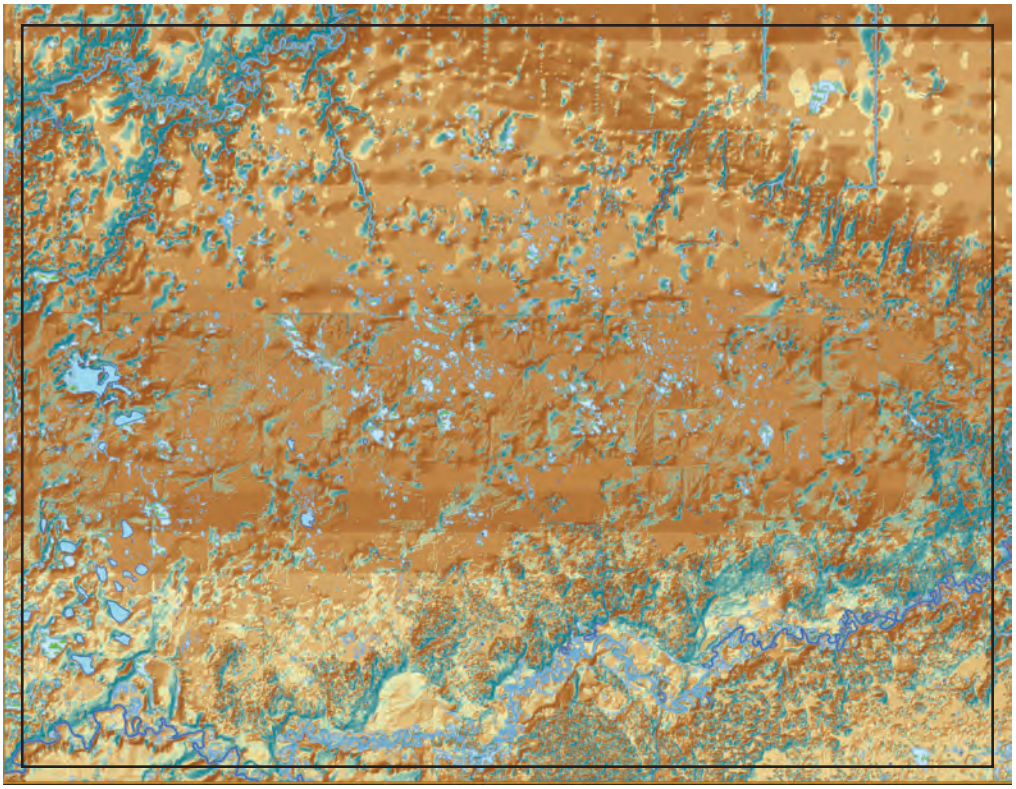
CASS RURAL WATER DISTRICT:

POTENTIAL FOR LARGE-SCALE WITHDRAWAL OF GROUND WATER FROM THE NORTHERN PORTION OF THE SHEYENNE DELTA AQUIFER



By Scott Parkin
North Dakota State Water Commission

North Dakota Ground-Water Studies No. 117

Prepared by the
North Dakota State Water Commission
In cooperation with the Cass Rural Water District

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INTRODUCTION AND PURPOSE

On November 8, 2006, Jerry Blomeke, General Manager, Cass Rural Water District (CRWD), and Ken Royce, Engineer, Bartlett and West Engineers Inc., and others met with staff from the North Dakota State Water Commission (NDSWC) to discuss the potential of developing a large scale groundwater supply for municipal, rural, and industrial uses within the northern portion of Sheyenne Delta aquifer (SDA).

The SDA underlies portions of Cass, Ransom, Sargent, and Richland Counties within southeastern North Dakota (Fig. 1). Mr. Blomeke stated a need for an annual appropriation of 1,200 acre-ft of groundwater at a maximum pumping rate of 1,500 gallons per minute (gpm) for municipal and rural use and an additional annual appropriation of 1,680 acre-ft of groundwater at a maximum pumping rate of 1,040 gpm for industrial use.

The requested point of diversion for the municipal and rural expansion was the SE1/4 of Section 19, T 136, N, R 52 W located adjacent to the existing well field utilized by the CRWD (Fig. 2). NDSWC staff expressed concern that additional withdrawal of groundwater from the SE1/4 of Section 19 may capture groundwater that currently discharges to the Sheyenne River valley and result in decreased stream flow within the Sheyenne River. Decreased stream flow would impact the existing appropriation of surface water from the Sheyenne River.

The central region of the northern portion of the SDA is characterized by shallow depth to the water table and discharge of groundwater as evapotranspiration (ET). It is possible that large-scale withdrawal of groundwater from the central region of the aquifer would result in little or no capture of groundwater that currently discharges to the Sheyenne River. The CRWD requested several additional points of diversion within the central region of the northern portion of the SDA (Fig. 2).

Additional groundwater exploration and development of a numerical groundwater flow model were deemed necessary to assess the potential for large-scale withdrawal of groundwater from the northern portion of the SDA.

Scope of Study

On December 26, 2006, the State of North Dakota, acting through the NDSWC, through its Chief Engineer-Secretary, Dale Frink, and the CRWD, acting through its General Manager, Jerry Blomeke entered into an agreement to conduct a groundwater exploration study within a two-township area (T 136 N, R 53 W and T 136 N, R. 52 W) overlying the northern portion of the SDA (Fig. 2). Study tasks assigned to Bartlett and West Engineers Inc. included: 1) selection of drill sites, 2) obtaining easements with landowners, and 3) surveying of the completed monitoring wells. Study tasks of the NDSWC included: 1) preparation of field geologic logs from drilling samples, 2) measurement of water levels within monitoring wells, 3) collection of water samples from monitoring wells, 4) laboratory analysis of water samples, and 5) data analysis, and 6) preparation of a hydrogeologic report. Leggette, Brashears, and Graham Inc. developed a numerical groundwater flow model to simulate large-scale pumping and aquifer response within the study area.

Location-Numbering System

The locations of test holes and wells referred to within this report are identified according to the public land classification system of the United States Bureau of Land Management (Fig. 3). The first numeral designates the township, the second numeral designates the range, and the third numeral designates the section in which the well or test hole is located. Subsequent letters following the section number denote the quarter division within each section. The first letter denotes the quarter section, the second letter denotes the quarter-quarter section, and the third letter denotes the quarter-quarter-quarter section or 10-acre area. The letters A, B, C, and D designate the northeast, northwest, southwest, and southeast quarter section divisions, respectively. If more than one well or test hole is recorded at the same location, numbers 1, 2, 3, etc., are added after the letters denoting the quarter section divisions. For example, well 136-053-15ADD is located in the SE1/4 of the SE1/4 of the NE1/4 of Section 15, Township 136 North, Range 53 West (Fig. 3).

Previous Work

Interpretation of the Pleistocene geology and description of the groundwater resources associated with the Sheyenne delta plain were included within the groundwater studies for Cass County (Klausing, 1968), Ransom and Sargent Counties (Bluemle, 1979; Armstrong, 1982), and Richland County (Baker, 1967a, b; Baker and Paulson, 1967). The stratification of the Sheyenne delta plain was described by Baker (1967b). Stream flow within the Sheyenne River due to groundwater discharge was measured by Paulson (1964). Determination of aquifer properties and development of a groundwater model for predicting the impacts upon the SDA due to construction of a proposed dam and reservoir on the Sheyenne River were completed by Downey and Paulson (1974).

Field Methods

Boart Longyear, Drilling Services, Little Falls MN, completed 18 test holes and constructed 14 monitoring wells for CRWD specifically for this study (Fig. 4). Monitoring wells were constructed using 20-foot lengths of 2-inch diameter schedule 40 PVC casing and 5-foot lengths of 2-inch diameter, 10-slot, schedule 40 PVC screen. A check-valve and screen were attached to the 2-inch diameter PVC casing prior to inserting into the drill hole. Additional lengths of 2-inch diameter PVC casing were attached as the screen and check-valve were placed at the desired depth within the drill hole. The drill hole was backwashed through the screen and check-valve. A silica sand pack was placed around the well screen and sealed with bentonite using a tremie pipe. The annular space above the bentonite seal to land surface was filled with cement using a tremie pipe.

A NDSWC hydrologist prepared a lithologic description based on examination of continuous core samples. The lithologic descriptions included texture, color, and petrologic composition when possible.

Water samples for chemical analysis were collected from 14 constructed monitoring wells and 22 existing monitoring wells located within the study area. Prior to sampling each well, at least three casing volumes of water were removed by bailing. Samples were collected using a PVC point-source bailer. Field measurement of electrical

conductivity, pH, and temperature were made at the time of sample collection. Four water samples were collected at each sampling site:

1) 500 ml raw sample – lab pH, electrical conductivity, SO_4, HCO_3, CO_3, Cl, total dissolved solids, hardness, alkalinity as $CaCO_3$, sodium adsorption ratio, and residual sodium carbonate.
2) 200 ml filtered and acidified (2 ml nitric acid) – Ca, Mg, Na, K, Fe, and Mn.
3) 200 ml unfiltered and acidified (2 ml sulfuric acid) – nitrate as N.
4) 250 ml filtered and acidified (2 ml nitric acid) – (trace elements) Se, Pb, As, Cd, Al, Be, Cr, Ni, Cu, Zn, Ag, Sb, Ba, and Tl.

Water levels measured in monitoring wells for this study were made using a Solinst Model 101 electric water-level meter. Prior to this study, historic water levels within monitoring wells were measured using a chalked steel tape. Water levels were recorded to 1/100 of a foot using both measurement techniques.

DESCRIPTION OF THE STUDY AREA

The SDA is located in the southeast portion of North Dakota within the Red River Valley division of the Central Lowland physiographic province (Fig. 1). Within the study area, the Red River Valley division is divided into two geomorphic units: the glacial Lake Agassiz plain and the Sheyenne delta plain (Fig. 1).

Climate

The Sheyenne delta is located within the southeast climatological division of North Dakota (NOAA, 2002). The climate within the study area is sub humid. Previous work by Cline and others (1993), determined that a large amount of the long-term variability in precipitation occurs as rain during the summer seasons (May through September). There is less variability in precipitation that falls as rain and snow during the winter seasons (October through May).

Daily precipitation data from six weather stations located in McLeod, Lisbon, Litchville, Enderlin, Chaffee, and Casselton (Fig. 1) were used to estimate the amount of annual precipitation that has fallen within the study area from 1933 through 2006 (Fig. 5). Total precipitation has varied between 9.0 and 32.1 inches per year with an average

of about 20 inches per year. Winter precipitation has varied between 2.8 and 11.7 inches per year with an average of about 6.5 inches per year.

The North Dakota Agricultural Weather Network (NDAWN) has an automated weather station located near Leonard (Fig. 1). The weather station measures rainfall and calculates potential evapotranspiration (PET). Summer precipitation is measured using a tipping bucket rain gage. Winter precipitation is not measured. PET is calculated using the Penman-Monteith method using temperature, dew point, solar radiation, and wind speed data measured at the NDAWN site.

Monthly rainfall and PET data from the Leonard area collected from 2002 through 2009 indicate that the study area is characterized by a moisture deficit during the summer months (Fig. 6). Subtracting average rainfall from average PET indicates that the average monthly moisture deficit ranges between 2.2 and 5.2 inches during the months of May through September.

Soils

The northern portion of the SDA aquifer is predominantly overlain by soils of the Hamar, Hecla, Serden, Ulen, and Wyndmere series formed in fluvial, lacustrine, and eolian deposits (Soil Survey Staff). The Hamar series consists of deep, somewhat poorly to poorly drained soils within level areas and shallow depressions. These soils formed in coarse-textured fluvial, lacustrine, and eolian deposits. The Hecla series also formed in coarse-textured fluvial, lacustrine, and eolian deposits and consists of deep, moderately well drained soils within nearly level to undulating areas. The Serden series consists of deep, excessively drained soils on hummocks and dunes within the Sheyenne delta. The Serden series of soils formed in eolian deposits. The Ulen series consists of deep, somewhat poorly drained fine sandy loam soils. Ulen soils formed in coarse-textured lacustrine deposits. The Wyndmere series consists of deep, somewhat poorly drained loam soils. Wyndmere soils formed in moderately to coarse textured lacustrine deposits.

The poorly drained soils are located within the central portion of the study area (Fig. 7) where depths to the to the water table are commonly less than 5 ft below land surface and characterized by numerous wetlands. Well drained to excessively drained soils are located within the southern portion of the study area along the northern edge of

the Sheyenne River valley. Depths to the water table underlying the excessively drained soils are greater than 10 ft below land surface.

Estimated soil properties (Soil Survey Staff) for the five predominate soil series overlying the northern portion of the SDA are summarized in Table 1. Soils within the study area are characterized by relatively rapid rates of permeability and relatively small available water capacities. Rapid permeability coupled with small moisture holding capacity facilitates deep percolation of precipitation and recharge to the underlying aquifer.

Table 1. Properties of the five major soil series within the northern portion of the Sheyenne Delta aquifer.

Soil Series	Depth (inches)	USDA Texture	Available Water Capacity (inches per inch)	Permeability (inches per hour)
Hamar	0 – 16 16 – 60	loamy fine sand - fine sandy loam loamy fine sand - fine sand	0.16 – 0.18 0.05 – 0.11	6 – 20 6 – 20
Hecla	0 – 16 16 – 60	fine sandy loam - loamy fine sand loamy fine sand - fine sand	0.09 – 0.18 0.06 – 0.13	6 – 20 6 – 20
Serden	0 – 8 8 – 60	fine sand - loamy fine sand fine sand	0.07 – 0.12 0.05 – 0.08	6 – 20 6 – 20
Ulen	0 – 16 16 – 60	loamy fine sand - fine sandy loam loamy fine sand/fine sand	0.16 – 0.18 0.05 – 0.11	6 – 20 6 – 20
Wyndmere	0 – 8 8 – 60	loam - fine sandy loam fine sandy loam	0.15 – 0.21 0.14 – 0.17	2 – 6 2 – 6

Geology

The northern portion of the SDA consists of fluvial, lacustrine, and glacial deposits of Pleistocene age. An unconformity separates the Pleistocene deposits from underlying Cretaceous age shale.

At the end of the Pleistocene epoch, the southern portion of glacial Lake Agassiz occupied what is currently the Red River valley. Prior to the formation of Lake Agassiz, the ancestral Sheyenne River was a southeast trending ice-marginal stream now indicated by the Milnor Channel (Fig. 1). Glacial recession allowed the ancestral Sheyenne River to abandon the ice-marginal channel and flow into the early stages of Lake Agassiz. The ancestral Sheyenne River carried abundant glacial melt-water sediment for rapid deposition of a delta within glacial Lake Agassiz.

The western boundary of the Sheyenne delta indicates that early delta formation corresponded to the highest water-level stage (beach ridge) of Lake Agassiz (Fig. 1). The escarpment along the northeast edge of the delta is most likely a wave-cut feature (Baker, 1967b) representing a later and lower water-level stage of Lake Agassiz (Figs. 1 and 2).

The lower part of the Sheyenne delta consists of lacustrine sediments (bottomset beds) with overlying interbeds of clay, silt, and sand deposits (foreset beds). The upper part of the delta is primarily fluvial sediments comprised of very-fine and fine sand (Baker, 1967b). During the decline of Lake Agassiz, eolian deposits developed over large portions of the exposed Sheyenne Delta plain.

After deposition of the delta and during the decline of Lake Agassiz, the Sheyenne River dissected the delta plain into northern and southern portions (Fig. 1). The Sheyenne River flood plain developed at the same water-level stage of Lake Agassiz that resulted in the delta escarpment along the northeast boundary of the delta. Entrenched meanders and erosional terraces within the Sheyenne River flood plain resulted as the base level of the Sheyenne River declined with Lake Agassiz.

Hydrogeology

The northern portion of the SDA covers an area of about 160 square miles (Fig. 2). The aquifer is unconfined and consists of saturated fluvial and eolian deposits within the upper part of the delta. The Sheyenne River valley is the southern boundary of the northern portion of the SDA. The wave-cut escarpment of the Sheyenne delta is the northeast boundary of the aquifer. A portion of the Maple River valley forms the northern boundary of the aquifer. A tributary to the Maple River comprises the northwest boundary of the aquifer. The western boundary of the aquifer is defined as the geologic contact between collapsed fluvial sediments to the west and Sheyenne delta deposits to the east.

The upper part of the Sheyenne delta consists of deposits of very-fine and fine sand intercalated with silt and clay. The lower part of the delta is predominantly deposits of silt and clay with some interbeds of very-fine sand. The lower part of the Sheyenne delta stores and contributes groundwater to the upper part of the delta. However, the interbeds of clay are most likely effective local aquitards.

The division between the upper and lower delta deposits was determined by field inspection of continuous core samples and interpretation of existing lithologic descriptions within the study area. A contour map indicating the elevation of the division between the upper and lower delta deposits is shown in Figure 8. The greatest thickness of upper delta deposits trends southeast within the central region of the study area.

The location of hydrogeologic section A – A' is shown on Figure 8. The depth to the underlying bedrock and glacial deposits increases towards the east (Fig. 9). The combined thickness of the upper and lower delta deposits also increases towards the east. The thickness of the upper delta increases near the central region of the study area and decreases towards the east and becomes more intercalated with clay and silt near the delta escarpment.

The location of hydrogeologic section B – B' is also shown on Figure 8. The thickness of the upper delta increases towards the east, but becomes more interacted with silt and clay approaching the Sheyenne River valley (Fig. 10).

The north to south location of hydrogeologic section C – C' (Fig. 8) also indicates increasing thickness of the upper delta near the central region of the study area and decreasing thickness near the Sheyenne River valley (Fig. 11).

Occurrence and Movement of Groundwater

A water-table contour map was prepared using water level data collected during the fall of 2009 (Fig. 12). Radial groundwater flow originates from a groundwater mound near Section 16, T 136 N, R 53 W located in the western region of the study area (Fig. 12). Decreasing elevation of the water table indicates groundwater flow to the north and northeast towards the Maple River valley and the delta escarpment. Declining water-table elevation also indicates movement of groundwater to the southeast towards the Sheyenne River valley.

The central region of the study area is characterized by a nearly level water-table gradient resulting in local groundwater flow cells and vertical movement of water (Fig. 12). The depth to the water table is normally less than 5 ft below land surface and the aquifer is coupled to the atmosphere (the capillary fringe above the water table and the

depth of the root zone overlap). Numerous wetlands located within the central region of the study area indicate the near surface position of the water table.

The water-table gradient increases to about 6 ft per mile approaching the Sheyenne River valley within the southern region of the study area (Fig. 12). The depth to the water table usually exceeds 10 ft below land surface underlying the excessively drained soils adjacent to the Sheyenne River valley. Within the southern region of the study area the aquifer is not connected to the atmosphere. Wetlands are typically absent adjacent to the Sheyenne River valley.

The reach of the Sheyenne River that crosses the SDA is a gaining stream (Fig. 1). Measured gains in river discharge are attributed to groundwater discharge and inflow from tributaries located on both sides of the Sheyenne River valley (Paulson, 1964). The data in Table 2 indicates an average gain of 28.8 cubic feet per second or 0.9 percent due to groundwater discharge and inflow of tributaries between gaging stations E and L (Fig. 1).

Table 2. Measurements of discharge of the Sheyenne River.

	October 1963 Discharge (cfs)	October 1986 Discharge (cfs)	November 2006 Discharge (cfs)
Station E	21.1	39.8	37.3
Station L	43.4	78.0	63.1
Gain Between Stations	22.3	38.2	25.8
Percent Gain	1.06	0.96	0.69

Short, somewhat consistently spaced streams located along the Sheyenne delta escarpment also indicate groundwater discharge as stream flow and ET. Additional groundwater discharge likely contributes to the base flow within the tributary of the Maple River located within the northwest portion of the SDA (Fig. 1).

Aquifer Hydraulic Properties

Downey and Paulson (1974) used laboratory methods to determine the hydraulic conductivity and specific yield of core samples collected from the SDA. Aquifer tests and analysis of water-table profiles were also used to estimate the hydraulic conductivity and specific yield of the aquifer. The hydraulic conductivity of very fine and fine sand was determined to be 7.2 ft/day. The hydraulic conductivity increased to 16.5

ft/day for fine sand. A specific yield value of 17 percent was determined from a long-term aquifer test and included the effect of delayed yield (Downey and Paulson; 1974).

Based on sediment descriptions, the range of hydraulic conductivity is 13 to 27 ft/day for poorly sorted, very fine or fine sand, respectively. The lower range of hydraulic conductivity for very fine and fine sand determined by Downey and Paulson (1974) most likely reflects silt content within the aquifer.

