NORTH DAKOTA

WELLHEAD PROTECTION

Hydrologic Assessment and Delineation of Wellhead Protection Areas for the City of Towner, North Dakota

By
Christopher D. Bader
and
Scott A. Radig

North Dakota Ground-Water Studies
Number 97
North Dakota State Water Commission

Prepared by the
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INTRODUCTION

In 1986, the amendments to the Safe Drinking Water Act (SDWA) provided for the development of a Wellhead Protection (WHP) Program designed to protect groundwater derived public water systems from potential contaminant sources. The goal of the WHP Program is to promote the protection of groundwater resources through local governmental entities such as municipalities and regional water resource districts. As mandated by the 1986 SDWA requirements, the North Dakota State Department of Health and Consolidated Laboratories has developed and is implementing a WHP Program.

The North Dakota Wellhead Protection Program addresses each of the following elements required by the SDWA:

1. Roles and duties of State agencies, local governments, and public water systems, with respect to the development and implementation of WHP programs.

2. Delineation of a Wellhead Protection Area (WHPA) around each public water supply well, utilizing reasonably available hydrogeologic information.

3. Identification of potential contaminant sources within each WHPA that may have adverse effects on the groundwater environment or public health.

4. Development of management approaches to protect the groundwater resource within each WHPA from potential contaminant sources.

5. Development of contingency plans for use in the case of an emergency that could threaten the quality of the groundwater resource or affect its suitability as a public water supply.

6. Locating new wells in areas that have a low probability of being contaminated.

7. Public participation in the development and implementation of the WHP Program.

The city council of Towner has chosen to participate in the North Dakota WHP Program. In May, 1989, the North Dakota State Department of Health and Consolidated Laboratories (NDSDHCL), the North Dakota State Water Commission (NDSWC), and the City of Towner entered into a cooperative agreement to complete a hydrogeologic investigation of the area surrounding Towner's municipal well field in order to delineate an appropriate WHPA.

Purpose and Objectives

The purpose of this report is to delineate a wellhead protection area for Towner's municipal wells which will establish the basis for implementing a WHP program for the city of Towner. In order to delineate a WHPA, an understanding of the hydrogeologic setting of the area surrounding Towner's municipal wells is required, which includes:

1.) Size and shape of the aquifer system contributing to Towner's municipal water supply.

2.) Groundwater flow characteristics of the aquifer system and the physical relationship between the aquifer material and adjacent material, as well as, the interaction between the surficial aquifer system and the Souris River.

3.) Water quality characteristics of the surficial aquifer, the underlying bedrock aquifer material, and the surface water reservoir.

The establishment of a wellhead protection area for the City of Towner will require designation of zone of contribution (ZOC) surrounding the municipal wells, which is defined as follows:

Zone of Contribution - the area contributing water to the city's wells, which would include the entire groundwater flow system contributing water to the municipal wells, as well as, any component of the surface water systems contributing to the municipal wells.

Description of Study Area

The study area consists of approximately 25 square miles surrounding the city of Towner in McHenry County (figure 1). The study area includes parts of Township 156 North, Range 76 West; Township 157 North, Range 75 West; and Township 157 North, Range 76 West. Towner's municipal well field is centrally located in the study area on the northern side of Towner in the NW1/4 Section 11, Township 156 North, Range 76 West.

The study area is situated in the Glacial Lake Souris Plain of the Central Lowland physiographic province in north-central North Dakota (figure 1). The study area is located on parts of two alluvial terrace features along the Souris River, and relief

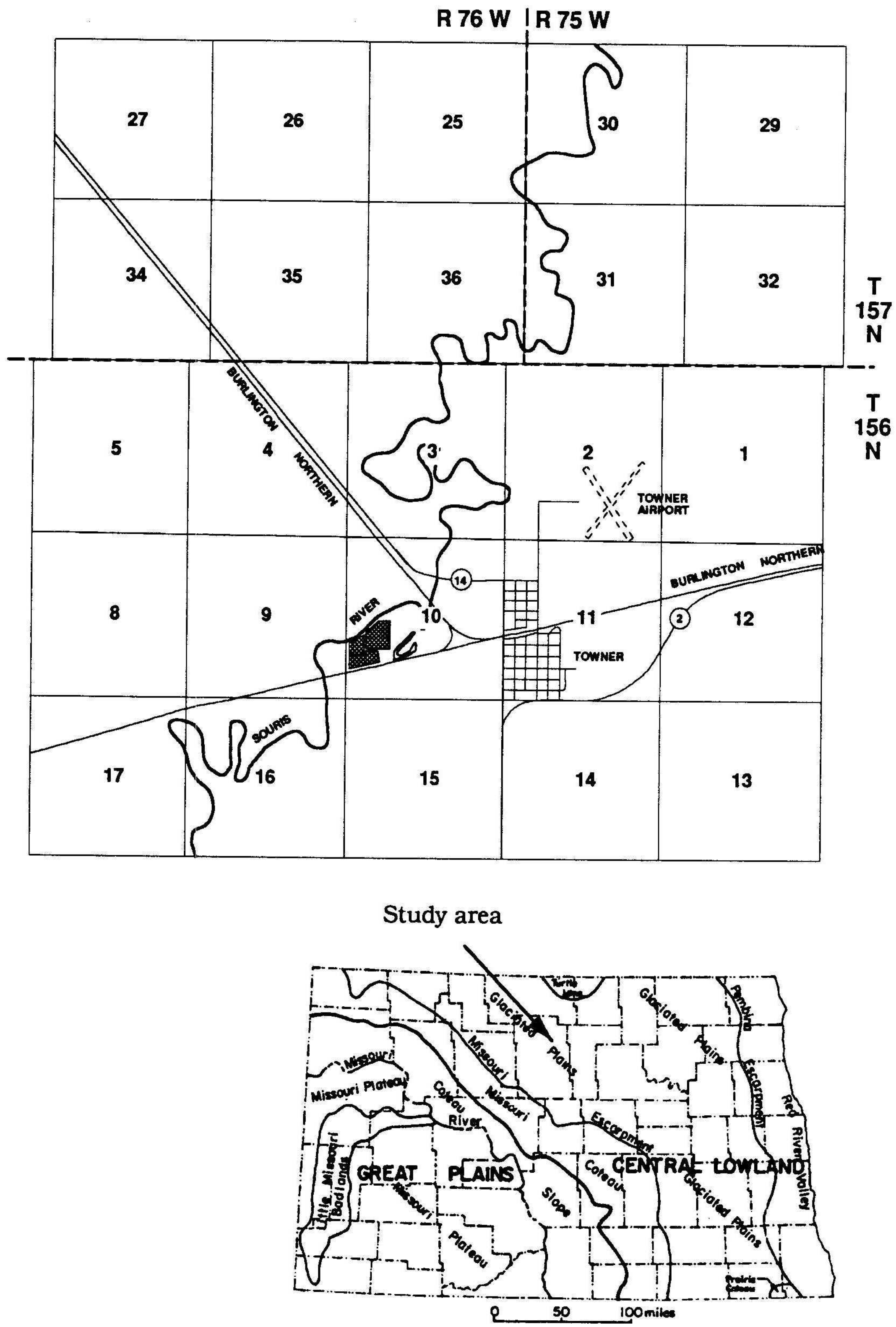

Figure 1 - Location of the study area.

within the study area is dominated by the terrace features. Elevation ranges from 1450 feet along the Souris river to 1505 feet in the southeast corner of the study area. The majority of the study area is located either on the current flood plain or the lower terrace of the Souris River valley, and generally, the elevation ranges from 1450 to 1480 feet.

Previous Investigations

The geology and groundwater resources of McHenry County were first described by Simpson (1929, p. 156-161) as part of an overview of groundwater resources within the state of North Dakota. Paulson and Powell (1957) completed a study of the geology and groundwater resources near Upham, in north-central McHenry County for purposes of defining groundwater resources for potential development as either a domestic or municipal supply. The geology of the Souris River area was further defined by Lemke (1960) as part of a program of the Department of the Interior for development of the Missouri River basin.

Adolphson (1961) published a report entitled, *Geology and Groundwater Resources of the Drake area, McHenry County, North Dakota*, which was completed on a cooperative basis by the U.S. Geological Survey and the North Dakota State Water Conservation Commission. The report was completed as part of a state-wide program which was originally implemented for purposes of defining groundwater resources that could provide the potential for development for municipal and domestic water supplies.

LaRocque, Swenson, and Greenman (1963) completed a study entitled, *Groundwater in the Crosby-Mohall Area, North Dakota.* The study was completed as part of the program of the Department of the Interior for the development of the Missouri River basin. The study focuses on the groundwater resources within the Souris River basin and the potential impacts of infiltration from irrigation and potential drainage problems associated with a large irrigation proposal which was part of the Missouri-Souris Diversion proposal.

A county groundwater survey was completed for McHenry County on a cooperative basis by the NDSWC, the North Dakota State Geological Survey (NDGS), and the United States Geological Survey (USGS). The groundwater survey was published in three parts. *Part I*

- *Geology of McHenry County, North Dakota* (Bluemle, 1982) describes the surface and subsurface geology in McHenry County. *Part II - Groundwater Data for McHenry County, North Dakota* (Randich, 1981) includes lithologic logs, chemical analyses, and water level records for wells and test holes within the McHenry county area. *Part III - Groundwater Resources of McHenry County, North Dakota* (Randich, 1981) describes the hydrogeology of McHenry County including the water yielding potential and chemical properties of the water from the major bedrock, glacial, and alluvial aquifers within the area (Randich, 1981).

Methodology

In addition to the available test hole information, test holes were drilled at 37 sites using a forward mud rotary drilling rig. Twenty three of the test holes were drilled during July of 1989, while the additional 14 test holes were drilled during June of 1990. Lithologic logs were prepared by the site geologist and driller's logs were completed by the driller for each site. Piezometers were installed at 26 of the 37 test hole locations. Water levels were measured at each of the piezometer sites, and water samples were obtained from each piezometer for water quality analysis. The location of all of the test holes and observation wells located within the study area are presented in figure 2. Lithologic logs for all of the test holes and wells are included in Appendix A.

Piezometer Construction

The piezometers were constructed of 2-inch diameter SDR 21 pvc pipe with either a 0.012 inch or 0.018 inch slot PVC screen. Piezometer lengths varied depending upon aquifer depth at the site location. The majority of the piezometers were constructed with 5 feet of screen with the exception of the wells located at 156-076-02DAA2, 156-076-11ADB2, and 156-076-11BAAC2 in which 10 feet of screen was installed. In each of the piezometers a check-valve was attached at the bottom of the screen. The screens in the majority of the piezometers were typically installed in the basal 5 feet of aquifer. The screens installed in wells 156-076-02DAA2, 156-076-11ADB2, and 156-076-11BAAC2 were installed at a depth that intersected water levels for purposes of obtaining representative water quality samples from the aquifer. The piezometer casing and screens were assembled with a PVC solvent weld cement.

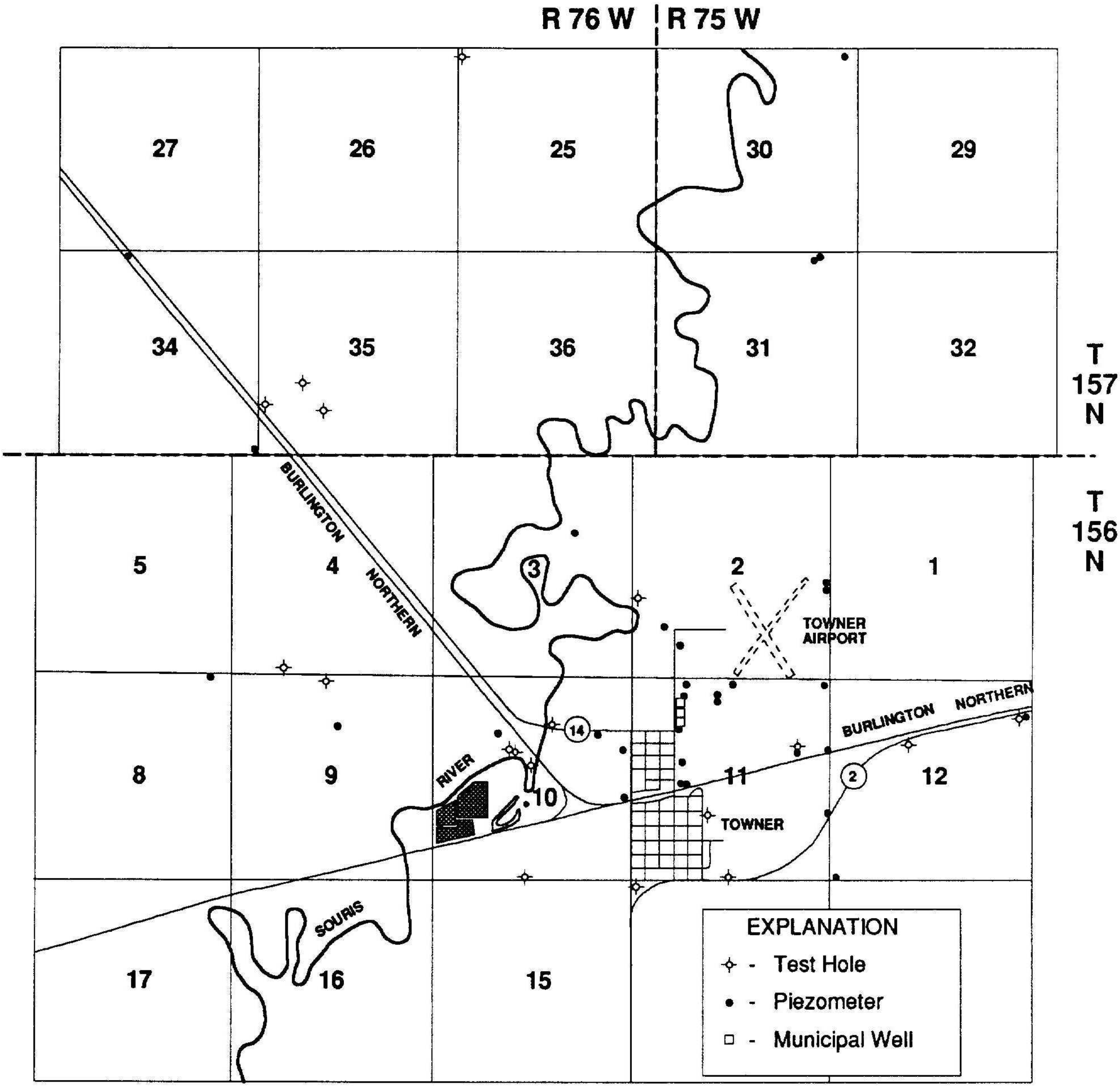

Figure 2 - Location of test holes and piezometers within the study area.

Upon installation of the casing, screen, and check valve assembly in the test hole, the test hole was back-washed with fresh water to remove the drilling fluid. A sand pack was placed around the screen using a 1.25-inch diameter PVC tremie pipe that was inserted in the annular area between the wall of the hole and the casing. The sand pack consisted of a #10, medium size quartzose sand. With the sand pack in place, the tremie pipe was used to inject a slurry consisting of a Volclay grout mixture from the top of the sand pack to land surface. After the cement was allowed to set, a bentonite grout was placed from the settled cement surface to land surface.

Upon completion of the installation of the piezometers, most of the piezometers were pumped with air using an air compressor. Some of the piezometers which could not be pumped using air-lift methods were bailed manually.

Water Level measurements

Beginning in August 1989, water levels were measured weekly in each of the piezometers. Weekly water level measurements were made by Towner's city maintenance personnel and were cross-referenced by monthly measurements made by NDSWC personnel. Water levels were measured by extending a chalked, steel tape into the piezometers and recording the depth to water from the top of the piezometer to the nearest 0.01 foot. The elevation of the top of the piezometer or the M.P. (measuring point) was established to the nearest 0.01 foot using differential leveling techniques.

In addition to measuring the water levels of the piezometers, the water level of the Souris River was measured to the nearest 0.1 foot from the Highway 14 bridge approximately 1/2 mile west of Towner. A measuring point was arbitrarily established on the bridge railing, and the measuring point was surveyed to the nearest 0.01 foot using differential leveling techniques.

Chemical sampling procedures

Water samples were collected for major cation-anion analyses from each of the piezometers. The chemical analyses for all of the samples obtained from the piezometers installed during July of 1989 were performed by the NDSDHCL. The chemical analyses for the additional samples collected from the test wells installed during June of 1990 were performed by the NDSWC Laboratory.

Each well was developed with compressed air to remove excess drilling fluid and potential contamination from the screen, sand-pack, and adjacent formation. The samples were collected after a volume equivalent to three times the static water column was purged from each well. Both the temperature and the conductance were measured in the field as the samples were collected. Water samples were collected from the majority of the piezometers using either a submersible pump or air-lift methods to pump the water. Water samples were also collected from the piezometers that could not be pumped with either the submersible pump or air-lift methods with a Teflon bailer.

Water samples for major cation-anion analysis included 500 milliliters of raw water, 500 milliliters of filtered water, and 500 milliliters of filtered water which was acidified with nitric acid. A 0.45 micron filter was used to obtain the filtered samples. The water quality analyses are included in Appendix B.

Location-Numbering System

The description used to denote a well or test hole location is based upon the federal system of rectangular surveys of public land (figure 3). The first number identifies the township north of an established baseline, and the second number identifies the range west of the Fifth Principal Meridian. The third number identifies the section within the designated township and range in which the well or test hole is located. The letters A, B, C, and D designate, respectively, the northeast, northwest, southwest, and southeast quarter section (160 acre tract), quarter-quarter section (40 acre tract), and quarter-quarter-quarter (10 acre tract). Therefore, a well identified as 156-076-11BAC would be located in the SW1/4 NE1/4 NW1/4 Section 11, Township 156 North, Range 76 West. Consecutive terminal numbers are added if more than one well is located in a given 10 acre tract, i.e., 156-076-11CAB$_1$ and 156-076-11CAB$_2$

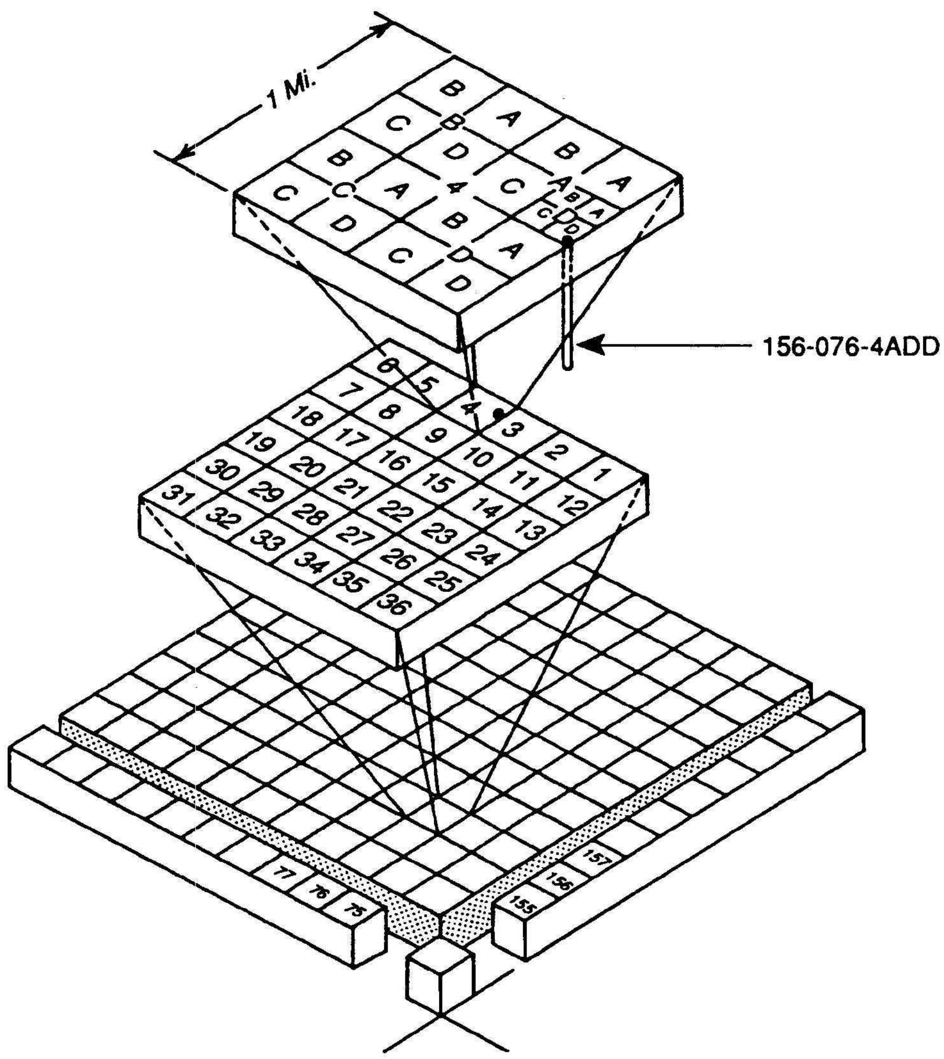

Figure 3 - Location-numbering system.

Acknowledgements

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GEOLOGIC SETTING

Regional Geology

Surface Geology in the vicinity of Towner is dominated by Late Wisconsin glacial activity. Shortly after the advance of the Late Wisconsin glacier had stagnated, the active glacial margin receded to the vicinity of Velva (Bluemle, 1982) creating some ponding in eastern McHenry County. The receding glacier created meltwater streams which drained to the southeast. As the recession of the glacier was beginning to stabilize the Souris ice lobe surged and rapidly advanced southeastward across southeastern McHenry County.

The Souris River channel was established upstream of Velva by meltwaters discharged from the Des Lacs River Valley northwest of Minot. The Souris River valley was cut off by the Souris ice lobe, and meltwaters were diverted to the southeast through the Velva diversion channel (Lemke, 1960). As the ice margin of the Souris lobe retreated, the Velva diversion channel was abandoned and diversion was established further to the northeast in the Lake Hester diversion channel and later in the Verendrye diversion channel (figure 4). Finally, after the ice had retreated to a position north of the Souris River valley, meltwaters drained directly into glacial Lake Souris.

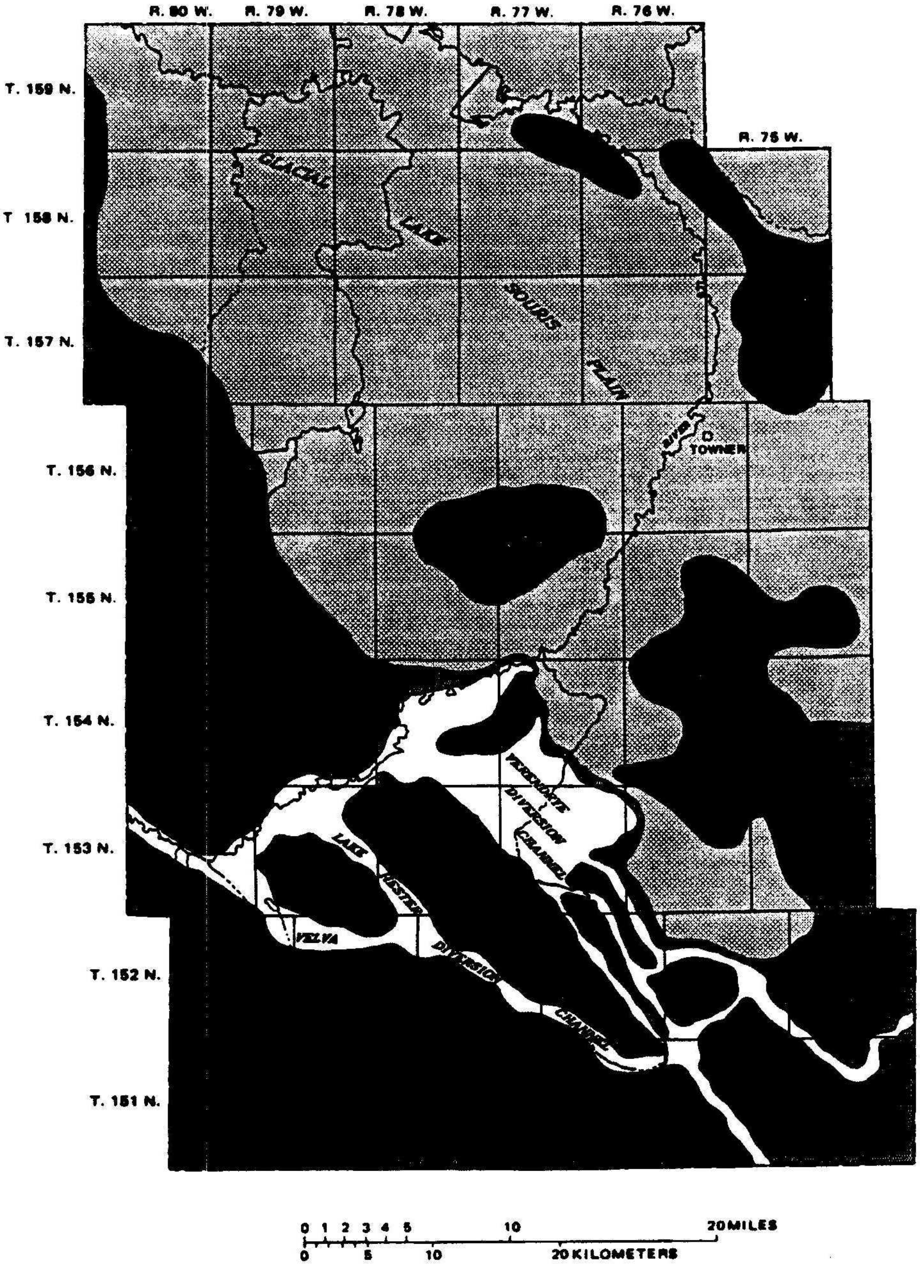


Figure 4 - Regional glacial geology of the McHenry County area.

The active ice margin of the Souris lobe retreated from McHenry County, and early glacial Lake Souris was formed in front of the ice margin which flooded much of eastern and northern McHenry County (Bluemle, 1982). As the stagnant ice melted and the ice margin continued to recede, glacial Lake Souris expanded and flooded much of the northern 2/3 of the county. The majority of the small streams established by glacial meltwaters were discharging into glacial Lake Souris from the west depositing significant volumes of coarse sand and gravel along the lake-shore and finer grained sediments in the deeper parts of the lake. As glacial Lake Souris began to drain, the lake shore receded to the northeast and the Souris River valley was established north of the Velva area. Meltwaters supplied significant volumes of water relative to current drainage. Subsequently, the Souris River valley is oversized for current drainage (Lemke, 1960), and it is characterized by numerous valley terrace deposits of outwash material supplied by the meltwaters.

After glacial Lake Souris drained, the resulting lake plain was fairly flat with almost no relief. Broad areas of the former lake floor, particularly interior areas where finer grained sediments were deposited, were subjected to intense wind erosion (Bluemle, 1982). Large dune features were built as a result of the wind erosion. Relief within the glacial Lake Souris Plain is primarily controlled by the oversized drainage systems established by the meltwaters and dune activity on the lake plain, and the city of Towner currently rests on the eastern banks of the Souris River between three major dune fields (figure 4).

