New Rockford Aquifer.



A

LOW RIVER STAGE
EVAPOTRANSPIRATION



B

HIGH RIVER STAGE
HIGH AREAL RECHARGE

FIGURE 5 . SCHEMATIC OF GROUND WATER FLOW IN THE SUNDRE AND SOURIS VALLEY AQUIFERS UNDER NATURAL CONDITIONS.

1970, 1974, 1975, and 1976. It appears that overbank flooding increased both recharge area and residence time, thereby increasing overall recharge for those particular high river stage events.

Channelization of the Souris River below Minot, to accommodate flood flows, was completed in 1976. Because of these efforts, inundation of the Souris River floodplain should not occur with the same frequency as it once did. Consequently, flood control efforts would reduce the amount of natural recharge to the Sundre aquifer by preventing major overbank recharge events. Data to conclusively substantiate this hypothesis is presently insufficient.

In 1985, fluctuations of ground–water levels and movement in the Sundre aquifer are dominated by pumping patterns of the Sundre well field. The cone of depression created by the pumping wells directs ground water in the Sundre aquifer toward the well field from all directions. During periods of heavy use (summer) water levels decline, and during less use (winter) water levels recover. Ten years of pumping has resulted in 17 to 25 feet of water level decline in the eastern channel of the Sundre aquifer (figure 4). In the well field, declines of 31 to 40 feet have occurred (figure 3). The water level decline occurring as a result of pumping, however, represents a very small percentage of the total amount of water available in storage (figures 3 and 4).

Ground–water quality, before development, ranged from a very good quality water in the shallow Souris Valley aquifer and underlying Sundre aquifer to a rather poor quality water in the eastern and western channels of the Sundre aquifer. Pumping of the Sundre wells over the past 10 years has drawn poorer quality water from the eastern channel of the Sundre aquifer towards the southern end of the well field. Recharge of good quality water from the Souris River and overlying Souris valley aquifer has kept the quality of ground water in the northern end of the well field constant. Ground–water quality in the Sundre aquifer now not only varies according to location within the ground–water flow system but also as a result of pumping pattern of the wells.

A mathematical three–dimensional ground–water flow model was developed to simulate ground–water movement in the Sundre aquifer system. The model simulates hydrologic conditions prior to development (1970–1975) and following the introduction of pumping wells (1976–1985). The model was calibrated by comparing model generated water levels with measured water levels.

The computer model simulation indicated that, before development (1970–1975), 67% of the annual recharge entered the system as precipitation and snowmelt. Only about 3% was derived from the river, while 30% was derived from storage. Discharge from the model before development was evenly divided between evapotranspiration, leakage into the river and water out of storage.

Pumping of wells from 1976–1985 changed the dynamic equilibrium of the system. About 88% of the water leaving the system within the model was from pumping wells. Ten percent (10%) of the water in the model was derived from storage within the aquifer. A portion of the water pumped was derived by reducing ground water discharging into the river (from 33 to 1%). Lowering of water levels also caused a large reduction in the amount of water leaving the system via evapotranspiration (35 to 2%). Most of the ground water in the model was derived, however, by increasing the amount of water leaking from the river into the aquifer (3 to 63%). No significant impacts to the river are expected, given that the average annual well discharge (2.1 mg/d) only represents a very small percentage of the average annual river flow (109 mg/d). The model does, however, point out the importance of the Souris River and Souris River valley to the long term productivity of the Sundre aquifer system.

The computer model of the Sundre aquifer system suggests that the following processes presently dominate ground–water flow in the area: 1) well pumpage from the Sundre aquifer, 2) leakage from the Souris River into the Souris Valley aquifer, 3) leakage from the overlying Souris Valley aquifer into the Sundre aquifer, 4) storage within the aquitards, and 5) areal recharge. A thorough knowledge of each one of these complex processes will be needed before a reliable predictive computer model of the Sundre auqifer system is possible.

The Sundre aquifer system is highly productive. Under present rates of withdrawal the water levels have stabilized with a relatively small decline. Larger withdrawals will result in a short interval of additional water level decline and then stabilize at some lower level. The total yield potential cannot be determined, however, the capacity of the aquifer is significantly larger than the amount currently being pumped. An increase in pumping, however, may result in some further change in water quality.