Transmissivity, specific yield, and hydraulic conductivity values for the SDA are difficult to determine from data collected during short-term well tests due to the effect of delayed yield.

Specific capacities are available from eight CRWD production wells located in the N1/2 of Section 29, T 136 N, R 52 W (Fig. 2). A summary of the test data is shown in Table 3. Using specific capacity as a proxy for estimating transmissivity yields a range of 400 to 1,000 ft^2/day. Based on the saturated thickness reported on the well driller's reports, hydraulic conductivity was estimated to range from about 10 to 15 ft/day. The estimated range of hydraulic conductivity is reasonable for very-fine to fine sand with low to moderate silt content.

Table 3. Specific capacity from eight CRWD production wells located in the N1/2 of Section 29, T 136 N, R 52 W.

Well Location	Specific Capacity gpm/ft	Duration of Pumping Hours	Pumping Rate gpm
136-052-29BBB	3.6	24	102
136-052-29BBC1	2.2	8	95
136-052-29BBC2	3.6	5	172
136-052-29BBB	3.5	24	116
136-052-29ABA	2.7	24	82
136-052-29ABB	6.8	24	128
136-052-29BAA	6.8	24	130
136-052-29BAB	5.9	24	114

Recharge and Discharge

The hummocky land surface of the SDA greatly influences the processes of groundwater recharge and discharge. Recharge to the aquifer is depression focused and occurs mainly during spring and early summer. During the winter, snow accumulates and a frost zone develops near land surface. In the spring, snowmelt commonly begins prior to dissipation of the underlying frost zone. Surface runoff of melt

water from adjacent upland areas accumulates within depressions and infiltrates after the frost zone dissipates.

Discharge of ground water from the aquifer is also depression focused. The aquifer and the atmosphere are coupled allowing for discharge of groundwater as ET wherever depth to the water table is less than the combined height of capillary rise of water above the water table and the depth of the root zone below land surface. During the summer, discharge of groundwater from the aquifer normally exceeds recharge to the aquifer.

Monitoring well 136-52-22DDD is located within the eastern portion of the study area in the southeast corner of Section 22, T 136 N, R 52 W (Fig. 12). Land-surface elevation near the monitoring well is 1051.2 ft. The well is screened from 33 to 38 ft below land surface (Fig. 10). The water-level elevation within monitoring well 136-52-22DDD has fluctuated between 1050.7 and 1041.9 ft or 0.5 and 9.3 ft below land surface (Fig. 13) over a 47-year period beginning in 1963.

The hydrograph for monitoring well 136-52-22DDD (Fig. 13) shows nearly 9 ft of water-level fluctuation within the northern portion of the SDA aquifer due to changes in precipitation. Water-level fluctuation within monitoring well 136-52-22DDD corresponds to the 5-year moving average of annual precipitation (Fig. 5).

Monitoring well 136-52-06BBB is located within the northern portion of the study area in the northwest corner of Section 6, T 136 N, R 52 W (Fig. 12). Land-surface elevation near the monitoring well is 1056.1 ft. The well is screened from 40 to 43 ft below land surface (Fig. 9). The water-level elevation within monitoring well 136-52-06BBB has fluctuated between 1055.9 and 1049.4 ft or 0.2 and 6.7 ft below land surface (Fig. 14) over a 15-year period beginning in 1995.

The shallow depth to the water table indicates that the aquifer is strongly coupled to the atmosphere within the proximity of monitoring well 136-52-06BBB. Seasonal water-level fluctuations of 3 to 5 ft indicate a predominant vertical component of groundwater flow due to springtime recharge and summer-time discharge as ET.

Monitoring well 136-52-29BBB is located within the southern portion of the study area in the northwest corner of Section 29, T 136 N, R 52 W (Fig. 12). Land-surface elevation near the monitoring well is 1061.5 ft. The well is screened from 47 to 50 ft below land surface (Fig. 10). The water-level elevation within monitoring well 136-52-

29BBB has fluctuated between 1053.4 and 1045.2 ft or 8.1 and 16.3 ft below land surface (Fig. 14) over a 15-year period beginning in 1995.

A portion of the water-level decline measured within monitoring well 136-52-29BBB is due to pumping of CRWD wells located along the northern perimeter of Section 29, T 136 N, R 52 W (Fig. 2). Although the depth to the water table exceeds 8 ft, the aquifer appears to be coupled to the atmosphere within the area of monitoring well 136-52-29BBB. Seasonal water-level fluctuations of nearly 5 ft indicate vertical movement of groundwater related to the processes of recharge and ET.

Monitoring well 136-52-30DDD is also located within the southern portion of the study area in the southeast corner of Section 30, T 136 N, R 52 W (Fig. 12). Land-surface elevation near the monitoring well is 1054.5 ft. The well is screened from 52 to 55 ft below land surface (Fig. 11). The water-level elevation within monitoring well 136-52-30DDD has fluctuated between 1047.1 and 1042.1 ft or 7.4 and 12.4 ft below land surface (Fig. 14) over a 15-year period beginning in 1995.

The aquifer appears to have less connection to the atmosphere within the area of monitoring well 136-52-30DDD. The magnitude of seasonal water-level fluctuation is significantly less in response to springtime recharge events and summer discharge.

The monitoring wells located within the central portion of study area indicate that the aquifer is strongly coupled to the atmosphere. Monitoring well 136-53-22BBB is located in the northwest corner of Section 22, T 136 N, R 53 W (Fig. 12). Land-surface elevation near the monitoring well is 1064.6 ft. The well is screened from 59 to 64 ft below land surface. The water-level elevation within monitoring well 136-53-22BBB has fluctuated between 1064.1 and 1058.4 ft or 0.5 and 6.2 ft below land surface over a 3-year period beginning in 2007 (Fig. 15).

Monitoring well 136-53-14CCC is located in the southwest corner of Section 14, T 136 N, R 53 W (Fig. 12). Land-surface elevation near the monitoring well is 1065.6 ft. The well is screened from 66 to 77 ft below land surface. The water-level elevation within monitoring well 136-53-14CCC has fluctuated between 1062.0 and 1057.3 ft or 3.6 and 8.3 ft below land surface over a 3-year period beginning in 2007 (Fig. 15).

Monitoring well 136-53-12ADD is located in the northeast portion of Section 12, T 136 N, R 53 W (Fig. 12). Land-surface elevation near the monitoring well is 1061.8 ft.

The well is screened from 50 to 55 ft below land surface. The water-level elevation within monitoring well 136-53-12ADD has fluctuated between 1059.7 and 1055.2 ft or 2.1 and 6.6 ft below land surface over a 3-year period beginning in 2007 (Fig. 15).

Groundwater Chemistry

The Oakes aquifer is located in western Sargent and eastern Dickey Counties. The Oakes aquifer also consists of deltaic sediments transported by the ancestral Sheyenne River. The Oakes aquifer consists primarily of quartz with lesser amounts of carbonates, silicates, detrital shale, and detrital lignite (Shaver and Schuh, 1990).

The chemical characteristics of groundwater within the Oakes aquifer are related to recharge and discharge of groundwater from the aquifer. Groundwater flow paths and residence times within the aquifer are relatively short. Rapid infiltration of precipitation in contact with carbon dioxide (CO_2) from atmospheric and biological sources dissolves carbonate minerals and results in bicarbonate (HCO_3) dominant groundwater and relatively low concentrations of total dissolved solids (TDS). Concentrations of bicarbonate, sulfate (SO_4), calcium (Ca), magnesium (Mg), and sodium (Na) increase with the duration of groundwater movement within the aquifer due to the dissolution of minerals and ion exchange processes (Shaver and Schuh, 1990).

Net discharge of groundwater from the Oakes aquifer occurs within lowland areas where the depth to the water table is usually less than 5 ft below land surface. Groundwater discharge as ET results in ion concentration and precipitation of calcite ($CaCO_3$), gypsum ($CaSO_4 \cdot 2H_2O$), and sodium and magnesium sulfate salts ($NaMgSO_4$). Dissolution of the sodium and magnesium sulfate salts results in sulfate dominant groundwater and elevated concentrations of sodium and magnesium near land surface (Shaver and Schuh, 1990).

Determination of the chemical characteristics of groundwater within the northern portion of the SDA was based on the chemical analysis of 67 groundwater samples from the SDA collected from 36 sites located within the study area (Appendix III).

Groundwater within the northern portion of the SDA is predominantly a Ca-HCO_3 type with TDS concentrations less than 500 mg/L (Fig. 16). Groundwater samples containing the highest TDS concentrations were collected within the central portion of

the study area characterized by a shallow depth to the water table and strongly coupled to the atmosphere (Fig. 17).

Ion concentration due to groundwater discharge as ET was indicated by a groundwater sample collected from monitoring well 136-53-09AAA with a TDS concentration of 2,900 mg/L. Monitoring well 136-53-09AAA is screened near land surface from a depth of 5 to 15 ft below land surface and located in the northeast corner of Section 9, T 136 N, R 53 W (Fig. 17). Analysis of water collected from monitoring well 136-53-09AAA indicated a SO_4 dominant groundwater and elevated concentrations of Na and Mg (Fig. 16) suggesting ion concentration and possible dissolution of Na and Mg sulfate salts at or near land surface.

Vertical mixing or dispersion of SO_4 dominant groundwater from near land surface to the lower portion of the aquifer was indicated by groundwater collected from monitoring well 136-53-10BBB located adjacent to monitoring well 136-53-9AAA. Monitoring well 136-53-10BBB is screened from 45 to 55 ft below land surface and located in the northwest corner of Section 10, T 136 N, R 53 W (Fig. 17). Groundwater collected from monitoring well 136-053-10BBB had a TDS concentration of 1,180 mg/L. The water was HCO_3 dominant with elevated concentrations of SO_4, Na, and Mg (Fig. 16).

Ion concentration due to ET was also indicated by a groundwater sample collected from monitoring well 136-53-07BBB located in the northwest corner of Section 7, T 136 N, R 52 W (Fig. 17). Monitoring well 136-52-07BBB is screened near land surface from a depth of 5 to 15 ft below land surface. Water collected from monitoring well 136-52-07BBB had a TDS concentration of 1,230 mg/L. The water was HCO_3 dominant with elevated concentrations of SO_4, Na, and Mg (Fig. 16).

Mixing or dispersion of higher TDS groundwater from near land surface to lower portions of the aquifer is also indicated by monitoring well 136-53-12ADD located in the southeast corner of the NE1/4 of Section 12, T 136 N, R 53 W (Fig. 17). Monitoring well 136-53-12ADD is screened from 50 to 55 ft below land surface and is located about 0.5 miles south of observation well 136-52-07BBB. Water collected from monitoring well 136-53-12ADD indicated a HCO_3 dominant groundwater with a TDS concentration of 830 mg/L and elevated concentrations of Na and Mg.

Monitoring well 136-52-09ADDD also indicates possible near-surface discharge of groundwater and ion concentration. Monitoring well 136-52-09ADDD is screened near the surface from 8 to 12 ft below land surface and located in the southeast corner of the NE1/4 of Section 9, T 136 N, R 52 W (Fig. 17). Water collected from monitoring well 136-52-09ADDD indicated a HCO_3 dominant ground water with a TDS concentration of 600 mg/L and elevated concentrations of Na and Mg.

Groundwater samples from three monitoring wells, 136-53-04BBB, 136-53-06BAA, and 136-53-08DDD located within the northwest portion of T 136 N, R 53 W (Fig. 17) had TDS concentrations between 700 and 730 mg/L. All three monitoring wells are screened within the lower portion of the aquifer. Bicarbonate dominant groundwater with elevated concentrations of Na and Mg may indicate either longer residence times or ion concentration near land surface and possible downward mixing of higher TDS groundwater within the lower portion of the aquifer.

Increasing ion concentration with depth is indicated by two monitoring wells located within the southwest portion of the SE1/4 of Section 19, T 136 N, R 52 W (Fig. 15) and screened at different depths within the aquifer. Monitoring well 136-52-19DCB3 is screened from 50 to 55 ft below land surface. Groundwater collected from the upper portion of the aquifer had a TDS concentration of 340 mg/L and low concentrations of SO_4, Na, and Mg. Monitoring well 136-52-19DCB2 is screened from 75 to 90 ft below land surface. Groundwater collected from the underlying portion of the aquifer had a TDS concentration of 580 mg/L and elevated concentrations of SO_4, Na, and Mg.

The lower TDS concentration of groundwater within the upper portion of the aquifer most likely reflects an area of net recharge. Increasing TDS concentration with depth suggests longer residence times and associated mineral dissolution and ion exchange processes.

Arsenic (As) concentrations ranged from 2.1 to 95.6 ug/L within groundwater samples collected from 31 monitoring wells located within the study area. Groundwater samples containing the highest concentrations of arsenic were collected from the central portion of the study area (Fig. 18) characterized by a shallow depth to the water table, strongly coupled to the atmosphere, and elevated TDS concentrations.

The source of arsenic is most likely dissolution of arsenopyrite (FeAsS) derived from detrital shale within the deltaic sediments. Dissolution of arsenopyrite releases soluble arsenic and iron (Fe) within groundwater. Soluble iron within the aquifer commonly forms hydrous iron oxides (redoximorphic features) within the zone of water-table fluctuation. Soluble arsenic frequently adsorbs to the surface of hydrous iron oxides.

Although quite variable, arsenic concentrations increase with TDS concentrations up to about 800 mg/L indicating increasing dissolution of arsenopyrite with increasing residence time. Arsenic concentrations generally decrease within groundwater samples with TDS concentrations greater than 800 mg/L.

Oxidation and reduction reactions both affect the mobility of arsenic within groundwater. Arsenic containing minerals release soluble arsenic under oxidizing conditions. Soluble arsenic absorbed to hydrous iron oxides within the zone of water-table fluctuation may be released under reducing conditions.

Large-scale withdrawal of groundwater within the study area would result in water-table decline. Long-term decline of the water table and oxidation of reduced aquifer sediments may increase the concentration of soluble arsenic. Conversely, the concentration of soluble arsenic may decrease due to adsorption upon newly formed hydrous iron oxides resulting from long-term decline of the water table.

PROPOSED WATER DEVELOPMENT

CRWD has filed two water permit applications requesting a combined annual use of 2,900 acre-ft of groundwater at a maximum pumping rate of 3,500 gpm. Water permit application No. 5817 requested an annual appropriation of 1,200 acre-ft of groundwater at a maximum pumping rate of 1,500 gpm from a point of diversion in the SE1/4 of Section 19, T 136 N, R 52 W (Fig. 19) for the purpose of rural and domestic water use.

CRWD filed an application to amend water permit application No. 5817 for additional points of diversion in the SE1/4 of Section 2, the E1/2 of Section 3, the N1/2 of the NW1/4 and the SE1/4 of Section 10, all of Section 11, all of Section 12, the NW1/4 of Section 13, all of Section 14, all of Section 15, and the N1/2 of Section 22, T 136 N, R 53 W (Fig. 19).

Water permit application No. 5905 requested an annual appropriation of 1,700 acre-ft of groundwater at a maximum pumping rate of 2,000 gpm for rural, domestic, and

industrial uses. Water permit application No. 5905 requested the points of diversion described in the application to amend water permit application No. 5817, but not including the point of diversion in the SE1/4 of Section 19, T 136 N, R 52 W (Fig. 19).

Additional pumping of groundwater from the requested points of diversion located within the central region of the study area would result in water-level decline and a decrease in the amount of groundwater discharge as ET.

The requested point of diversion in the SE1/4 of Section 19, T 136 N, R 52 W overlies a portion of the aquifer located about 2 miles north of the Sheyenne River valley (Fig. 19). Additional pumping of ground water from the SE1/4 of Section 19 will result in water-level decline, decrease the amount of groundwater discharge as ET, and may capture groundwater that currently discharges as stream flow within tributaries to the Sheyenne River. Significant reduction in stream flow within the Sheyenne River could impact prior appropriators of surface water located downstream from the requested point of diversion in the SE1/4 of Section 19 (Fig. 19). A numerical groundwater model was developed to predict the potential decrease in stream flow within the Sheyenne River due to additional groundwater use.

Numerical Groundwater Model

Oswald and Kannenberg (2008) completed a steady state, numerical, groundwater flow model on behalf of CRWD to predict the impact of additional groundwater use from the Sheyenne Delta aquifer. The model software (MODFLOW) utilized a finite difference method. The model domain included the entire northern portion of the SDA (Fig. 2). The northeastern aquifer margin represented by the delta escarpment and the western aquifer margin represented by the collapsed sediments were defined as no-flow boundaries. Drains representing discharge to the rivers simulated the northwestern aquifer margin formed by the Maple River and the southern aquifer margin formed by the Sheyenne River. Additional drains were used to simulate drainage channels along the delta escarpment.

The aquifer model was divided into two vertical layers: 1) upper layer representing the fluvial sediments (very-fine and fine sand) and 2) lower layer representing the lacustrine sediments (intercalated clay, silt, and sand). The hydraulic conductivity of the upper layer was 10 ft/day. The hydraulic conductivity of the lower layer was 4 ft/day.

Recharge was simulated as 5 inches per year. Maximum potential ET was simulated as 20 inches per year with an ET extinction depth of 4 ft below land surface.

Forty-six monitoring wells were utilized as calibration points for the numerical model. Residual head values were determined by the difference between measured and calculated heads for each monitoring well. Error analysis indicated an overall root mean squared (RMS) error of 7.5 ft or a normalized RMS error of 5.8 percent.

Model calibration also included comparing the calculated depth to groundwater to soil drainage classification. Modeled depth to the water table of 4 ft or less coincided with areas of poor soil drainage. Calculated depth to the water table greater than 20 ft coincided with areas of excessively drained soils.

Evaluation of the groundwater model also included comparing the amount of calculated groundwater discharge to the Sheyenne River to the actual gain of the Sheyenne River. The gain of the Sheyenne river due to groundwater discharge from the northern portion of the SDA was assumed to be about 12 cfs, based on one half of the measured gain of the Sheyenne River during November of 2006 (Table 2).

Within the model, groundwater discharge to the Sheyenne River valley was assumed to occur within the incised Sheyenne River channel and was simulated by drains. Simulation of groundwater discharge to the river channel resulted in about 10.9 cfs or 91 percent of the estimated groundwater discharge from the northern portion of the SDA to the Sheyenne River. Groundwater discharge to the Sheyenne River also occurs as overland flow from springs. Simulated loss as ET within the river valley was 9.2 cfs. Assuming that a portion of the simulated ET results in overland flow within springs, the numerical model appeared to reasonably replicate groundwater discharge from the northern portion of the SDA to the Sheyenne River.

The calibrated model was used to simulate groundwater conditions under two scenarios: 1) the current annual water use and 2) additional annual use of 2,900 acre-ft of groundwater requested by CRWD. The effect on the amount of groundwater discharge to the Sheyenne River was estimated using the Zonebudget function within the MODFLOW software. The result of the two simulations indicated that an additional use of 2,900 acre-ft of groundwater might decrease the amount of groundwater discharge to the Sheyenne River by 0.4 cfs or 3.8 percent.

Potential For Large-Scale Water Use

The base of the SDA underlying the requested point of diversion in the SE1/4 of Section 19, T 136 N, R 52 W (Fig. 19) is at an elevation of about 980 ft (Fig. 8). The saturated thickness of the aquifer is estimated to be about 70 ft, based on an average water-table elevation of 1050 ft in monitoring well 136-52-29BBB (Fig. 14). Maximum individual well yield from the aquifer underlying the SE1/4 of Section 19 is predicted to be about 160 gpm, based on a specific well capacity of 4 gpm/ft and 40 ft of available well drawdown.

The base of the aquifer is at or below an elevation of about 980 ft underlying portions of the requested points of diversion located within the north central portion of the study area (Fig. 19). The saturated thickness of the aquifer is estimated to be about 73 ft, based on an average water-table elevation of 1053 ft in monitoring well 136-52-06BBB (Fig. 14). Maximum individual well yield from the aquifer underlying the north central portion of the study area is predicted to be about 170 gpm, based on a specific well capacity of 4 gpm/ft and 42 ft of available well drawdown.

Large-scale withdrawal of groundwater will require the use of multiple production wells. The requested combined pumping rate of 3,500 gpm would require construction of at least 22 production wells, based on an average individual well yield of 160 gpm.

Additional withdrawal of groundwater from the points of diversion located within the north central portion of the study area would have an impact upon the existing appropriators of groundwater within the permit area (Fig. 19). However, the amount of water-level decline and the areal extent of water capture would be reduced because the withdrawal of groundwater would also include groundwater discharge lost as ET that currently occurs throughout the north central portion of the study area.