Stratigraphy

Surficial deposits in McHenry County are related either directly or indirectly to the Late Wisconsin Pleistocene glacial and glaciofluvial activity. The study area lies within the glacial Lake Souris plain along the banks of the Souris River, and the majority of the surface deposits are dominated by lacustrine sands and silts which were deposited on the lake plain. Fluvial sand and gravel was deposited along the Souris River valley resulting from either meltwater or post-glacial drainage. Much of the lacustrine deposits were exposed to wind erosion resulting in eolian deposits of reworked fine sand and silt. Glacial till is also exposed at the surface where the lacustrine material has been removed by wind action and meltwaters. The majority of the surface deposits are underlain by till except where the till was stripped off by the subsequent establishment of the Souris River valley by meltwaters. In places, where the till has been removed by meltwaters, fluvial sand and gravel directly overlie bedrock.

The surficial deposits within the study area unconformably overlie the Fox Hills Formation which rests conformably on the Pierre Shale. South of the study area, surficial deposits overlie the Hell Creek Formation which rests conformably on the Fox Hills Formation.

Cross-sections were included for purposes of identifying the relationship between the surficial deposits and the underlying Fox Hills Formation. Figure 5 represents a traverse across the Souris River valley, while figure 6 represents a longitudinal traverse along the eastern terrace slope.

Bedrock deposits

The Fox Hills Formation consists of a sequence of sandstone, silty shales, and siltstones which were deposited in near shore coastal marine or deltaic coastal marine environments. The Fox Hills Formation was deposited during a major late Cretaceous regression of the epicontinental seas that covered much of the western interior at the time (Cvancara, 1976). In the study area, the Fox Hills Formation consists of a greenish gray, glauconitic, fine to medium grained, friable, sandstone with a considerable clay content. None of the wells in the study area completely penetrated the Fox Hills Formation; however, Bluemle (1982) estimated the thickness of the Fox Hills Formation to be between 150 and 200 feet for much of northern McHenry County. The Fox Hills Formation unconformably underlies the surficial deposits within the study area, and the Fox Hills Formation rests conformably on the Pierre Shale.

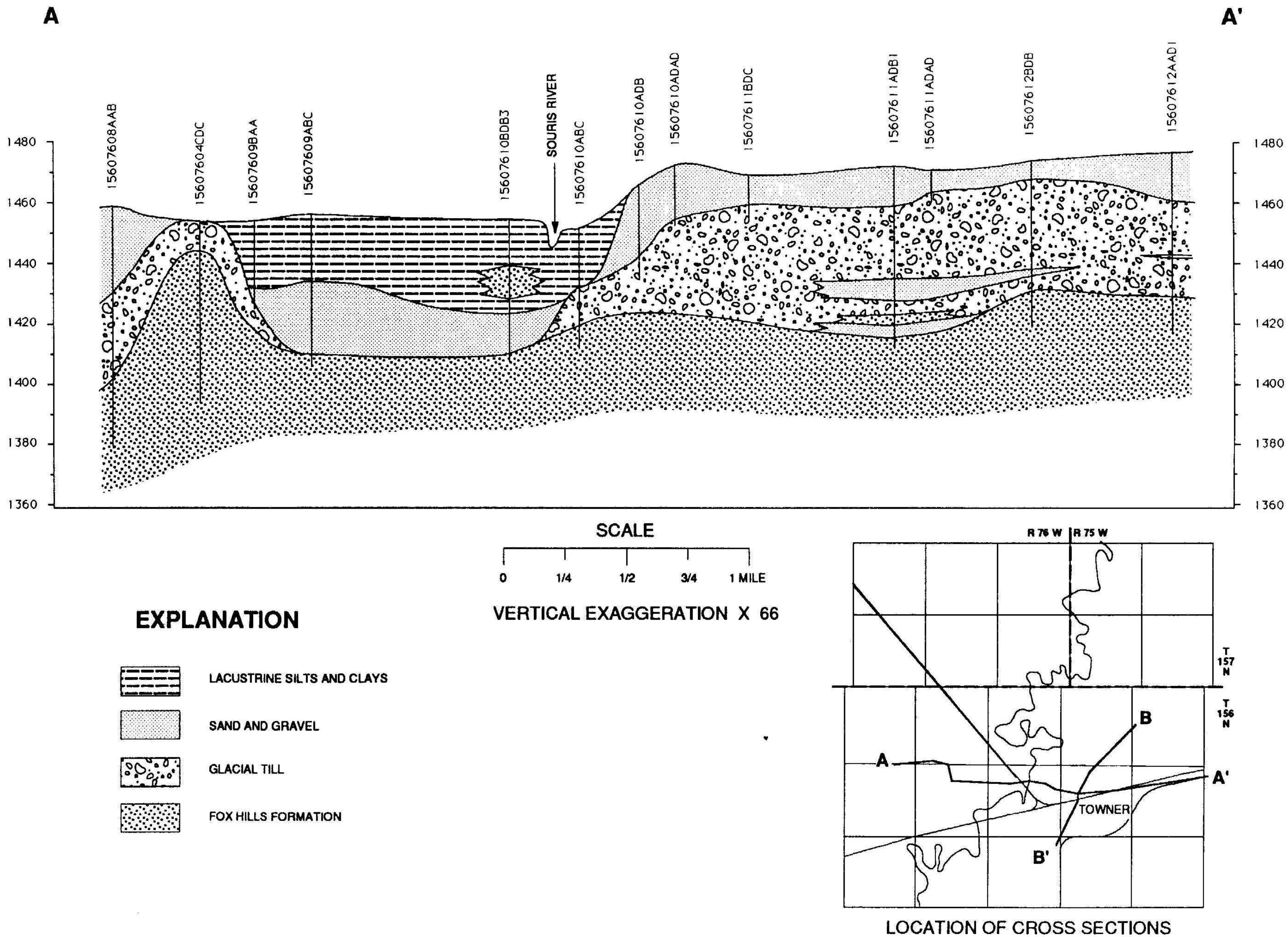


Figure 5 - Geologic Section A - A' of the Souris Valley aquifer in the vicinity of Towner, North Dakota.

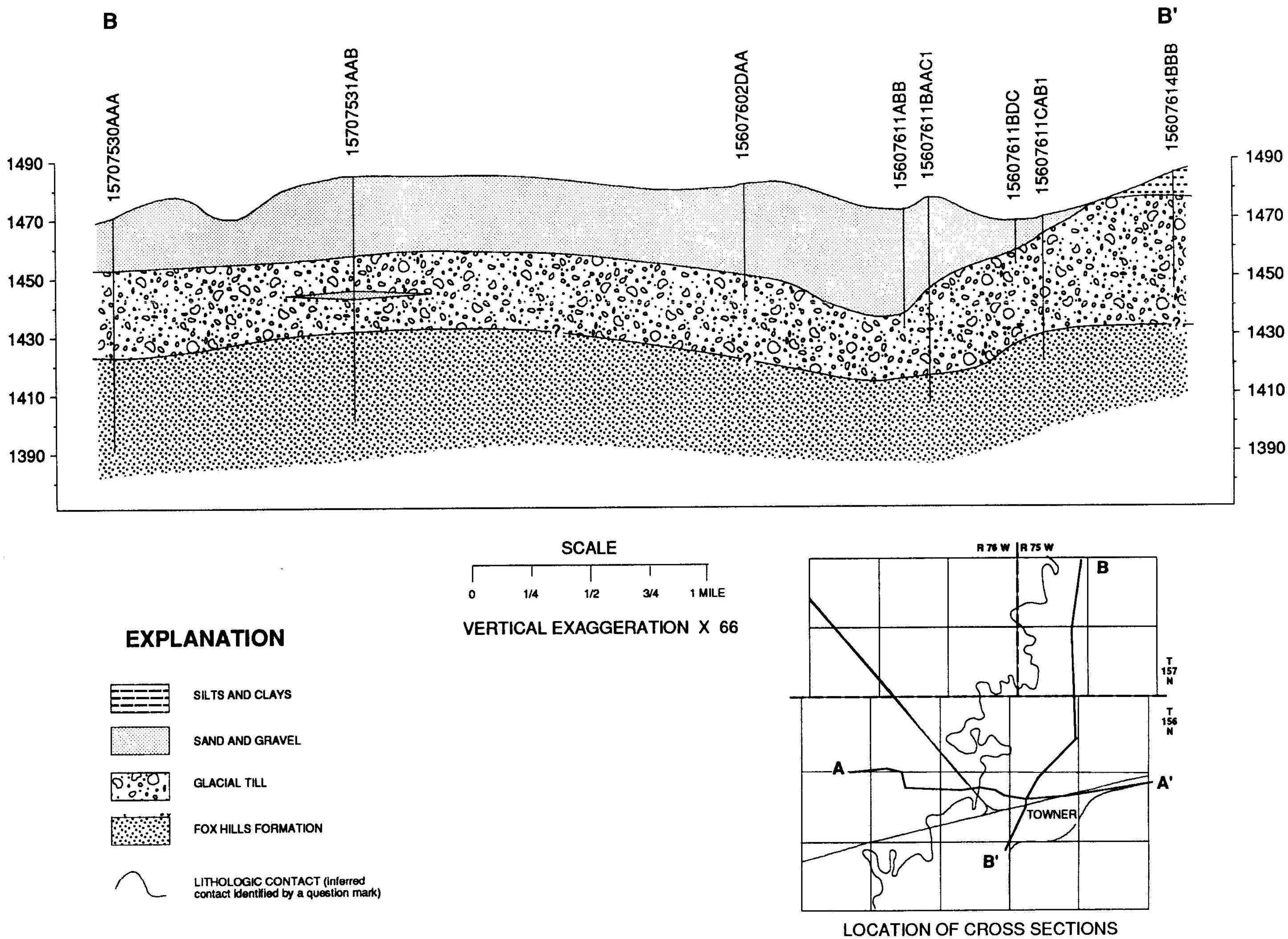


Figure 6 - Geologic Section B - B' of the Souris Valley aquifer in the vicinity of Towner, North Dakota.

Unconsolidated deposits

Unconsolidated deposits in the study area include all of the sediments which overlie the Fox Hills Formation. Most, if not all, of unconsolidated deposits in the study area are of glacial origin with the exception of the Quaternary alluvium deposited along the Souris river valley. Pleistocene sediments deposited by glacial ice or subsequent glacial activity are commonly referred to as the Coleharbor Group. The Coleharbor Group is commonly subdivided into three main facies, including till, sand and gravel, and silt and clay (Bluemle, 1982), and all three facies are represented in the study area.

The majority of the test holes in the study area were not drilled to bedrock. However, the till facies of the Coleharbor Group was present in the majority of the test holes in the study area. The till facies is generally absent in areas underlying the Souris River valley flood plain, and it approaches a maximum thickness within the study area of approximately 54 feet in test hole 156-076-11DCC. The till within the study area consists of a poorly sorted mixture of clay to boulder size particles with a predominate clay matrix. Unweathered till is fairly soft and plastic with colors ranging from gray to olive gray. Weathering was apparent in the till in several test holes extending to a maximum depth of 31 feet in 156-076-12CCC. The weathered till was characterized by an orange and yellowish mottled appearance.

The sand and gravel facies within the study area occurs predominately as terrace deposits and channel deposits along the Souris River. Sand and gravel also occurs as thin layers dispersed throughout the till, as well as, thicker more continuous units within the till. The majority of the sand and gravel deposits are the result of glaciofluvial processes and primarily occur as river channel deposits (Bluemle, 1982). The sand and gravel facies ranges in thickness from a few inches to approximately 34 feet (156-076-11BABC and 156-076-11ABB) in some of the more continuous sections. The sand and gravel facies within the study area consists of subangular to rounded, fine sand to very coarse gravel sized particles. The mineralogical composition of the sand and gravel facies includes quartz, carbonates, various shield silicate material, and detrital lignite.

The silt and clay facies of the Coleharbor Group is not present in most of the study area and was only encountered in the southeastern corner. The silt and clay facies was deposited as an offshore turbidity sediment (Bluemle, 1982) in glacial Lake Souris and was subsequently removed in the vicinity of the study area by the establishment of the Souris River valley. In the study area the, silt and clay facies is represented as a slightly clayey silt, absent in most of the study area ranging to approximately 16 feet in southeastern corner at location 156-076-12CCC. Weathering was apparent in all of the samples obtained, and the color was predominately a dark, yellowish, orangish, brown.

Throughout the study area a thin veneer of sand is also present at the surface consisting of very fine to fine, well sorted, wind-blown sand. The wind-blown sand deposits are inconsistent in the study area and are generally not more than three feet in thickness. South of the study area more extensive local accumulations of the wind-blown sand can be found in conjunction with the major dune features (figure 4).

GROUND WATER HYDROLOGY

Within the study area, there are basically two aquifers with sufficient transmitting capacity for the development of a municipal water supply for the city of Towner; the Fox Hills aquifer and the Souris Valley aquifer. The Fox Hills aquifer is a bedrock aquifer that underlies the entire study area. The Souris Valley aquifer is primarily located along the flood plain and the lowest terrace of the Souris River valley.

Fox Hills Formation

The Fox Hills Formation subcrops beneath the surficial unconsolidated glacial deposits and is generally considered to be confined within the study area. The Fox Hills aquifer within the study area generally consists of greenish gray, glauconitic, fine to medium grained, friable, sandstone with a fairly high clay content.

The regional potentiometric surface of the Fox Hills aquifer, which was constructed by Randich (1981), identifies a lateral hydraulic gradient ranging from 2 to 8 feet per mile toward the northeast (figure 7). Based upon the potentiometric surface constructed by Randich (1981), the Souris River valley more than likely serves as a regional discharge area for the Fox Hills aquifer. Randich (1981) also suggested a general upward gradient in the Fox Hills aquifer to the overlying material.

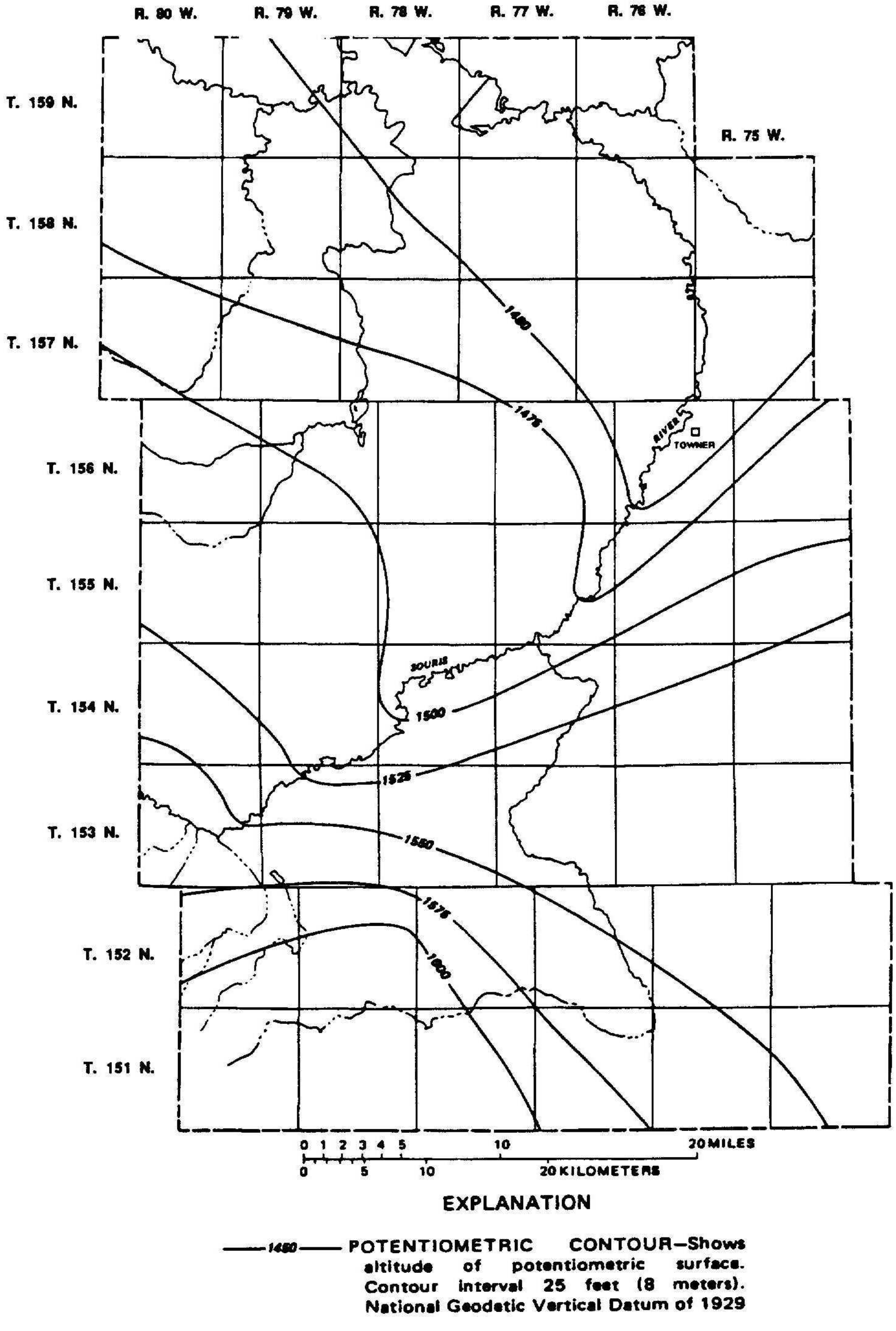


Figure 7 - Potentiometric surface of the Fox Hills Formation, July 1977, (modified from Randich, 1981).

None of the piezometers were installed directly into the Fox Hills aquifer within the study area. However, three piezometers were constructed in local accumulations of sand and gravel directly overlying the Fox Hills aquifer. It is somewhat likely that the sand and gravel is well connected to the Fox Hills aquifer, and water level measurements from these piezometers should provide a fair representation of the hydraulic head in the Fox Hills aquifer in the vicinity of Towner.

Water levels observed in the three piezometers installed in the sand and gravel directly overlying the Fox Hills aquifer identify an upward gradient that would tend to suggest water is generally moving upwards (figure 8) into the overlying units. The Souris Valley aquifer directly overlies the Fox Hill aquifer beneath the Souris Valley flood plain, and it is likely that the channel portion of the Souris Valley aquifer is connected to the Fox Hills aquifer. In contrast, both of the terrace portions of the Souris Valley aquifer are generally underlain by as much as 20 to 30 feet of till which does not readily transmit water. Even though the till may contain local accumulations of sand and gravel, and in places, these sand and gravel accumulations may provide a connection between the Fox Hills aquifer and the terrace units, the Fox Hills aquifer is probably not well connected to the terrace portion of the Souris Valley aquifer within the study area. Differences between water level fluctuations in piezometers installed in the terrace portion of the Souris Valley aquifer and the piezometers installed in the sand and gravel overlying the Fox Hills aquifer would also tend to suggest a poor connection between these units (figure 8).

Souris Valley aquifer

The Souris Valley aquifer is generally considered to consist of the sand and gravel deposits included within the unconsolidated valley fill along the Souris River valley. The unconsolidated valley fill of the Souris River valley consists of fluvial and glaciofluvial alluvium ranging from interbedded silts and clays to coarse sand, gravel, cobbles, and boulders. The Souris Valley aquifer is predominately composed of a poorly sorted, subangular to rounded, fine to very coarse sand and gravel. The sand and gravel deposits generally becomes coarser downward with local accumulations of cobbles and boulders. The sand and gravel consists predominately of quartz and carbonate material with various percentages of igneous, metamorphic, detrital shale, and lignite material included.

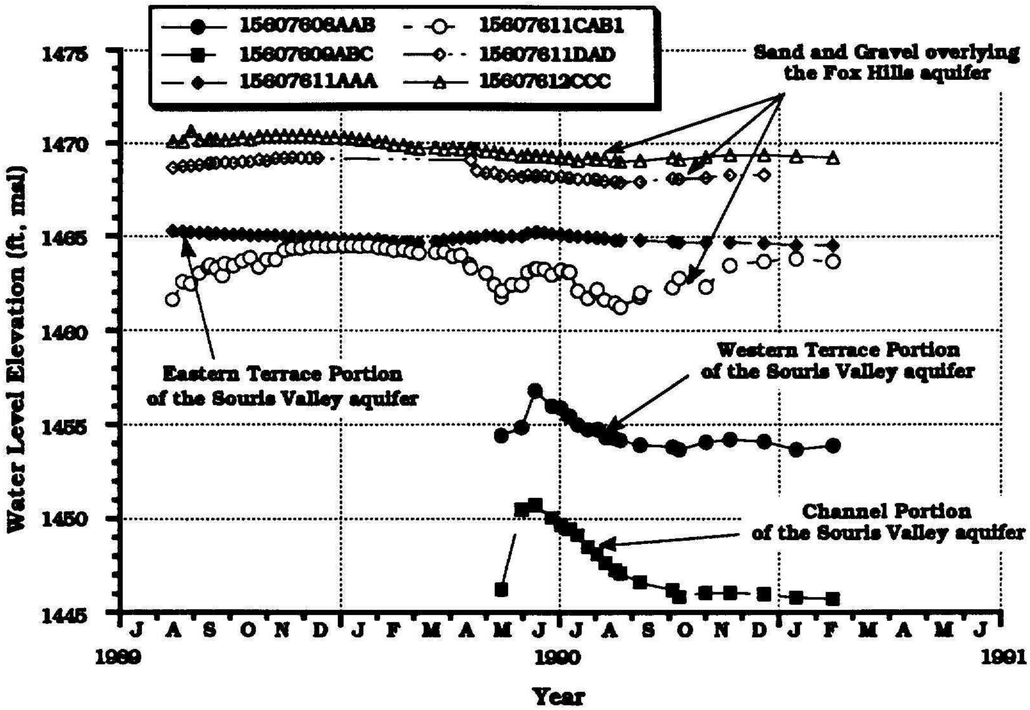


Figure 8 - Hydrograph comparing the relationship between the water levels observed in the sand and gravel overlying the Fox Hills aquifer with the water levels observed in the Souris Valley aquifer.

In the study area, the Souris Valley aquifer reaches a maximum thickness of approximately 34 feet in test holes 156-076-11ABB and 156-076-11BABC located north of the city of Towner. The aquifer material was deposited by meltwaters as the Souris River valley was incised into the glacial till, and in many places, the sand and gravel deposits rest directly over the Fox Hills Formation (figure 5).

Based upon available test hole information, the Souris Valley aquifer, within the study area, is comprised of three distinct sand and gravel units consisting of a deeper channel unit, an eastern terrace unit, and a western terrace unit (figure 9). Both of the terrace sequences are unconfined within the study area, while the deeper channel sequence is primarily confined (figure 5). In test hole 156-076-10BDB1, the deeper channel sequence was overlain by approximately 32 feet of flood plain deposits consisting predominately of silts and clays. The deeper channel unit underlies the Souris River flood plain within the study area, while the geographic distribution of the sand and gravel deposits of the eastern and western terrace units establish the Souris Valley terraces. The eastern terrace unit of the Souris Valley aquifer is truncated along an approximate east-west line through the southern half of Towner (figure 9). Both of the terrace units generally thin and pinch out moving away from the Souris River.