Additional withdrawal of groundwater from the single point of diversion in the SE1/4 of Section 19, T 136 N, R 52 W (Fig. 19) would be limited by the small number of additional wells that could be constructed. Any additional water-level decline may have a substantial impact upon the existing appropriation of groundwater from the NE1/4 of Section 30 and the CRWD wells located in the N1/2 of Section 29.

The SE1/4 of Section 19 overlies a portion of the aquifer with a southeast trending water table gradient (Fig. 12) and adjacent to the well-drained soils north of the

Sheyenne River valley (Fig. 7). The increasing water table gradient and depth to the water table indicate increasing groundwater discharge to the Sheyenne River and decreasing groundwater discharge as ET. Any additional withdrawal of groundwater from the SE1/4 of Section 19 would most likely be offset by a reduction in the amount of groundwater discharge as surface water inflow within the tributaries to the Sheyenne River located within the southern portion of the study area (Fig. 19).

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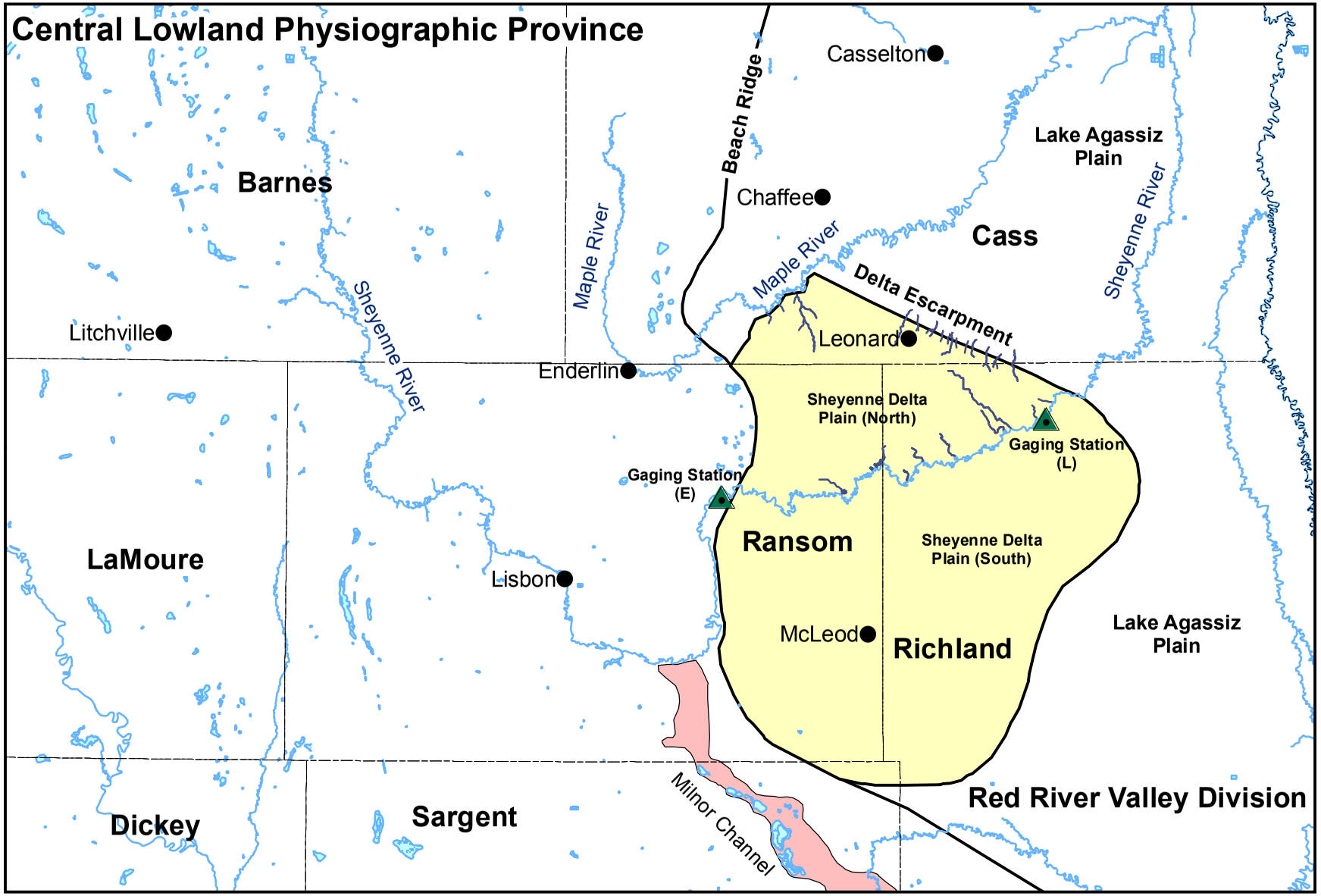

Figure 1. Location of the Sheyenne Delta plain in southeastern North Dakota.

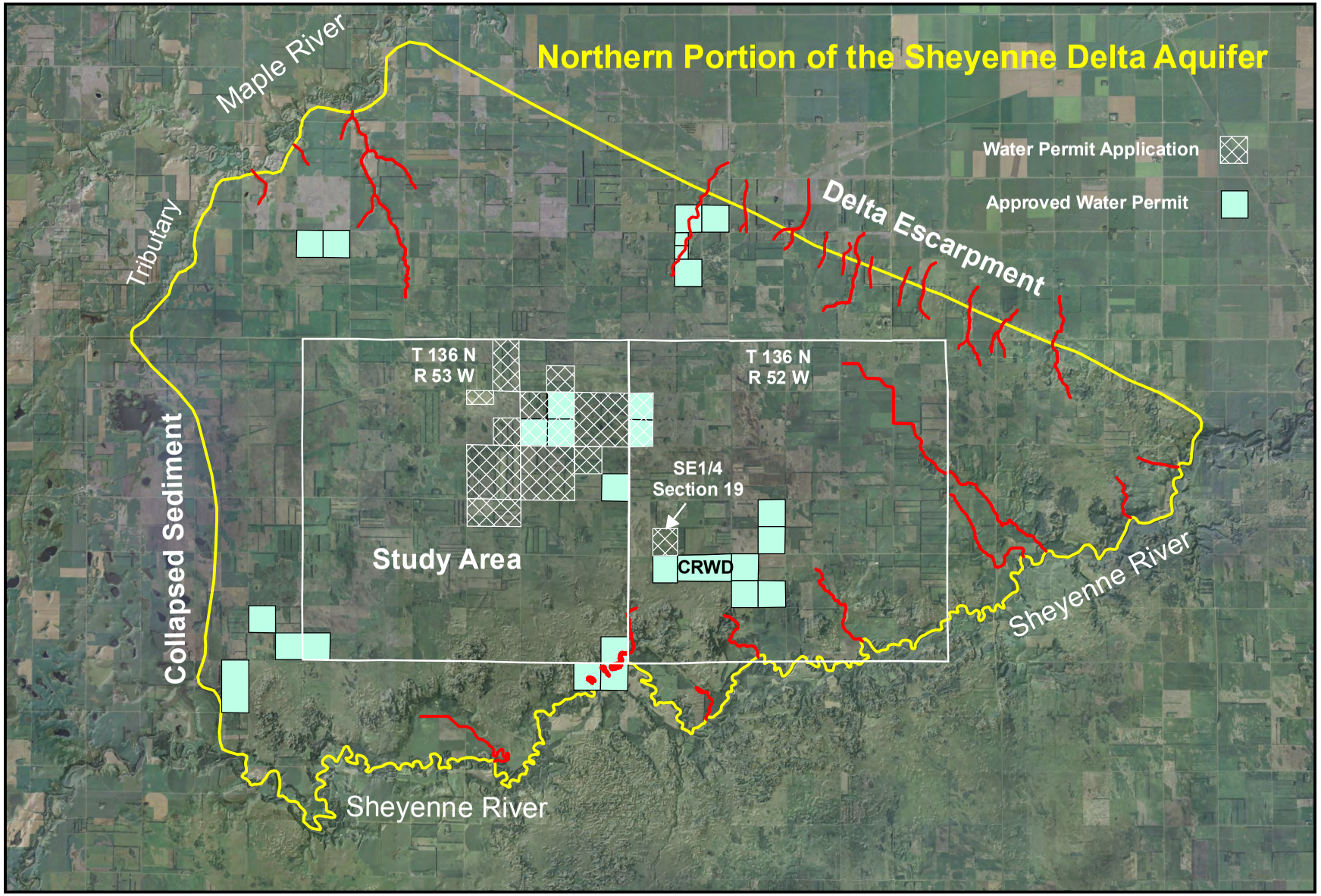

Figure 2. Plan view of the northern portion of the Sheyenne Delta aquifer showing aquifer boundaries, tributaries, water permits, and the location of the study area.

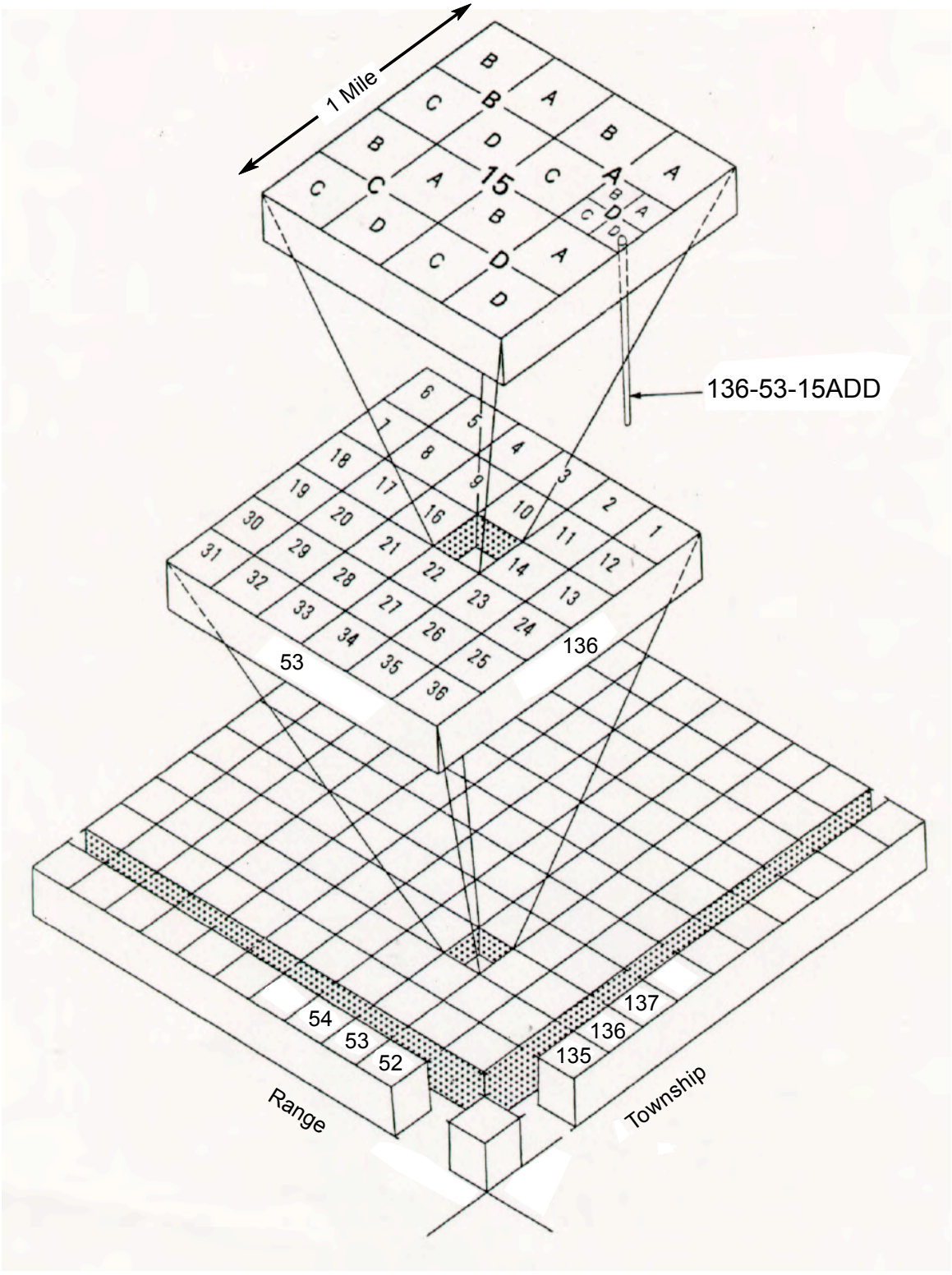

Figure 3. Location-numbering system of test holes and monitoring wells.

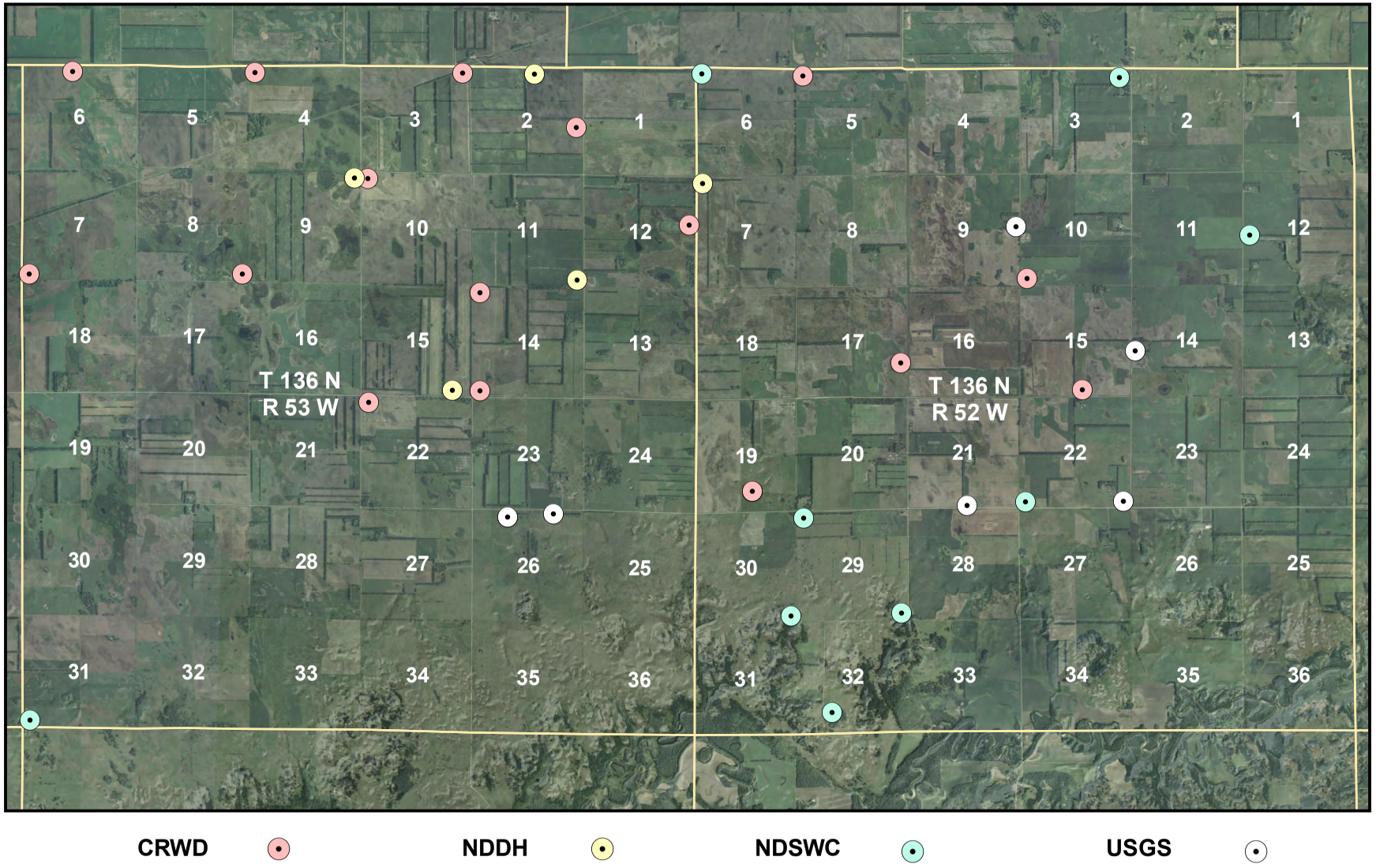

Figure 4. Plan view of the study area showing the locations of existing monitoring wells and the additional test drilling and monitoring wells completed by CRWD.

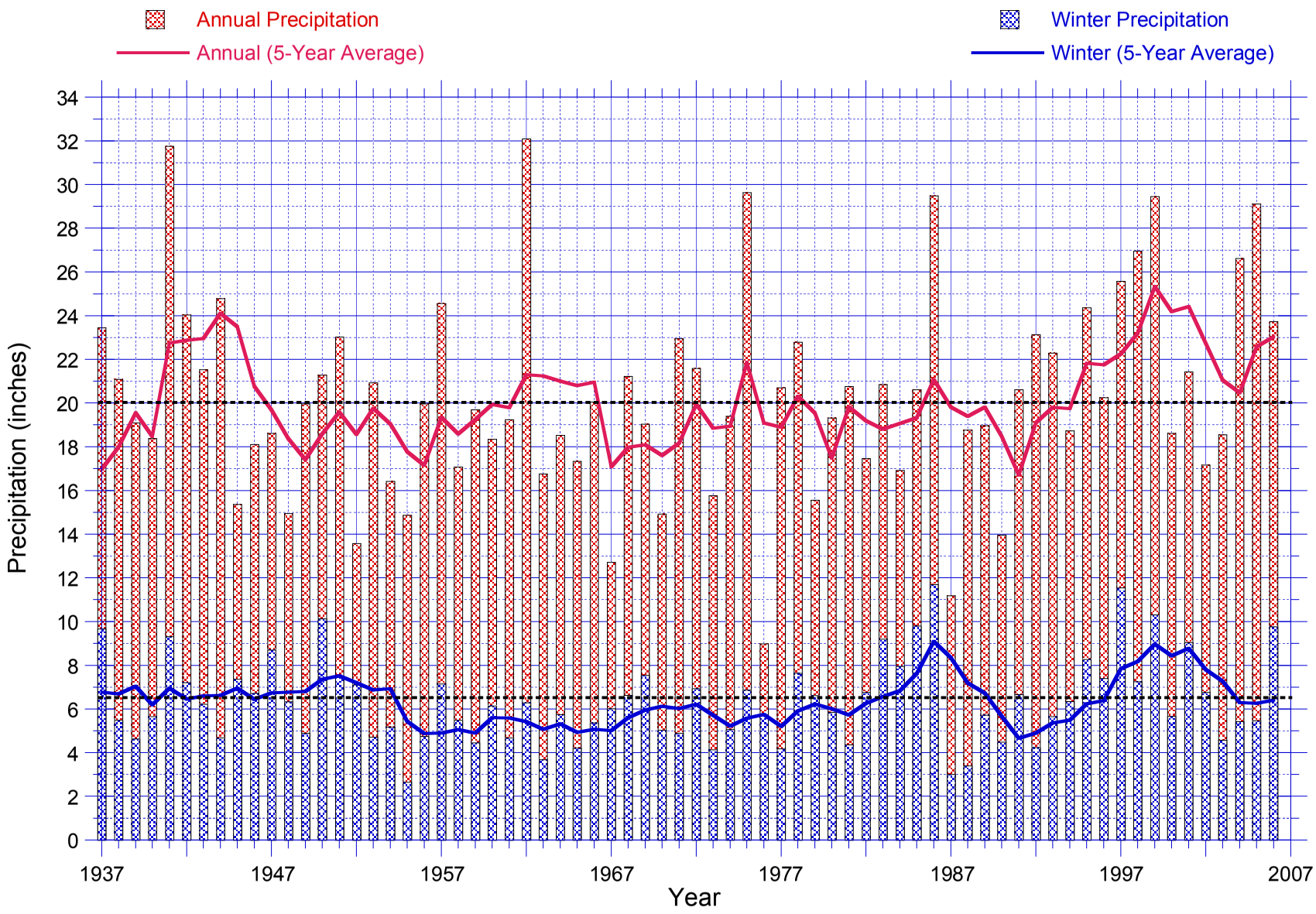

Figure 5. Estimated annual and winter precipitation within the study area and associated 5-year moving averages.