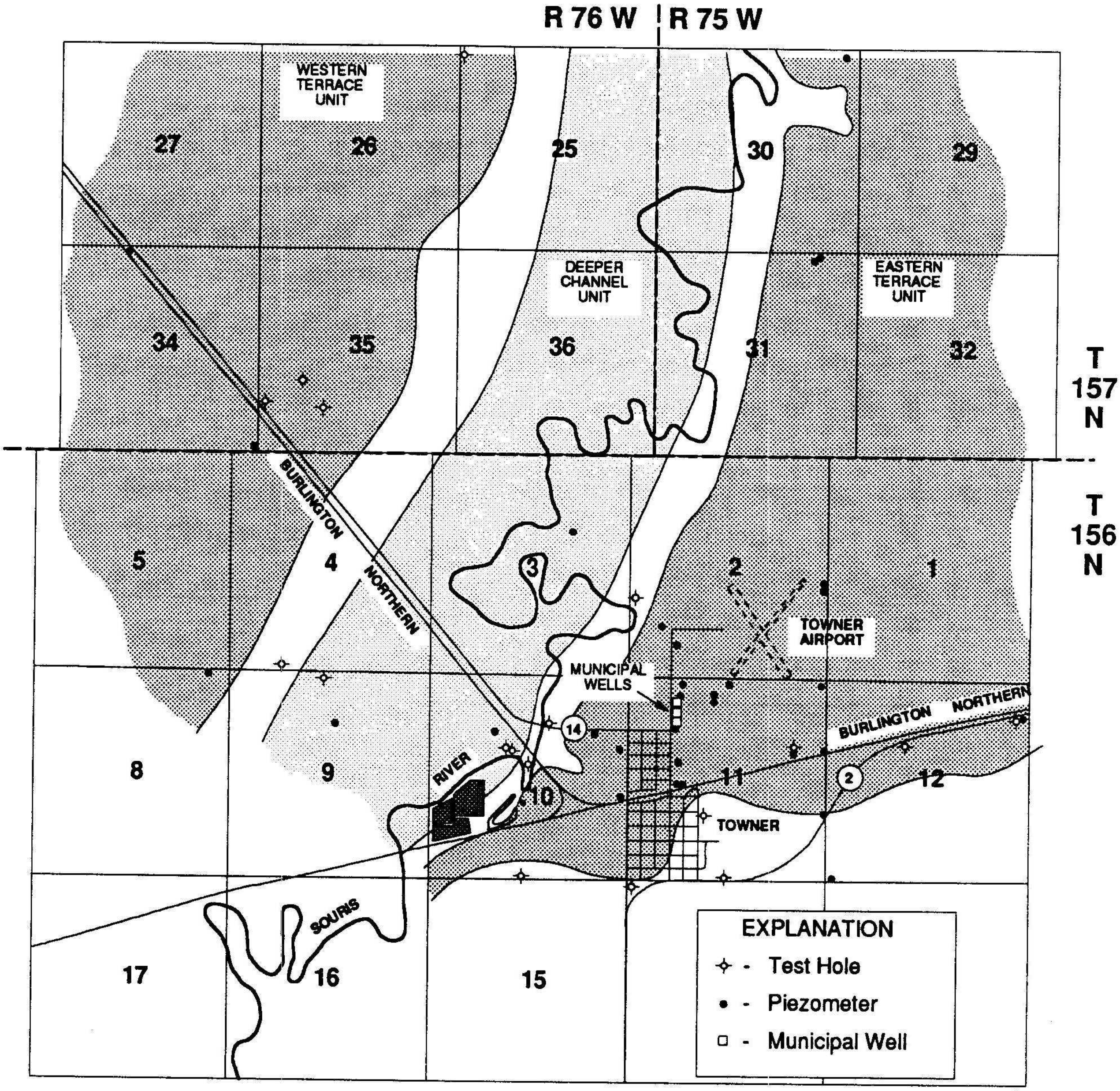


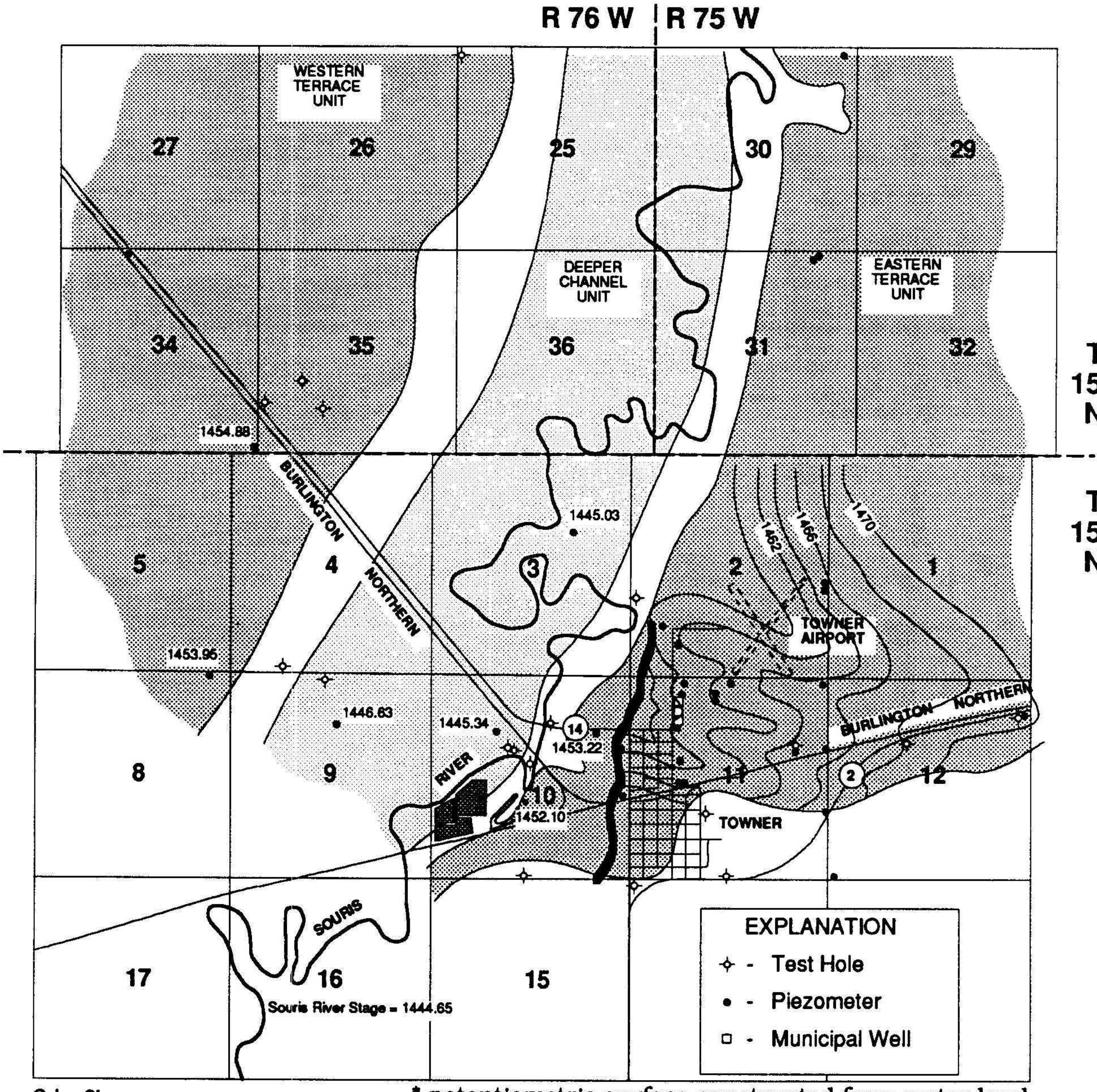
Figure 9 - Areal extent of the terrace and channel units of the Souris Valley aquifer within the study area.

The silt and clay facies of the Souris valley fill is generally not considered to be part of the Souris Valley aquifer. However, the sequence may contain local accumulations of sand and gravel which may provide a connection between the deeper channel deposits and the surficial terrace deposits.

The city of Towner currently obtains water from three wells located along the northern edge of Towner in the NW/4 Section 11, Township 156 North, Range 76 West (figure 9). The wells are screened in the sand and gravel deposits of the eastern terrace unit which is the primary focus for wellhead protection consideration. The wells were constructed to depths, from north to south, of 39, 42, and 40 feet, respectively.

As both of the terrace units are unconfined, groundwater flow within the terrace units is generally influenced by topographic control. While there was insufficient data available to construct a potentiometric surface for the western terrace unit, water-level elevations from the two available piezometers indicate a gradient toward the Souris River. The map of the potentiometric surface presented in figure 10 identifies a lateral hydraulic gradient within the eastern terrace unit of approximately 7 to 10 feet per mile which indicates water is generally moving toward the Souris River. A low transmissivity zone exists along the southwestern margin of the eastern terrace unit, and water levels measured in the two wells located west of the low transmissivity zone are between 5 and 8 feet below the water levels measured in the wells east of the low transmissivity zone.

Based upon the lithologic information, the terrace units extend to the Souris flood plain where they are truncated by the fine, sandy, silty, clay sequence deposited along the current Souris River floodplain (figure 5). Water may move from the terrace units into the finer floodplain deposits locally. However, numerous springs occur along the floodplain margins of both terrace units indicating that the floodplain deposits provide an effective hydraulic barrier and the terrace units are not likely to be well connected to the deeper channel unit underlying the floodplain.



* potentiometric surface constructed from water level measurements obtained on September 9, 1990.

Figure 10 - Potentiometric surface of the eastern terrace unit of the Souris Valley aquifer in the vicinity of Towner's municipal wellfield.

Recharge to the Souris Valley aquifer is controlled by the relationship between precipitation and evapotranspiration. Average annual precipitation in the vicinity of Towner is 16.43 inches (NOAA, 1990) with over 13 inches occurring during the months of May through September (figure 11). The majority of precipitation received during the summer will be lost to evaporation and plant activity, and recharge to the aquifer will normally occur as a result of either spring snowmelt and early spring rainfall or rainfall occurring after the growing season during the late fall. The water-level record for both the western terrace unit and the deeper channel unit is not sufficient to evaluate effects of recharge resulting from the spring snowmelt and rainfall as the piezometers in both of these systems were not installed or monitored until June of 1990. However, the water levels observed in the eastern terrace unit have steadily declined over the period of record with the exception of the rising water levels observed during the spring period from late March to early June of 1990 (figure 12).

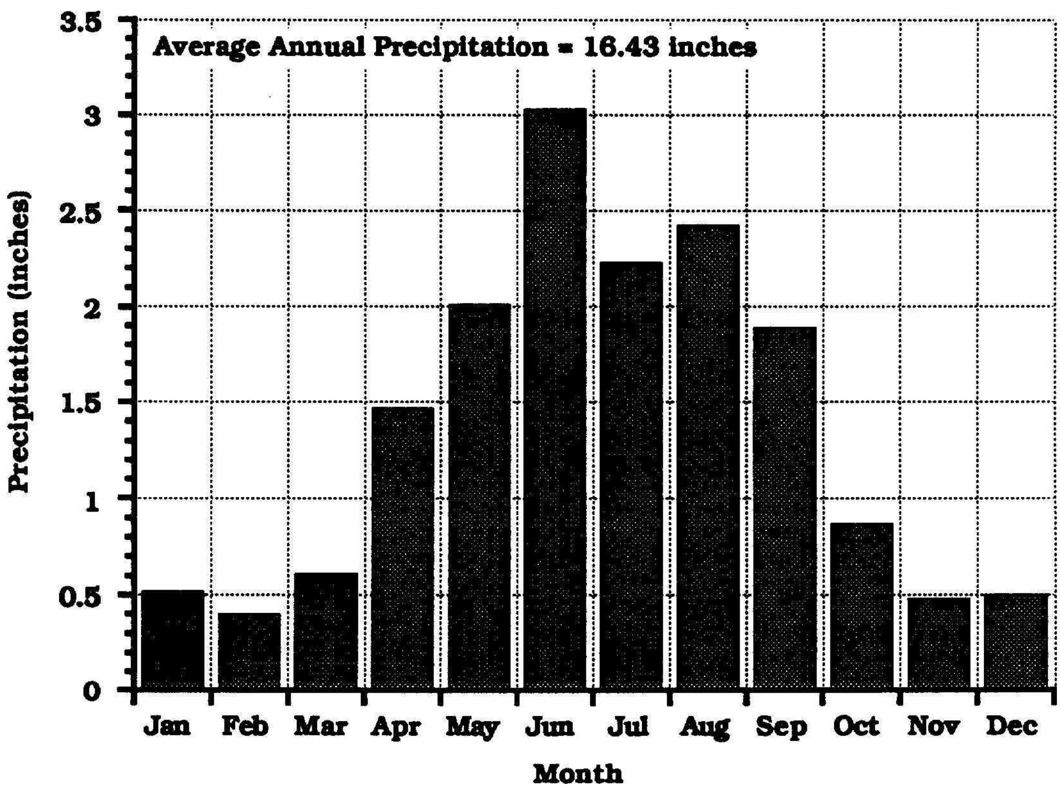


Figure 11 - Average monthly precipitation recorded at a substation located 2 miles northeast of Towner, North Dakota.

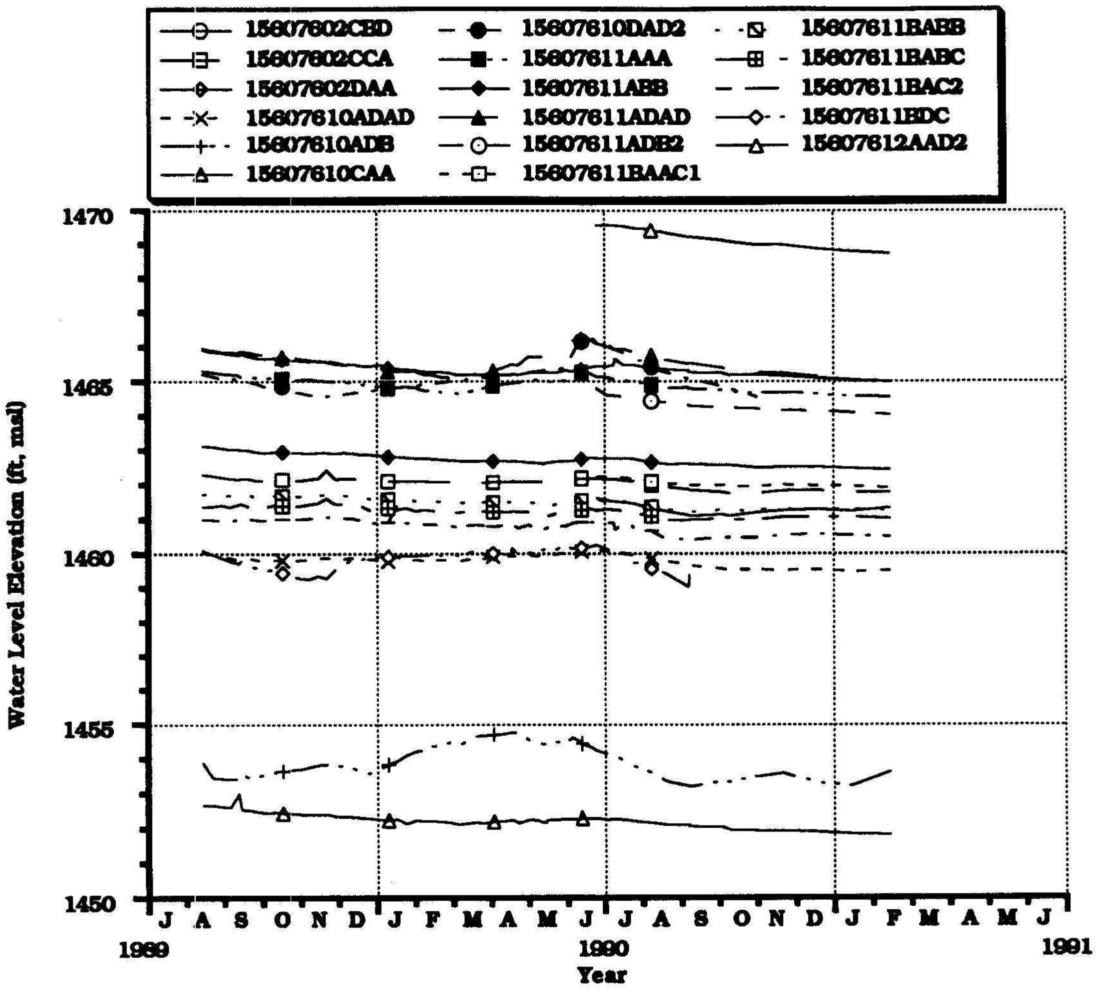


Figure 12 - Hydrograph of water-level elevations observed in the eastern terrace unit of the Souris Valley aquifer.

The majority of the water levels in the eastern terrace unit responded similarly with the exception of the water levels observed in 156-076-10ADB. While water levels in the majority of the piezometers completed in the eastern terrace unit were steadily declining during the summer, late fall, and winter of 1989, water levels in 156-076-10ADB began to rise in early October of 1989 and continued to rise until early April of 1990 (figure 12). Piezometer 156-076-10ADB is located approximately 800 feet east of a spring which discharges over-land to the Souris River. The area surrounding the spring also has a fairly heavy cover of vegetation. It is possible that rising water levels in 156-076-10ADB during the late fall and winter correspond to either a reduction in the discharge from the spring resulting from freezing which would provide a temporary seasonal hydraulic barrier, a reduction in discharge through the transpiration effects from the vegetation cover, or a combination of both mechanisms.

In addition to recharge from the early spring rainfall and snowmelt, anomalous precipitation events during the summer will also provide some recharge to the system. During June, approximately 4.37 inches of rainfall was recorded at the substation located approximately 2 miles northeast of Towner (NOAA, 1990). Average precipitation for the month of June is 3.03 inches. A rise in water levels was observed in each of the three units of the Souris Valley aquifer in response to the increased precipitation (figure 13). It is obvious, when comparing the water levels in the Souris Valley aquifer with the precipitation recorded at the substation, that the Souris Valley aquifer also receives significant amounts of recharge from anomalous rainfall events during the summer growing season.

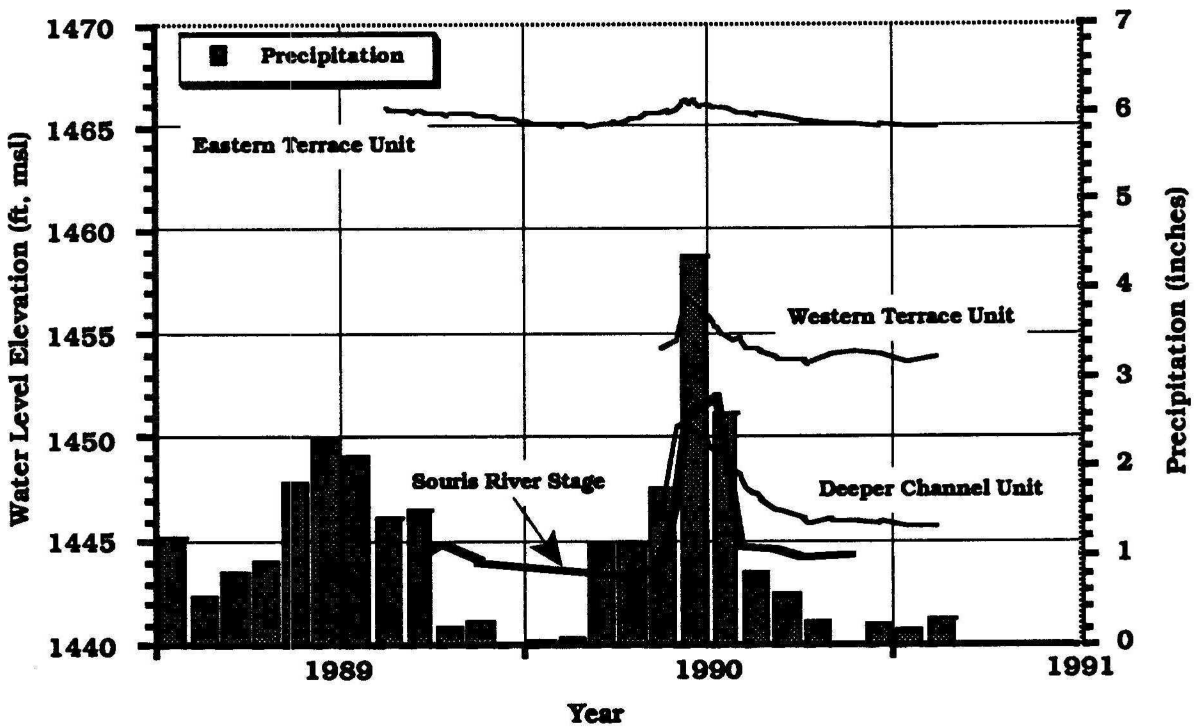


Figure 13 - Hydrograph comparing water-level elevations in each of the three units of the Souris Valley aquifer with the Souris River stage and recorded precipitation.

The response to the increased precipitation varied between the different units of the Souris Valley aquifer, with the rise in water levels ranging from approximately 4 feet in the deeper channel unit to less than 1 foot in the eastern terrace unit. The deeper channel unit responded more dramatically to the increased precipitation which may be due in part to the increased stage observed in the Souris River at the same time (figure 13). However, the rise in the water levels observed in 156-076-9ABC preceded the rise in the Souris River stage (figure 14) and then began to decline while the Souris River Stage continued to rise. The inconsistency between the water level response observed in the deeper channel unit and the Souris River stage would tend to suggest that a certain component of the recharge to the deeper channel unit is derived directly from precipitation.

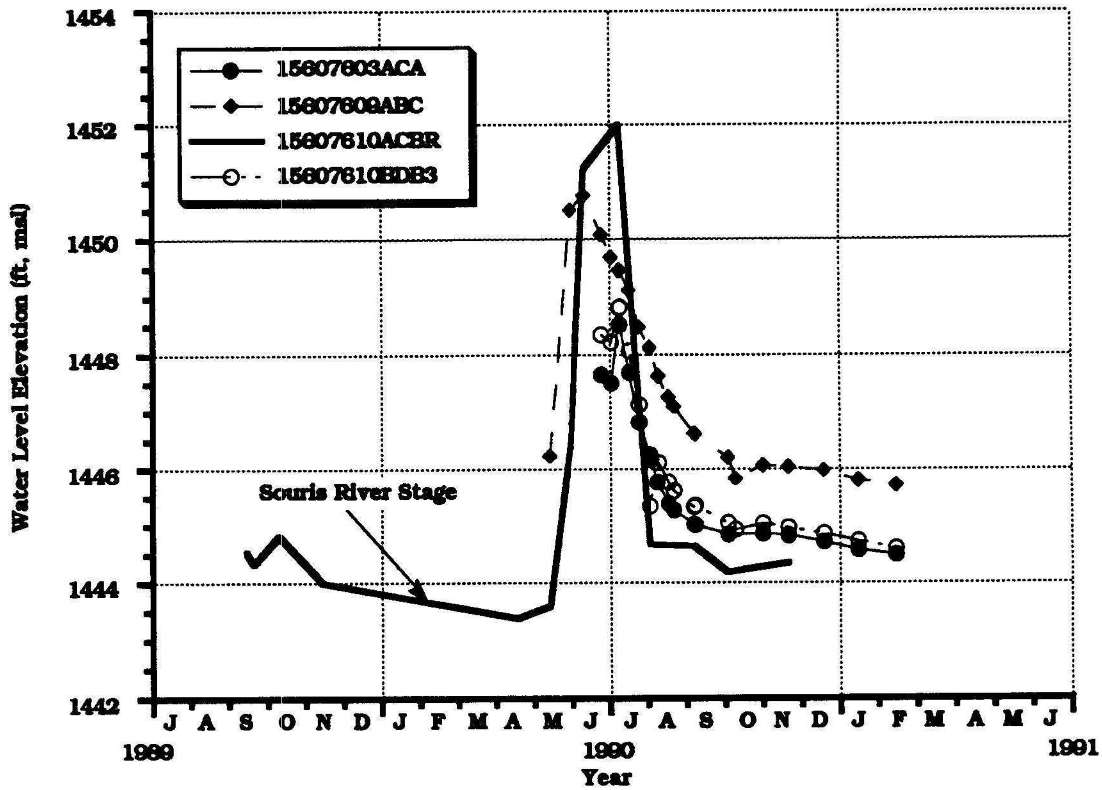


Figure 14 - Hydrograph comparing the water-level elevations in the deeper channel unit of the Souris Valley aquifer with the Souris River stage.

WATER QUALITY

Analysis from a total of 40 water samples were available within the study area which includes water samples obtained from the eastern terrace unit, the western terrace unit, and the deeper channel unit of the Souris Valley aquifer, as well as, samples obtained from the sand and gravel deposits directly overlying the Fox Hills Formation. The majority of the water samples for the analysis included in this report were collected through the course of this study during 1989 and 1990. However, analyses were also included for samples that were collected prior to this study, and most of the earlier samples were obtained as part of the county groundwater study (Randich, 1981). The chemical analysis for all of the samples are included in Appendix B.

The percent distribution of the major cations and anions for all of the water samples was plotted on a Piper tri-linear diagram (figure 15) for purposes of demonstrating hydrochemical variations associated with water from the Souris Valley aquifer and the underlying bedrock system. Water within the area is generally identified by the Piper diagram as either a sodium (Na) or calcium (Ca) bicarbonate (HCO_3) type water with very low chloride (Cl) levels. Water from wells completed in both the Souris Valley aquifer deeper channel unit and the wells completed in the sand and gravel overlying the Fox Hills Formation generally possess higher percentages of both sodium (Na) and sulfate (SO_4) which tends to place water from these units as a sodium sulfate type water.

Fox Hills Formation

None of the piezometers installed in the study area were completed in the Fox Hills Formation. However, Randich (1981) included samples from wells to the north and west of the study area that were completed in the Fox Hills Formation. Basically, Randich (1981) identified water from the Fox Hills as either sodium (Na) bicarbonate (HCO_3) or sodium (Na) chloride (Cl) type water with a range in TDS from 410 mg/l to 3180 mg/l.

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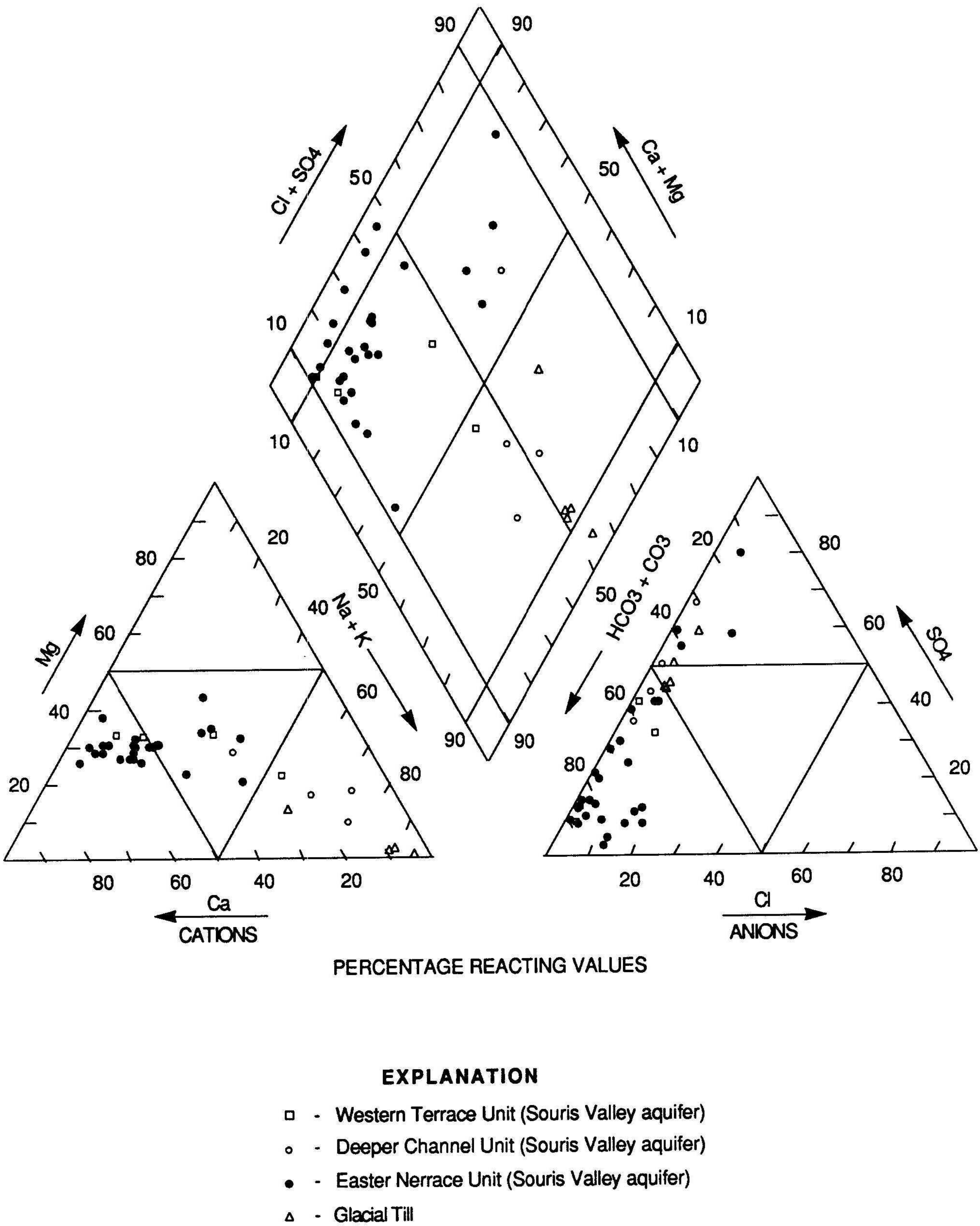


Figure 15 - Piper diagram showing water quality variations within the different units and the surrounding glacial till.

Souris Valley aquifer

The eastern and the western terrace units of the Souris Valley aquifer are unconfined within the study area with water levels ranging from a few feet to over 20 feet below land surface. In contrast, the deeper channel unit is confined within the study area. The flow system within each of the terrace systems is dominated by local recharge from precipitation events within the area and discharge in the form of evapotranspiration, municipal pumping, and springs and seeps along the floodplain margins, while the flow system of the deeper channel unit is predominately influenced by the regional flow system of the underlying bedrock system. As a result of the differences in factors influencing the flow systems, water from the Souris Valley aquifer eastern and western terrace units is distinctively different than water from the deeper channel unit.