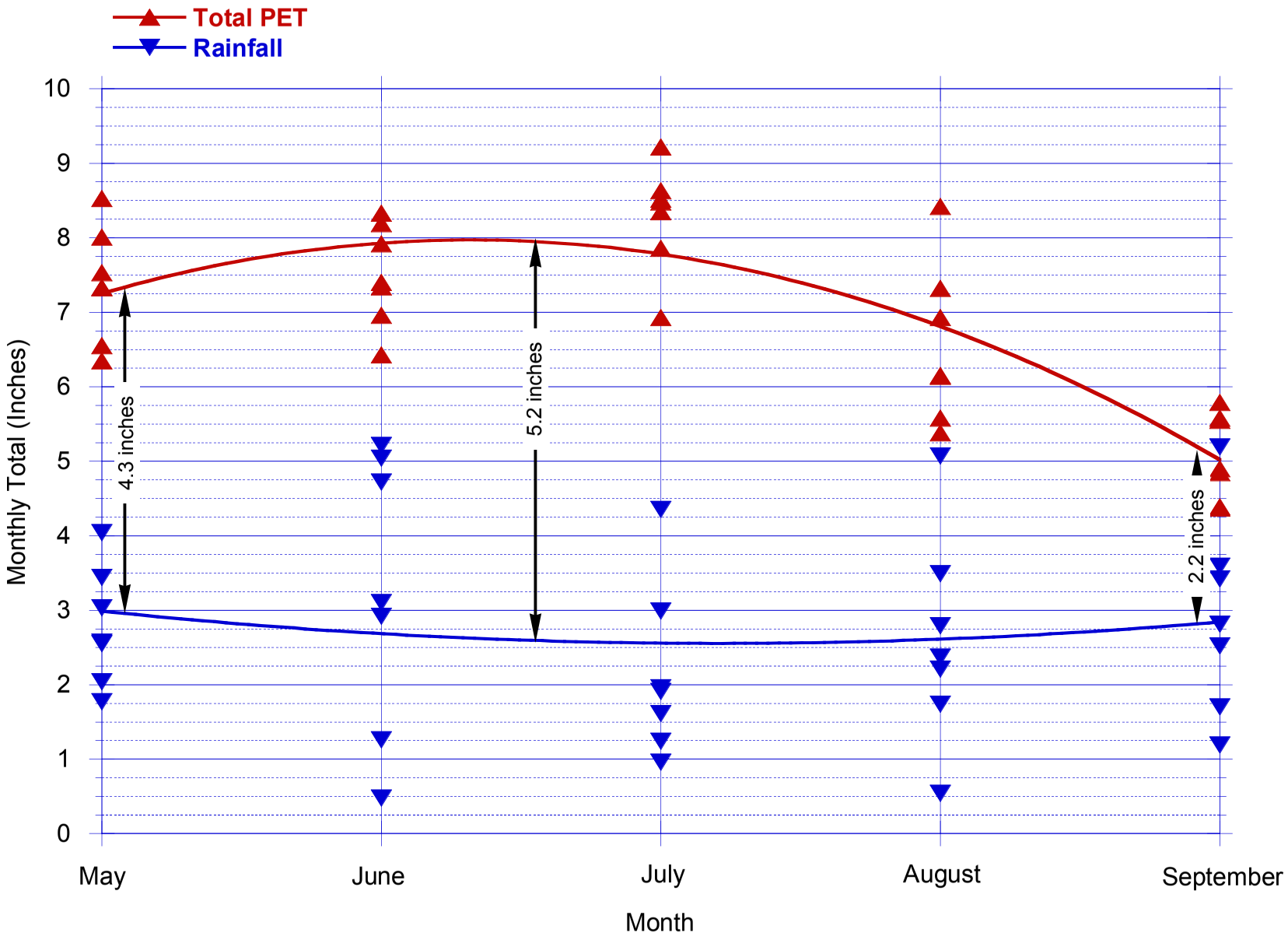

Figure 6. Average soil water deficit during the summer based on monthly totals between the years of 2003 through 2009.

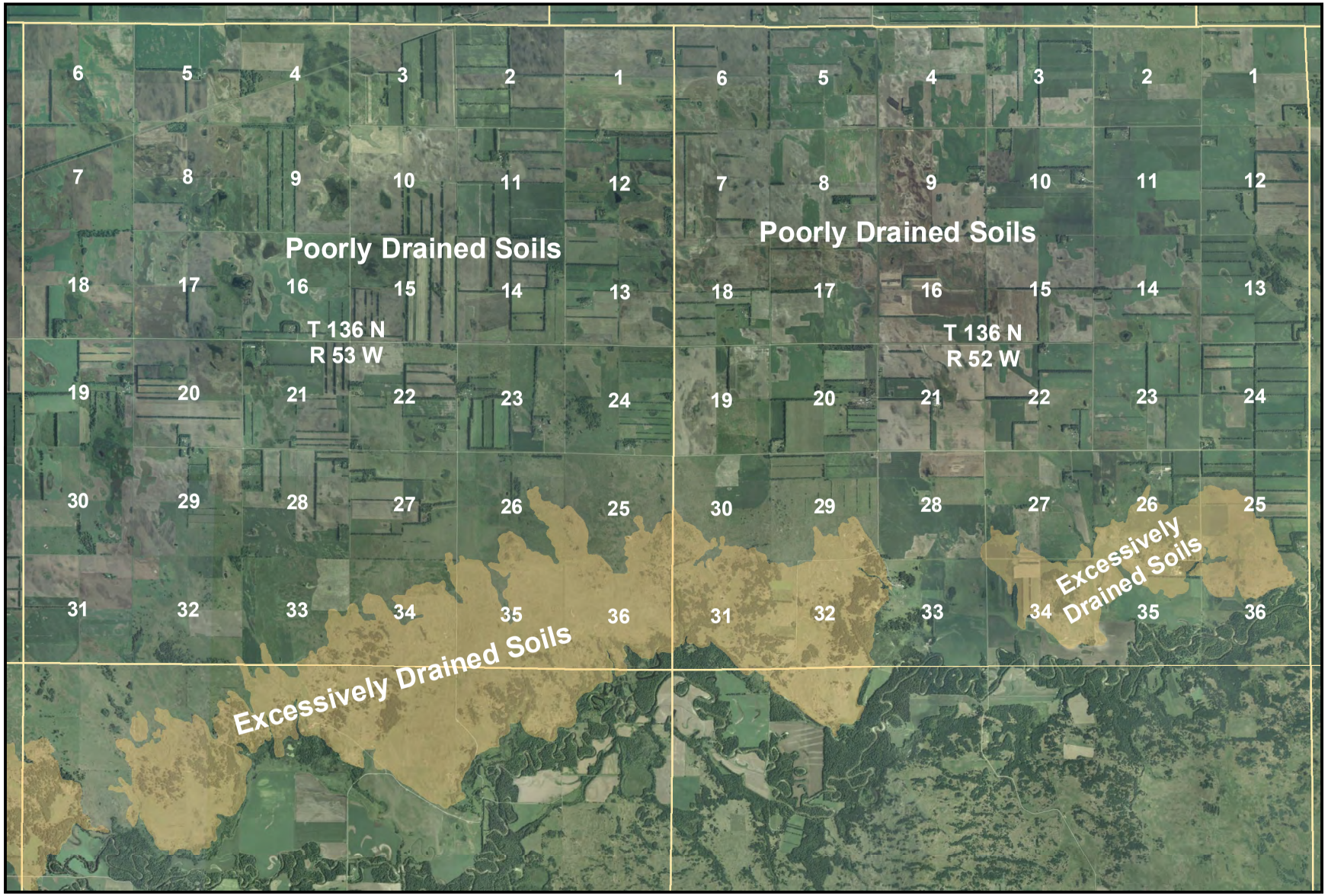

Figure 7. Plan view of the study area showing the locations of poorly drained and excessively drained soils.

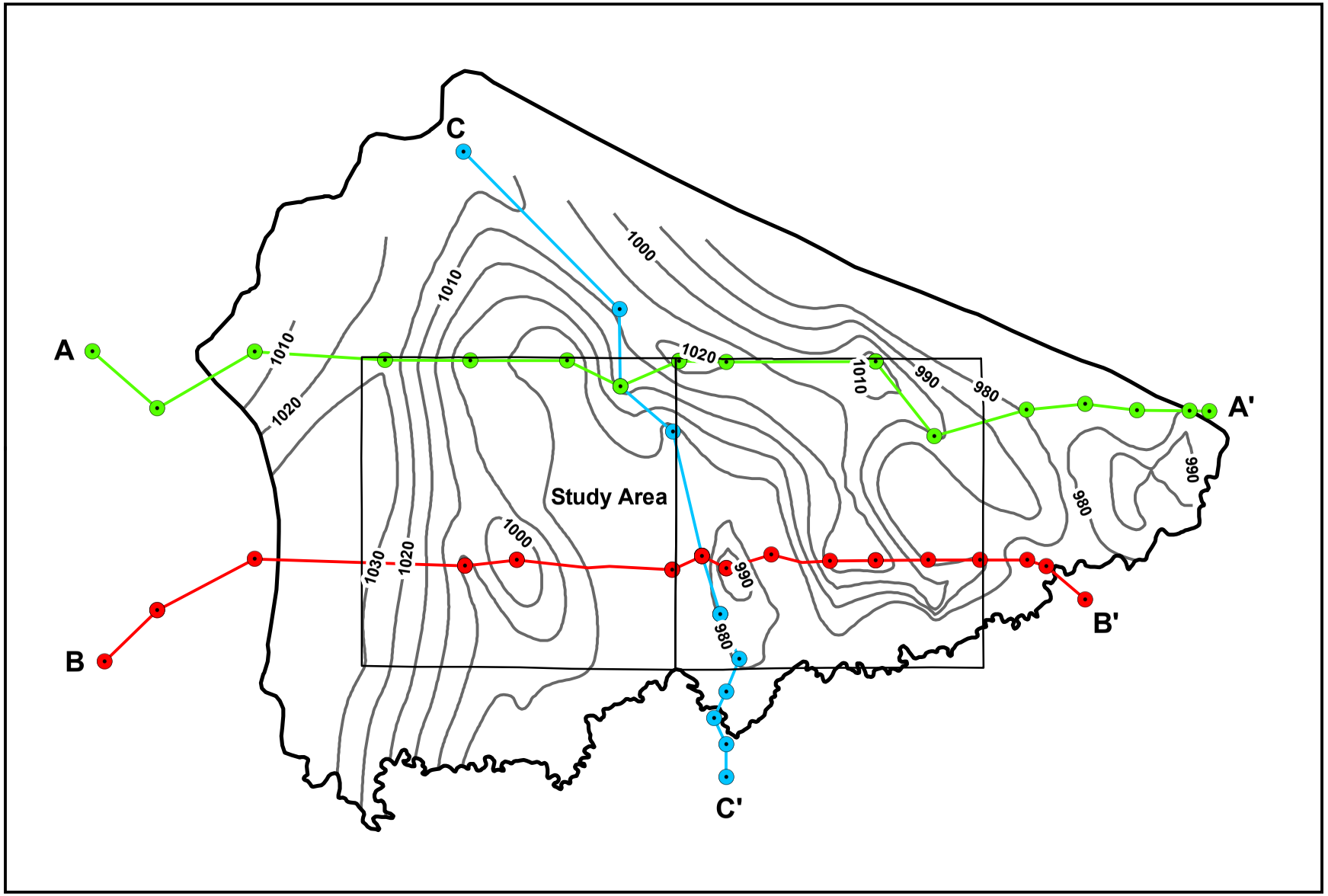

Figure 8. Plan view of the northern portion of the Sheyenne Delta aquifer. Contour map of the elevation (in feet) of the division between the upper and lower delta deposits. Locations of hydrogeologic sections A, B, and C.

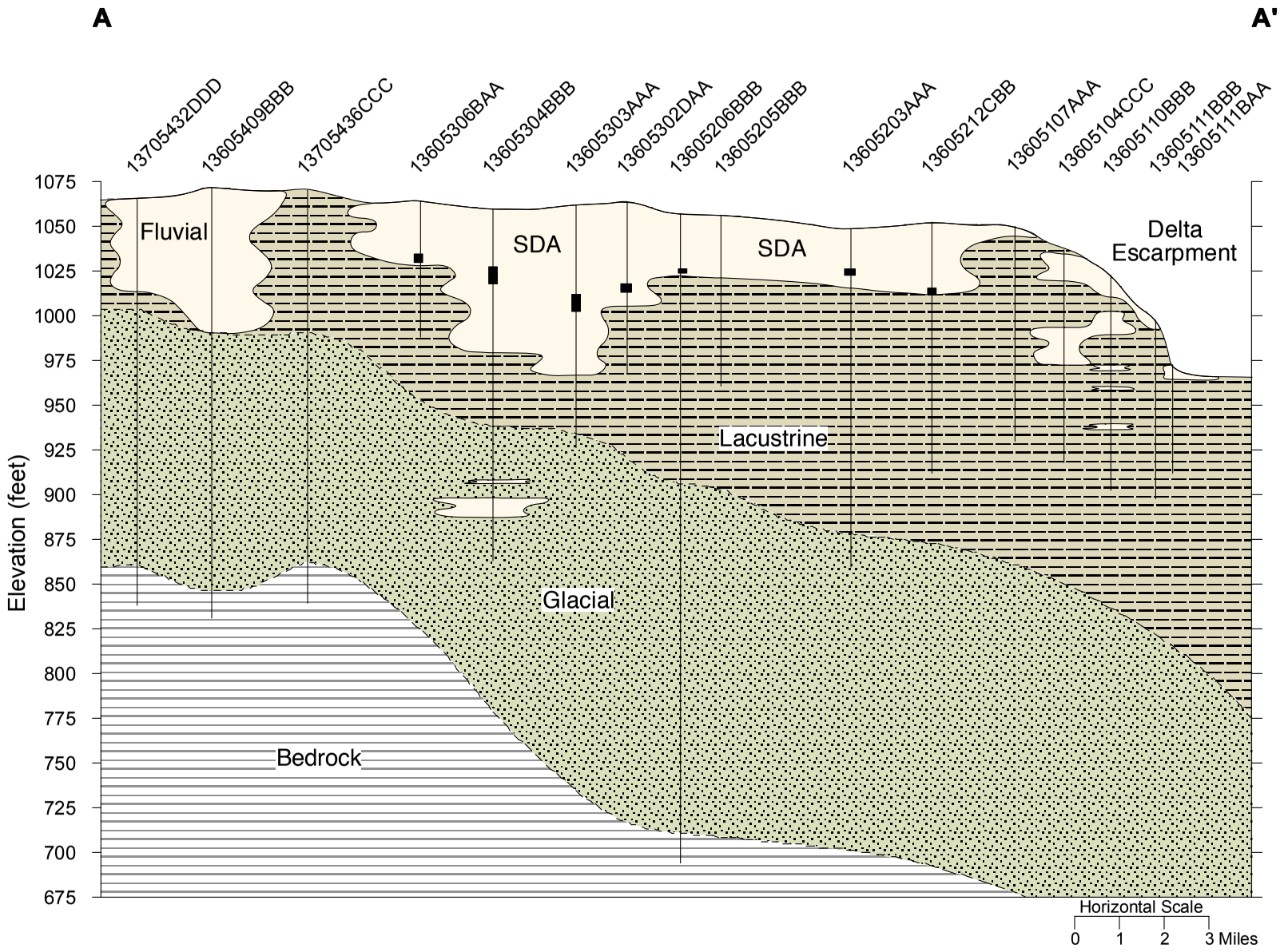

Figure 9. Hydrogeologic section A - A' showing the Sheyenne Delta aquifer (SDA).

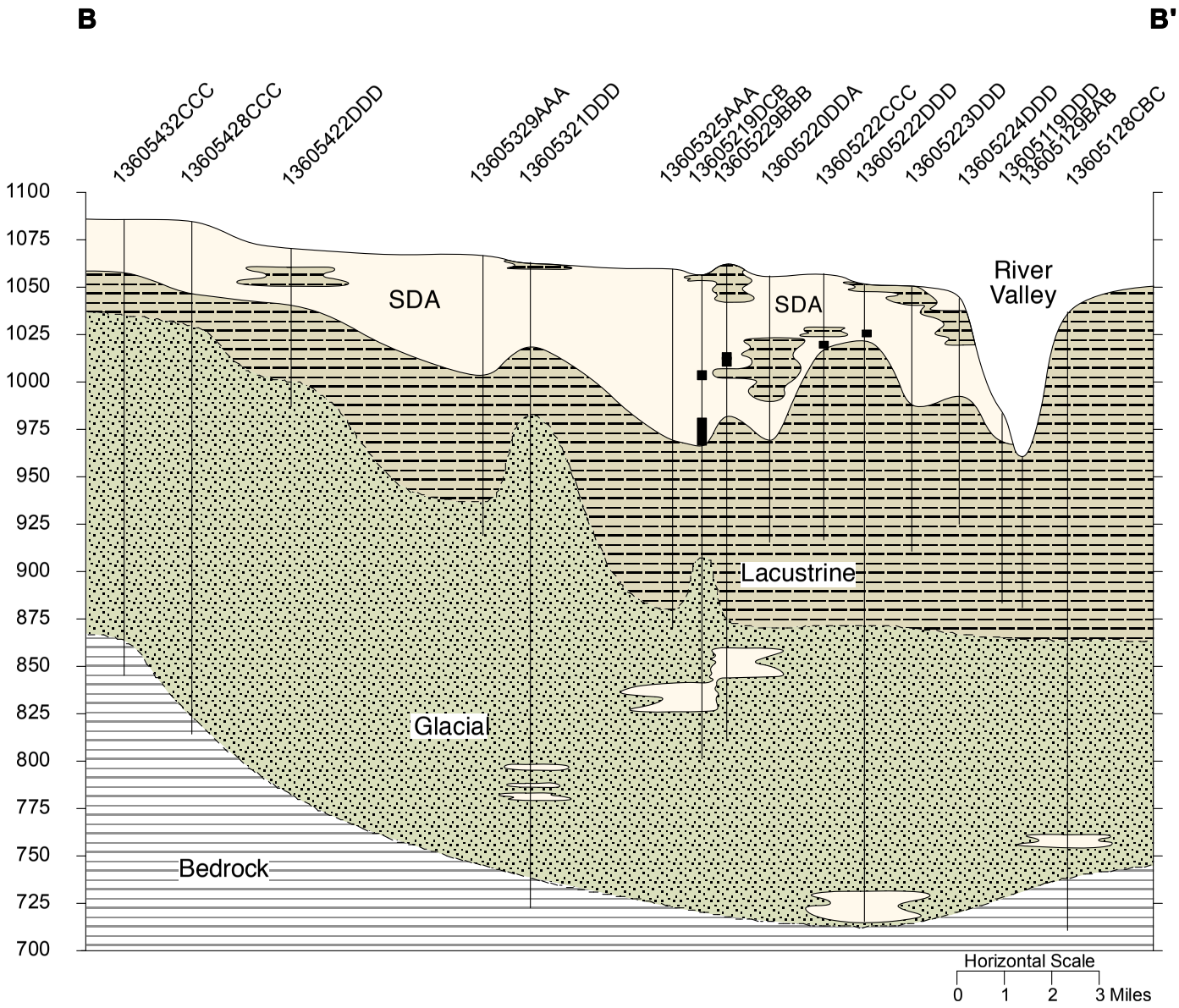

Figure 10. Hydrogeologic section B - B' showing the Sheyenne Delta aquifer (SDA).

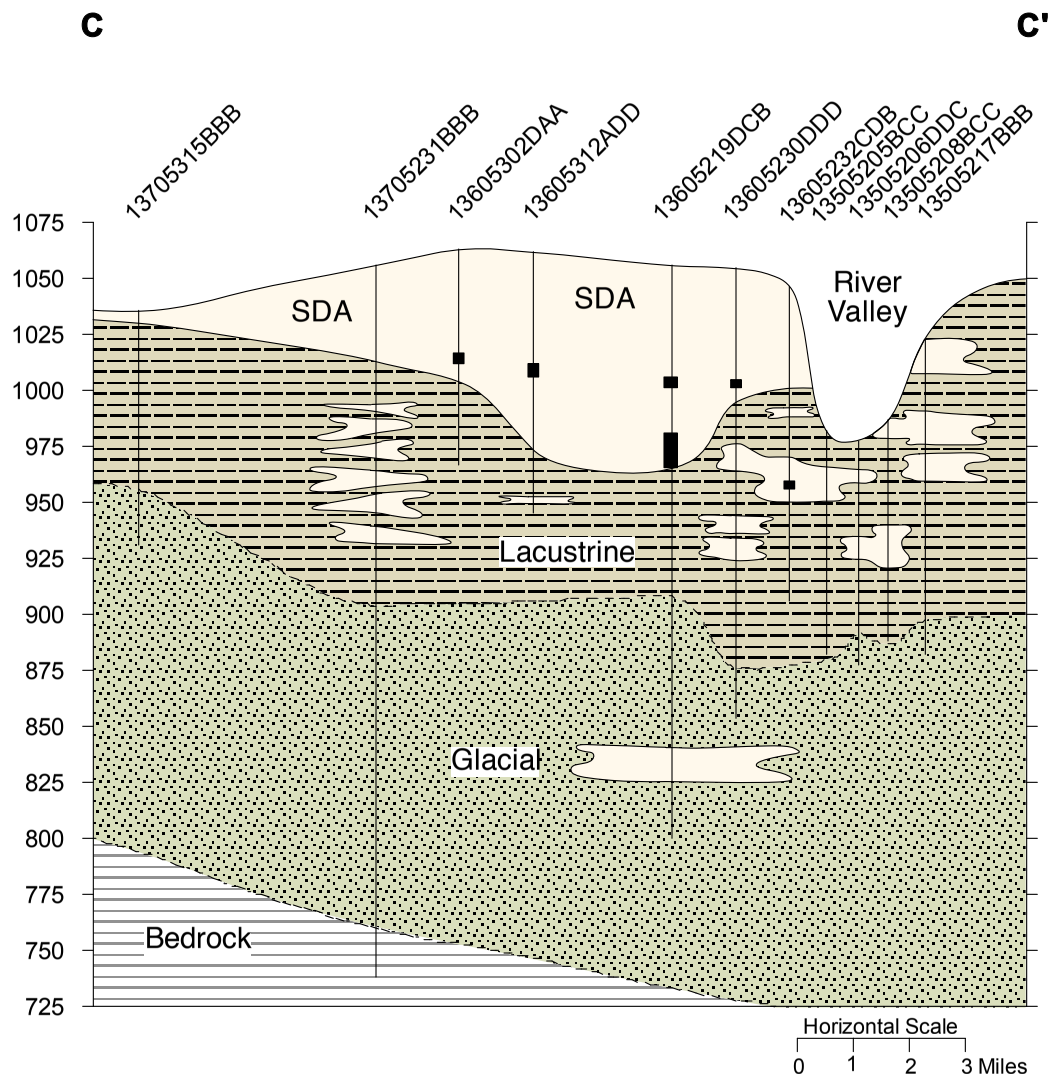

Figure 11. Hydrogeologic section C - C' showing the Sheyenne Delta aquifer (SDA).

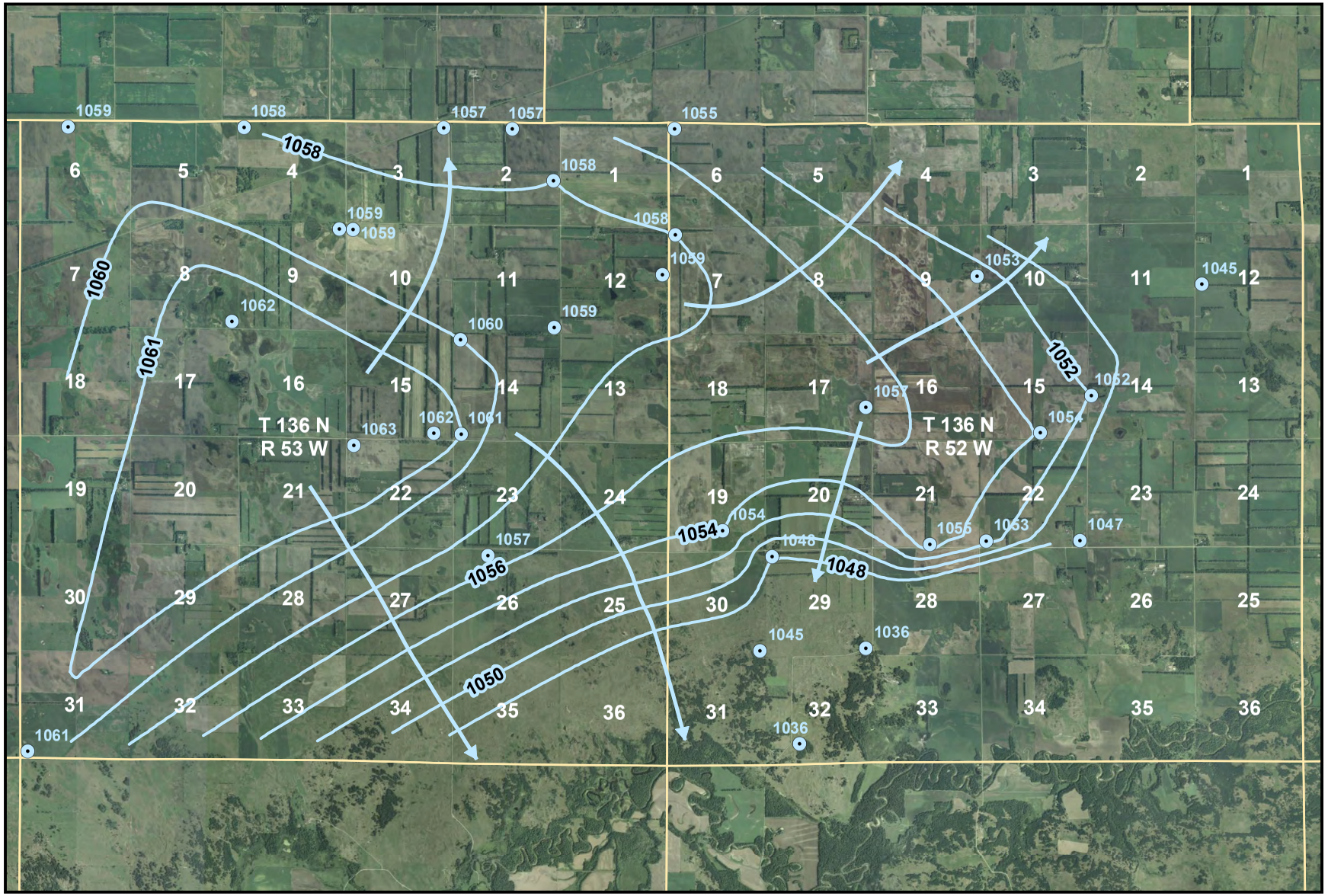

Figure 12. Plan view of study area showing the elevation of the water table in feet above MSL and the general direction of groundwater flow (water-level elevation measured during the fall of 2009).

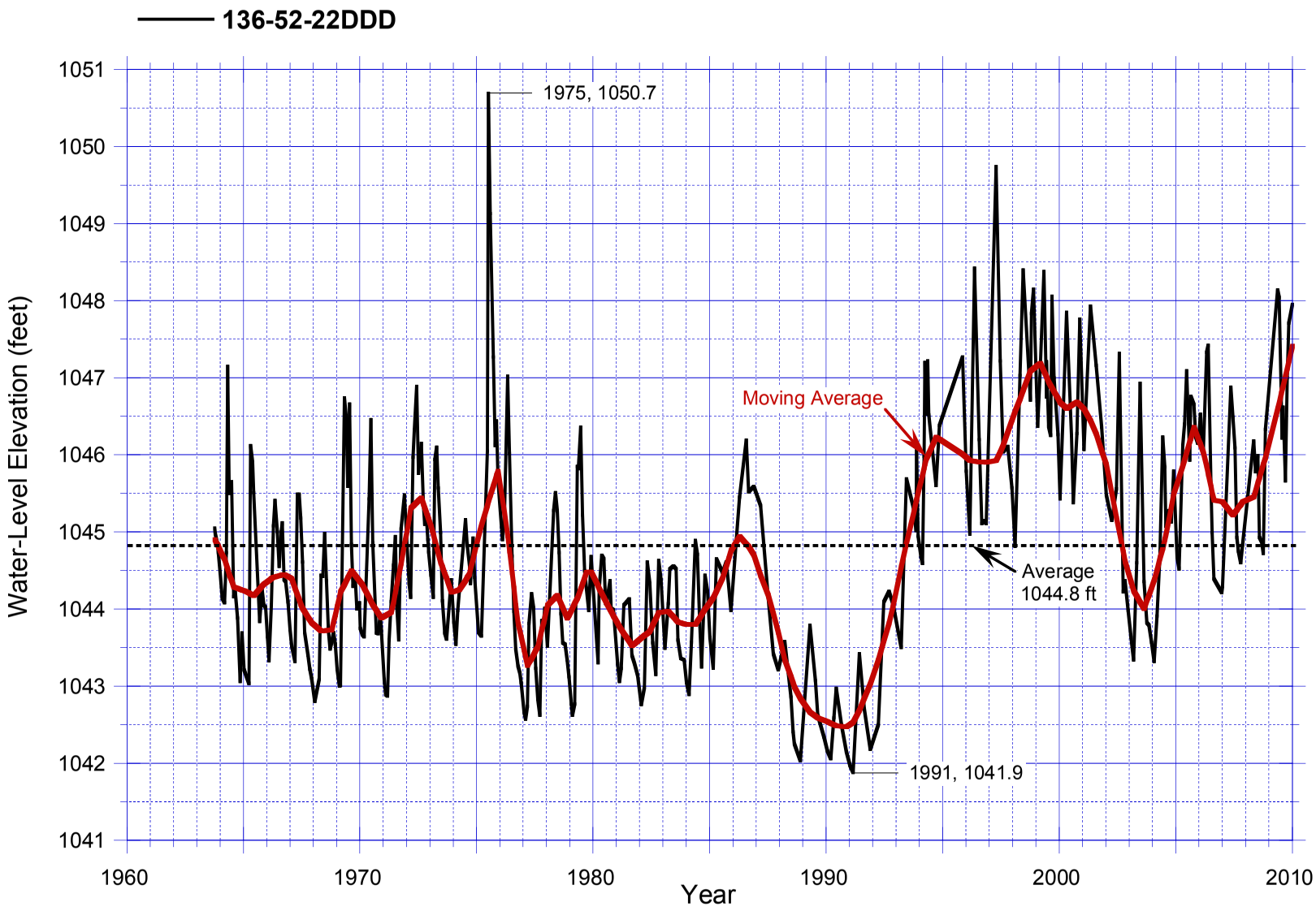

Figure 13. Water-level hydrograph for monitoring well 136-52-22DDD.

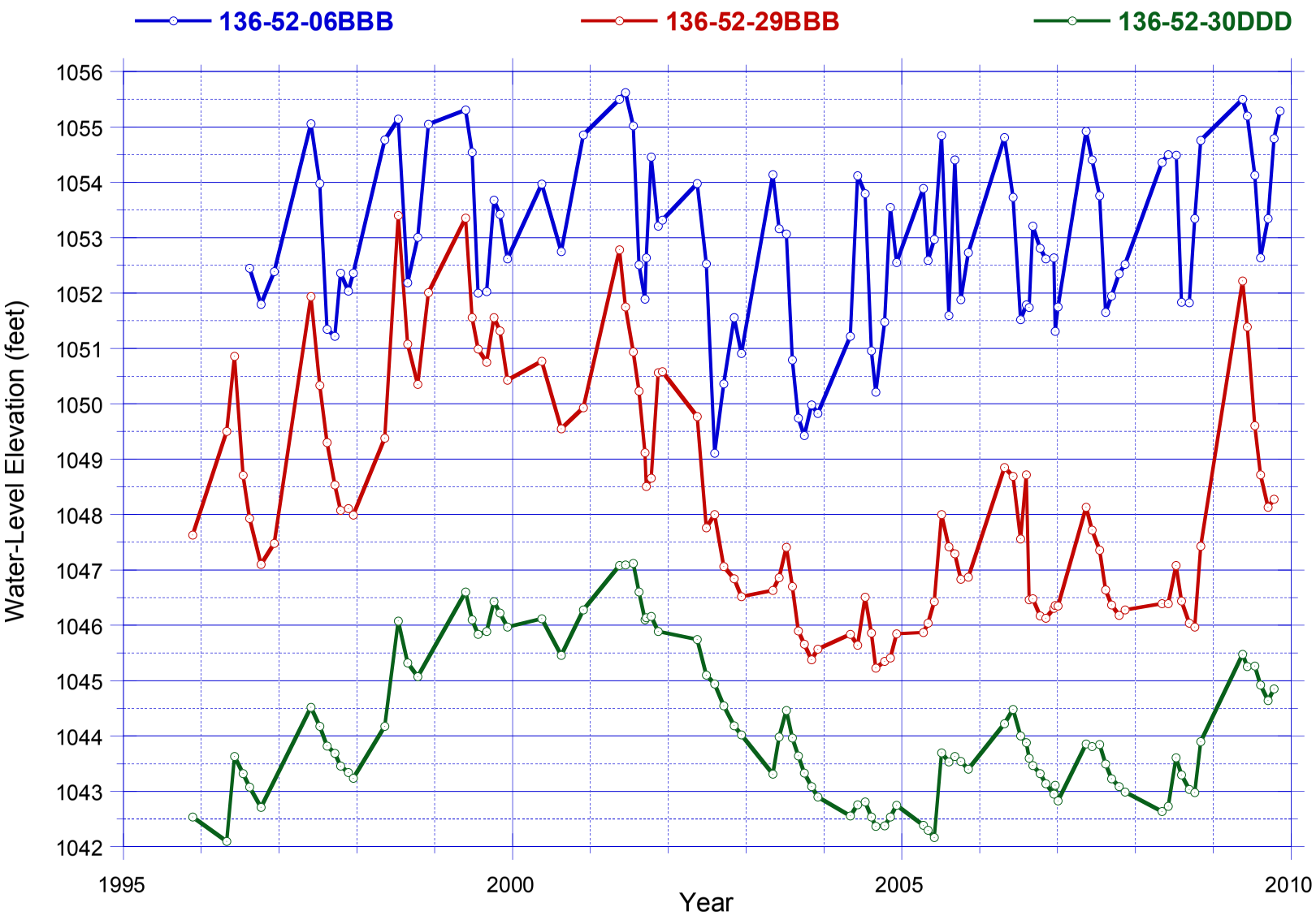

Figure 14. Water-level hydrographs for monitoring wells 136-52-06BBB, 136-52-29BBB, and 136-52-30DDD.

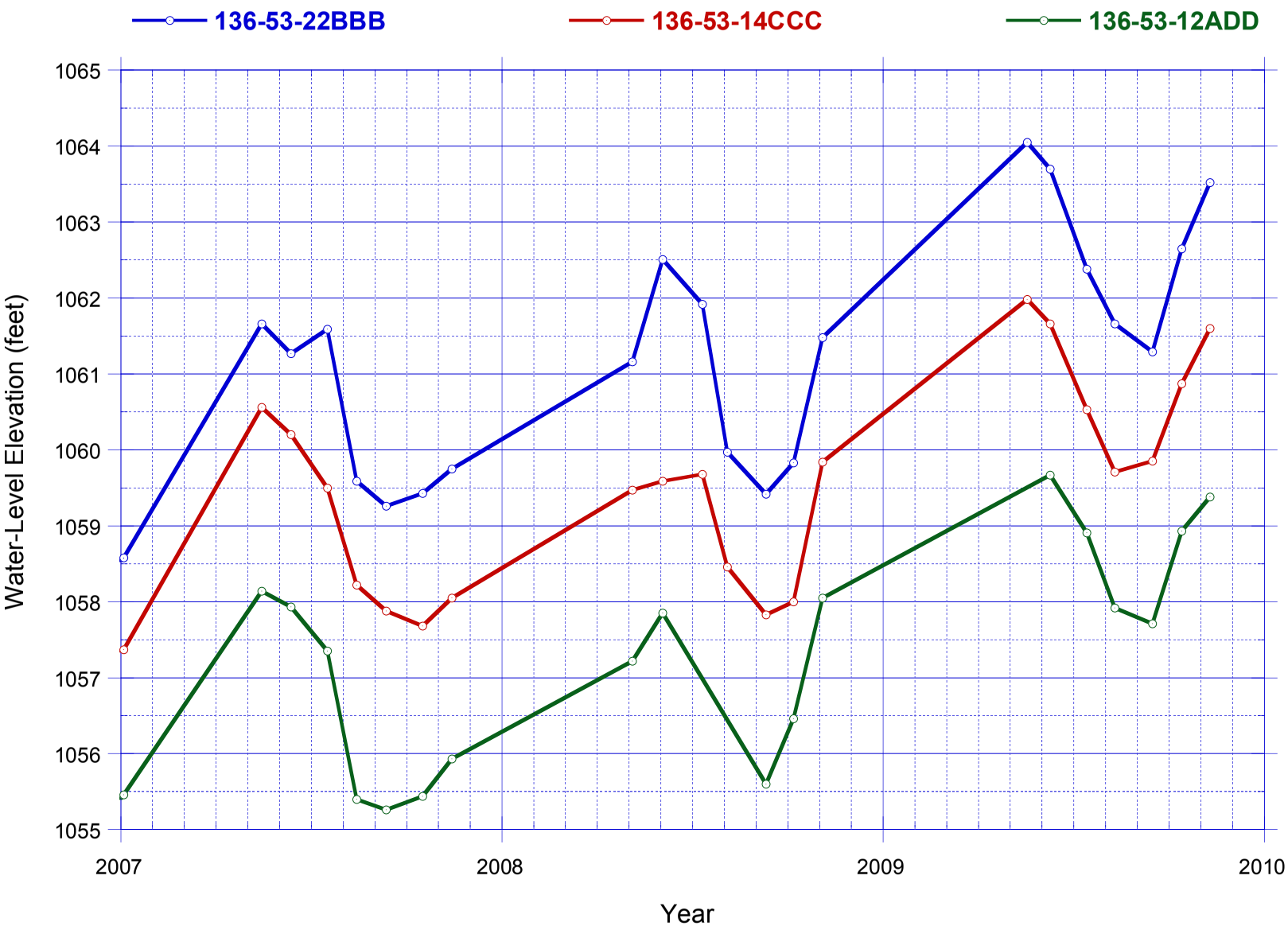

Figure 15. Water-level hydrographs for monitoring wells 136-53-22BBB, 136-53-14CCC, and 136-53-12ADD.

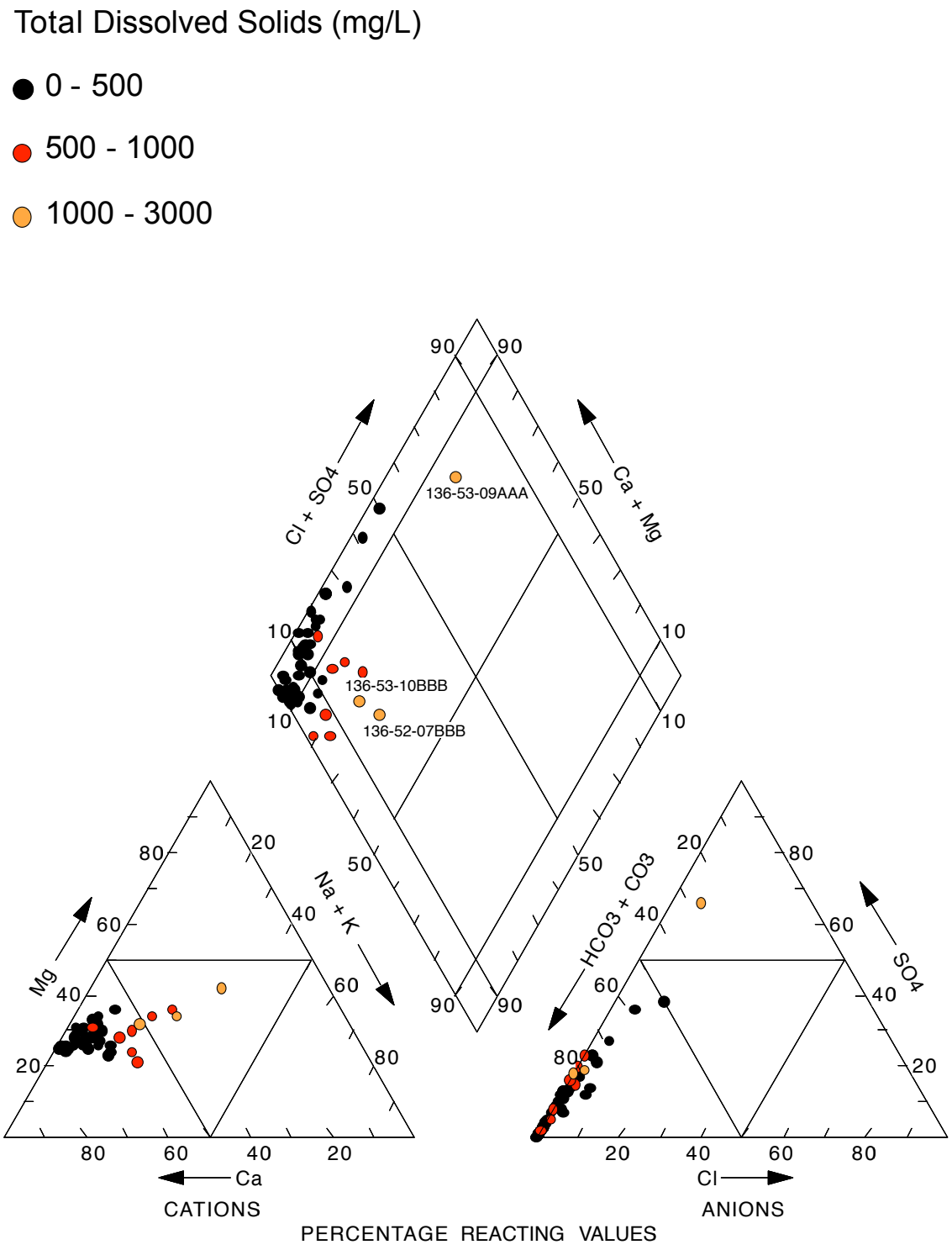

Figure 16. Relative distribution of major ions in groundwater samples collected from the Sheyene Delta aquifer within the study area.