Eastern Terrace Unit

Based upon the Piper diagram (figure 15) water from the eastern terrace unit is predominately of a calcium (Ca) bicarbonate (HCO_3) type. The samples obtained from the eastern terrace unit exhibited a wide variation in water quality with a range in the total dissolved solids (TDS) from 274 to 3170 mg/l with a median TDS of approximately 451 mg/l. Calcium (Ca) levels were generally less than 100 mg/l, but concentrations of calcium (Ca) in the wells sampled ranged from 45 mg/l to 561 mg/l. The concentration of bicarbonate (HCO_3) ranged from 225 mg/l to 2550 mg/l with a median bicarbonate concentration of approximately 312 mg/l. Concentrations of both sodium (Na) and magnesium(Mg) within the eastern terrace unit were generally less than 50 mg/l, with a range in sodium (Na) levels from approximately 8 mg/l to 268 mg/l and a range in magnesium (Mg) levels from approximately 18 mg/l to 232 mg/l. Sulfate (SO_4) levels within the eastern terrace unit were generally low with a median concentration of approximately 84 mg/l; however, sulfate (SO_4) levels observed in some of the samples were as high as 1830 mg/l. Chloride (Cl) levels ranged from approximately 2 mg/l to 215 mg/l, while the median concentration of chloride (Cl) was approximately 19 mg/l.

The variation in the water quality observed in the eastern terrace unit is likely influenced by several factors. Groundwater mixing, resulting from water moving upward through the till from the underlying Fox Hills Formation, may account for some of the local variation in water quality. However, the water quality variation appears to be the greatest along the southern edge of the aquifer where dramatic increases in TDS are observed as the aquifer thins and pinches out toward its southern boundary. The dramatic increases in TDS are more than likely related to the concentrating effects associated with evaporative processes which will generally be more prevalent in the thinner more restricted portions of the aquifer.

If the samples obtained from the wells completed in thinner sections along the southern edge of the aquifer are excluded, the variation in the water quality associated with the eastern terrace unit does not appear to be quite as dramatic. The Schoeller diagram presented in figure 16 provides a fairly appropriate representation of the type of water that would generally be encountered in the eastern terrace unit.

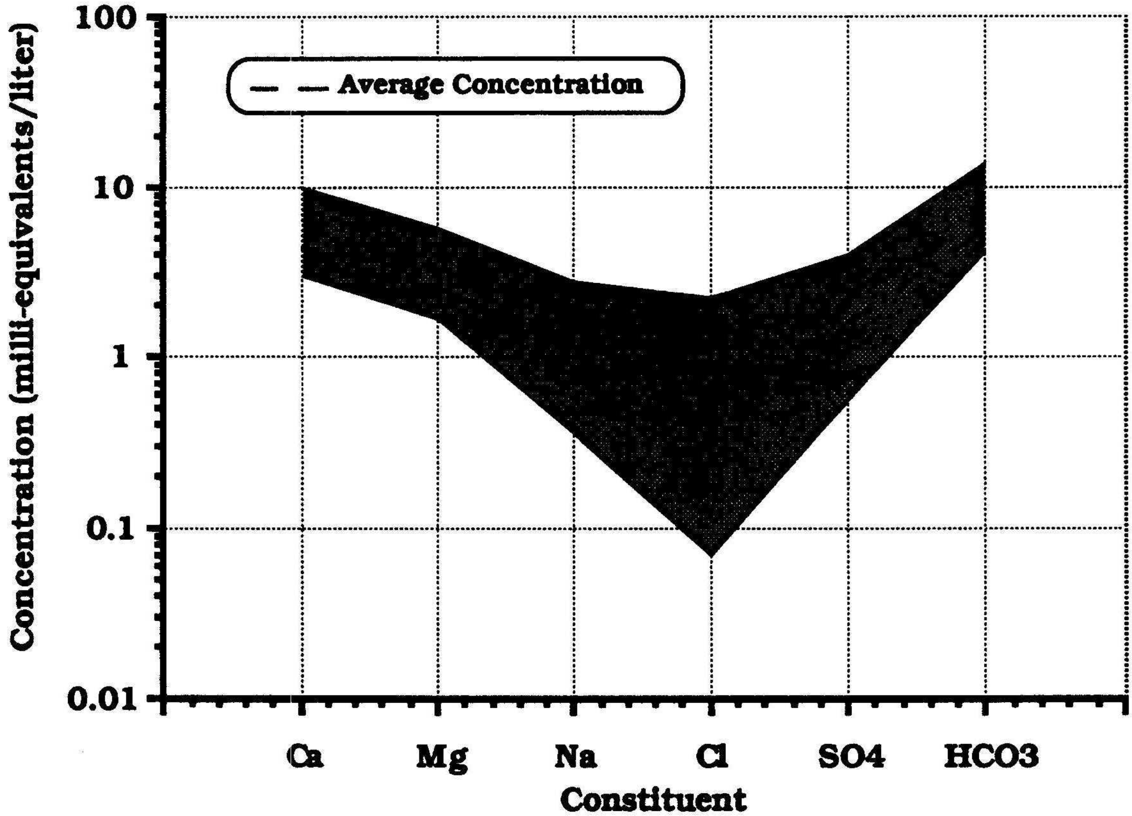


Figure 16 - Schoeller diagram identifying the range and average concentration of the major cations and anions from wells completed in the eastern terrace unit with the exception of wells completed along the southern boundary.

In addition to the variation introduced from groundwater mixing, and evaporative processes, some variation in water quality may be related to various surface activities. Nitrate (NO_3) levels in waters from the eastern terrace unit are generally less than 2 mg/l. However, the piezometers located at 156-076-2DAA2 and 156-076-11ADB2 were constructed with a screened interval that intersects the water table, and nitrate (NO_3) levels in these wells were 65 mg/l and 72 mg/l, respectively, which is nearly twice the recommended limits for drinking water of 45 mg/l set by the Safe Drinking Water Act of 1986. Some of the other wells in which the water levels intersects the screen also show elevated levels of nitrate (NO_3), but none are as dramatic as the nitrate (NO_3) levels observed in 156-076-2DAA2 and 156-076-11ADB2.

Western Terrace Unit

Based upon the Piper diagram (figure 15) and the Schoeller diagram (figure 17), water from the western terrace unit of the Souris Valley aquifer consists predominately of a calcium (Ca) bicarbonate (HCO_3) type water. Water samples were obtained from only two wells in the western terrace unit. In each well a water sample was obtained during the early 1970's and again as part of this study in 1990. Upon comparison the samples did not demonstrate a great deal of variation over time; however, the samples obtained from the two wells are distinctively different indicating that there is some local variation in the water quality within the western terrace unit.

The range in the total dissolved solids (TDS) within the western terrace unit was from 313 mg/l in well 156-076-8AAB to 913 mg/l in well 157-076-34BAA. While levels of all the major cation and anion constituents were higher in well 157-076-34BAA as compared with the levels observed in 156-076-8AAB, sodium (Na) and sulfate (SO_4) levels were noticeably higher (figure 17). In comparison, sodium levels in 156-076-8AAB are approximately 20 mg/l versus the sodium level of approximately 150 mg/l observed in 157-076-34BAA. Sulfate levels ranged from approximately 35 mg/l in 156-076-8AAB to approximately 300 mg/l in 157-076-34BAA. The range in calcium is from 65 mg/l to 100 mg/l, while the range in the level of bicarbonate is from 313 to 551 mg/l.

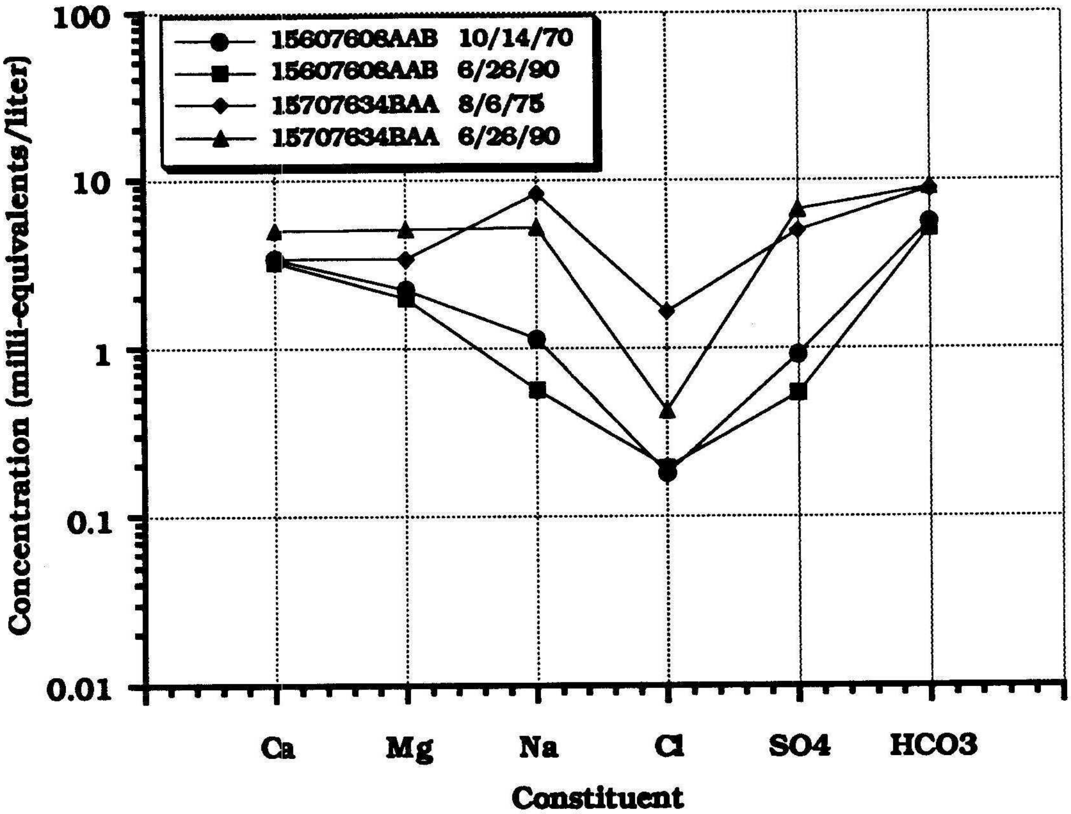


Figure 17 - Schoeller diagram of water samples collected from the western terrace unit of the Souris Valley aquifer.

Deeper Channel Unit

Water from the deeper channel unit of the Souris Valley aquifer is different than the water from both of the terrace units. Based upon the Piper diagram (figure 15) and the Schoeller diagram (figure 18), water from the deeper channel unit is characteristically similar to the water quality inferred from the underlying bedrock system. Water from the deeper channel unit is predominately of a sodium (Na) sulfate (SO_4) type with TDS ranging from 848 mg/l to 2290 mg/l. Sodium levels range from 250 mg/l to 350 mg/l with a median concentration of 320 mg/l. Levels of both calcium (Ca) and magnesium (Mg) are generally less than 100 mg/l with a median calcium (Ca) concentration of approximately 63 mg/l and a median magnesium (Mg) concentration of approximately 47 mg/l. Sulfate (SO_4), which is the dominant anion, ranges from 240 mg/l to 1200 mg/l with a median level of 490 mg/l. Bicarbonate (HCO_3) levels generally range from 514 mg/l to 759 mg/l with a median concentration of approximately 612 mg/l. Chloride (Cl) levels are generally very low with a median concentration of 22 mg/l

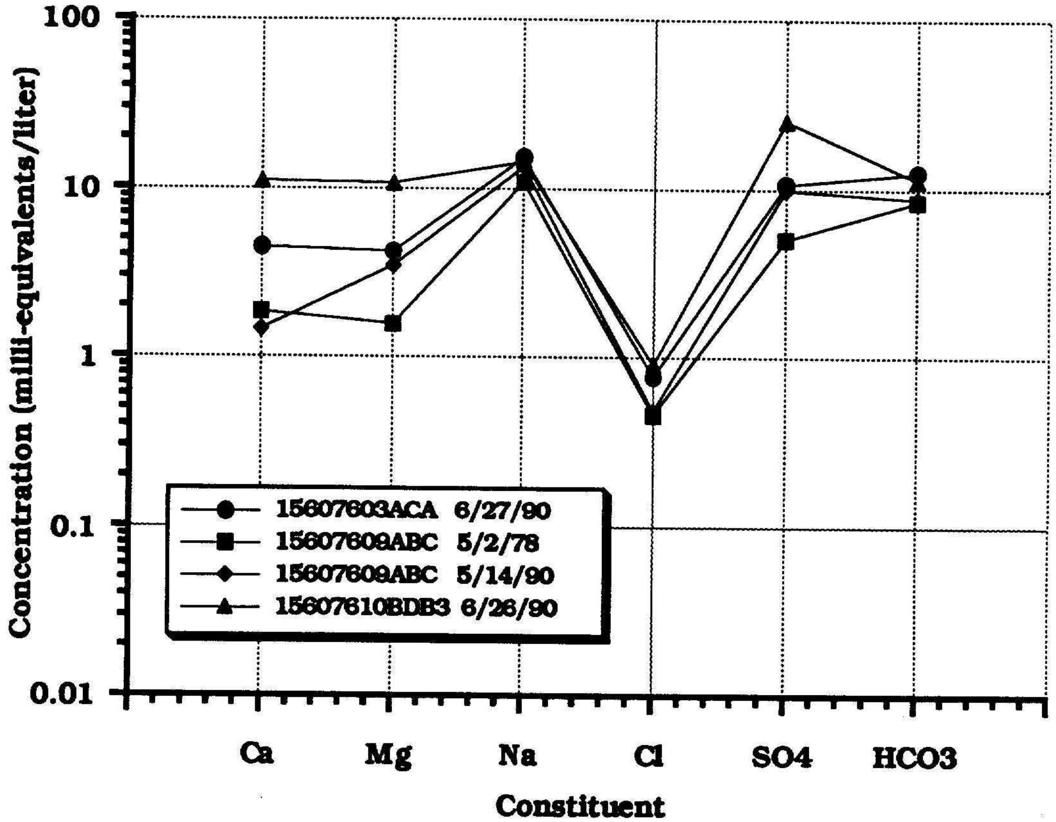


Figure 18 - Schoeller diagram of water samples collected from the deeper channel unit of the Souris Valley aquifer.

WELL HEAD PROTECTION AREA

The WHP program is designed to protect groundwater around public water supply well fields from various possible threats. These threats include : direct introduction of contaminants to the area immediately surrounding the well through improper well construction, road runoff, or spills, microbial contaminants such as bacteria or viruses, and a broad range of chemical contaminants, both naturally occurring and man-made. A major element of the WHP program is the determination of zones within which contaminant source assessment and management will be addressed. These zones, called Wellhead Protection Areas (WHPAs), are defined by the Safe Drinking Water Act amendments of 1986 as "The surface and subsurface area surrounding a water well or well field, supplying a public water system, through which contaminants are likely to move toward and reach such water well or well field.".

A WHPA protects the groundwater entering public water supply (PWS) wells by performing these three functions:

1. Provides a remedial action zone to protect wells from unexpected contaminant releases.
2. Provides a management zone for all or part of a well's recharge or contribution area.
3. Provides an attenuation zone in which the concentration of a contaminant in the groundwater is reduced before entering the well.

Wellhead Protection Area Delineation

A number of factors or "criteria" form the technical basis for the delineation or mapping of WHPAs. The North Dakota WHP program uses a combination of the following criteria for delineating WHPAs:

1. Distance to the well.
2. Time of travel (TOT) which is the length of time it takes for water to travel through the aquifer from the WHPA boundary to the well.
3. Flow boundaries which are groundwater divides or other physical hydrologic features that control groundwater flow.

Methods used to delineate a WHPA using these criteria include the arbitrary fixed radius method, the calculated fixed radius method, the analytical zone of contribution method, and the hydrogeologic mapping method.

The North Dakota WHP program has also selected minimum standards, called criteria thresholds, by which these criteria are implemented. As a guideline, thresholds have been set at a minimum distance of 500 feet, and 10 years TOT if the WHPA is delineated using the zone of contribution method or 15 years TOT if the WHPA is delineated using the calculated fixed radius method. These thresholds may be modified on a case-by-case basis due to flow boundaries or other site specific conditions.

In some instances, it may be advantageous to delineate more than one zone within the WHPA. This would be done if varying levels of protection or management was desired around the well. The zone closest to the well, with the most stringent protection is called the primary WHPA and the zone of less stringent protection is called the secondary WHPA.

Arbitrary Fixed Radius Method

The Arbitrary Fixed Radius method is the simplest method of delineating a WHPA. It involves drawing a circle with a specific radius around the well to be protected (figure 19). The Arbitrary Fixed Radius method is simple and inexpensive, but due to the lack of any quantitative basis for choosing the radius there is much uncertainty about the effectiveness in any specific setting. This method could be employed in situations where it is necessary to define a WHPA before it is possible to collect more definitive site specific information for delineation by other methods.

The North Dakota WHP program has established a minimum distance of 500 feet as the distance threshold to be used for WHPA delineation using the Arbitrary Fixed Radius method. The minimum distance of 500 feet is to be used in situations where the wells are completed in a confined aquifer with unknown or undefined recharge areas or in systems where no other method can be applied.

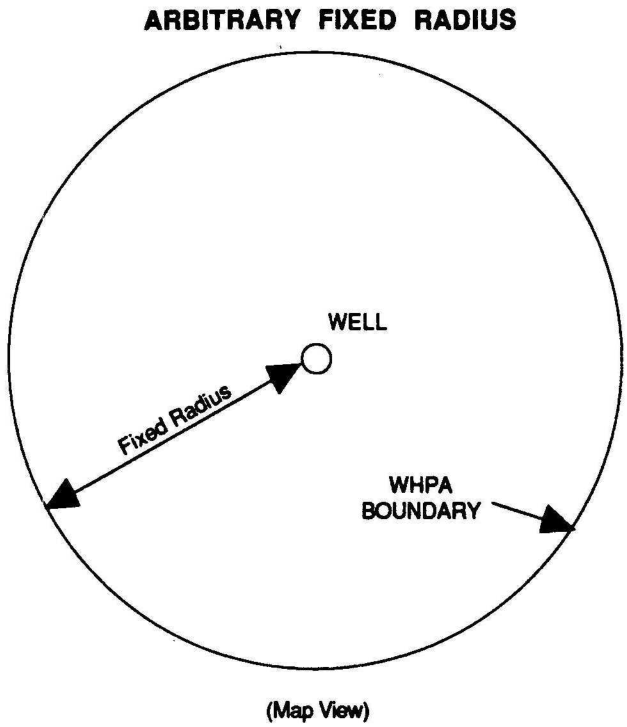


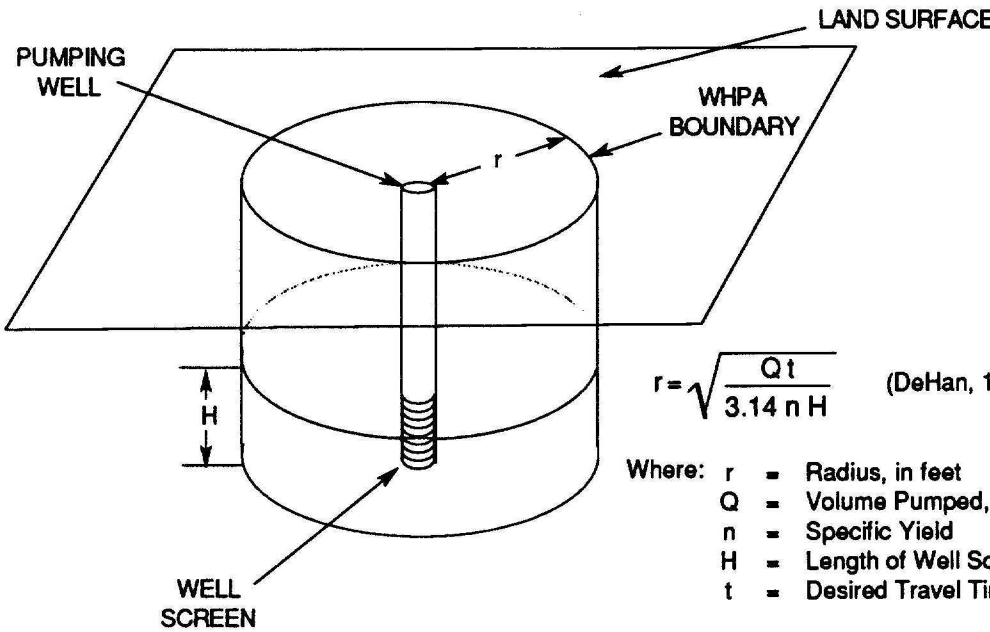
Figure 19 - Arbitrary Fixed Radius method of Wellhead Protection Area Delineation.

Calculated Fixed Radius Method

The Calculated Fixed Radius method involves drawing a circle around the well with a radius tied to a TOT, which under the North Dakota WHP program is generally 15 years. The radius is calculated using a volumetric equation (DeHan, 1986), based on the volume of water that will be drawn to the well in the specified time, specific yield of the aquifer, and length of the well screened (figure 20). It provides more accuracy than the Arbitrary Fixed Radius method but still does not account for hydrogeologic factors that may influence contaminant transport.

In the case of a well that is completed in a confined aquifer with an arbitrary WHPA of 500 foot radius, it is recommended that a secondary WHPA be established using a calculated fixed radius with a TOT of 15 years. The secondary WHPA would then be checked for abandoned or improperly constructed wells or other artificial penetrations that could provide a direct conduit for contaminants to enter the aquifer.

CALCULATED FIXED RADIUS



$$r = \sqrt{\frac{Q\,t}{3.14\,n\,H}}$$ (DeHan, 1986)

Where:
r = Radius, in feet
Q = Volume Pumped, in cubic feet per day
n = Specific Yield
H = Length of Well Screen, in feet
t = Desired Travel Time, in days

Figure 20 - Calculated Fixed Radius method of Wellhead Protection Area delineation.

Analytical Zone Of Contribution Method

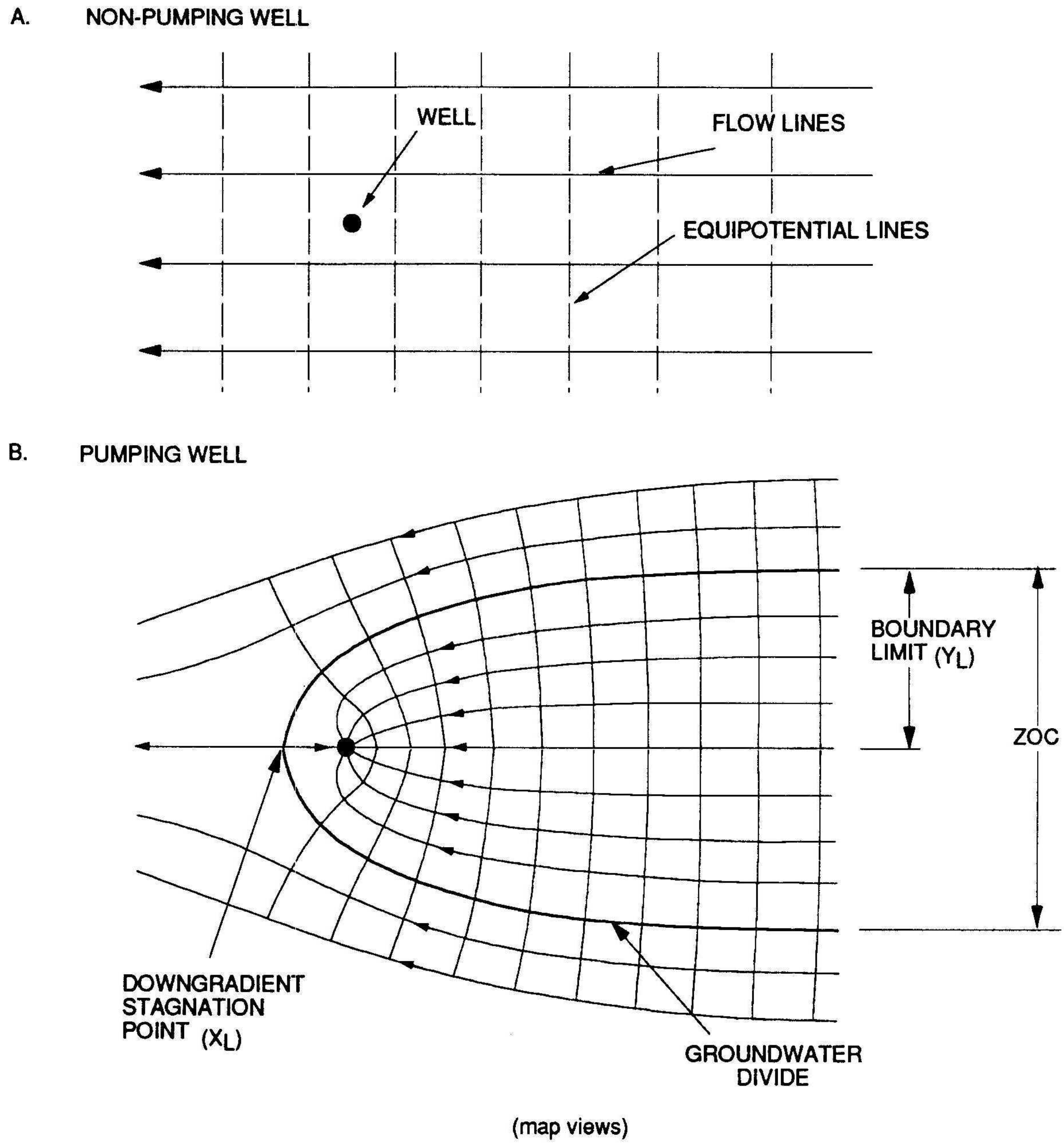
The Zone of Contribution (ZOC) for a well is the land surface, including recharge areas, and subsurface areas through which water flows, that will contribute water to the well. One method of delineating the ZOC involves the use of the uniform flow equation (Todd, 1980) to determine the stagnation point down-gradient from a well and the width of the up-gradient zone that contributes flow to the well (figure 21). The stagnation point marks the distance beyond which flow in the aquifer will not be drawn into the well under the influence of pumping. The boundary limits of the ZOC in the up-gradient direction define the width of the aquifer required to supply flow to the pumping well. The distance to the up-gradient WHPA boundary within the ZOC is tied to the desired time of travel (TOT) chosen to protect the well or wellfield. The distance groundwater will move through the aquifer during the specified TOT is calculated using a derivation of Darcy's law:

$$x_t = \frac{(K)\,(i)\,(t)}{(n)}$$

where:

x_t = up-gradient distance to WHPA boundary, in feet
K = hydraulic conductivity, in feet / day
i = hydraulic gradient
t = desired TOT, in years
n = porosity

ZONE OF CONTRIBUTION



DISTANCE TO DOWN-GRADIENT STAGNATION POINT

$$(X_L) = \frac{Q}{6.28\ K\ b\ i}$$

DISTANCE TO BOUNDARY LIMIT

$$(Y_L) = \frac{Q}{2\ K\ b\ i}$$

WHERE :
Q = VOLUME PUMPED, in cubic feet / day
K = HYDRAULIC CONDUCTIVITY, in feet / day
b = SATURATED THICKNESS, in feet
i = HYDRAULIC GRADIENT

Figure 21 - Zone of Contribution method of Wellhead Protection Area delineation (modified from Todd, 1980).