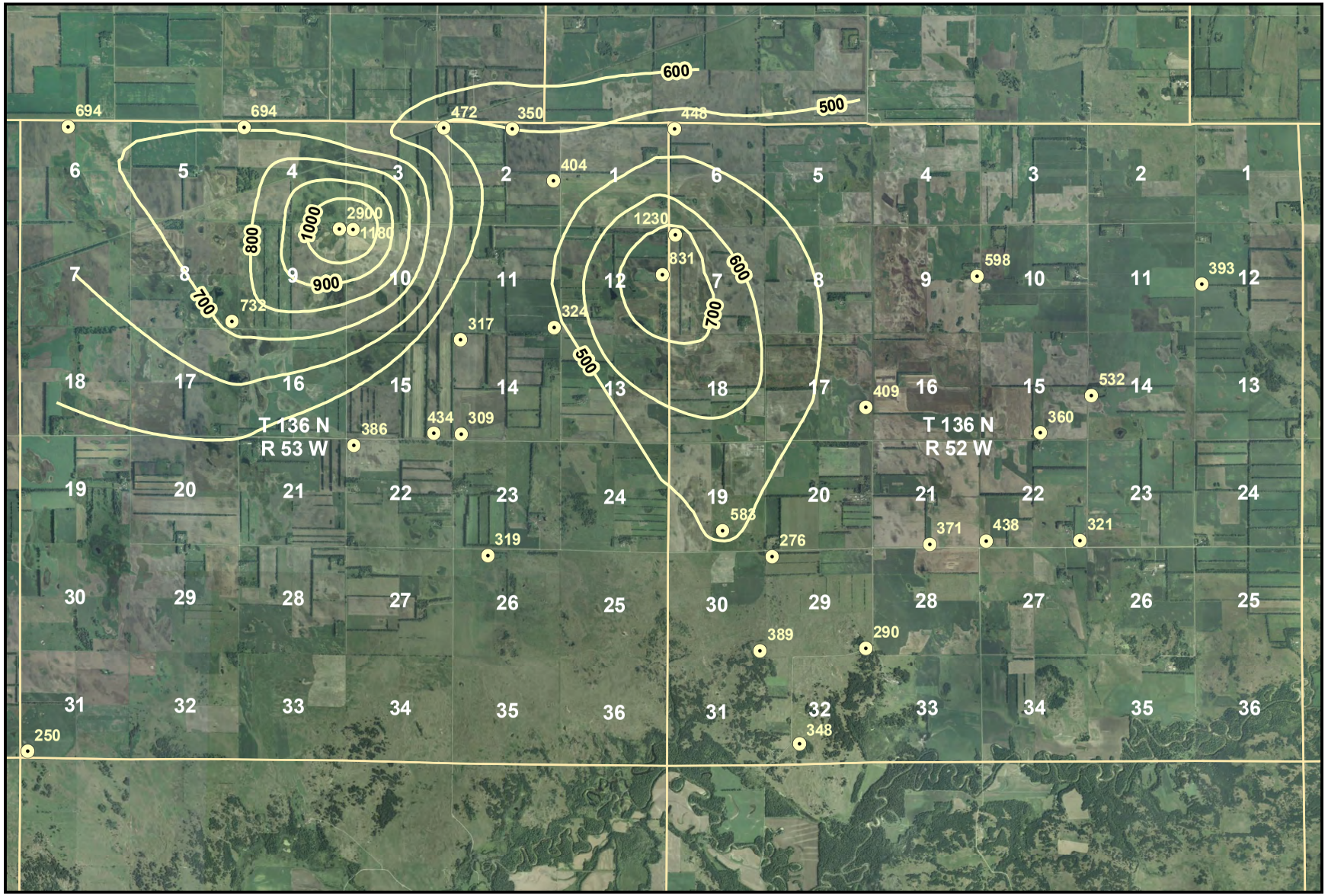

Figure 17. Distribution of total dissolved solids in groundwater samples collected from the Sheyenne Delta aquifer within the study area (concentration in mg/L).

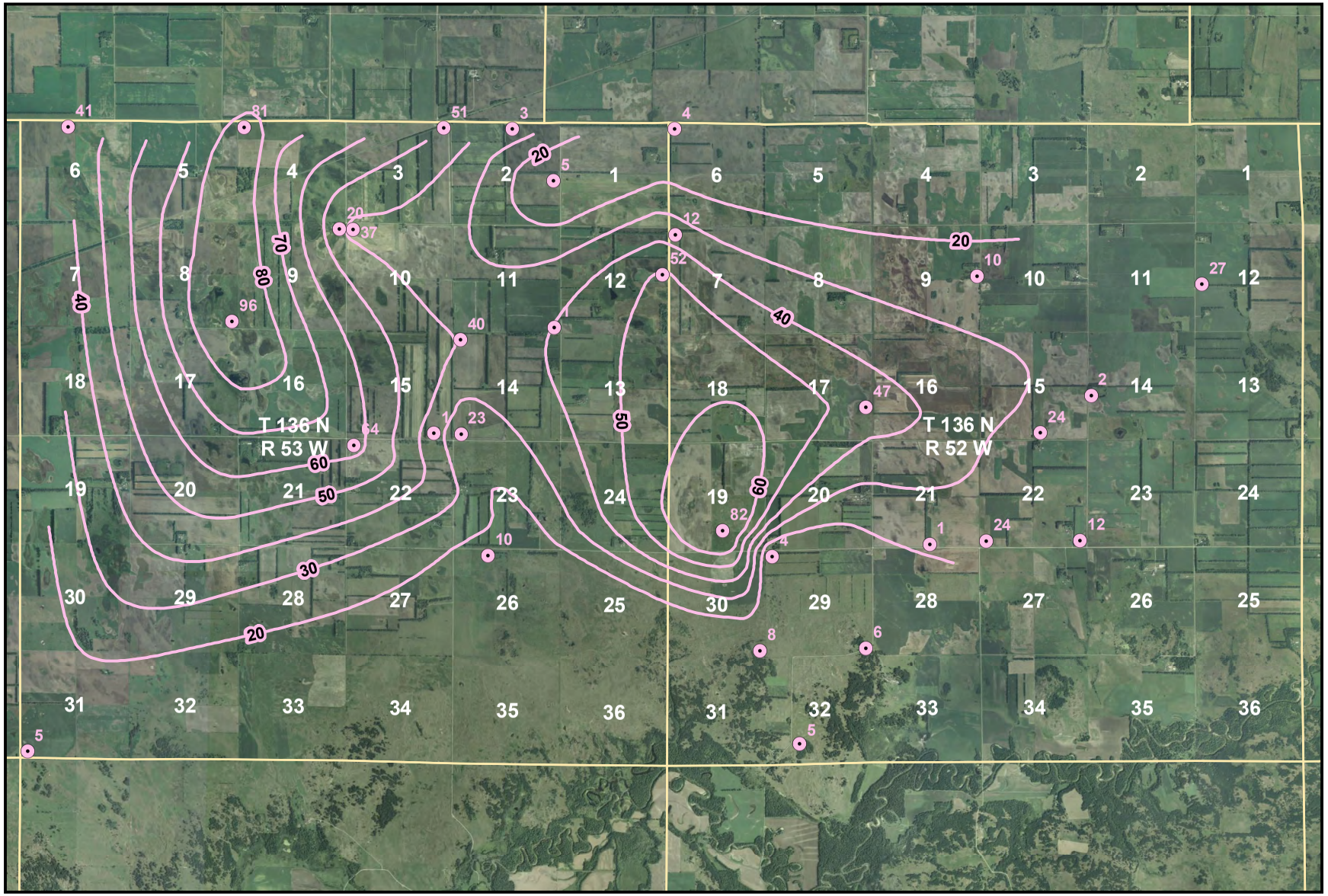

Figure 18. Distribution of arsenic in groundwater samples collected from the Sheyenne Delta aquifer within the study area (concentration in ug/L).

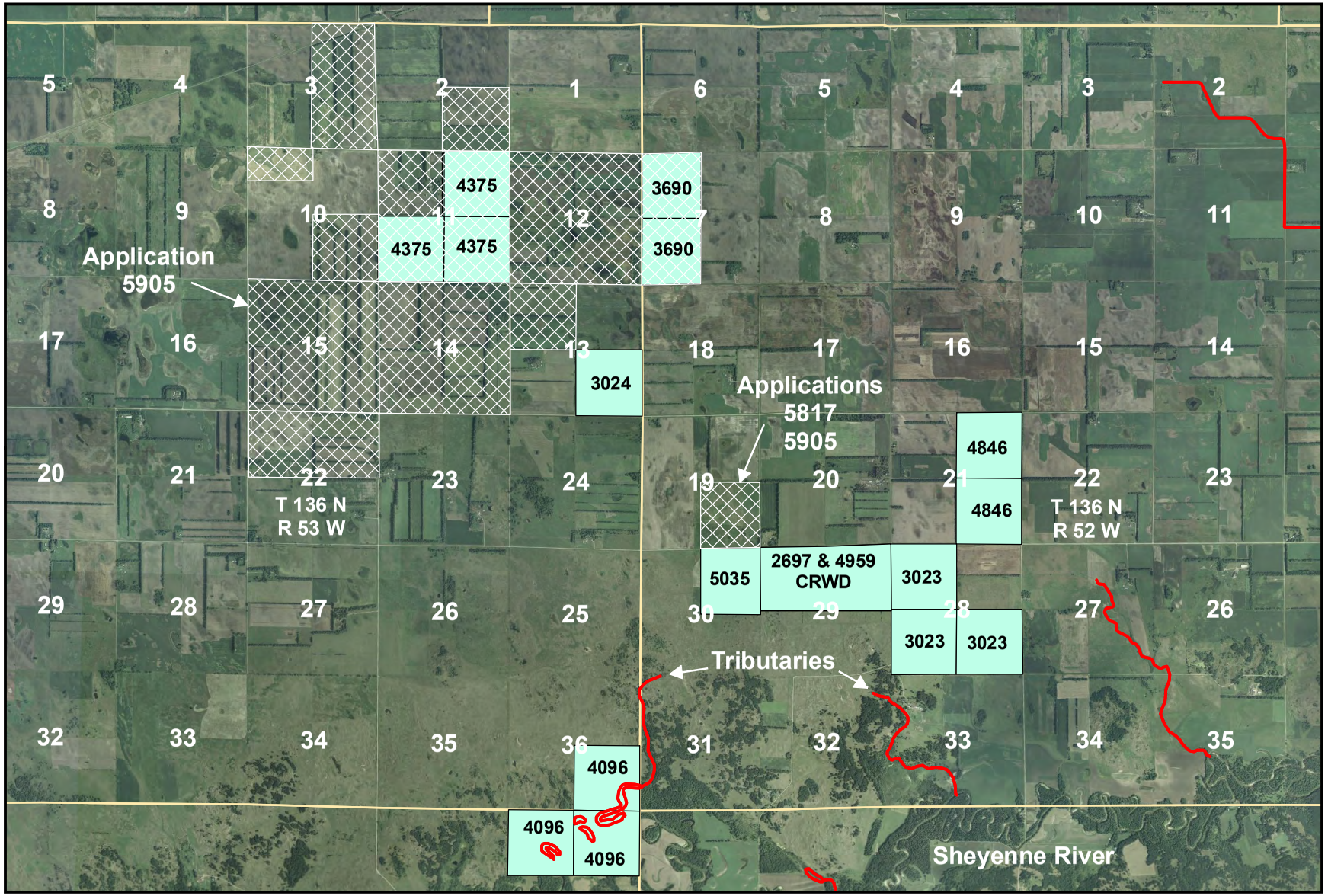

Figure 19. Locations of approved water permits, permit applications, and tributaries to the Sheyenne River.

APPENDIX I: LITHOLOGIC DATA

136-052-03AAA
NDSWC 2202

Date Completed:	10/09/1963	Purpose:	Test Hole
L.S. Elevation (ft):	1048		
Depth Drilled (ft):	189		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Topsoil, sandy loam, black.
1-4	SAND	Sand, fine, dark brown, well sorted, rounded, moderately calcareous.
4-6	CALICHE	Caliche, white, indurated, highly calcareous.
6-10	SILT	Silt, clayey, moderate olive-brown to light olive-gray, soft, cohesive, slightly plastic, calcareous.
10-30	SAND	Sand, fine and medium, olive-gray to dark greenish-gray, well sorted, rounded, quartz, igneous, shale, carbonate, lignite; clayey, silty from 20 to 30 feet.
30-170	SILT	Silt, clayey, sandy, very fine, olive-gray, soft, cohesive, slightly sticky, plastic, calcareous; very clayey from 50 to 170 feet.
170-189	TILL	Clay, silty, sandy, pebbly, olive-gray, cohesive, moderately plastic, calcareous; interbedded gravel; contains cobbles (Till).

136-052-03AAA2
NDSWC 2201A

Date Completed:	10/09/1963	Purpose:	Observation Well-Plugged
L.S. Elevation (ft):	1048	Well Type:	1.25 in. - ABS
Depth Drilled (ft):	42	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	23-26		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Topsoil, clay, silty, black.
1-4	SAND	Sand, fine and medium.
4-11	CLAY	Clay, silty, yellowish-brown.
11-33	SAND	Sand, fine and medium.
33-42	SILT	Silt, clayey, sandy, very fine, olive-gray.

136-052-05BBB
CRWD

Date Completed:	12/14/2006	Purpose:	Test Hole
L.S. Elevation (ft):	1055.6		
Depth Drilled (ft):	95		

Depth (ft)	Unit	Description
0-3	SILT	Silt, clayey, sandy, very fine, light olive brown (5Y 5/6), oxidized
3-9	SAND	Sand, very fine, silty, moderate brown (5YR 4/4), mottles, oxidized (eolian)
9-17	SAND	Sand, very fine and fine, silty, light olive gray (5Y 5/2), reduced (upper delta)
17-18	SAND	Sand, very fine and fine, silty, olive black (5Y 2/1); carbonaceous (upper delta)
18-20	SAND	Sand, very fine and fine, silty, olive gray (5Y 3/2) (upper delta)
20-24	SAND	Sand, very fine and fine, silty, olive black; carbonaceous (upper delta)
24-35	SAND	Sand, very fine, very silty, olive gray (upper delta)
35-45	SILT	Silt, sandy, very fine, olive gray (lower delta)
45-50	SILT	Silt, clayey, olive gray (lower delta)

50-53	SILT	Silt, very clayey, olive gray (lower delta)
53-55	SILT	Silt, clayey, olive gray (lower delta)
55-62	CLAY	Clay, silty, olive gray (lower delta)
62-69	CLAY	Clay, very silty, olive gray (lower delta)
69-75	SILT	Silt, clayey, sandy, very fine, olive gray (lower delta)
75-90	SILT	Silt, olive gray (lower delta)
90-95	SILT	Silt, very clayey, olive gray (lower delta)

136-052-06BBB
NDSWC 2203

Date Completed:	10/09/1963	Purpose:	Test Hole
L.S. Elevation (ft):	1056		
Depth Drilled (ft):	362		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Topsoil, sandy loam, dark brown.
1-6	SAND	Sand, medium, well sorted, rounded, oxidized.
6-30	SAND	Sand, medium, dark greenish-gray, well sorted, rounded, quartz, moderately calcareous; silty from 10 to 20 feet.
30-150	SILT	Silt, very clayey, light olive-gray to olive-gray, soft, cohesive, calcareous.
150-345	TILL	Clay, silty, sandy, pebbly, olive-gray, cohesive, moderately plastic, calcareous; interbedded gravel; contains cobbles and boulders (till).
345-362	CLAYSTONE	Clay, silty, olive-gray, soft, moderately cohesive, plastic, highly calcareous; mottled; numerous elongated secondary crystals (Bedrock)

136-052-06BBB2
NDSWC 2203A

Date Completed:	10/09/1963	Purpose:	Observation Well
L.S. Elevation (ft):	1056.12	Well Type:	1.25 in. - ABS
Depth Drilled (ft):	42	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	40-43		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Topsoil, clay, silty, black.
1-34	SAND	Sand, fine and medium; contains lignite.
34-42	SILT	Silt, clayey, sandy, olive-gray.

136-052-07BBB
NDDH

Date Completed:	07/26/2000	Purpose:	Observation Well
L.S. Elevation (ft):	1060.1	Well Type:	2 in. - PVC
Depth Drilled (ft):	15	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	5-15		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Topsoil
1-10	SAND	Sand, fine, brown
10-15	SAND	Sand, fine, gray

APPENDIX I: LITHOLOGIC DATA

136-052-09ADDD
USGS

Date Completed:	11/06/1993	Purpose:	Observation Well
L.S. Elevation (ft):	1056.5	Well Type:	2 in. - PVC
Depth Drilled (ft):	12.9	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	7.9-12.3		

136-052-10CCC
CRWD

Date Completed:	12/13/2006	Purpose:	Test Hole
L.S. Elevation (ft):	1057.2		
Depth Drilled (ft):	95		

Depth (ft)	Unit	Description
0-3	SILT	Silt, clayey, sandy, very fine, light olive brown (5Y 5/6), oxidized
3-4	SAND	Sand, very fine, silty, light olive brown, oxidized (eolian)
4-5	SILT	Silt, sandy, very fine, moderate brown (5YR 4/4), mottles, oxidized (upper delta)
5-9	SAND	Sand, very fine and fine, silty, moderate brown, mottles, oxidized (upper delta)
9-17	SAND	Sand, very fine and fine, silty, light olive gray (5Y 5/2), reduced (upper delta)
17-21	SILT	Silt, sandy, very fine, olive gray (5Y 3/2) (upper delta)
21-35	SAND	Sand, very fine and fine, silty, olive gray; carbonaceous at 35 ft (upper delta)
35-41	SAND	Sand, very fine, very silty, olive gray (upper delta)
41-49	SILT	Silt, clayey, olive gray (lower delta)
49-51	SILT	Silt, sandy, very fine, olive gray (lower delta)
51-55	CLAY	Clay, very silty, olive gray (lower delta)
55-60	SILT	Silt, very clayey, olive gray (lower delta)
60-67	SILT	Silt, clayey, sandy, very fine, olive gray (lower delta)
67-71	CLAY	Clay, very silty, olive gray (lower delta)
71-75	CLAY	Clay, olive gray (lower delta)
75-78	CLAY	Clay, silty, olive gray (lower delta)
78-95	SILT	Silt, very clayey, olive gray; sandy, very fine at 92 ft (lower delta)

136-052-12CBB
NDSWC 8446

Date Completed:	08/14/1972	Purpose:	Observation Well-Plugged
L.S. Elevation (ft):	1051.3	Well Type:	1.25 in. - ABS
Depth Drilled (ft):	140	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	37-40		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Topsoil, clay, silty, sandy, loam, brownish-black.
1-40	SAND	Sand, very fine to medium, well sorted, subangular to rounded; oxidized to 10 feet; interbedded thin sandy silt.
40-47	SILT	Silt, slightly clayey, sandy, medium gray, slightly cohesive, slightly plastic.
47-50	SAND	Sand, very fine and fine, well sorted, subrounded.
50-76	SILT	Silt, slightly clayey, sandy, medium gray, slightly cohesive, slightly plastic, highly calcareous; interbedded thin sand, silty.
76-78	SAND	Sand, very fine and fine, silty, medium sorted, subangular to rounded.