The use of this equation assumes that the well is completed in an aquifer that has a sloping water table or regional hydraulic gradient. The effects of the pumping well are also ignored.

The Analytical Zone of Contribution method is fairly accurate and provides excellent protection for a water supply. However, the use of this method does require a significant amount of site specific data that may not be available.

Hydrogeologic Mapping Method

Hydrogeologic mapping is the determination of aquifer characteristics, flow boundaries and flow directions (figure 22). It is well suited to hydrogeologic settings dominated by near surface flow boundaries as are many glacial and alluvial aquifers. It provides for site specific modification to WHPAs calculated using the other methods or can be used alone if the whole aquifer is to be the WHPA.

Towner Wellhead Protection Areas

The city of Towner currently obtains water from three wells located along the northern edge of Towner in the NW/4 Section 11, Township 156 North, Range 76 West (figure 9). The wells are completed in the sand and gravel deposits of the eastern terrace unit of the Souris Valley aquifer, and they are constructed to depths, from north to south, of 39, 42, and 40 feet, respectively. The city of Towner is currently authorized to withdraw a maximum of 293 acre-feet of water annually from the wellfield. However, the city of Towner has reported an average annual withdrawal of approximately 163 acre-feet over the past 6 years (Table 1) (NDWUDP, 1990).

Year	Reported Use
1985	167.5
1986	149.6
1987	178.0
1988	164.8
1989	168.0
1990	149.5

Table 1 - Annual municipal withdrawals reported by the city of Towner.

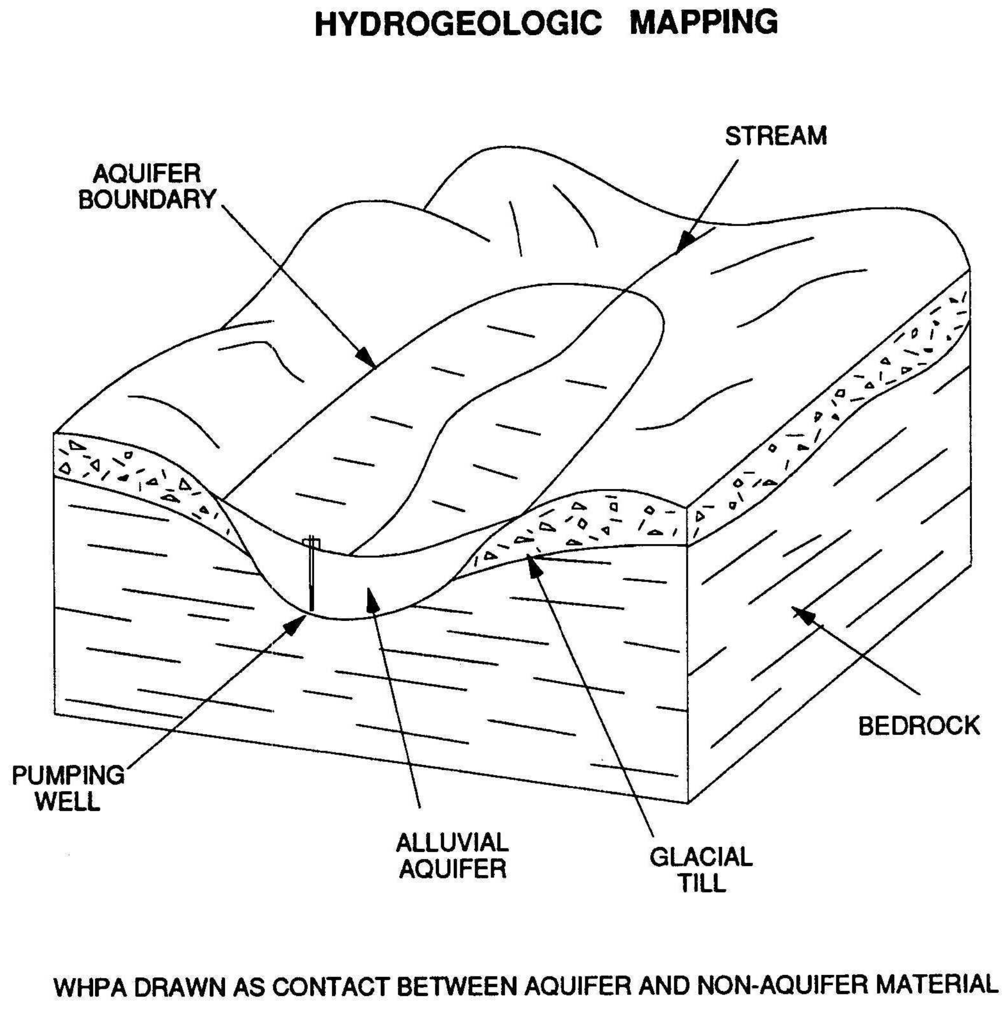


Figure 22 - Hydrologic Mapping method of Wellhead Protection Area delineation.

The eastern terrace unit of the Souris Valley aquifer is generally a shallow unconfined system. Because the aquifer is shallow and unconfined, infiltration from local precipitation events would make the aquifer vulnerable to direct contamination from surface activity. Therefore, the WHPA was defined using the analytical zone of contribution methods combined with hydrogeologic mapping methods to provide an appropriate WHPA.

Because Towner's wells are relatively close together, the wells can be treated as a single pumping point. The maximum annual withdrawal, reported by the city of Towner over the past 6 years, consists of 178 acre-feet of water which was withdrawn in 1987. The primary WHPA was, therefore, determined based upon the maximum annual withdrawal of 178 acre-feet combined with other parameters determined or estimated from data collected during the hydrogeologic field investigation. Assuming an annual withdrawal of 178 acre-feet, the average daily pumping rate would be approximately 21,250 cubic feet per day. A lateral hydraulic gradient of 7 feet per mile was selected, based upon the potentiometric surface generated from water level measurements obtained on September 9, 1990 (figure 10). An average saturated thickness of approximately 23 feet was estimated for the vicinity surrounding Towner's wellfield. Randich (1981) estimated a hydraulic conductivity of 200 feet per day based upon the grain size of the aquifer material. An average porosity of 0.25 was also estimated based upon the grain size of the aquifer material (Freeze & Cherry, 1979).

The uniform flow equation was used to calculate the ZOC for purposes of defining the primary WHPA (figure 23). The distance to the down-gradient stagnation point located west of the wellfield is approximately 600 feet. The maximum width of the ZOC is approximately 3,800 feet. The up-gradient distance corresponding to a ten-year time of travel (TOT) was calculated to be approximately 3900 feet.

A secondary WHPA was also delineated to provide an additional measure of safety for the wellfield and to allow for an increased use of water by the city of Towner (figure 23). The ZOC for the secondary WHPA was calculated using Towner's permitted annual withdrawal of 293 acre-feet of water which translates to a withdrawal rate of approximately 35,000 cubic feet per day. All other parameters used to calculate the ZOC for the primary WHPA were left unchanged. The distance to the down-gradient stagnation point is approximately 900 feet and the maximum width of the ZOC is approximately 5,700 feet.

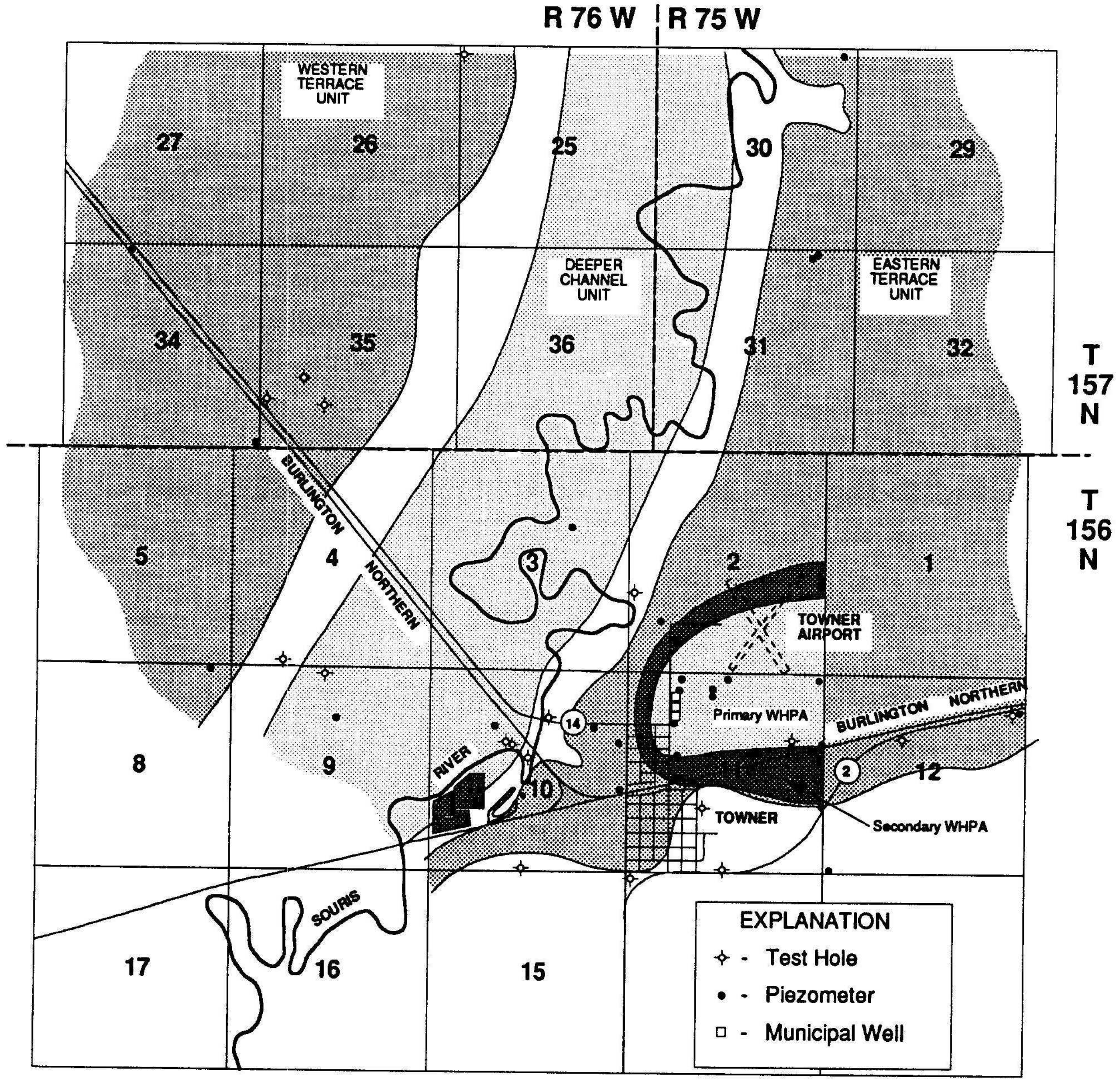


Figure 23 - Map identifying the primary and secondary wellhead protection areas for Towner's municipal wellfield.

SUMMARY AND CONCLUSIONS

The city of Towner obtains its municipal water supply from three wells. Towner's municipal wells are completed in the surficial outwash deposits of the Souris Valley aquifer.

The Fox Hills Formation subcrobs beneath the surficial deposits throughout the study area. The Fox Hills Formation consists of a sequence of sandstone, silty shales, and siltstones. The Souris River Valley generally serves as a discharge area for the Fox Hills aquifer. The lateral hydraulic gradient of the Fox Hills aquifer ranges from 2 to 8 feet per mile toward the northeast. The Fox Hills aquifer is confined within the study area, and the deeper channel unit of the Souris Valley aquifer directly overlies the Fox Hills aquifer beneath the Souris Valley flood plain. The terrace units of the Souris Valley aquifer are underlain by as much as 20 to 30 feet of glacial till, and water level data suggests that the Fox Hills aquifer is not well connected to the terrace units of the Souris Valley aquifer.

The sand and gravel deposits comprising the Souris Valley aquifer were deposited as Late Wisconsin glacial meltwaters incised the Souris River valley into the glacial till. Within the study area, the Souris Valley aquifer is separated into three distinct units; a deeper channel unit, an eastern terrace unit, and a western terrace unit. The deeper channel unit generally underlies the flood plain of the Souris River while the eastern and western terrace units generally define the extent of the Souris Valley terraces. Towner's municipal wells are completed in the eastern terrace unit of the Souris valley aquifer.

The deeper channel unit is confined within the study area, and it is overlain by as much as 32 feet of flood plain deposits consisting predominately of silts and clays. Lithologic information, water-level data, and water quality data, all suggests that the eastern and western terrace units are not generally connected to the deeper channel unit within the study area. Because the terrace units are generally shallow and unconfined, hydraulic gradients within the terrace units are controlled primarily by topography. The lateral hydraulic gradient within the eastern terrace unit is approximately 7 to 10 feet per mile, and water within both terrace units is generally moving toward the Souris River. The hydraulic gradient within the deeper channel unit indicates that water generally moves from the deeper channel unit to the Souris River.

Since the terrace units of the Souris Valley aquifer are fairly shallow and unconfined, recharge is generally controlled by local precipitation. Both the terrace units receive recharge as direct infiltration from local precipitation events and local runoff. Even though the deeper channel unit is confined within the study area, water level data suggests that the deeper channel unit also receives a certain component of recharge directly from local precipitation. Discharge from the eastern terrace unit occurs primarily as a result of evapotranspiration, pumping from wells, and from springs and seeps along the flood plain margin of the eastern terrace deposits.

Water from the Fox Hills aquifer is generally of either a sodium (Na) bicarbonate (HCO_3) or a sodium (Na) chloride (Cl) type. Water from the terrace units of the Souris Valley aquifer is distinctly different than the water from the deeper channel unit. The flow system of the deeper channel unit is predominately influenced by the regional flow system of the underlying bedrock aquifer, while the flow system within the terrace units is dominated by local recharge from precipitation events and discharge from evapotranspiration, municipal pumping, and springs and seeps. Water from both of the terrace units can generally be classified as a calcium (Ca) bicarbonate (HCO_3) type water. Both the eastern and the western terrace units demonstrated a wide variation in water quality. The variation in water quality observed in the terrace units is likely due to a combination of groundwater mixing with water from the underlying till, concentrating effects associated with evaporative processes, and various related surface activities. Water from the deeper channel unit is predominately of a sodium (Na) sulfate (SO_4) type.

Both a primary and a secondary wellhead protection area (WHPA) were delineated for Towner's municipal wells. The zone of contribution (ZOC) for the primary WHPA was calculated based upon Towner's maximum annual withdrawal over the past 6 years of 178 acre-feet of water. The down-gradient stagnation point would be located approximately 600 feet west of the municipal wellfield. The up-gradient distance which complies with the minimum ten year travel time (TOT) established by the North Dakota WHP program would extend approximately 3,900 feet east of the wellfield. The maximum width of the ZOC is approximately 3,800 feet.

The ZOC for the secondary WHPA was calculated based upon Towner's maximum authorized annual withdrawal of 293 acre-feet of water. The down-gradient stagnation point would be located approximately 900 feet west of the municipal wellfield. The maximum width of the ZOC for the secondary WHPA is approximately 5,700 feet.

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APPENDIX A - Lithologic Logs of test holes and wells

156-076-02CBCB

NDSWC 12605

Date Completed:	6/20/90	Purpose:	Test Hole
Depth Drilled (ft):	60	Source of Data:	NDSWC
L.S. Elevation (ft)	1452		

Lithologic Log

Unit	Description	Depth (ft)
CLAY	black, moderately cohesive and sticky, very little silt, abundant organic material	0-5
CLAY	light to medium yellowish gray, soft, plastic, slightly silty	5-10
CLAY	yellowish brown, soft, plastic, silty, abundant organic material	10-12
SAND & GRAVEL	fine to very coarse sand and gravel (less than 1 inch in diameter), poorly sorted, subangular to subround, predominately subround, predominately carbonate and shield silicates, oxidized	12-13
CLAY	(TILL) oxidized, yellowish brown, silty, moderately cohesive	13-16
CLAY	(TILL) medium to dark gray, silty, cohesive, somewhat rigid abundant, sand size carbonates, quartz, and shale grains common	16-20
SAND & GRAVEL	medium sand to coarse gravel, predominately coarse sand and gravel, subangular to subround, predominately subround, moderate sorting, predominately carbonates, shales, and shield silicates	20-21
CLAY	(TILL) dark gray, slightly silty, very cohesive, almost rigid, numerous sand size grains of quartz and carbonates	21-34
SAND	(Kfh) silty, clayey, equal parts of very fine sand, clay and silt, light greenish gray, soft, not lithified slightly glauconitic	34-44
CLAY	(Kfh) sandy, silty, white, soft, and not well lithified, sand is predominately very fine to fine, silty sands ranging from light greenish gray to brownish gray, abundant carbonaceous material	44-60

156-076-02CBD

NDSWC 12600

Date Completed:	6/19/90	Well Type:	2" PVC
Depth Drilled (ft):	70	Source of Data:	NDSWC
Screened Interval (ft):	21-26	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1478		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	very fine to medium, predominately very fine, poor recovery, well sorted, subround	2-5
SAND	very fine to coarse with some gravel, predominately medium to coarse, subangular to well rounded, predominately well rounded, moderate to fair sorting, quartz - 40%, carbonates - 20%, shield silicates - 20%, shales - 15%, lignite - 5%, quartz and shield silicate grains are well rounded, carbonate, shale, and lignite grains are more angular, oxidized to 25 feet, becomes coarser to gravel at bottom	5-26
CLAY	(TILL) light to medium gray, silty, soft and plastic, large carbonate pebbles common	26-52
CLAY	(TILL) interbedded with bedrock silts and sands; soft, plastic, medium gray, silty clay, numerous pebble inclusions; bedrock, light gray, clayey, greasy, light mottled, black and gray, silty	52-58
SAND	(Kfh) medium, greenish gray, mottled with black, glauconitic, very fine to fine, silty and clayey, soft, non-cohesive	58-70

156-076-02CCA

NDSWC 12309

Date Completed:	7/20/89	Well Type:	2" PVC
Depth Drilled (ft):	30	Source of Data:	NDSWC
Screened Interval (ft):	21-26	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1482.98		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	gravelly, medium sand to medium pebbles, predominately, coarse to very coarse, subround to round sand, less than 10% round pebbles, remainder round granules and medium sand, detrital lignitic gravel at 21'.	2-26
CLAY	(till)	26-30

156-076-02DAA

NDSWC 12308

Date Completed:	7/20/89	Well Type:	2" PVC
Depth Drilled (ft):	40	Source of Data:	NDSWC
Screened Interval (ft):	26-31	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1482.04		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	fine to coarse, predominately medium to coarse, subround to round.	2-5
SAND	medium sand to fine granules predominately very coarse sand, subround to round, interbedded clay or silt at 12' and 14'.	5-26
GRAVEL	sandy, very coarse sand, to coarse pebbles, predominately subround to round granules, much coarse detrital lignite.	26-31
CLAY	(till), silty, sandy, pebbly, soft plastic, olive gray.	31-40

156-076-02DAA2

NDSWC 12595

Date Completed:	6/14/90	Well Type:	2" PVC
Depth Drilled (ft):	25	Source of Data:	NDSWC
Screened Interval (ft):	12-22	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1481.88		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND	very fine to medium, predominately medium, moderately sorted, angular to subround, predominately subangular, quartz - 30%, carbonates - 40%, shield silicates - 20%, shales and lignite - 10%, oxidized to 10 feet	1-25

156-076-03ACA

NDSWC 12604

Date Completed:	6/19/90	Well Type:	2" PVC
Depth Drilled (ft):	50	Source of Data:	NDSWC
Screened Interval (ft):	23-28	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1451.07		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-3
CLAY	mottled orangish, brown to gray, fairly cohesive, sticky, very little silt	3-10
CLAY	(Kfh) sandy, silty, very fine to fine sand, greenish gray, glauconitic, lignitic, soft, not lithified	10-15
SAND & GRAVEL	fine to very coarse sand and gravel, ranging up to approximately 2 inches in the samples recovered, predominately shield silicates, with abundant carbonates and shales, subangular to well rounded, predominately well rounded, predominately gravel size, lignite appeared at 31 feet	15-40
SAND	(Kfh) light greenish gray, very fine to fine sand, with abundant silt and clay, soft, not lithified, glauconitic, lignitic	40-50

156-076-04CDC

NDSWC 12602

Date Completed:	6/19/90	Purpose:	Test Hole
Depth Drilled (ft):	60	Source of Data:	NDSWC
L.S. Elevation (ft)	1454		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	light yellowish brown, very cohesive and stiff, almost rigid, very little silt	1-6
CLAY	(TILL) light to medium gray, silty, moderately cohesive, quartz and carbonate pebbles common, slightly lignitic	6-10
SAND	(Kfh) very fine to fine, greenish gray, mottled with black, soft, not lithified, glauconitic, significant silt and clay present, coal and dark brown siltstone lenses from 50-51	10-60

156-076-08AAB

NDSWC 5861

Date Completed:	10/14/70	Well Type:	1.25" PVC
Depth Drilled (ft):	80	Source of Data:	NDSWC
Screened Interval (ft):	22-25	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1458.87		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	sandy, silty, clayey, brownish black	0-1
SAND	slightly silty, very fine to medium grained, subangular to rounded, moderately well sorted, mostly quartz and feldspar, some shale, carbonates and lignite, no appreciable water loss	1-29
CLAY	(TILL) silty, slightly sandy, pebbly, a few cobbles, occasional thin sand lenses, olive gray, cohesive, moderately plastic, calcareous	29-57
SHALE	(Kfh) moderately clayey, sandy to very sandy, medium bluish gray to brownish gray, bedded, moderately indurated, non-calcareous	57-80

156-076-09ABC

NDSWC 10037

Date Completed:	10/31/77	Well Type:	1.25" PVC
Depth Drilled (ft):	50	Source of Data:	NDSWC
Screened Interval (ft):	37-40	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1456.17		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	medium brown to light gray, lacustrine, silty, greenish inclusions within the clay, fine, silty sand lenses	1-22
GRAVEL	very coarse, well rounded, predominately crystalline in composition, detrital lignite common	22-46
SAND	(Kfh) light gray, fine, silty	46-50

156-076-09BAA

Date Completed:	7/17/70	Purpose:	Test Hole
Depth Drilled (ft):	29	Source of Data:	Randich (1981)
L.S. Elevation (ft)	1454		

Lithologic Log

Unit	Description	Depth (ft)
CLAY	slightly sandy, brown, oxidized, overbank fluvial	0-4
CLAY	gray, slightly sandy, overbank fluvial	4-9
CLAY	as above, contains gypsum	9-14
CLAY	as above	14-19
CLAY	silty, brown, some beds of gray and white	19-21
CLAY	silty, black, organics	21-22
SAND	very fine, silty, greenish brown	22-27
TILL	auger was definitely hitting stones, but poor recovery	27-29

156-076-10ABC

NDSWC 12315

Date Completed:	7/20/89	Purpose:	Test Hole
Depth Drilled (ft):	40	Source of Data:	NDSWC
L.S. Elevation (ft)	1452		

Lithologic Log

Unit	Description	Depth (ft)
CLAY	silty, dark brownish gray, soft, plastic, (fluvial)	0-8
CLAY	slightly silty, to non silty, dark yellow orange mottle with reddish brown and light tan, silty partings.	8-16
CLAY	very silty, very soft, plastic, shell fragments.	16-20
CLAY	(TILL) silty, sandy, pebbly, soft, plastic, olive gray. sand 25-26', 30-32'.	20-32
SANDSTONE	(Kfh) very clayey, poorly indurated, friable, glauconitic greenish gray.	32-40

156-076-10ADAD

NDSWC 12313

Date Completed:	7/20/89	Well Type:	2" PVC
Depth Drilled (ft):	20	Source of Data:	NDSWC
Screened Interval (ft):	13-18	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1472.56		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND & GRAVEL	sand to coarse pebbles, very round	2-18
CLAY	(TILL)	18-20

156-076-10ADB

NDSWC 12314

Date Completed:	7/20/89	Well Type:	2" PVC
Depth Drilled (ft):	30	Source of Data:	NDSWC
Screened Interval (ft):	15-20	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1466.09		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND		2-4
SAND	gravelly, medium sand to coarse pebbles, predominately subrounded to rounded, coarse to very coarse sand and fine gravels, approx. 10% coarse pebbles, approx. 10% medium sand	4-24
CLAY	(TILL), silty, sandy, pebbly, soft, plastic, olive gray	24-30

156-076-10BDB1

NDSWC 10035

Date Completed:	10/28/77	Purpose:	Test Hole
Depth Drilled (ft):	40	Source of Data:	NDSWC
L.S. Elevation (ft)	1455		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	dark brown, with thin layers of alternating silts and sands	1-32
GRAVEL	fine to medium, subangular to subround, predominately quartz and carbonates	32-40

156-076-10BDB2

NDSWC 10036

Date Completed:	10/28/77	Purpose:	Test Hole
Depth Drilled (ft):	36	Source of Data:	NDSWC
L.S. Elevation (ft)	1455		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	dark brown, with thin alternating layers of silty sands	1-22
SAND & GRAVEL	fine to medium, subrounded, mixed sandy clay on top	22-30
GRAVEL	very coarse, rounded, predominately crystalline	30-36

156-076-10BDB3

NDSWC 12603

Date Completed:	6/19/90	Well Type:	2" PVC
Depth Drilled (ft):	47	Source of Data:	NDSWC
Screened Interval (ft):	28-33	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1454.52		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	road fill	2-6
CLAY	light yellowish, brownish gray, very stiff and cohesive, almost rigid, very little silt, greasy, oxidized	6-15
SAND	(Kfh) dark greenish brown, very silty, very fine to fine sand, abundant silt and clay, glauconitic, very soft not lithified	15-26
CLAY	soft, milky white to gray, very silty and sandy	26-31
SAND	very fine to medium, angular to subround, predominately fine to medium and angular, moderate sorting, quartz - 40%, shield silicates - 25%, lignite - 25%, carbonates and shales - 10%, coarsens downward	31-35
SAND & GRAVEL	medium sand to very coarse gravel and cobbles, difficult drilling, poor recovery, limited recovery included 0.5 to 1 inch diameter, sub angular to well rounded, pebbles and cobbles, predominately shield silicates	35-44
SAND	(Kfh) silty, clayey, greenish gray, soft, non-cohesive, glauconitic, lignitic	44-47