78-140	SILT	Silt, clayey, medium gray; cohesive, moderately plastic, highly calcareous; light olive-gray laminae.

136-052-14CBBC
USGS

Date Completed:	11/06/1993	Purpose:	Observation Well
L.S. Elevation (ft):	1055.8	Well Type:	2 in. - PVC
Depth Drilled (ft):	11.6	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	6.6-11		

136-052-14DDD
NDSWC 8445

Date Completed:	08/14/1972	Purpose:	Observation Well - Destroyed
L.S. Elevation (ft):	1053	Well Type:	1.25 in. - PVC
Depth Drilled (ft):	140	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	77-80		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Topsoil, clay, silty, sandy, loam, brownish-black.
1-9	SAND	Sand, very fine to medium, slightly silty, well sorted, subangular to rounded, oxidized.
9-11	SILT	Silt, slightly clayey, sandy, medium gray, slightly cohesive, slightly plastic.
11-40	SAND	Sand, very fine to medium, well sorted, subangular to rounded; interbedded thin silt, sandy.
40-48	SILT	Silt, slightly clayey, sandy, medium gray, slightly cohesive, slightly plastic, highly calcareous.
48-55	SAND	Sand, very fine and fine, silty, medium sorted, subrounded.
55-65	SILT	Silt, slightly clayey, sandy, medium gray, slightly cohesive, slightly plastic, highly calcareous; light olive-gray laminae.
65-100	SAND	Sand, very fine and fine, medium sorted, subrounded; occasional interbedded thin silt, clayey.
100-134	SILT	Silt, clayey, sandy, very fine, olive-gray to medium gray, slightly cohesive, plastic, highly calcareous; interbedded thin sand, silty; light olive-gray laminae.
134-140	TILL	Clay, silty, pebbly, medium dark gray, moderately cohesive, slightly plastic, calcareous (till).

136-052-15DCC
CRWD

Date Completed:	12/13/2006	Purpose:	Observation Well
L.S. Elevation (ft):	1055.9	Well Type:	2 in. - PVC
Depth Drilled (ft):	95	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	39-44		

Depth (ft)	Unit	Description
0-3	SILT	Silt, clayey, sandy, very fine, light olive brown (5Y 5/6), oxidized
3-9	SAND	Sand, very fine and fine, silty, moderate brown (5YR 4/4), oxidized (upper delta)
9-15	SAND	Sand, fine, silty, light olive gray (5Y 5/2), reduced (upper delta)
15-24	SAND	Sand, very fine and fine, silty, light olive gray (upper delta)

24-27	SILT	Silt, sandy, very fine, olive gray (5Y 3/2) (upper delta)
27-30	SAND	Sand, very fine, very silty, olive gray (upper delta)
30-44	SAND	Sand, very fine and fine, silty, olive gray (upper delta)
44-51	SILT	Silt, very clayey, olive gray (lower delta)
51-70	CLAY	Clay, silty, olive gray (lower delta)
70-75	CLAY	Clay, olive gray (lower delta)
75-83	SILT	Silt, very clayey, olive gray (lower delta)
83-84	CLAY	Clay, silty, olive gray (lower delta)
84-87	SILT	Silt, very clayey, olive gray (lower delta)
87-88	CLAY	Clay, silty, olive gray (lower delta)
88-95	SILT	Silt, very clayey, olive gray (lower delta)

136-052-16BBB
NDSWC 8334

Date Completed:	05/16/1972	Purpose:	Observation Well-Destroyed
L.S. Elevation (ft):	1058	Well Type:	1.25 in. - PVC
Depth Drilled (ft):	140	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	57-60		

Depth (ft)	Unit	Description
0-3	FILL	Clay, sandy.
3-7	CLAY	Clay, very silty, olive-gray, cohesive, plastic, highly calcareous.
7-70	SAND	Sand, very fine to medium, well sorted, subangular and subrounded; contains lignite pebbles; occasional interbedded thin clay, silty.
70-140	SILT	Silt, very clayey, olive-gray, cohesive, highly calcareous.

136-052-17DAD
CRWD

Date Completed:	12/14/2006	Purpose:	Observation Well
L.S. Elevation (ft):	1057	Well Type:	0 in. -
Depth Drilled (ft):	95	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	77-82		

Depth (ft)	Unit	Description
0-2	SILT	Silt, clayey, sandy, very fine, light olive brown (5Y 5/6), oxidized
2-8	SAND	Sand, very fine, silty, moderate brown (5YR 4/4), mottles, oxidized (eolian)
8-35	SAND	Sand, very fine and fine, silty, light olive gray (5Y 5/2), reduced (upper delta)
35-42	CLAY	Clay, very silty, olive gray (5Y 3/2) (upper delta)
42-83	SAND	Sand, very fine, very silty, olive gray (upper delta)
83-93	SILT	Silt, very clayey, olive gray (lower delta)
93-95	CLAY	Clay, olive gray (lower delta)

APPENDIX I: LITHOLOGIC DATA

136-052-19DCB
CRWD

Date Completed:	12/05/2006	Purpose:	Observation Well
L.S. Elevation (ft):	1056	Well Type:	2 in. - PVC
Depth Drilled (ft):	255	Aquifer:	Undefined
Screen Int. (ft.):	215-230		

Depth (ft)	Unit	Description
0-1.5	TOPSOIL	Topsoil, sandy loam
1.5-3.5	SAND	Sand, very fine, silty, light olive brown (5Y 5/6), calcareous, oxidized (eolian)
3.5-9	SAND	Sand, very fine, silty, moderate brown (5 YR 4/4), mottles, oxidized (eolian)
9-45	SAND	Sand, fine, silty, light olive gray (5Y 3/2), reduced (upper delta)
45-70	SAND	Sand, very fine and fine, silty, light olive gray; increasing silt with depth (upper delta)
70-75	SILT	Silt, clayey, olive gray (5Y 3/2) (upper delta)
75-95	SAND	Sand, very fine and fine, silty, olive gray; 1-foot thick silt layer at 84 ft; increasing silt and clay with depth (upper delta)
95-148	CLAY	Clay, silty, olive gray; decreasing silt with depth (lower delta - lacustrine)
148-215	CLAY	Clay, silty, sandy, pebbly, olive gray (till)
215-220	SAND	Sand, fine to coarse, gravelly, fine to coarse, (outwash)
220-230	SAND	Sand, fine and medium, gravelly; increasing gravel with depth (outwash)
230-255	CLAY	Clay, silty, sandy, pebbly, olive gray, firm (till)

136-052-19DCB2
CRWD

Date Completed:	12/11/2006	Purpose:	Observation Well
L.S. Elevation (ft):	1055.8	Well Type:	2 in. - PVC
Depth Drilled (ft):	105	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	75-90		

Depth (ft)	Unit	Description
0-1.5	TOPSOIL	Topsoil, sandy loam
1.5-3	SILT	Silt, sandy, very fine, light olive brown (5Y 5/6), oxidized
3-14	SAND	Sand, very fine and fine, silty, moderate brown (5YR 4/4), mottles, oxidized (upper delta)
14-24	SAND	Sand, very fine and fine, silty, light olive gray (5Y 5/2), reduced (upper delta)
24-26	SAND	Sand, very fine, very silty, olive gray (5Y 3/2) (upper delta)
26-48	SAND	Sand, very fine and fine, silty, olive gray (upper delta)
48-54	SAND	Sand, very fine and fine, silty, olive black (5Y 2/1); carbonaceous (upper delta)
54-57	SAND	Sand, very fine and fine, silty, olive gray (upper delta)
57-60	SILT	Silt, clayey, olive gray (upper delta)
60-70	SAND	Sand, very fine and fine, silty, olive gray (upper delta)
70-73	SILT	Silt, very clayey, olive gray (upper delta)
73-90	SAND	Sand, very fine and fine, very silty, olive gray (upper delta)
90-92	SILT	Silt, very clayey, olive gray (lower delta)
92-95	SILT	Silt, clayey, sandy, very fine, olive gray (lower delta)
95-100	SILT	Silt, very clayey, olive gray (lower delta)
100-105	CLAY	Clay, very silty, olive gray (lower delta)

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136-052-19DCB3
CRWD

Date Completed:	12/11/2006	Purpose:	Observation Well
L.S. Elevation (ft):	1055.9	Well Type:	2 in. - PVC
Depth Drilled (ft):	75	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	50-55		

Depth (ft)	Unit	Description
0-1.5	TOPSOIL	Topsoil, sandy loam
1.5-3	SILT	Silt, sandy, very fine, light olive brown (5Y 5/6), oxidized
3-14	SAND	Sand, very fine and fine, silty, moderate brown (5YR 4/4), mottles, oxidized (upper delta)
14-24	SAND	Sand, very fine and fine, silty, light olive gray (5Y 5/2), reduced (upper delta)
24-26	SAND	Sand, very fine and fine, very silty, olive gray (5Y 3/2) (upper delta)
26-50	SAND	Sand, very fine and fine, silty, olive gray (upper delta)
50-55	SAND	Sand, very fine and fine, silty, olive black (5Y 2/1); carbonaceous (upper delta)
55-60	SAND	Sand, very fine, silty, olive gray (upper delta)
60-63	SILT	Silt, sandy, very fine, olive gray (upper delta)
63-71	SAND	Sand, very fine and fine, silty, olive gray (upper delta)
71-73	CLAY	Clay, silty, olive gray (upper delta)
73-75	SILT	Silt, very clayey, olive gray (upper delta)

136-052-19DCD
CRWD

Date Completed:	7/2004	Purpose:	Test Well
L.S. Elevation (ft):	1055.4	Well Type:	6 in. - PVC
Depth Drilled (ft):	71	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	40-55		

Depth (ft)	Unit	Description
0-2	TOPSOIL	Sandy loam
2-6	SAND	Sand, brown
6-10	SAND	Sand, red
10-14	SAND	Sand, brown
14-20	SAND	Sand, silty, gray
20-55	SAND	Sand, gray
55-71	SAND	Sand, finer than above (tight)

136-052-19DDC
CRWD

Date Completed:	7/2004	Purpose:	Test Well
L.S. Elevation (ft):	1055.1	Well Type:	4 in. - PVC
Depth Drilled (ft):	100	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	0-51		

Depth (ft)	Unit	Description
0-2	TOPSOIL	Topsoil, sandy loam
2-4	SAND	Sand, brown
4-6	CLAY	Clay, white, soft
6-9	SAND	Sand, brown

9-15	SAND	Sand, silty, gray
15-40	SAND	Sand, fine and medium
40-50	SAND	Sand, as above, some shale
50-77	SAND	Sand, finer than above
77-100	SILT	Silt, clayey, gray

136-052-20BBB
NDSWC 8453

Date Completed:	08/22/1972	Purpose:	Observation Well-Destroyed
L.S. Elevation (ft):	1060	Well Type:	1.25 in. - PVC
Depth Drilled (ft):	140	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	57-60		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Topsoil, clay, sandy, silty, loam, dark brown.
1-6	SAND	Sand, very fine to medium, silty, well sorted, subangular to rounded, oxidized.
6-11	SILT	Silt, slightly clayey, sandy, dusky yellow, slightly cohesive, highly calcareous; olive-gray mottling.
11-60	SAND	Very fine to medium grained, moderately well sorted, subangular to rounded, lignitic, some shale, taking water, mixed 1 bag bentonite
60-72	SILT	Moderately sandy, moderately clayey, medium grain with light brownish-gray laminae, slightly cohesive, crumbly, highly calcareous
72-80	SAND	Very fine to fine grained, well sorted, subrounded, some lignite, very clayey, silty
80-140	SILT	Moderately clayey to clayey, medium gray, some thin, light olive gray laminae, slightly cohesive, moderately plastic, highly calcareous, becomes more clayey with depth

136-052-20DDA
NDSWC 8449

Date Completed:	08/22/1972	Purpose:	Observation Well-Destroyed
L.S. Elevation (ft):	1055	Well Type:	1.25 in. - PVC
Depth Drilled (ft):	140	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	77-80		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Clay, sandy, silty, loam, black
1-32	SAND	Sand, slightly silty, very fine to fine grained, subangular to rounded, well sorted, lignitic, shaley, oxidized to about 15' below land surface, taking water
32-66	SILT	Silt, moderately clayey, sandy (some thin, very fine sand interbeds), medium gray with light olive gray laminae, slightly cohesive, slightly plastic, highly calcareous, samples washing out
66-86	SAND	Sand, very fine and fine grained, occasional clayey silt and sandy silt interbeds, subrounded, moderately well sorted, some detrital lignite, taking a little water
86-94	SILT	Silt, moderately clayey, slightly sandy, medium gray, slightly cohesive, slightly plastic, highly calcareous
94-98	SAND	Sand, very fine grained, silty, subrounded, lignitic, some shale
98-140	CLAY	Clay, very silty to silty, olive gray with light olive gray laminae, moderately cohesive, highly plastic, pliable, highly calcareous

APPENDIX I: LITHOLOGIC DATA

136-052-21DCCC
USGS

Date Completed:	06/10/1993	Purpose:	Observation Well
L.S. Elevation (ft):	1057.5	Well Type:	2 in. - PVC
Depth Drilled (ft):	14.9	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	9.9-14.3		

136-052-22CCC
NDSWC 8326

Date Completed:	05/15/1972	Purpose:	Observation Well-Plugged
L.S. Elevation (ft):	1056.4	Well Type:	1.25 in. - ABS
Depth Drilled (ft):	140	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	38-41	Data Source:	NDSWC

Depth (ft)	Unit	Description
0-4	ROADFILL	Sand, clayey, silty
4-28	SAND	Sand, very fine to medium grained, slightly silty, well sorted, subangular to subrounded, oxidized
28-33	CLAY	Clay, very silty, olive gray, slightly cohesive, plastic, calcareous
33-40	SAND	Sand, very fine to medium grained, slightly silty, occasional clay layers, subangular to subrounded, well sorted, lignitic, taking some water
40-140	SILT	Silt, clayey, olive gray, occasional thin sandy silty layers, interbedded, very slightly cohesive, plastic, highly calcareous

136-052-22DDD
NDSWC 2200

Date Completed:	10/07/1963	Purpose:	Test Hole
L.S. Elevation (ft):	1051.2		
Depth Drilled (ft):	336		

Depth (ft)	Unit	Description
0-2	TOPSOIL	Sandy loam, black
2-4	CLAY	Clay, sandy, yellowish gray, soft
4-10	SAND	Sand, fine and medium, well sorted, rounded, oxidized
10-20	SAND	Sand, fine and medium, dark greenish gray, rounded, well sorted, predominantly quartz with some limestone, shale, feldspar, greenstone, and lignite, moderately calcareous
20-30	SAND	Sand, fine and medium, nice looking, taking water
30-40	SILT	Silt, olive gray, soft, moderately calcareous, poor sample return
40-50	SILT	Silt, olive gray, tight drilling, most of it washing out in the mud
50-60	SILT	Silt, olive gray, uniform drilling
60-70	SILT	Silt, olive gray, sand in mud pit but it may be coming from above
70-100	SILT	Silt, olive gray
100-110	SILT	Silt, clayey, olive gray, soft, plastic, sticky
110-120	SILT	Silt, olive gray, tight drilling
120-180	SILT	Silt, olive gray
180-190	TILL	Clay, silty, sandy, pebbly, cobbles and boulders, olive gray, tightly compacted, cohesive, fairly plastic, calcareous (till)
190-200	TILL	As above, gravelly and rocky, rough drilling
200-210	TILL	As above, gravelly
210-220	TILL	As above, sandy clay, with pebbles and rocks

220-230	TILL	As above
230-240	TILL	As above, gravelly to rocky, rough drilling
240-250	TILL	As above, very little gravel
250-260	TILL	As above, moderately soft, fairly tight
260-270	TILL	As above, sandy
270-280	TILL	As above, rocky in spots
280-290	TILL	As above
290-300	TILL	As above, very sandy
300-310	TILL	As above
310-320	TILL	As above, very gravelly and rocky, large rocks at base, mainly angular granite chips in sample return, very rough drilling
320-336	GRAVEL	Mainly limestone and granite; very rough drilling to shale, olive black, tight, cohesive, plastic, shaley partings, slightly calcareous, tough, tight, slow drilling

136-052-22DDD2
NDSWC 2200A

Date Completed:	10/08/1963	Purpose:	Observation Well-Recorder
L.S. Elevation (ft):	1051.2	Well Type:	4 in. - PVC
Depth Drilled (ft):	42	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	33-38		

136-052-23DDD
NDSWC 8444

Date Completed:	08/11/1972	Purpose:	Observation Well-Destroyed
L.S. Elevation (ft):	1050	Well Type:	1.25 in. - PVC
Depth Drilled (ft):	140	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	57-63		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Clay, silty, sandy, loam, brownish-black
1-10	SILT	Silt, slightly clayey, very sandy, moderate yellowish-brown, slightly cohesive, crumbles easily, oxidized
10-63	SAND	Sand, very fine to medium grained, slightly silty, mostly fine, subangular to rounded, well sorted, some lignite, oxidized to about 25' below land surface, taking some water
63-86	SILT	Silt, moderately clayey, medium gray, some light olive gray laminae, slightly to moderately cohesive, breaks rather easily, plastic, highly calcareous
86-124	SILT	Silt, slightly clayey, sandy, very fine grained sand interbeds, medium gray with light olive gray laminae, slightly cohesive, plastic, breaks easily, highly calcareous
124-140	CLAY	Clay, very silty to silty, olive gray, highly plastic, cohesive, highly calcareous

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136-052-24DDD
NDSWC 8314

Date Completed:	05/10/1972	Purpose:	Observation Well-Destroyed
L.S. Elevation (ft):	1044	Well Type:	1.25 in. - PVC
Depth Drilled (ft):	120	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	47-50		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Clay, very silty, sandy, brownish-black
1-7	SAND	Sand, very fine to medium grained,silty, clayey, subangular to subrounded, oxidized, lignitic
7-12	SILT	Silt, slightly clayey, sandy, moderate yellowish brown, slightly cohesive, soft, oxidized
12-25	SILT	Silt, moderately clayey, slightly sandy, olive gray, slightly cohesive, plastic, highly calcareous
25-52	SAND	Sand, very fine to fine grained, slightly silty, occasional thin clay layers, subrounded, lignitic
52-120	CLAY	Clay, very silty, numerous sandy silt layering, olive gray, cohesive, very plastic, highly calcareous

136-052-25CCB
NDSWC 8443

Date Completed:	08/11/1972	Purpose:	Observation Well-Destroyed
L.S. Elevation (ft):	1045	Well Type:	1.25 in. - ABS
Depth Drilled (ft):	140	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	135-140		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Clay, silty, sandy, loam black
1-15	SILT	Silt, slightly clayey, sandy (sand fraction is extremely fine grained), moderate yellowish-brown with dusky yellow and light gray mottling, laminated, slightly cohesive, crumbly, oxidized
15-18	SILT	Silt, slightly to moderately clayey, sandy, medium gray with light olive gray laminae, slightly cohesive, slightly plastic, crumbles rather easily, highly calcareous
18-25	SAND	Sand, very fine to fine grained, silty, subrounded, well sorted, lignitic, shaley, probably some clay
25-34	SILT	Silt, slightly to moderately clayey, sandy (some interbedded sand) (sand is extremely fine-grained) medium gray, light olive gray laminae, slightly cohesive, slightly plastic, highly calcareous
34-78	SILT	Silt, slightly to moderately clayey, medium gray with light olive gray laminae, moderately cohesive, slightly plastic, breaks easily, highly calcareous, a few lignite chips
78-116	SILT	Silt, slightly clayey, sandy (sand fraction is extremely fine grained) almost silt-sized, medium gray with light olive gray laminae, slightly cohesive, slightly plastic, highly carcareous
116-140	CLAY	Clay, very silty to silty, olive gray, some light olive gray laminae, moderately cohesive, plastic, highly calcareous