156-076-10BDD

NDSWC 12601

Date Completed:	6/19/90	Purpose:	Test Hole
Depth Drilled (ft):	40	Source of Data:	NDSWC
L.S. Elevation (ft)	1455		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	oxidized, light mottled, yellowish gray, very cohesive and stiff, very greasey, little or no silt	2-15
CLAY	light to medium gray, very cohesive and stiff, greasey, little or no silt	15-19
CLAY	dark gray to black, silty and sandy, soft and plastic, (river bottom or lake sediment, has quite an odor)	19-20
SAND & GRAVEL	very poor recovery	20-21
CLAY	(TILL) medium gray, fairly soft, silty, with numerous gravel size carbonate pebbles, rock from 28-29	21-31
SAND	(Kfh) very fine to fine, very silty and clayey, light greenish gray, glauconitic, lignitic, loosely lithified, soft, carbonaceous streaks common	31-40

156-076-10CAA

NDSWC 12316

Date Completed:	7/20/89	Well Type:	2" PVC
Depth Drilled (ft):	15	Source of Data:	NDSWC
Screened Interval (ft):	5-10	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1461.4		

Lithologic Log

Unit	Description	Depth (ft)
SAND	fine to medium	0-4
SAND	gravelly, coarse sand to medium pebbles, predominately very coarse sand granules, subrounded to rounded, more gravel 9-10'	4-10
CLAY	(TILL), silty, sandy, pebbly, soft, plastic, olive gray oxidized to 12'	10-15

156-076-10CDD

NDSWC 12317

Date Completed:	7/20/89	Purpose:	Test Hole
Depth Drilled (ft):	60	Source of Data:	NDSWC
L.S. Elevation (ft)	1481		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SILT	clayey, yellow orange, soft, plastic.	2-6
CLAY	(TILL) very silty, sandy, pebbly, soft, plastic, oxidized to 17'.	6-52
SANDSTONE	(Kfh) fine to medium, very clayey, poorly indurated, friable, glauconitic greenish gray.	52-60

156-076-10DAD1

NDSWC 12312A

Date Completed:	7/20/89	Purpose:	Test Hole
Depth Drilled (ft):	60	Source of Data:	NDSWC
L.S. Elevation (ft)	1475		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	sandy	0-3
SAND	fine to coarse, predominately medium round, oxidized stain	3-5
CLAY	(TILL), silty, sandy, pebbly, soft, plastic, oxidized to 12', gravel 22'-24' and at 26'	5-32
CLAY	(TILL), very silty, sandy, pebbly, firm, olive gray, cuttings are more brittle, 36-42 interbedded carbonate gravel	32-42
SANDSTONE	(Kfh), fine to medium, very clayey, poorly indurated, friable, glauconitic	42-60

156-076-10DAD2

NDSWC 12312B

Date Completed:	7/20/89	Well Type:	2" PVC
Depth Drilled (ft):	7	Source of Data:	NDSWC
Screened Interval (ft):	0-5	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1469.94		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	sandy	0-3
SAND	fine to coarse, predominately, medium rounded, oxidized stain	3-5
CLAY	(TILL) silty, sandy, pebbly, soft, plastic, oxidized	5-7

156-076-11AAA

NDSWC 12324

Date Completed:	7/21/89	Well Type:	2" PVC
Depth Drilled (ft):	15	Source of Data:	NDSWC
Screened Interval (ft):	6-11	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1468.5		

Lithologic Log

Unit	Description	Depth (ft)
SAND	gravelly, medium sand to coarse granules, predominately very coarse sand and fine granules, subround to round, oxidized to 4 feet, lignitic.	0-11
CLAY	(TILL)	11-15

156-076-11ABB

NDSWC 12307

Date Completed:	7/19/89	Well Type:	2" PVC
Depth Drilled (ft):	40	Source of Data:	NDSWC
Screened Interval (ft):	31-36	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1473.4		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	medium to coarse.	2-6
SAND	gravelly, coarse sand to coarse pebbles, 80% very coarse sand and fine granules, subround to round, 10% medium granules to coarse pebbles round, 10% coarse sand, detrital lignite at 13', oxidized stain to 21'.	6-36
CLAY	(till), silty, sandy, pebbly, soft, plastic, olive gray.	36-40

156-076-11ADAD

NDSWC 12323

Date Completed:	7/21/89	Well Type:	2" PVC
Depth Drilled (ft):	10	Source of Data:	NDSWC
Screened Interval (ft):	5-10	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1470.42		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	gravelly	2-7
TILL	olive gray	7-10

156-076-11ADB1

NDSWC 12596

Date Completed:	6/15/90	Purpose:	Test Hole
Depth Drilled (ft):	60	Source of Data:	NDSWC
L.S. Elevation (ft)	1472		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	oxidized, very fine to medium, predominately fine to medium, subangular to subround, predominately subround, well sorted, quartz - 30%, carbonates - 40%, shales - 10%, shield silicates - 20%, with some lignite, becomes coarser toward the bottom	2-11
SAND	fine to very coarse, predominately coarse, subangular to subround, predominately subangular, poorly sorted, quartz - 30%, carbonates - 30%, shales - 20%, shield silicates - 20%,	11-13
CLAY	light gray, soft, smooth slightly silty	13-15
CLAY	(TILL) dark gray, moderately cohesive, silty, contains numerous large carbonate pebbles, rock at 26	15-37
SAND	(Kfh) very fine to fine, well sorted, greenish gray, glauconitic, poorly lithified, soft, breaks apart easily	37-42
SAND	very fine to coarse, predominately medium, subangular to subround, predominately subangular, poorly sorted, predominately quartz and carbonates, with some lignite and shield silicates	42-44
CLAY	(TILL) dark gray, moderately cohesive, very silty, with large carbonate pebbles	44-49
SILTSTONE	(Kfh) dark grown, soft, clayey, sandy	49-52
SAND & GRAVEL	fine to very coarse, sand and gravel, predominately very coarse sand gravel, angular to round, cuttings include large fragments of shales and well lithified, well rounded, pebbles of Fox Hills sandstone	52-56
SAND	(Kfh) light greenish gray, white discoloration, very fine, very silty, soft, not well lithified, glauconitic, black specs of either mica or lignite	56-60

156-076-11ADB2

NDSWC 12597

Date Completed:	6/15/90	Well Type:	2" PVC
Depth Drilled (ft):	20	Source of Data:	NDSWC
Screened Interval (ft):	3-13	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1471.5		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	very fine to medium, predominately fine, oxidized, well sorted, subangular to rounded, predominately subround, predominately quartz and carbonates, with some lignite, shale and shield silicates	2-11
SAND	as above, unoxidized	11-12
CLAY	slightly silty, soft, light gray	12-14
CLAY	(TILL) dark gray, silty, carbonate and detrital shale gravel size pebbles common	14-20

156-076-11BAAC1

NDSWC 12598

Date Completed:	6/18/90	Well Type:	2" PVC
Depth Drilled (ft):	70	Source of Data:	NDSWC
Screened Interval (ft):	26-31	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1476.86		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	very fine to coarse, predominately very fine to fine, well sorted, subangular to round, predominately round, predominately quartz and carbonates, with some lignite, detrital shale and shield silicates, quartz grains are more rounded while carbonate and shale grains tend to be somewhat more angular, oxidized	2-19
SAND	very fine to coarse, predominately very fine to medium, fair sorting, subangular to subround, approximately 65-70% quartz and carbonates, with some lignite, detrital shale, and shield silicates	19-23
SAND & GRAVEL	fine to coarse sand, predominately medium to coarse sand and gravel, subangular to well rounded, predominately round, poorly sorted, coarsens toward bottom to become predominately gravel.	23-31
CLAY	(TILL) medium to dark gray, moderately cohesive and rigid, very silty, with numerous carbonate and quartz pebbles, rock at 34 feet, sand and gravel and rock lense from 44-45, rock at 47 feet	31-48
CLAY	(TILL) sandy clay sequence with interbedded sequence of moderately cohesive silty clays with very sandy clay to clayey sand lenses, also includes light gray soft plastic clay (bentonite), gravel size bedrock shale inclusions, carbonate boulder 59-60	48-61
SAND	(Kfh) clayey, silty, dark grayish green, with reddish brown stain, glauconitic, lignitic, very fin to fine sand, well sorted, very tight, not well lithified, (well lithified, hard sandstone bed from 66-67, gray, greenish, tan, highly calcified)	61-70

156-076-11BAAC2

NDSWC 12599

Date Completed:	6/19/90	Well Type:	2" PVC
Depth Drilled (ft):	25	Source of Data:	NDSWC
Screened Interval (ft):	9-19	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1476.8		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	very fine to very coarse, predominately very fine to medium, subangular to round, predominately subround, fair sorting, predominately quartz and carbonates, with some shield silicates, shales, and lignite, oxidized	2-19
SAND	fine to very coarse, predominately medium, subangular to subround, predominately subround, large lignite fragments (approximately 1 inch diameter) from 19-21, quartz and carbonates - 60%, shield silicates - 25%, shales and lignite - 15%	19-25

156-076-11BABB

NDSWC 12306

Date Completed:	7/19/89	Well Type:	2" PVC
Depth Drilled (ft):	40	Source of Data:	NDSWC
Screened Interval (ft):	29-34	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1477.94		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	fine	2-5
SAND	gravelly, coarse sand to coarse pebbles, predominately, very coarse sand to fine granules, 10-15% round coarse pebbles, 5-10% round medium granules and fine pebbles, from 26'. much coarse detrital lignite.	5-34
CLAY	(TILL) silty, sandy, pebbly, soft, plastic, olive gray.	34-40

156-076-11BABC

NDSWC 12305

Date Completed:	7/19/89	Well Type:	2" PVC
Depth Drilled (ft):	40	Source of Data:	NDSWC
Screened Interval (ft):	31-36	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1476.62		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	very fine to fine.	2-4
SAND	gravelly, coarse sand to coarse pebbles, angular to rounded, 10% round granules, 10% round pebbles, quartz, igneous, limestone, oxidized to 26'	4-36
CLAY	(TILL) silty, sandy, pebbly, soft, plastic, olive gray, cuttings slightly blocky	36-40

156-076-11BAC

NDSWC 12304

Date Completed:	7/19/89	Well Type:	2" PVC
Depth Drilled (ft):	30	Source of Data:	NDSWC
Screened Interval (ft):	20-25	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1474.24		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	very fine to fine	2-5
SAND	gravelly, coarse sand to coarse pebbles, 80% coarse to very coarse sand, subrounded to rounded, some angular and subangular, 10% round gravel, 10% round coarse pebbles, much igneous and feldspar grains, pebbles are limestone, oxidized stain to 21', lignite gravel at 12'	5-25
CLAY	silty, slightly sandy, slightly pebbly, slightly firm, slightly plastic, cuttings are blocky, olive gray (TILL)	25-30

156-076-11BDC

NDSWC 12311

Date Completed:	7/20/89	Well Type:	2" PVC
Depth Drilled (ft):	15	Source of Data:	NDSWC
Screened Interval (ft):	5-10	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1469.38		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	fine to medium, very clayey	2-6
SAND	gravelly, medium to very coarse sand to medium gravels.	6-10
CLAY	(TILL)	10-15

156-076-11CAB1

NDSWC 12310A

Date Completed:	7/20/89	Well Type:	2" PVC
Depth Drilled (ft):	49	Source of Data:	NDSWC
Screened Interval (ft):	36-41	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1470.8		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	gravelly, medium sand to fine pebbles, predominately coarse to very coarse sand.	2-6
CLAY	(TILL) silty, sandy, pebbly, soft, plastic, oxidized to 16'.	6-36
SAND	gravelly, fine sand to fine pebbles, subrounded to rounded predominately fine to medium sand, subrounded to rounded granules.	36-40
SANDSTONE	fine to medium grained, very clayey, friable, glauconitic.	40-49

156-076-11CAB2

NDSWC 12310B

Date Completed:	7/20/89	Well Type:	2" PVC
Depth Drilled (ft):	8	Source of Data:	NDSWC
Screened Interval (ft):	1-6	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1470.92		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	gravelly, medium sand to fine pebbles, predominately coarse to very coarse sand.	2-6
CLAY	(TILL) silty, sandy, pebbly, soft, plastic, oxidized.	6-8

156-076-11CACD

NDSWC 12319

Date Completed:	7/21/89	Purpose:	Test Hole
Depth Drilled (ft):	40	Source of Data:	NDSWC
L.S. Elevation (ft)	1475		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SILT	clayey	2-3
CLAY	(TILL) silty, sandy, pebbly, soft, plastic, oxidized to 15', 18'19' very coarse sand to fine gravel.	3-40

156-076-11DAD

NDSWC 12322

Date Completed:	7/21/89	Well Type:	2" PVC
Depth Drilled (ft):	48	Source of Data:	NDSWC
Screened Interval (ft):	39-44	Principal Aquifer :	Undefined
L.S. Elevation (ft)	1470.86		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SILT	clayey.	1-3
SAND	fine to very coarse, oxidized.	3-5
CLAY	(TILL) very silty, sandy, pebbly, soft, plastic. Oxidized to 12 feet, interbedded sand 32-33'.	5-37
SAND	very fine to medium, subround to round, quartz.	37-44
SANDSTONE	Kfh	44-48

156-076-11DCC

NDSWC 12320

Date Completed:	7/21/89	Purpose:	Test Hole
Depth Drilled (ft):	60	Source of Data:	NDSWC
L.S. Elevation (ft)	1485		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	small sand lense at 2'.	0-2
CLAY	(TILL) very silty, sandy, pebbly, soft, plastic, oxidized to 18', sand at 47', 52-56'.	2-56
SANDSTONE	(Kfh) fine grained, clayey, poorly indurated, glauconitic.	56-60

156-076-12AAD1

NDSWC 12593

Date Completed:	6/14/90	Purpose:	Test Hole
Depth Drilled (ft):	60	Source of Data:	NDSWC
L.S. Elevation (ft)	1477		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-3
SAND	very fine to fine, well sorted, oxidized, orangish brown, predominately quartz and carbonates, with some lignite and shales	3-11
SAND	very fine to fine, as above, subrounded to well rounded, coarsening downward	11-14
SAND & GRAVEL	very fine to coarse, predominately coarse to very coarse, subangular to round, predominately subround, poorly sorted, quartz - 40%, carbonate - 25%, shales - 15%, shield silicates - 10%, lignite - 10%	14-16
CLAY	(TILL) silty, sandy, light gray, soft, large carbonate and detrital shale pebbles common	16-29
CLAY	(TILL) medium to dark gray, silty, moderately cohesive, much stiffer than above	29-34
GRAVEL	angular, predominately carbonates and shield silicates	34-35
CLAY	(TILL) dark gray, silty cohesive, blocky, pebbles of carbonate and shield silicate common	35-48
SAND	(Kfh) very fine, glauconitic, greenish gray, poorly lithified, soft, well sorted, very silty	48-55
SAND	(Kfh) very fine, slightly glauconitic, white to light gray, well sorted, silty, clayey, soft not well lithified, (well lithified sandstone from 55-56)	55-60

156-076-12AAD2

NDSWC 12594

Date Completed:	6/14/90	Well Type:	2" PVC
Depth Drilled (ft):	20	Source of Data:	NDSWC
Screened Interval (ft):	11-16	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1474.49		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-3
SAND	very fine to fine, well sorted, oxidized, oarngish brown, predominately quartz and carbonates, some lignite and shield silicates, well rounded	3-11
SAND	very fine to fine, as above, well sorted, light gray, predominately quartz and carbonates, some lignite and shield silicates	11-14
SAND	fine to very coarse, predominately coarse, poorly sorted, subangular to round, predominatley subround	14-16
CLAY	(TILL) silty, sandy, light gray, soft	16-20

156-076-12BDB

NDSWC 12592

Date Completed:	6/14/90	Purpose:	Test Hole
Depth Drilled (ft):	55	Source of Data:	NDSWC
L.S. Elevation (ft)	1474		

Lithologic Log

Unit	Description	Depth (ft)
SAND	oxidized from 0-5 feet, very fine to medium, predominately fine, subangular to rounded, moderately well sorted, orangish yellow brown, 40% carbonates, 30% quartz, 20% detrital shales, 10% lignite and shield silicates	0-6
CLAY	(TILL) very silty and sandy, medium to dark gray, soft, numerous gravel sized carbonate pebbles	6-36
SAND & GRAVEL	fine to very coarse, predominately medium to coarse, angular to subround, predominately angular, poorly sorted, predominately carbonate, lignites, and detrital shales, remainder is quartz and shield silicates	36-38
CLAY	(TILL) very silty and sandy, light medium gray, soft, large carbonate and detrital shale pebbles	38-43
SANDSTONE	(Kfh) very fine to fine, greenish gray, glauconitic, micaceous, well sorted	43-48
SILTSTONE	(Kfh) dark brown, clayey, poorly lithified	48-55

156-076-12CCC

NDSWC 12321

Date Completed:	7/21/89	Well Type:	2" PVC
Depth Drilled (ft):	80	Source of Data:	NDSWC
Screened Interval (ft):	55-60	Principal Aquifer :	Undefined
L.S. Elevation (ft)	1503.12		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SILT	slightly clayey, oxidized, dark yellow orange mottled with gray.	2-18
CLAY	(till), silty, sandy, pebbly, soft, plastic, oxidized (26') olive gray 26'-27'.	18-27
CLAY	silty, sandy, pebbly, firm, dark yellow orange mottled with reddish brown 27-30', boulder 30-31', olive gray at 31' softer and plastic.	27-55
SAND	gravelly, very coarse sand to coarse pebbles, predominately very coarse sand and gravel, angular to round, 10% coarse pebbles including quartz, limestone and igneous.	55-60
GRAVEL	Interbedded gravel and till	60-70
SANDSTONE	(Kfh), fine to medium, clayey, poorly indurated, friable, glauconitic, interbedded, lignitic material.	70-80

156-076-14BBB

NDSWC 12318

Date Completed:	7/21/89	Purpose:	Test Hole
Depth Drilled (ft):	40	Source of Data:	NDSWC
L.S. Elevation (ft)	1486		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-4
GRAVEL		4-5
SILT	very fine sand , clayey, soft, oxidized.	5-9
CLAY	(TILL) very silty, sandy, pebbly, soft, plastic, oxidized to 18'	9-40

157-075-30AAA

NDSWC 10178

Date Completed:	8/8/78	Purpose:	Test Hole
Depth Drilled (ft):	80	Source of Data:	NDSWC
L.S. Elevation (ft)	1471		

Lithologic Log

Unit	Description	Depth (ft)
SAND	very fine to very coarse, predominately medium sand - 40%, very fine - 10%, fine - 20%, coarse - 20%, very coarse - 10%, well sorted, predominately quartz - 40%, carbonates - 30%, shale - 30%, subrounded, to rounded, oxidized	0-10
SAND & GRAVEL	fine to medium gravel, very fine to very coarse sand, predominately fine gravel - 50%, medium gravel - 5%, very coarse sand - 30%, fine to medium sand -10-20%, very fine sand - 5%, predominately quartz - 40%, carbonates - 40%, shale -20%, subangular to rounded	10-18
CLAY	silty, sandy, pebbly, dark gray, compact and cohesive clay, thin sandy gravel lenses from 44-48	18-48
SANDSTONE	(Kfh) light gray, very fin grained, clayey, silty, interbedded with gray, brown, compact, clayey, siltstone	48-80

157-075-31AAB

Date Completed:	11/1/66	Well Type:	4"
Depth Drilled (ft):	84	Source of Data:	Randich, (1981)
Screened Interval (ft):	20-30	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1485		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	dusky brown, sandy	0-1
SAND	medium to coarse, angular to subrounded	1-21
GRAVEL	fine to medium, about 25% medium to coarse sand, subangular to subrounded	21-27
TILL	olive gray, silty, pebbly	27-39
GRAVEL	fine to medium, about 30% medium to coarse sand, subangular to subrounded	39-42
TILL	dark gray, silty, pebbly	42-53
SANDSTONE	(Kfh) dark greenish gray, very fine, moderately indurated, silty to clayey intervals	53-84

157-075-31AAB2

Date Completed:	11/1/66	Purpose:	Test Hole
Depth Drilled (ft):	84	Source of Data:	Randich, (1981)
L.S. Elevation (ft)	1485		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	dusky brown, sandy	0-1
SAND	medium to coarse, angular to subrounded	1-21
GRAVEL	fine to medium, about 25% medium to coarse sand, subangular to subrounded	21-27
TILL	olive gray, silty, pebbly	27-39
GRAVEL	fine to medium, about 30 % medium to coarse sand, subangular to subrounded	39-42
TILL	dark gray, silty, pebbly	42-53
SANDSTONE	(Kfh) dark greenish gray, very fine, moderately indurated, silty to clayey intervals	53-84

157-076-25BBB

NDSWC 10038

Date Completed:	11/1/77	Purpose:	Test Hole
Depth Drilled (ft):	40	Source of Data:	NDSWC
L.S. Elevation (ft)	1455		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	brownish black	0-1
SAND	medium, subrounded to rounded, about 30% detrital lignite, oxidized	1-20
TILL	dark gray, sandy, cobbles from 27 to 28 feet	20-32
SANDSTONE	(Kfh) light green, fine, clayey, moderately indurated	32-40

157-076-34BAA

NDSWC 9365

Date Completed:	7/31/75	Well Type:	1.25" PVC
Depth Drilled (ft):	80	Source of Data:	NDSWC
Screened Interval (ft):	18-21	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1465.88		

Lithologic Log

Unit	Description	Depth (ft)
SAND	very fine to fine, subround to rounded, predominately quartz, some carbonates and igneous, small interbedded layers of clay, oxidized	0-6
SAND	medium to very coarse, predominately coarse, angular to subround, quartz - 70%, carbonates - 15%, igneous - 10%, lignite - 5%, clean, moderately well sorted	6-22
CLAY	(TILL) silty, sandy, pebbly, medium gray, hard, tight, brittle	22-52
SHALE	(Kfh) clayey, sandy (fine grained), silty, medium light gray to greenish gray, hard, tight, friable to brittle	52-80

157-076-34DDD

NDSWC 9366

Date Completed:	7/28/75	Well Type:	1.25" PVC
Depth Drilled (ft):	80	Source of Data:	NDSWC
Screened Interval (ft):	16-19	Principal Aquifer :	Souris Valley
L.S. Elevation (ft)	1465		

Lithologic Log

Unit	Description	Depth (ft)
SAND	fine to coarse, predominately medium, quartz - 70%, carbonates - 15%, igneous - 10%, lignite - 5%, clean, well sorted, coarsens toward the base	0-16
CLAY	(TILL) sandy, silty, pebbly, medium gray, tight, hard, brittle	16-56
SHALE	(Kfh) clay, sandy, silty, light to medium gray to greenish gray, hard, brittle, to friable, hard sandstone layer from 62 to 64	56-80

APPENDIX B - Water Quality Analyses

Location	Screened Interval (ft)	Date Sampled	SiO_2	Fe	Mn	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl	F	NO_3	B	TDS	Hardness as $CaCO_3$	NCH	% Na	SAR	Spec Cond (µmho)	Temp (°C)	pH
			|<---(milligrams per liter)														--->|						
156-076-02CBD	21-26	06/27/90	15	0.02	0.16	59	21	21	1.7	289	0	43.0	6.2	0.1	1.0	0.07	310		0	16	0.6	562	8	
156-076-02CCA	21-26	09/21/89		0.02	0.138	80.5	26	13.6	2.4	312	0	46	11.7	0.12			335	256		8.7	0.34			
156-076-02DAA	26-31	09/21/89		0.703	0.652	104	43.3	54.1	5.3	518	0	81	71.7	0.14			615	424		21.1	1.12			
156-076-02DAA2	12-22	06/27/90	22	0.02	0.22	130	40	54	2.6	514	0	52	79	0.1	65	0.05	698		68	19	1.1	1243	8	
156-076-03ACA	23-28	06/27/90	26	0.87	0.31	89.0	51	350.0	5.1	759.0	0	510	27	0.3	2	0.54	1440		0	63	7.4	2150	6	
156-076-08AAB	22-25	10/14/70	16	0.22	0.29	68	27	26	2.7	340	0	44	6.4	0.1	1	0.42	358		4	16	0.7	540	8	
156-076-08AAB	22-25	06/26/90	19	0.05	0.24	65	24	13	3.8	313	0	26	6.9	0.1	1	0.06	313		4	10	0.4	579	13	
156-076-09ABC	37-40	05/02/78	25	1.3	0.04	37	19	250	3.6	514	0	240	16	0.2	2.5	0.05	848		0	76	8.3	1300	8	7.6
156-076-09ABC	37-40	05/14/90	23	1.1	0.14	29	42	310	4.1	534	0	470	17	0.3	1	0.19	1160		0	73	8.5	1759	9	
156-076-10ADAD	13-18	09/22/89		0.097	0.058	45.1	17.7	67.7	8.8	308	0	27	6.2	0.23			348	252		44.1	2.16			
156-076-10ADB	15-20	09/22/89		0.879	1.08	112	40.2	41.4	3.4	310	0	196	22.3	0.12			568	254		16.8	0.85			
156-076-10BDB3	28-33	06/26/90	21	3.8	0.4	220	130	330	6.7	690.0	0	1200	32	0.2	1.0	0.16	2290		520	40	4.3	2750	8	
156-076-10CAA	5-10	09/22/89		0.037	0.043	80.2	52	84.2	6.5	225	0	277	5.1	0.19			689	184		30.6	1.8			
156-076-11AAA	6-11	09/21/89		29.4	0.36	258	232	158	182	2550	0	87	215	0.15			2390	2090		17.6	1.72			
156-076-11ABB	31-36	09/21/89		0.351	0.337	76.3	28.2	34.4	2.4	370	0	40	10.2	0.11			374	303		19.5	0.85			
156-076-11ADAD	5-10	09/21/89		0.022	0.117	114	65.6	104	8.4	676	0	103	7.4	0.28			767	554		28.9	1.92			
156-076-11ADB2	3-13	06/26/90	13	0.03	0.25	130	93.0	180	64	546	0	620	34	0.1	72	5.2	1480		260	33	2.9	2140	9	
156-076-11BAAC1	26-31	06/29/90	20	2.3	0.58	200	71	64	21	834.0	0	43.0	76	0.1	1.0	0.15	910		110	15	1.0	1743	8	
156-076-11BAAC2	9-19	06/27/90	18	0.03	0.26	70	28	35	2.4	367.0	0	37	21	0.2	4.4	0.05	397		0	21	0.9	763	9	
156-076-11BAB	28-40	07/15/75	13	2	0.32	77	29	27	2.8	303	0	93	21	0.1	1	0	415		61	16	0.7	650	10	7.4
156-076-11BABB	29-34	09/21/89		0.027	0.579	91.5	30	32.3	2.4	395	0	38	42.1	0.13			431	324		16.6	0.75			
156-076-11BABC	31-36	09/21/89		0.027	0.561	69.9	21.7	26.8	1.9	297	0	40	37.4	0.12			344	243		18	0.72			
156-076-11BAC	25-40	07/15/75	14	2.6	0.32	81	24	28	2.1	304	0	92	19	0.1	1	0.35	414		51	17	0.7	650	8.5	7.4
156-076-11BAC2	20-25	09/21/89		3.6	0.834	179	57.5	147	4.7	311	0	567	104	0.14			1210	255		31.7	2.44			
156-076-11BDC	5-10	09/21/89		0.863	0.265	561	213	268	6.9	362	0	1830	113	0.19			3170	296		20.3	2.44			
156-076-11CAB1	36-41	09/22/89		0.151	0.222	35.8	10.3	514	4.5	779	0	581	58.4	0.45			1590	638		89.4	19.5			
156-076-11CAB1	36-41	03/20/90	28	0.06	0.31	36	11	490	6.3	736.0	11	590	60	0.5	1.0	1.4	1600		0	88	18	2300	7	
156-076-11CAB1	36-41	03/20/90	24	0.12	0.15	34	10.0	470	6.1	733.0	11	570	60	0.5	1.0	1.3	1550		0	88	18	2370	7	
156-076-11DAD	39-44	09/21/89		0.111	0.009	16.7	5.3	654	4	812	0	761	51.5	0.41			1890	665		95.7	35.5			
156-076-12AAD2	11-16	06/26/90	22	1.5	0.27	85	32	29	2.1	341	0	130	8.1	0.2	1.0	0.08	479		64	15	0.7	802	7	
156-076-12CCC	55-60	09/21/89		1.09	0.164	184	57.6	524	10	753	0	1050	74.2	0.29			2270	617		61.9	8.63			
157-075-31AAB2	0-0	11/03/66	21	2.9		77	22	21	3	311	0	70	6.7	0.1	0.1	0.08	377		28	14	0.5			
157-075-31DAD	0-40	07/08/75	15	0.63	0.22	60	20	11	1.7	276	0	26	2.5	0.1	1	0	274		4	9	0.3	420	8.5	7.4
157-075-31DBC	0-40	07/08/75	13	0.02	0.36	84	24	8.1	2.2	258	0	88	3.7	0.1	26	0	376		98	5	0.2	560	8.5	7.2
157-075-31DBD	0-40	07/08/75	13	0.06	0.18	73	21	10	2.1	264	0	61	2.6	0.1	14	0	327		53	7	0.3	500	9	7.5
157-075-31DCC	0-44	07/08/75	12	0.89	0.54	120	51	12	3	340	0	210	19	0.1	6.1	0.28	602		230	5	0.2	875	8.5	7.1
157-075-31DDA	0-26	07/08/75	13	0.08	0.24	69	21	13	1.4	299	0	36	2.5	0.1	2.5	0	306		15	10	0.4	480	8.5	7.3
157-075-31DDB	0-35	07/08/75	10	0.21	0.58	110	26	11	2.9	283	0	150	4.3	0.1	18	0.12	472		150	6	0.2	600	8.5	7.3
157-076-34BAA	18-21	08/06/75	16	0.27	0.12	68	41	190	4.5	536	0	240	58	0.6	1	0.24	884		0	54	4.5	1300	8.5	8
157-076-34BAA	18-21	06/26/90	19	0.06	0.21	100	62	120	4.5	551	0	320	15	0.3	1	0.17	913		53	34	2.3	1428	7	

APPENDIX C - Water Level Data

156-076-02CBD

Souris Valley Aquifer

LS Elev (msl,ft)=1478

SI (ft.)=21-26

Date	Depth to Water (ft)	WL Elev (msl, ft)
06/25/90	16.39	1461.61
07/03/90	16.45	1461.55
07/09/90	16.49	1461.51
07/10/90	16.49	1461.51
07/17/90	16.52	1461.48
07/25/90	16.55	1461.45
08/01/90	16.63	1461.37
08/02/90	16.66	1461.34
08/08/90	16.69	1461.31
08/17/90	16.74	1461.26
08/21/90	16.79	1461.21
09/06/90	16.88	1461.12
09/07/90	16.89	1461.11
10/03/90	16.87	1461.13
10/09/90	16.89	1461.11
10/31/90	16.80	1461.20
11/20/90	16.75	1461.25
12/18/90	16.70	1461.30
01/14/91	16.76	1461.24
02/13/91	16.66	1461.34
03/14/91	16.63	1461.37

156-076-02CCA

Souris Valley Aquifer

LS Elev (msl,ft)=1482.98

SI (ft.)=21-26

Date	Depth to Water (ft)	WL Elev (msl, ft)
08/14/89	20.70	1462.28
08/22/89	20.73	1462.25
08/29/89	20.76	1462.22
09/05/89	20.80	1462.18
09/12/89	20.83	1462.15
09/14/89	20.81	1462.17
09/19/89	20.81	1462.17
09/26/89	20.86	1462.12
10/03/89	20.84	1462.14
10/10/89	20.84	1462.14
10/17/89	20.83	1462.15
10/24/89	20.85	1462.13
10/31/89	20.86	1462.12
11/07/89	20.82	1462.16
11/14/89	20.80	1462.18
11/21/89	20.56	1462.42
11/28/89	20.82	1462.16
12/05/89	20.79	1462.19
12/12/89	20.81	1462.17
12/19/89	20.84	1462.14
12/26/89	20.86	1462.12
01/03/90	20.86	1462.12
01/09/90	20.88	1462.10
01/16/90	20.88	1462.10
01/23/90	20.88	1462.10
01/31/90	20.88	1462.10
02/06/90	20.88	1462.10
02/13/90	20.89	1462.09
02/21/90	20.89	1462.09
02/27/90	20.91	1462.07
03/06/90	20.93	1462.05
03/20/90	20.89	1462.09
03/27/90	20.92	1462.06
04/03/90	20.91	1462.07
04/10/90	20.89	1462.09
04/17/90	20.89	1462.09
04/18/90	20.87	1462.11
04/23/90	20.89	1462.09
05/01/90	20.89	1462.09
05/08/90	20.89	1462.09
05/14/90	20.91	1462.07
05/15/90	20.90	1462.08
05/23/90	20.88	1462.10
05/31/90	20.84	1462.14
06/05/90	20.86	1462.12
06/11/90	20.79	1462.19
06/13/90	20.80	1462.18
06/19/90	20.79	1462.19
06/25/90	20.79	1462.19
07/03/90	20.83	1462.15
07/09/90	20.83	1462.15
07/10/90	20.83	1462.15
07/17/90	20.86	1462.12
07/25/90	20.88	1462.10
08/01/90	20.92	1462.06
08/02/90	20.95	1462.03
08/08/90	20.99	1461.99
08/17/90	21.04	1461.94
08/21/90	21.06	1461.92
09/06/90	21.12	1461.86
09/07/90	21.14	1461.84
10/03/90	21.20	1461.78
10/09/90	21.24	1461.74
10/31/90	21.22	1461.76
11/20/90	21.15	1461.83
12/18/90	21.14	1461.84
01/14/91	21.20	1461.78
02/13/91	21.20	1461.78
03/14/91	21.16	1461.82

156-076-02DAA
Souris Valley Aquifer

LS Elev (msl,ft)=1482.04
SI (ft.)=26-31

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/14/89	16.16	1465.88	04/10/90	16.86	1465.18
08/22/89	16.19	1465.85	04/17/90	16.85	1465.19
08/29/89	16.21	1465.83	04/18/90	16.83	1465.21
09/05/89	16.24	1465.80	04/23/90	16.85	1465.19
09/12/89	16.28	1465.76	05/01/90	16.81	1465.23
09/14/89	16.25	1465.79	05/08/90	16.78	1465.26
09/19/89	16.30	1465.74	05/14/90	16.79	1465.25
09/26/89	16.37	1465.67	05/15/90	16.80	1465.24
10/03/89	16.38	1465.66	05/23/90	16.79	1465.25
10/10/89	16.36	1465.68	05/31/90	16.73	1465.31
10/17/89	16.40	1465.64	06/05/90	16.75	1465.29
10/24/89	16.43	1465.61	06/11/90	16.69	1465.35
10/31/89	16.44	1465.60	06/13/90	16.69	1465.35
11/07/89	16.47	1465.57	06/19/90	16.64	1465.40
11/14/89	16.44	1465.60	06/25/90	16.60	1465.44
11/21/89	16.49	1465.55	07/03/90	16.59	1465.45
11/28/89	16.54	1465.50	07/09/90	16.58	1465.46
12/05/89	16.57	1465.47	07/10/90	16.38	1465.66
12/12/89	16.55	1465.49	07/17/90	16.57	1465.47
12/19/89	16.59	1465.45	07/25/90	16.57	1465.47
12/26/89	16.60	1465.44	08/02/90	16.62	1465.42
			08/03/90	16.63	1465.41
01/03/90	16.56	1465.48	08/08/90	16.65	1465.39
01/09/90	16.66	1465.38	08/17/90	16.68	1465.36
01/16/90	16.68	1465.36	08/21/90	16.70	1465.34
01/23/90	16.69	1465.35	09/06/90	16.73	1465.31
01/31/90	16.71	1465.33	09/07/90	16.77	1465.27
02/05/90	16.75	1465.29	10/03/90	16.79	1465.25
02/06/90	16.75	1465.29	10/09/90	16.85	1465.19
02/13/90	16.77	1465.27	10/31/90	16.84	1465.20
02/21/90	16.77	1465.27	11/20/90	16.88	1465.16
02/27/90	16.80	1465.24	12/18/90	16.93	1465.11
03/06/90	16.85	1465.19			
03/20/90	16.83	1465.21	01/14/91	16.99	1465.05
03/27/90	16.86	1465.18	02/13/91	17.05	1464.99
04/03/90	16.85	1465.19	03/14/91	17.09	1464.95

156-076-02DAA2
Souris Valley Aquifer

LS Elev (msl,ft)=1481.88
SI (ft.)=12-22

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
06/25/90	16.52	1465.36	09/06/90	16.68	1465.20
07/03/90	16.50	1465.38	09/07/90	16.68	1465.20
07/09/90	16.50	1465.38	10/03/90	16.69	1465.19
07/10/90	16.56	1465.32	10/09/90	16.75	1465.13
07/17/90	16.50	1465.38	10/31/90	16.75	1465.13
07/25/90	16.50	1465.38	11/20/90	16.79	1465.09
08/02/90	16.53	1465.35	12/18/90	16.84	1465.04
08/03/90	16.54	1465.34			
08/07/90	16.56	1465.32	01/14/91	16.90	1464.98
08/17/90	16.61	1465.27	02/13/91	16.97	1464.91
08/21/90	16.63	1465.25	03/14/91	17.00	1464.88

156-076-03ACA LS Elev (msl,ft)=1451.07

Souris Valley Aquifer SI (ft.)=23-28

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
06/25/90	3.41	1447.66	09/06/90	6.04	1445.03
07/03/90	3.55	1447.52	09/07/90	6.05	1445.02
07/09/90	2.54	1448.53	10/03/90	6.22	1444.85
07/10/90	2.54	1448.53	10/31/90	6.20	1444.87
07/17/90	3.37	1447.70	11/20/90	6.23	1444.84
07/25/90	4.24	1446.83	12/18/90	6.34	1444.73
08/02/90	4.82	1446.25			
08/03/90	4.90	1446.17	01/14/91	6.49	1444.58
08/08/90	5.29	1445.78	02/13/91	6.57	1444.50
08/17/90	5.67	1445.40	03/14/91	6.68	1444.39
08/21/90	5.79	1445.28			

156-076-08AAB LS Elev (msl,ft)=1458.87

Souris Valley Aquifer SI (ft.)=22-25

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
05/14/90	4.41	1454.46	08/21/90	4.67	1454.20
05/31/90	4.01	1454.86	09/06/90	4.92	1453.95
06/11/90	2.02	1456.85	09/07/90	4.93	1453.94
06/25/90	2.85	1456.02	10/03/90	5.03	1453.84
07/03/90	2.95	1455.92	10/09/90	5.17	1453.70
07/09/90	3.39	1455.48	10/31/90	4.78	1454.09
07/10/90	3.39	1455.48	11/20/90	4.63	1454.24
07/17/90	3.85	1455.02	12/18/90	4.74	1454.13
07/25/90	4.12	1454.75			
08/02/90	4.09	1454.78	01/14/91	5.16	1453.71
08/03/90	4.10	1454.77	02/13/91	4.95	1453.92
08/09/90	4.55	1454.32	03/14/91	4.92	1453.95
08/17/90	4.58	1454.29			

156-076-09ABC LS Elev (msl,ft)=1456.17

Souris Valley Aquifer SI (ft.)=37-40

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
05/14/90	9.93	1446.24	08/21/90	9.06	1447.11
05/31/90	5.66	1450.51	09/06/90	9.54	1446.63
06/11/90	5.40	1450.77	09/07/90	9.55	1446.62
06/25/90	6.08	1450.09	10/03/90	9.96	1446.21
07/03/90	6.47	1449.70	10/09/90	10.33	1445.84
07/09/90	6.70	1449.47	10/31/90	10.10	1446.07
07/10/90	6.70	1449.47	11/20/90	10.13	1446.04
07/17/90	7.04	1449.13	12/18/90	10.19	1445.98
07/25/90	7.68	1448.49			
08/02/90	8.04	1448.13	01/14/91	10.36	1445.81
08/09/90	8.54	1447.63	02/13/91	10.45	1445.72
08/17/90	8.90	1447.27	03/14/91	10.49	1445.68

156-076-10ACBR LS Elev (msl,ft)=1464.75

Souris River Aquifer SI (ft.)=0-0

Date	Depth to Water (ft)	WL Elev (msl, ft)
09/14/89	20.21	1444.54
09/20/89	20.42	1444.33
10/10/89	19.92	1444.83
11/14/89	20.75	1444.00
04/18/90	21.36	1443.39
05/14/90	21.15	1443.60
05/31/90	18.30	1446.45
06/11/90	13.52	1451.23
07/09/90	12.75	1452.00
08/02/90	20.07	1444.68
09/06/90	20.10	1444.65
10/03/90	20.56	1444.19
11/20/90	20.40	1444.35

156-076-10ADAD LS Elev (msl,ft)=1472.56

Souris Valley Aquifer SI (ft.)=13-18

Date	Depth to Water (ft)	WL Elev (msl, ft)
08/14/89	12.53	1460.03
08/22/89	12.58	1459.98
08/29/89	12.62	1459.94
09/05/89	12.67	1459.89
09/12/89	12.72	1459.84
09/14/89	12.68	1459.88
09/19/89	12.68	1459.88
09/26/89	12.74	1459.82
10/03/89	12.76	1459.80
10/10/89	12.74	1459.82
10/17/89	12.75	1459.81
10/24/89	12.76	1459.80
10/31/89	12.74	1459.82
11/07/89	12.73	1459.83
11/14/89	12.67	1459.89
11/21/89	12.68	1459.88
11/28/89	12.71	1459.85
12/05/89	12.69	1459.87
12/12/89	12.67	1459.89
12/19/89	12.72	1459.84
12/26/89	12.71	1459.85
01/03/90	12.74	1459.82
01/09/90	12.78	1459.78
01/16/90	12.64	1459.92
01/23/90	12.74	1459.82
01/31/90	12.74	1459.82
02/06/90	12.75	1459.81
02/13/90	12.74	1459.82
02/21/90	12.74	1459.82
02/27/90	12.74	1459.82
03/06/90	12.78	1459.78
03/20/90	12.69	1459.87
03/27/90	12.69	1459.87
04/03/90	12.65	1459.91
04/10/90	12.64	1459.92
04/17/90	12.62	1459.94
04/18/90	12.64	1459.92
04/23/90	12.62	1459.94
05/01/90	12.61	1459.95
05/08/90	12.62	1459.94
05/14/90	12.61	1459.95
05/15/90	12.61	1459.95
05/23/90	12.58	1459.98
05/31/90	12.52	1460.04
06/05/90	12.54	1460.02
06/11/90	12.51	1460.05
06/13/90	12.49	1460.07
06/19/90	12.47	1460.09
06/25/90	12.45	1460.11
07/03/90	12.48	1460.08
07/09/90	12.53	1460.03
07/10/90	12.53	1460.03
07/17/90	12.54	1460.02
07/25/90	12.61	1459.95
08/02/90	12.64	1459.92
08/08/90	12.72	1459.84
08/17/90	12.76	1459.80
08/21/90	12.79	1459.77
09/06/90	12.89	1459.67
09/07/90	12.91	1459.65
10/03/90	13.00	1459.56
10/09/90	13.04	1459.52
10/31/90	13.03	1459.53
11/20/90	13.05	1459.51
12/18/90	13.03	1459.53
01/14/91	13.09	1459.47
02/13/91	13.05	1459.51
03/14/91	13.01	1459.55

156-076-10ADB

Souris Valley Aquifer

LS Elev (msl,ft)=1466.09

SI (ft.)=15-20

Date	Depth to Water (ft)	WL Elev (msl, ft)
08/14/89	12.19	1453.90
08/22/89	12.63	1453.46
08/29/89	12.65	1453.44
09/05/89	12.67	1453.42
09/12/89	12.66	1453.43
09/14/89	12.51	1453.58
09/19/89	12.60	1453.49
09/26/89	12.56	1453.53
10/03/89	12.55	1453.54
10/10/89	12.47	1453.62
10/17/89	12.43	1453.66
10/24/89	12.40	1453.69
10/30/89	12.38	1453.71
10/31/89	12.38	1453.71
11/07/89	12.32	1453.77
11/14/89	12.25	1453.84
11/21/89	12.23	1453.86
11/28/89	12.28	1453.81
12/05/89	12.28	1453.81
12/12/89	12.34	1453.75
12/19/89	12.49	1453.60
12/26/89	12.49	1453.60
01/03/90	12.33	1453.76
01/09/90	12.24	1453.85
01/16/90	12.13	1453.96
01/23/90	11.98	1454.11
01/31/90	11.87	1454.22
02/06/90	11.81	1454.28
02/13/90	11.72	1454.37
02/21/90	11.67	1454.42
02/27/90	11.60	1454.49
03/06/90	11.68	1454.41
03/20/90	11.44	1454.65
03/27/90	11.41	1454.68
04/03/90	11.38	1454.71
04/10/90	11.37	1454.72
04/17/90	11.34	1454.75
04/18/90	11.30	1454.79
04/23/90	11.34	1454.75
05/01/90	11.54	1454.55
05/08/90	11.61	1454.48
05/14/90	11.67	1454.42
05/15/90	11.66	1454.43
05/23/90	11.59	1454.50
05/31/90	11.63	1454.46
06/05/90	11.47	1454.62
06/11/90	11.58	1454.51
06/13/90	11.64	1454.45
06/19/90	11.73	1454.36
06/25/90	11.83	1454.26
07/03/90	11.94	1454.15
07/09/90	12.02	1454.07
07/10/90	12.02	1454.07
07/17/90	12.14	1453.95
07/25/90	12.29	1453.80
08/02/90	12.38	1453.71
08/09/90	12.51	1453.58
08/17/90	12.68	1453.41
08/21/90	12.74	1453.35
09/06/90	12.87	1453.22
09/07/90	12.89	1453.20
10/03/90	12.72	1453.37
10/09/90	12.74	1453.35
10/31/90	12.59	1453.50
11/20/90	12.49	1453.60
12/18/90	12.76	1453.33
01/14/91	12.85	1453.24
02/13/91	12.45	1453.64
03/14/91	11.90	1454.19

156-076-10BDB3

Souris Valley Aquifer

LS Elev (msl,ft)=1454.52

SI (ft.)=28-33

Date	Depth to Water (ft)	WL Elev (msl, ft)
06/25/90	6.17	1448.35
07/03/90	6.30	1448.22
07/09/90	5.69	1448.83
07/10/90	5.68	1448.84
07/17/90	6.45	1448.07
07/25/90	7.38	1447.14
08/02/90	9.17	1445.35
08/09/90	8.40	1446.12
08/17/90	8.75	1445.77
08/21/90	8.90	1445.62
09/06/90	9.18	1445.34
09/07/90	9.16	1445.36
10/03/90	9.46	1445.06
10/09/90	9.58	1444.94
10/31/90	9.47	1445.05
11/20/90	9.55	1444.97
12/18/90	9.65	1444.87
01/14/91	9.78	1444.74
02/13/91	9.91	1444.61
03/14/91	9.98	1444.54

156-076-10CAA LS Elev (msl,ft)=1461.4

Souris Valley Aquifer SI (ft.)=5-10

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/14/89	8.73	1452.67	04/18/90	9.13	1452.27
08/22/89	8.73	1452.67	04/23/90	9.24	1452.16
08/29/89	8.77	1452.63	05/01/90	9.14	1452.26
09/05/89	8.79	1452.61	05/08/90	9.15	1452.25
09/12/89	8.38	1453.02	05/14/90	9.23	1452.17
09/14/89	8.84	1452.56	05/16/90	9.14	1452.26
09/19/89	8.85	1452.55	05/23/90	9.13	1452.27
09/26/89	8.90	1452.50	05/31/90	9.11	1452.29
10/03/89	8.93	1452.47	06/05/90	9.12	1452.28
10/10/89	8.91	1452.49	06/11/90	9.12	1452.28
10/17/89	8.95	1452.45	06/13/90	9.10	1452.30
10/24/89	8.96	1452.44	06/19/90	9.09	1452.31
10/31/89	8.97	1452.43	06/25/90	9.10	1452.30
11/07/89	8.98	1452.42	07/03/90	9.13	1452.27
11/14/89	8.98	1452.42	07/09/90	9.12	1452.28
11/21/89	8.97	1452.43	07/10/90	9.12	1452.28
11/28/89	9.03	1452.37	07/17/90	9.14	1452.26
12/05/89	9.03	1452.37	07/25/90	9.17	1452.23
12/12/89	9.05	1452.35	08/02/90	9.21	1452.19
			08/09/90	9.24	1452.16
01/09/90	9.15	1452.25	08/17/90	9.27	1452.13
01/16/90	9.12	1452.28	08/21/90	9.29	1452.11
01/23/90	9.25	1452.15	09/06/90	9.30	1452.10
01/31/90	9.16	1452.24	09/07/90	9.33	1452.07
02/06/90	9.18	1452.22	10/03/90	9.35	1452.05
02/13/90	9.18	1452.22	10/09/90	9.42	1451.98
02/21/90	9.20	1452.20	10/31/90	9.45	1451.95
02/27/90	9.22	1452.18	11/20/90	9.44	1451.96
03/06/90	9.26	1452.14	12/18/90	9.49	1451.91
03/20/90	9.21	1452.19			
03/27/90	9.23	1452.17	01/14/91	9.55	1451.85
04/03/90	9.20	1452.20	02/13/91	9.57	1451.83
04/10/90	9.18	1452.22	03/14/91	9.60	1451.80
04/17/90	9.16	1452.24			

156-076-10DAD2 LS Elev (msl,ft)=1469.94

Souris Valley Aquifer SI (ft.)=0-5

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/14/89	4.74	1465.20	06/13/90	3.78	1466.16
08/22/89	4.80	1465.14	06/19/90	3.58	1466.36
08/29/89	4.86	1465.08	06/25/90	3.79	1466.15
09/05/89	4.84	1465.10	07/03/90	3.77	1466.17
09/12/89	4.87	1465.07	07/09/90	4.00	1465.94
09/14/89	4.92	1465.02	07/10/90	4.00	1465.94
09/19/89	4.97	1464.97	07/17/90	4.11	1465.83
09/26/89	5.00	1464.94	07/25/90	4.31	1465.63
10/03/89	5.09	1464.85	08/02/90	4.34	1465.60
10/10/89	5.10	1464.84	08/03/90	4.35	1465.59
10/17/89	5.07	1464.87	08/08/90	4.53	1465.41
10/24/89	5.23	1464.71	08/17/90	4.66	1465.28
10/31/89	5.26	1464.68	08/21/90	4.70	1465.24
11/07/89	5.32	1464.62	09/06/90	4.86	1465.08
11/14/89	5.37	1464.57	09/07/90	4.87	1465.07
11/21/89	5.36	1464.58	10/03/90	5.06	1464.88
			10/09/90	5.13	1464.81
05/31/90	4.55	1465.39	10/31/90	5.38	1464.56
06/11/90	3.76	1466.18			

156-076-11AAA LS Elev (msl,ft)=1468.5

Souris Valley Aquifer SI (ft.)=6-11

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/14/89	3.20	1465.30	04/10/90	3.59	1464.91
08/22/89	3.23	1465.27	04/17/90	3.55	1464.95
08/29/89	3.28	1465.22	04/18/90	3.55	1464.95
09/05/89	3.29	1465.21	04/23/90	3.54	1464.96
09/12/89	3.32	1465.18	05/01/90	3.45	1465.05
09/14/89	3.38	1465.12	05/08/90	3.46	1465.04
09/19/89	3.35	1465.15	05/14/90	3.53	1464.97
09/26/89	3.39	1465.11	05/15/90	3.52	1464.98
10/03/89	3.42	1465.08	05/23/90	3.48	1465.02
10/10/89	3.38	1465.12	05/31/90	3.47	1465.03
10/17/89	3.44	1465.06	06/05/90	3.29	1465.21
10/24/89	3.44	1465.06	06/11/90	3.25	1465.25
10/31/89	3.46	1465.04	06/13/90	3.24	1465.26
11/07/89	3.44	1465.06	06/19/90	3.27	1465.23
11/14/89	3.48	1465.02	06/25/90	3.35	1465.15
11/21/89	3.49	1465.01	07/03/90	3.38	1465.12
11/28/89	3.52	1464.98	07/09/90	3.43	1465.07
12/05/89	3.53	1464.97	07/10/90	3.43	1465.07
12/12/89	3.53	1464.97	07/17/90	3.47	1465.03
12/19/89	3.58	1464.92	07/25/90	3.51	1464.99
12/26/89	3.61	1464.89	08/01/90	3.55	1464.95
			08/02/90	3.56	1464.94
01/03/90	3.67	1464.83	08/08/90	3.60	1464.90
01/09/90	3.68	1464.82	08/17/90	3.68	1464.82
01/16/90	3.67	1464.83	08/21/90	3.68	1464.82
01/23/90	3.65	1464.85	09/06/90	3.67	1464.83
01/31/90	3.67	1464.83	09/07/90	3.71	1464.79
02/05/90	3.75	1464.75	10/03/90	3.74	1464.76
02/06/90	3.75	1464.75	10/09/90	3.79	1464.71
02/13/90	3.77	1464.73	10/31/90	3.80	1464.70
02/21/90	3.80	1464.70	11/20/90	3.80	1464.70
02/27/90	3.80	1464.70	12/18/90	3.85	1464.65
03/06/90	3.84	1464.66			
03/20/90	3.76	1464.74	01/14/91	3.93	1464.57
03/27/90	3.69	1464.81	02/13/91	3.94	1464.56
04/03/90	3.61	1464.89	03/14/91	3.94	1464.56

156-076-11ABB LS Elev (msl,ft)=1473.4

Souris Valley Aquifer SI (ft.)=31-36

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/14/89	10.27	1463.13	04/10/90	10.72	1462.68
08/22/89	10.30	1463.10	04/17/90	10.74	1462.66
08/29/89	10.33	1463.07	04/18/90	10.72	1462.68
09/05/89	10.37	1463.03	04/23/90	10.73	1462.67
09/12/89	10.38	1463.02	05/01/90	10.75	1462.65
09/14/89	10.39	1463.01	05/08/90	10.77	1462.63
09/19/89	10.39	1463.01	05/14/90	10.78	1462.62
09/26/89	10.46	1462.94	05/15/90	10.77	1462.63
10/03/89	10.47	1462.93	05/23/90	10.74	1462.66
10/10/89	10.45	1462.95	05/31/90	10.72	1462.68
10/17/89	10.46	1462.94	06/05/90	10.70	1462.70
10/24/89	10.47	1462.93	06/11/90	10.68	1462.72
10/31/89	10.48	1462.92	06/13/90	10.66	1462.74
11/07/89	10.49	1462.91	06/19/90	10.60	1462.80
11/14/89	10.48	1462.92	06/25/90	10.62	1462.78
11/21/89	10.48	1462.92	07/03/90	10.62	1462.78
11/28/89	10.49	1462.91	07/09/90	10.63	1462.77
12/05/89	10.47	1462.93	07/10/90	10.63	1462.77
12/12/89	10.50	1462.90	07/17/90	10.63	1462.77
12/19/89	10.53	1462.87	07/25/90	10.65	1462.75
12/26/89	10.54	1462.86	08/01/90	10.71	1462.69
			08/02/90	10.70	1462.70
01/03/90	10.56	1462.84	08/08/90	10.75	1462.65
01/09/90	10.59	1462.81	08/17/90	10.78	1462.62
01/16/90	10.59	1462.81	08/21/90	10.80	1462.60
01/23/90	10.61	1462.79	09/06/90	10.79	1462.61
01/31/90	10.62	1462.78	09/07/90	10.81	1462.59
02/05/90	10.64	1462.76	10/03/90	10.82	1462.58
02/06/90	10.64	1462.76	10/09/90	10.83	1462.57
02/13/90	10.65	1462.75	10/31/90	10.90	1462.50
02/21/90	10.67	1462.73	11/20/90	10.88	1462.52
02/27/90	10.68	1462.72	12/18/90	10.88	1462.52
03/06/90	10.70	1462.70			
03/20/90	10.70	1462.70	01/14/91	10.93	1462.47
03/27/90	10.71	1462.69	02/13/91	10.96	1462.44
04/03/90	10.72	1462.68	03/14/91	10.98	1462.42

156-076-11ADAD LS Elev (msl,ft)=1470.42

Souris Valley Aquifer SI (ft.)=5-10

Date	Depth to Water (ft)	WL Elev (msl, ft)
08/14/89	4.45	1465.97
08/20/89	4.51	1465.91
08/22/89	4.51	1465.91
08/29/89	4.56	1465.86
09/05/89	4.56	1465.86
09/12/89	4.60	1465.82
09/14/89	4.55	1465.87
09/19/89	4.57	1465.85
09/26/89	4.62	1465.80
10/03/89	4.65	1465.77
10/10/89	4.69	1465.73
10/17/89	4.73	1465.69
10/24/89	4.73	1465.69
10/31/89	4.77	1465.65
11/07/89	4.80	1465.62
11/14/89	4.84	1465.58
11/21/89	4.84	1465.58
11/28/89	4.87	1465.55
12/05/89	4.92	1465.50
12/12/89	4.93	1465.49
12/19/89	4.98	1465.44
12/26/89	5.05	1465.37
01/03/90	5.04	1465.38
01/09/90	5.13	1465.29
01/16/90	5.13	1465.29
01/23/90	5.14	1465.28
01/31/90	5.14	1465.28
02/06/90	5.22	1465.20
02/13/90	5.24	1465.18
02/21/90	5.30	1465.12
02/27/90	5.32	1465.10
03/06/90	5.36	1465.06
03/20/90	5.30	1465.12
03/27/90	5.23	1465.19
04/03/90	5.12	1465.30
04/10/90	5.04	1465.38
04/17/90	4.95	1465.47
04/18/90	4.92	1465.50
04/23/90	4.96	1465.46
05/01/90	4.71	1465.71
05/08/90	4.73	1465.69
05/14/90	4.72	1465.70
05/15/90	4.71	1465.71
05/23/90	4.60	1465.82
05/31/90	4.53	1465.89
06/05/90	4.24	1466.18
06/11/90	4.18	1466.24
06/13/90	4.19	1466.23
06/19/90	4.18	1466.24
06/25/90	4.31	1466.11
07/03/90	4.38	1466.04
07/09/90	4.47	1465.95
07/10/90	4.47	1465.95
07/17/90	4.46	1465.96
07/25/90	4.56	1465.86
08/01/90	4.61	1465.81
08/02/90	4.60	1465.82
08/08/90	4.67	1465.75
08/17/90	4.76	1465.66
08/21/90	4.80	1465.62
09/06/90	4.90	1465.52
09/07/90	4.89	1465.53
10/03/90	5.03	1465.39
10/09/90	5.07	1465.35
10/31/90	5.15	1465.27
11/20/90	5.19	1465.23
12/18/90	5.27	1465.15
01/14/91	5.39	1465.03
02/13/91	5.41	1465.01
03/14/91	5.45	1464.97

156-076-11ADB2 LS Elev (msl,ft)=1471.5

Souris Valley Aquifer SI (ft.)=3-13

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
06/25/90	6.69	1464.81	09/07/90	7.20	1464.30
07/03/90	6.88	1464.62	10/03/90	7.24	1464.26
07/10/90	6.90	1464.60	10/09/90	7.26	1464.24
07/17/90	6.93	1464.57	10/31/90	7.27	1464.23
07/25/90	6.97	1464.53	11/20/90	7.31	1464.19
08/01/90	7.08	1464.42	12/18/90	7.35	1464.15
08/02/90	7.00	1464.50			
08/08/90	7.06	1464.44	01/14/91	7.39	1464.11
08/17/90	7.10	1464.40	02/13/91	7.45	1464.05
08/21/90	7.10	1464.40	03/14/91	7.43	1464.07
09/06/90	7.17	1464.33			

156-076-11BAAC1 LS Elev (msl,ft)=1476.86

Souris Valley Aquifer SI (ft.)=26-31

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
06/25/90	14.63	1462.23	09/07/90	14.87	1461.99
07/03/90	14.63	1462.23	10/03/90	14.87	1461.99
07/09/90	14.64	1462.22	10/09/90	14.91	1461.95
07/10/90	14.64	1462.22	10/31/90	14.91	1461.95
07/17/90	14.65	1462.21	11/20/90	14.86	1462.00
07/25/90	14.71	1462.15	12/18/90	14.89	1461.97
08/02/90	14.74	1462.12			
08/08/90	14.77	1462.09	01/14/91	14.90	1461.96
08/17/90	14.78	1462.08	02/13/91	14.95	1461.91
08/21/90	14.83	1462.03	03/14/91	14.97	1461.89
09/06/90	14.87	1461.99			

156-076-11BAAC2 LS Elev (msl,ft)=1476.8

Souris Valley Aquifer SI (ft.)=9-19

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
06/25/90	14.58	1462.22	09/06/90	14.79	1462.01
07/03/90	14.60	1462.20	09/07/90	14.84	1461.96
07/09/90	14.60	1462.20	10/03/90	14.83	1461.97
07/10/90	14.60	1462.20	10/09/90	14.88	1461.92
07/17/90	14.62	1462.18	10/31/90	14.88	1461.92
07/25/90	14.67	1462.13	11/20/90	14.83	1461.97
08/02/90	14.71	1462.09	12/18/90	14.85	1461.95
08/03/90	14.70	1462.10			
08/08/90	14.74	1462.06	01/14/91	14.88	1461.92
08/17/90	14.78	1462.02	02/13/91	14.91	1461.89
08/21/90	14.80	1462.00	03/14/91	14.92	1461.88

156-076-11BABB LS Elev (msl,ft)=1477.94

Souris Valley Aquifer SI (ft.)=29-34

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/14/89	16.25	1461.69	04/10/90	16.46	1461.48
08/22/89	16.23	1461.71	04/17/90	16.45	1461.49
08/29/89	16.25	1461.69	04/18/90	16.46	1461.48
09/05/89	16.25	1461.69	04/23/90	16.45	1461.49
09/12/89	16.25	1461.69	05/01/90	16.47	1461.47
09/14/89	16.21	1461.73	05/08/90	16.47	1461.47
09/19/89	16.23	1461.71	05/14/90	16.55	1461.39
09/26/89	16.28	1461.66	05/15/90	16.56	1461.38
10/03/89	16.28	1461.66	05/23/90	16.51	1461.43
10/10/89	16.25	1461.69	05/31/90	16.52	1461.42
10/17/89	16.26	1461.68	06/05/90	16.45	1461.49
10/24/89	16.27	1461.67	06/11/90	16.42	1461.52
10/31/89	16.28	1461.66	06/13/90	16.41	1461.53
11/07/89	16.25	1461.69	06/19/90	16.37	1461.57
11/14/89	16.23	1461.71	06/25/90	16.39	1461.55
11/21/89	16.23	1461.71	07/03/90	16.40	1461.54
11/28/89	16.23	1461.71	07/09/90	16.40	1461.54
12/05/89	16.25	1461.69	07/10/90	16.40	1461.54
12/12/89	16.27	1461.67	07/17/90	16.43	1461.51
12/19/89	16.30	1461.64	07/25/90	16.50	1461.44
12/26/89	16.35	1461.59	08/01/90	16.52	1461.42
			08/03/90	16.53	1461.41
01/03/90	16.34	1461.60	08/08/90	16.60	1461.34
01/09/90	16.36	1461.58	08/17/90	16.64	1461.30
01/16/90	16.37	1461.57	08/21/90	16.67	1461.27
01/23/90	16.35	1461.59	09/06/90	16.69	1461.25
01/31/90	16.40	1461.54	09/07/90	16.73	1461.21
02/05/90	16.40	1461.54	10/03/90	16.67	1461.27
02/06/90	16.40	1461.54	10/09/90	16.71	1461.23
02/13/90	16.41	1461.53	10/31/90	16.65	1461.29
02/21/90	16.43	1461.51	11/20/90	16.65	1461.29
02/27/90	16.44	1461.50	12/18/90	16.65	1461.29
03/06/90	16.48	1461.46			
03/20/90	16.43	1461.51	01/14/91	16.63	1461.31
03/27/90	16.45	1461.49	02/13/91	16.69	1461.25
04/03/90	16.46	1461.48	03/14/91	16.68	1461.26

156-076-11BABC LS Elev (msl,ft)=1476.62

Souris Valley Aquifer SI (ft.)=31-36

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/14/89	15.25	1461.37	04/17/90	15.40	1461.22
08/22/89	15.24	1461.38	04/18/90	15.39	1461.23
08/29/89	15.20	1461.42	04/23/90	15.40	1461.22
09/05/89	15.27	1461.35	05/01/90	15.41	1461.21
09/12/89	15.19	1461.43	05/08/90	15.42	1461.20
09/14/89	15.16	1461.46	05/14/90	15.51	1461.11
09/19/89	15.24	1461.38	05/15/90	15.54	1461.08
09/26/89	15.22	1461.40	05/23/90	15.47	1461.15
10/03/89	15.25	1461.37	05/31/90	15.51	1461.11
10/10/89	15.21	1461.41	06/05/90	15.38	1461.24
10/17/89	15.23	1461.39	06/11/90	15.33	1461.29
10/24/89	15.20	1461.42	06/13/90	15.34	1461.28
10/31/89	15.23	1461.39	06/19/90	15.30	1461.32
11/07/89	15.18	1461.44	06/25/90	15.36	1461.26
11/14/89	15.15	1461.47	07/03/90	15.33	1461.29
11/21/89	15.01	1461.61	07/09/90	15.34	1461.28
11/28/89	15.19	1461.43	07/10/90	15.34	1461.28
12/05/89	15.19	1461.43	07/17/90	15.38	1461.24
12/12/89	15.23	1461.39	07/25/90	15.45	1461.17
12/19/89	15.25	1461.37	08/01/90	15.50	1461.12
12/26/89	15.37	1461.25	08/02/90	15.47	1461.15
			08/08/90	15.53	1461.09
01/03/90	15.29	1461.33	08/17/90	15.62	1461.00
01/09/90	15.29	1461.33	08/21/90	15.66	1460.96
01/16/90	15.34	1461.28	09/06/90	15.66	1460.96
01/23/90	15.29	1461.33	09/07/90	15.65	1460.97
01/31/90	15.38	1461.24	10/03/90	15.61	1461.01
02/06/90	15.34	1461.28	10/09/90	15.63	1460.99
02/13/90	15.36	1461.26	10/31/90	15.63	1460.99
02/21/90	15.42	1461.20	11/20/90	15.56	1461.06
02/27/90	15.40	1461.22	12/18/90	15.55	1461.07
03/06/90	15.43	1461.19			
03/20/90	15.34	1461.28	01/14/91	15.56	1461.06
03/27/90	15.38	1461.24	02/13/91	15.60	1461.02
04/03/90	15.41	1461.21	03/14/91	15.60	1461.02
04/10/90	15.41	1461.21			

156-076-11BAC2

Souris Valley Aquifer

LS Elev (msl,ft)=1474.24

SI (ft.)=20-25

Date	Depth to Water (ft)	WL Elev (msl, ft)
08/14/89	13.26	1460.98
08/22/89	13.25	1460.99
08/29/89	13.28	1460.96
09/05/89	13.28	1460.96
09/12/89	13.26	1460.98
09/14/89	13.22	1461.02
09/19/89	13.23	1461.01
09/26/89	13.26	1460.98
10/03/89	13.28	1460.96
10/10/89	13.24	1461.00
10/17/89	13.24	1461.00
10/24/89	13.25	1460.99
10/31/89	13.23	1461.01
11/07/89	13.21	1461.03
11/14/89	13.21	1461.03
11/21/89	13.18	1461.06
11/28/89	13.18	1461.06
12/05/89	13.21	1461.03
12/12/89	13.22	1461.02
12/19/89	13.27	1460.97
12/26/89	13.35	1460.89
01/03/90	13.34	1460.90
01/09/90	13.32	1460.92
01/16/90	12.84	1461.40
01/23/90	13.33	1460.91
01/31/90	13.37	1460.87
02/06/90	13.37	1460.87
02/13/90	13.38	1460.86
02/21/90	13.41	1460.83
02/27/90	13.42	1460.82
03/06/90	13.45	1460.79
03/20/90	13.39	1460.85
03/27/90	13.42	1460.82
04/03/90	13.43	1460.81
04/10/90	13.41	1460.83
04/17/90	13.38	1460.86
04/18/90	13.39	1460.85
04/23/90	13.49	1460.75
05/01/90	13.40	1460.84
05/08/90	13.49	1460.75
05/14/90	13.52	1460.72
05/15/90	13.50	1460.74
05/23/90	13.43	1460.81
05/31/90	13.44	1460.80
06/05/90	13.36	1460.88
06/11/90	13.32	1460.92
06/13/90	13.31	1460.93
06/19/90	13.30	1460.94
06/25/90	13.32	1460.92
07/03/90	13.33	1460.91
07/09/90	13.34	1460.90
07/10/90	13.54	1460.70
07/17/90	13.34	1460.90
07/25/90	13.47	1460.77
08/01/90	13.55	1460.69
08/02/90	13.55	1460.69
08/08/90	13.57	1460.67
08/17/90	13.77	1460.47
08/21/90	13.81	1460.43
09/06/90	13.81	1460.43
09/07/90	13.84	1460.40
10/03/90	13.75	1460.49
10/09/90	13.78	1460.46
10/31/90	13.78	1460.46
11/20/90	13.70	1460.54
12/18/90	13.67	1460.57
01/14/91	13.71	1460.53
02/13/91	13.74	1460.50
03/14/91	13.71	1460.53

156-076-11BDC LS Elev (msl,ft)=1469.38

Souris Valley Aquifer SI (ft.)=5-10

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/14/89	9.28	1460.10	02/27/90	9.41	1459.97
08/22/89	9.40	1459.98	03/06/90	9.42	1459.96
08/29/89	9.50	1459.88	03/20/90	9.30	1460.08
09/05/89	9.59	1459.79	03/27/90	9.40	1459.98
09/12/89	9.67	1459.71	04/03/90	9.37	1460.01
09/14/89	9.58	1459.80	04/10/90	9.38	1460.00
09/19/89	9.73	1459.65	04/17/90	9.39	1459.99
09/26/89	9.80	1459.58	04/18/90	9.22	1460.16
10/03/89	9.87	1459.51	04/23/90	9.37	1460.01
10/10/89	9.84	1459.54	05/01/90	9.36	1460.02
10/17/89	9.95	1459.43	05/08/90	9.35	1460.03
10/24/89	10.04	1459.34	05/14/90	9.25	1460.13
10/31/89	10.10	1459.28	05/15/90	9.31	1460.07
11/07/89	10.12	1459.26	05/23/90	9.26	1460.12
11/14/89	10.03	1459.35	05/31/90	9.13	1460.25
11/21/89	10.11	1459.27	06/05/90	9.23	1460.15
11/28/89	9.86	1459.52	06/11/90	9.15	1460.23
12/05/89	9.71	1459.67	06/13/90	9.21	1460.17
12/12/89	9.47	1459.91	06/19/90	9.18	1460.20
12/19/89	9.53	1459.85	06/25/90	9.13	1460.25
12/26/89	9.50	1459.88	07/03/90	9.24	1460.14
			07/09/90	9.33	1460.05
01/03/90	9.47	1459.91	07/10/90	9.33	1460.05
01/09/90	9.47	1459.91	07/17/90	9.38	1460.00
01/16/90	9.45	1459.93	07/25/90	9.66	1459.72
01/23/90	9.44	1459.94	08/02/90	9.65	1459.73
01/30/90	9.44	1459.94	08/08/90	9.82	1459.56
01/31/90	9.44	1459.94	08/17/90	9.93	1459.45
02/06/90	9.43	1459.95	08/21/90	10.00	1459.38
02/13/90	9.43	1459.95	09/06/90	10.35	1459.03
02/21/90	9.41	1459.97	09/07/90	10.01	1459.37

156-076-11CAB1 LS Elev (msl,ft)=1470.8

Souris Valley Aquifer SI (ft.)=36-41

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/14/89	9.17	1461.63	04/10/90	6.79	1464.01
08/22/89	8.21	1462.59	04/17/90	7.29	1463.51
08/29/89	8.31	1462.49	04/18/90	7.48	1463.32
09/05/89	7.75	1463.05	05/01/90	7.75	1463.05
09/12/89	7.43	1463.37	05/08/90	8.36	1462.44
09/14/89	7.31	1463.49	05/14/90	9.00	1461.80
09/19/89	7.51	1463.29	05/15/90	8.67	1462.13
09/24/89	7.88	1462.92	05/23/90	8.37	1462.43
09/26/89	7.25	1463.55	05/31/90	8.35	1462.45
10/03/89	7.36	1463.44	06/05/90	7.69	1463.11
10/10/89	7.10	1463.70	06/11/90	7.51	1463.29
10/17/89	6.91	1463.89	06/13/90	7.51	1463.29
10/24/89	7.43	1463.37	06/19/90	7.55	1463.25
10/31/89	7.05	1463.75	06/25/90	7.84	1462.96
11/07/89	7.03	1463.77	07/03/90	7.57	1463.23
11/14/89	6.53	1464.27	07/09/90	7.67	1463.13
11/21/89	6.44	1464.36	07/10/90	7.67	1463.13
11/28/89	6.41	1464.39	07/17/90	8.67	1462.13
12/05/89	6.32	1464.48	07/25/90	9.07	1461.73
12/12/89	6.30	1464.50	08/01/90	8.71	1462.09
12/19/89	6.31	1464.49	08/02/90	8.60	1462.20
12/26/89	6.27	1464.53	08/08/90	9.17	1461.63
			08/17/90	9.34	1461.46
01/03/90	6.27	1464.53	08/21/90	9.54	1461.26
01/09/90	6.29	1464.51	09/06/90	9.03	1461.77
01/16/90	6.31	1464.49	09/07/90	8.79	1462.01
01/23/90	6.29	1464.51	10/03/90	8.49	1462.31
01/31/90	6.38	1464.42	10/09/90	8.00	1462.80
02/06/90	6.42	1464.38	10/31/90	8.45	1462.35
02/13/90	6.52	1464.28	11/20/90	7.31	1463.49
02/21/90	6.51	1464.29	12/18/90	7.09	1463.71
02/27/90	6.60	1464.20			
03/06/90	6.66	1464.14	01/14/91	6.97	1463.83
03/20/90	6.65	1464.15	02/13/91	7.12	1463.68
03/27/90	6.62	1464.18	03/14/91	7.27	1463.53
04/03/90	6.84	1463.96			

156-076-11DAD LS Elev (msl,ft)=1470.86

Undefined Aquifer SI (ft.)=39-44

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/14/89	2.17	1468.69	05/15/90	2.57	1468.29
08/22/89	2.09	1468.77	05/23/90	2.58	1468.28
08/29/89	2.05	1468.81	05/31/90	2.65	1468.21
09/05/89	2.01	1468.85	06/05/90	2.56	1468.30
09/12/89	1.95	1468.91	06/11/90	2.63	1468.23
09/14/89	1.92	1468.94	06/13/90	2.60	1468.26
09/19/89	1.89	1468.97	06/19/90	2.58	1468.28
09/26/89	1.88	1468.98	06/25/90	2.65	1468.21
10/03/89	1.90	1468.96	07/03/90	2.62	1468.24
10/10/89	1.82	1469.04	07/09/90	2.70	1468.16
10/17/89	1.84	1469.02	07/10/90	2.70	1468.16
10/24/89	1.74	1469.12	07/17/90	2.77	1468.09
10/31/89	1.78	1469.08	07/25/90	2.75	1468.11
11/07/89	1.67	1469.19	07/31/90	2.78	1468.08
11/14/89	1.66	1469.20	08/02/90	2.79	1468.07
11/21/89	1.62	1469.24	08/08/90	2.86	1468.00
11/28/89	1.64	1469.22	08/17/90	2.92	1467.94
12/05/89	1.64	1469.22	08/21/90	2.94	1467.92
12/12/89	1.66	1469.20	09/06/90	2.89	1467.97
			09/07/90	2.89	1467.97
04/18/90	1.77	1469.09	10/03/90	2.72	1468.14
04/23/90	2.35	1468.51	10/09/90	2.78	1468.08
05/01/90	2.43	1468.43	10/31/90	2.68	1468.18
05/08/90	2.43	1468.43	11/20/90	2.56	1468.30
05/14/90	2.62	1468.24	12/18/90	2.54	1468.32

156-076-12AAD2 LS Elev (msl,ft)=1474.49

Souris Valley Aquifer SI (ft.)=11-16

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
06/25/90	4.93	1469.56	09/06/90	5.27	1469.22
07/03/90	4.91	1469.58	09/07/90	5.27	1469.22
07/09/90	4.93	1469.56	10/03/90	5.36	1469.13
07/10/90	4.93	1469.56	10/09/90	5.40	1469.09
07/17/90	4.94	1469.55	10/31/90	5.49	1469.00
07/25/90	5.00	1469.49	11/20/90	5.51	1468.98
07/31/90	5.02	1469.47	12/18/90	5.62	1468.87
08/02/90	5.02	1469.47			
08/08/90	5.09	1469.40	01/14/91	5.69	1468.80
08/17/90	5.13	1469.36	02/13/91	5.76	1468.73
08/21/90	5.17	1469.32	03/14/91	5.79	1468.70

156-076-12CCC

Undefined Aquifer

LS Elev (msl,ft)=1503.12

SI (ft.)=55-60

Date	Depth to Water (ft)	WL Elev (msl, ft)
08/14/89	33.01	1470.11
08/22/89	33.01	1470.11
08/29/89	32.44	1470.68
09/05/89	32.94	1470.18
09/12/89	32.96	1470.16
09/14/89	32.88	1470.24
09/19/89	32.90	1470.22
09/26/89	32.94	1470.18
10/03/89	32.91	1470.21
10/10/89	32.80	1470.32
10/17/89	32.91	1470.21
10/24/89	32.72	1470.40
10/31/89	32.72	1470.40
11/07/89	32.69	1470.43
11/14/89	32.71	1470.41
11/21/89	32.72	1470.40
11/28/89	32.70	1470.42
12/05/89	32.74	1470.38
12/12/89	32.76	1470.36
12/19/89	32.85	1470.27
12/26/89	32.82	1470.30
01/03/90	32.84	1470.28
01/09/90	32.89	1470.23
01/16/90	32.93	1470.19
01/23/90	32.94	1470.18
01/31/90	33.06	1470.06
02/06/90	33.10	1470.02
02/13/90	33.22	1469.90
02/21/90	33.22	1469.90
02/27/90	33.38	1469.74
03/06/90	33.42	1469.70
03/20/90	33.39	1469.73
03/27/90	33.45	1469.67
04/03/90	33.39	1469.73
04/10/90	33.46	1469.66

Date	Depth to Water (ft)	WL Elev (msl, ft)
04/17/90	33.46	1469.66
04/18/90	33.39	1469.73
04/23/90	33.46	1469.66
05/01/90	33.54	1469.58
05/08/90	33.54	1469.58
05/14/90	33.68	1469.44
05/15/90	33.67	1469.45
05/23/90	33.69	1469.43
05/31/90	33.79	1469.33
06/05/90	33.74	1469.38
06/11/90	33.80	1469.32
06/13/90	33.80	1469.32
06/19/90	33.77	1469.35
06/25/90	33.84	1469.28
07/03/90	33.86	1469.26
07/09/90	33.92	1469.20
07/10/90	33.92	1469.20
07/17/90	34.07	1469.05
07/25/90	33.93	1469.19
07/31/90	33.95	1469.17
08/02/90	33.99	1469.13
08/08/90	33.99	1469.13
08/17/90	34.07	1469.05
08/21/90	34.11	1469.01
09/06/90	34.04	1469.08
09/07/90	34.07	1469.05
10/03/90	33.86	1469.26
10/09/90	34.00	1469.12
10/31/90	33.83	1469.29
11/20/90	33.74	1469.38
12/18/90	33.75	1469.37
01/14/91	33.79	1469.33
02/13/91	33.89	1469.23
03/14/91	34.13	1468.99

157-076-34BAA

Souris Valley Aquifer

LS Elev (msl,ft)=1465.88

SI (ft.)=18-21

Date	Depth to Water (ft)	WL Elev (msl, ft)
06/25/90	9.37	1456.51
07/09/90	9.61	1456.27
07/10/90	9.61	1456.27
07/17/90	10.01	1455.87
07/25/90	10.30	1455.58
08/03/90	10.38	1455.50
08/09/90	10.67	1455.21
08/17/90	10.83	1455.05
08/25/90	10.91	1454.97
09/06/90	11.00	1454.88

Date	Depth to Water (ft)	WL Elev (msl, ft)
09/07/90	11.03	1454.85
10/03/90	11.20	1454.68
10/09/90	11.38	1454.50
10/31/90	11.25	1454.63
11/20/90	11.24	1454.64
12/18/90	11.31	1454.57
01/14/91	11.52	1454.36
02/13/91	11.50	1454.38
03/14/91	11.55	1454.33