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136-052-25CCB5
NDSWC 8447

Date Completed:	08/15/1972	Purpose:	Observation Well-Destroyed
L.S. Elevation (ft):	1046	Well Type:	4 in. - PVC
Depth Drilled (ft):	65	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	60-65		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Clay, silty, sandy, loam, brownish-black
1-14	SILT	Silt, sandy, slightly clayey (sand fraction is extremely fine), moderate yellowish-brown with dusky yellow mottling, slightly cohesive, laminated, crumbles easily, oxidized
14-19	SILT	Silt, sandy, slightly clayey, medium gray with light olive gray mottling and laminae, slightly cohesive, crumbles easily, highly calcareous, sand fraction is extremely fine grained
19-34	SAND	Sand, very fine to fine grained, silty, (some thin sandy silt interbeds) (clayey), subrounded to rounded, well sorted, lignitic, some shale, taking some water, attempted coring from 20'-25', no recovery
34-65	SILT	Silt, slightly to moderately clayey, medium gray with light olive gray laminae, slightly cohesive, crumbles and breaks easily, highly calcareous, cored from 45'-50' recovered 5 feet of core, cored from 60'-65' recovered 5 feet of core, becomes slightly sandy lower 3' (sand is very fine to extremely fine grained)

136-052-29BBB
NDSWC 8452

Date Completed:	08/22/1972	Purpose:	Observation Well-Plugged
L.S. Elevation (ft):	1061.5	Well Type:	1.25 in. - ABS
Depth Drilled (ft):	140	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	47-50		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Clay, silty, very sandy, loam, dark brown
1-2	SAND	Sand, very fine grained, silty, subrounded, oxidized
2-10	SILT	Silt, sandy, slightly clayey, dusky yellow, slightly cohesive, slightly plastic, crumbly, oxidized
10-14	SILT	Silt, slightly sandy, clayey, medium gray, slightly cohesive, crumbly, highly calcareous
14-56	SAND	Sand, very fine to fine grained, occasional thin clayey silt interbeds, subangular to rounded, well sorted, lignitic, taking some water
56-70	SILT	Silt, moderately sandy, moderately clayey, medium gray with light olive gray mottling, slightly cohesive, slightly plastic, highly calcareous, some thin sand interbeds
70-102	SAND	Sand, very fine to fine grained, occasional thin sandy, very clayey silt interbeds, subangular to rounded, well sorted, lignitic, taking some water
102-140	SILT	Silt, moderately clayey to clayey, becomes more clayey with depth, medium gray with light olive gray mottling and laminae, slightly to moderately cohesive, slightly plastic to plastic, samples break easily, highly calcareous

APPENDIX I: LITHOLOGIC DATA

136-052-29BBB2
NDSWC 15682

Date Completed:	10/20/2009	Purpose:	Observation Well
L.S. Elevation (ft):	1060.81	Well Type:	2 in. - PVC
Depth Drilled (ft):	250	Aquifer:	Undefined
Screen Int. (ft.):	212-217		

Depth (ft)	Unit	Description
0-14	SILT	Silt, clayey, sandy, oxidized; mottles
14-40	INTERBEDDED	Clay, silt, sand, very fine, olive gray (5Y3/2), reduced
40-80	SAND	Sand, very fine to medium
80-170	SILT	Silt, sandy, very fine, olive gray
170-188	CLAY	Clay, olive gray
188-202	CLAY	Clay, silty, sandy, olive gray; cobble at 188 ft (Glacial sediment)
202-218	SAND & GRAVEL	Sand, fine to coarse, gravelly, fine, mixed petrology
218-250	CLAY	Clay, silty, sandy, olive gray; cobble at 250 ft (Glacial sediment)

136-052-29BBB3
NDSWC 15683

Date Completed:	10/21/2009	Purpose:	Observation Well
L.S. Elevation (ft):	1060.58	Well Type:	2 in. - PVC
Depth Drilled (ft):	60	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	49-54		

Depth (ft)	Unit	Description
0-15	SILT	Silt, clayey, sandy, very fine, oxidized; mottles
15-20	SILT	Silt, clayey, sandy, very fine, olive gray (5Y 3/2), reduced
20-55	SAND	Sand, very fine to medium
55-60	SILT	Silt, clayey, olive gray

136-052-29DDD
NDSWC 8450

Date Completed:	08/22/1972	Purpose:	Observation Well-Plugged
L.S. Elevation (ft):	1054	Well Type:	1.25 in. - PVC
Depth Drilled (ft):	140	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	67-70		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Clay, sandy, silty, loam, dark brown
1-23	SAND	Sand, very fine to medium grained, slightly silty, subangular to rounded, well sorted, oxidized throughout, taking some water
23-38	SILT	Silt, moderately clayey to clayey, a few thin sand interbeds, medium gray with light olive gray laminae, slightly calcareous, plastic to slightly plastic
38-72	SAND	Sand, very fine to fine grained, occasional thin silty clay interbeds, subangular to rounded, modertely well sorted, lignitic, taking some water
72-86	SILT	Silt, moderately clayey to clayey, very slightly sandy, medium gray with light olive gray laminae, slightly cohesive, slightly plastic, breaks easily, highly calcareous
86-88	SAND	Sand, very fine to fine grained, silty, subrounded, well sorted
88-140	CLAY	Clay, very silty to silty, olive gray with light olive gray laminae, cohesive, highly plastic and calcareous

APPENDIX I: LITHOLOGIC DATA

136-052-29DDD2
NDSWC 15294

Date Completed:	08/08/2005	Purpose:	Observation Well
L.S. Elevation (ft):	1053.5	Well Type:	2 in. - PVC
Depth Drilled (ft):	80	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	58-63		

Depth (ft)	Unit	Description
0-5	SAND	Sand, oxidized
5-22	CLAY	Clay, sandy, yellow, oxidized
22-34	CLAY	Clay, silty, gray, reduced
34-72	SAND	Sand, fine
72-80	CLAY	Clay, silty, gray

136-052-30DDD
NDSWC 8451

Date Completed:	08/22/1972	Purpose:	Observation Well-Plugged
L.S. Elevation (ft):	1054.5	Well Type:	1.25 in. - ABS
Depth Drilled (ft):	140	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	52-55		

Depth (ft)	Unit	Description
0-57	SAND	Sand, very fine to medium grained, slightly silty, moderately welll sorted, subangular to rounded, oxidized to about 20' below land surface, taking some water, some lignite
57-70	SILT	Silt, moderately clayey, occasional thin sand interbeds, medium gray with light olive gray laminae, slightly cohesive, crumbly, highly calcareous
70-73	SAND	Sand, very fine to fine grained, silty, subrounded, moderately well sorted, lignitic
73-106	SILT	Silt, moderately clayey, medium gray with light olive gray laminae, slightly cohesive, moderately plastic, highly calcareous
106-123	SAND	Sand, very fine to fine grained, moderately clayey, silty, subrounded, moderately well sorted, some lignite "dirty-looking samples"
123-140	CLAY	Clay, very silty to silty, olive gray with some thin light brownish-gray laminae, moderately cohesive, highly plastic, very calcareous

136-052-30DDD2
NDSWC 15684

Date Completed:	10/22/2009	Purpose:	Observation Well
L.S. Elevation (ft):	1051.61	Well Type:	2 in. - PVC
Depth Drilled (ft):	0	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	50-53		

Depth (ft)	Unit	Description
0-3	SAND	Sand, very fine, silty, oxidized (eolian)
3-15	SAND	Sand, fine and medium, oxidized; mottles
15-58	SAND	Sand, fine and medium, reduced
58-78	SILT	Silt, sandy, very fine, olive gray
78-90	SAND	Sand, very fine, silty
90-110	SILT	Silt, sandy, very fine, olive gray
110-118	SAND	Sand, very fine, silty

118-120	SILT	Silt, sandy, very fine, olive gray
120-130	SAND	Sand, very fine, silty
130-178	SILT	Silt, clayey, olive gray
178-200	CLAY	Clay, silty, sandy, olive gray (glacial sediment)

136-052-32CDB1
NDSWC 8454

Date Completed:	08/23/1972	Purpose:	Observation Well
L.S. Elevation (ft):	1046.54	Well Type:	4 in. - PVC
Depth Drilled (ft):	140	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	87-90		

Depth (ft)	Unit	Description
0-46	SAND	Sand, very fine to medium grained, few thin silt interbeds, mostly fine, subangular to rounded, well sorted, oxidized to about 20' below land surface, taking some water, lignitic
46-54	SILT	Silt, moderately clayey, medium gray with light olive gray laminae, slightly cohesive, slightly plastic, highly calcareous
54-58	SAND	Sand, very fine to fine grained, silty, well sorted, subrounded, lignitic
58-76	SILT	Silt, moderately clayey to clayey, medium gray with light olive gray laminae, slightly cohesive, slightly to moderately plastic, highly calcareous
76-96	SAND	Sand, very fine to fine grained, silty, mostly very fine grained, subangular to rounded, well sorted, lignitic, taking some water
96-113	SILT	Silt, moderately clayey to clayey, occasional thin fine grained sand interbeds, medium gray with light olive gray laminae, slightly cohesive, moderately plastic, highly calcareous
113-140	CLAY	Clay, silty to very silty, olive gray, some light brownish gray laminae, cohesive, very plastic, highly calcareous

136-052-32CDB2
NDSWC 8454A

Date Completed:	08/23/1972	Purpose:	Observation Well
L.S. Elevation (ft):	1045	Well Type:	1.25 in. - ABS
Depth Drilled (ft):	60	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	37-40		

136-052-32CDB3
NDSWC 8454B

Date Completed:	08/29/1972	Purpose:	Test Hole
L.S. Elevation (ft):	1045		
Depth Drilled (ft):	75		

Depth (ft)	Unit	Description
0-50	SAND	Sand, fine, a few very thin clay lenses (interbedded) 10'-20', at 20' back to clean very fine medium sand, well sorted, subangular to rounded, oxidized to about 20', mixed 1 bag mud, taking some water. Cored from 45'-50', sand, lignitic to 49.5' (1/2" lenses of lignite)
50-55	SILT	Silt, clayey, with lenses of lignite, sandy, olive gray, slightly cohesive, highly calcareous
55-59	SAND	Sand, very fine, wouldn't stay in core, well sorted, subrounded, lignitic

59-75	CLAY	Clay, very silty, medium gray, slightly cohesive, slightly to moderately plastic, highly calcareous (were able to obtain only about 2' of core from 70'-75'

136-052-34BBA
NDSWC 8327

Date Completed:	05/15/1972	Purpose:	Observation Well-Plugged
L.S. Elevation (ft):	1025	Well Type:	1.25 in. - ABS
Depth Drilled (ft):	120	Aquifer:	Sheyenne Delta

Depth (ft)	Unit	Description
0-5	SAND	Sand, very fine to fine grained, silty, subangular to subrounded, well sorted, oxidized
5-14	SILT	Silt, clayey, moderate yellowish-brown, slightly cohesive, plastic, oxidized
14-38	CLAY	Clay, very silty, occasional thin sandy silt layers, olive gray, cohesive, highly plastic, very calcareous, interbedded
38-40	SAND	Sand, very fine to fine grained, subangular to subrounded, well sorted
40-45	CLAY	Clay, very silty, olive gray, modeately cohesive, highly plastic, very calcareous
45-49	SAND	Sand, very fine to fine grained, silty, subangular to subrounded, well sorted, lignitic
49-120	CLAY	Clay, very silty to silty, olive gray, a few thin silty layers, moderately cohesive to cohesive, highly plastic, highly calcareous, interbedded

136-052-35AAD
NDSWC 8442

Date Completed:	08/11/1972	Purpose:	Observation Well-Destroyed
L.S. Elevation (ft):	1000	Well Type:	1.25 in. - PVC
Depth Drilled (ft):	100	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	42-45		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Clay, silty, sandy, loam, brownish-black
1-50	SAND	Sand, very fine to very coarse grained, mostly medium, subangular to rounded, moderately well sorted, oxidized to about 20' below land surface, taking some water, about 10% shale, small amount of lignite, a few shell fragments, some interbedded clayey silt
50-68	SILT	Silt, moderately clayey, occasional thin sandy silt interbeds, slightly sandy, medium gray with light olive gray laminae, moderately plastic, slightly cohesive, highly calcareous
68-100	CLAY	Clay, very silty to silty, olive gray with a few light brownish-gray laminae, cohesive, plastic, highly calcareous, a few lignite chips

136-052-35ADD
NDSWC 8441

Date Completed:	08/10/1972	Purpose:	Observation Well-Destroyed
L.S. Elevation (ft):	980	Well Type:	1.25 in. - PVC
Depth Drilled (ft):	100	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	37-40		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Clay, silty, very sandy, loam, brown

1-6	SAND	Sand, very fine to fine grained, slightly clayey, silty, well sorted, subrounded, oxidized
6-19	SILT	Silt, moderately clayey, olive gray with dusky yellow mottling, moderately cohesive, moderately plastic, highly calcareous
19-40	SAND	Sand, very fine to very coarse grained, mostly fine to medium, subangular to rounded, moderately well sorted, about 20% shale, lignitic, taking some water, a few thin sandy clay lenses, numerous shell fragments
40-95	CLAY	Clay, very silty to silty, olive gray with greenish gray to light olive gray laminae, moderately cohesive, plastic, highly calcareous, a few lignite chips
95-100	CLAY	Clay, silty, pebbly, olive gray, cohesive, moderately plastic, calcareous (till)

136-052-35DAD
NDSWC 8440

Date Completed:	08/10/1972	Purpose:	Observation Well-Destroyed
L.S. Elevation (ft):	968	Well Type:	1.25 in. - PVC
Depth Drilled (ft):	100	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	37-40		

Depth (ft)	Unit	Description
0-14	SAND	Sand, very fine to medium grained, subrounded, moderately well sorted, oxidized, some lignite, taking water
14-32	SILT	Silt, moderately clayey, slightly sandy, medium gray, slightly cohesive, slightly plastic, numerous clam and snail shells and wood fragments
32-42	SAND	Sand, very slightly clayey, very fine to coarse grained, mostly medium, subangular to rounded, moderately well sorted, about 25% shale, lignitic, some shell fragments, taking water
42-88	CLAY	Clay, very silty to silty, olive gray with a few light olive gray laminae, cohesive, moderately plastic, highly calcareous
88-100	CLAY	Clay, silty, pebbly, olive gray, cohesive, slightly plastic, moderately calcareous (till)

136-052-35DDD
NDSWC 8439

Date Completed:	08/10/1972	Purpose:	Observation Well-Destroyed
L.S. Elevation (ft):	975	Well Type:	1.25 in. - PVC
Depth Drilled (ft):	100	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	47-50		

Depth (ft)	Unit	Description
0-7	SAND	Sand, very fine to medium grained, subrounded to rounded, well sorted, lignitic, shaley
7-34	SILT	Silt, moderately clayey, slightly sandy, a few pebbles, olive gray with greenish gray mottling, moderately cohesive, slightly plastic to plastic, highly calcareous
34-55	SAND	Sand, very fine to coarse grained, few thin, clayey silt interbeds, mostly medium, subangular to rounded, moderately well sorted, lignitic, a few wood fragments, taking some water
55-88	CLAY	Clay, very silty to silty, olive gray with a few light olive gray laminae, cohesive, highly plastic to plastic, highly calcareous
88-100	CLAY	Clay, silty, pebbly, olive gray, cohesive, moderately plastic, calcareous (till)

APPENDIX I: LITHOLOGIC DATA

136-053-02ABB
NDDH

Date Completed:	07/25/2000	Purpose:	Observation Well
L.S. Elevation (ft):	1060.2	Well Type:	2 in. - PVC
Depth Drilled (ft):	19	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	9-19		

Depth (ft)	Unit	Description
0-1	SAND	Sand, fill
1-8	SAND	Sand, fine, brown
8-19	SAND	Sand, fine, gray

136-053-02DAA
CRWD

Date Completed:	12/14/2006	Purpose:	Observation Well
L.S. Elevation (ft):	1062.9	Well Type:	0 in. -
Depth Drilled (ft):	96	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	46-51		

Depth (ft)	Unit	Description
0-1	SILT	Silt, clayey, sandy, very fine, light olive brown (5Y 5/6), oxidized
1-6	SAND	Sand, very fine, silty, light olive brown, oxidized; carbonaceous (eolian)
6-12	SAND	Sand, very fine and fine, silty, moderate brown (5YR 4/4), mottles, oxidized (upper delta)
12-51	SAND	Sand, very fine and fine, silty, light olive gray (5Y 5/2), reduced (upper delta)
51-55	SAND	Sand, very fine and fine, very silty, olive black (5Y 2/1); carbonaceous (upper delta)
55-58	SAND	Sand, very fine and fine, silty, olive gray (upper delta)
58-90	SILT	Silt, very clayey, olive gray (lower delta)
90-92	CLAY	Clay, olive gray (lower delta)
92-95	SILT	Silt, very clayey, olive gray (lower delta)
95-96	CLAY	Clay, olive gray (lower delta)

136-053-03AAA
CRWD

Date Completed:	12/08/2006	Purpose:	Observation Well
L.S. Elevation (ft):	1061.4	Well Type:	2 in. - PVC
Depth Drilled (ft):	136	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	50-60		

Depth (ft)	Unit	Description
0-3	SILT	Silt, sandy, very fine, light olive brown (5Y 5/6), oxidized
3-5	SAND	Sand, very fine, silty, light olive brown, oxidized (eolian)
5-8	SILT	Silt, sandy, very fine, light olive gray (5Y 5/2), mottles
8-9	SAND	Sand, very fine and fine, silty, moderate brown (5YR 4/4), mottles, oxidized (upper delta)
9-60	SAND	Sand, very fine and fine, silty, light olive gray (5Y 5/2), reduced (upper delta)
60-61	CLAY	Clay, very silty, olive gray (5Y 3/2) (upper delta)
61-64	SAND	Sand, very fine, silty, dark olive gray (upper delta)
64-65	SILT	Silt, very sandy, very fine, olive gray (upper delta)
65-70	SAND	Sand, very fine, silty, olive gray (upper delta)

70-72	CLAY	Clay, very silty, olive gray (upper delta)
72-78	SAND	Sand, very fine, silty, olive gray (upper delta)
78-82	SAND	Sand, very fine, very silty, olive gray (upper delta)
82-86	SAND	Sand, very fine, slightly silty, olive gray (upper delta)
86-87	SAND	Sand, very fine, very silty, olive gray (upper delta)
87-95	SAND	Sand, very fine, silty, olive gray (upper delta)
95-100	SILT	Silt, very clayey, olive gray (lower delta)
100-106	CLAY	Clay, silty, slightly sandy, very fine (lower delta)
106-116	SILT	Silt, clayey, slightly sandy, very fine (lower delta)
116-128	CLAY	Clay, firm, olive gray; trace pebbles (lacustrine)
128-136	CLAY	Clay, silty, slightly pebbly, olive gray; increasing pebbles with depth (till)

136-053-04BBB
CRWD

Date Completed:	12/09/2006	Purpose:	Observation Well
L.S. Elevation (ft):	1058.9	Well Type:	2 in. - PVC
Depth Drilled (ft):	196	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	32-42		

Depth (ft)	Unit	Description
0-3	SILT	Silt, clayey, moderate olive brown (5Y 4/4), oxidized
3-4	SILT	Silt, clayey, sandy, very fine, light olive brown (5Y 5/6), mottles, oxidized
4-6	SAND	Sand, very fine and fine, silty, moderate brown (5YR 4/4), oxidized (upper delta)
6-10	SAND	Sand, very fine and fine, silty, light olive gray (5Y 5/2), reduced (upper delta)
10-18	SILT	Silt, very clayey, slightly sandy, very fine, olive gray (5Y 3/2) (upper delta)
18-22	SAND	Sand, very fine, silty, olive gray (upper delta)
22-42	SAND	Sand, very fine and fine, silty, olive gray (upper delta)
42-55	SAND	Sand, very fine,very silty, olive gray (upper delta)
55-56	SAND	Sand, very fine, silty, olive gray (upper delta)
56-60	CLAY	Clay, very silty, slightly sandy, very fine, olive gray (upper delta)
60-62	SILT	Silt, very clayey, olive gray (upper delta)
62-65	SAND	Sand, very fine and fine, very silty, olive gray (upper delta)
65-71	SAND	Sand, very fine and fine, silty, olive gray (upper delta)
71-76	SAND	Sand, very fine and fine, very silty, olive gray (upper delta)
76-80	SAND	Sand, very fine and fine, silty, olive gray (upper delta)
80-84	SILT	Silt, sandy, very fine, olive gray (lower delta)
84-85	SILT	Silt, very clayey, olive gray (lower delta)
85-87	CLAY	Clay, very silty, olive gray (lower delta)
87-94	CLAY	Clay, silty, olive gray (lower delta)
94-116	CLAY	Clay, very silty, olive gray (lower delta)
116-121	CLAY	Clay, silty, olive gray (lower delta)
121-125	CLAY	Clay, silty, sandy, pebbly, olive gray, firm (till)
125-126	CLAY	Clay, very silty, olive gray
126-143	CLAY	Clay, silty, sandy, pebbly, olive gray, firm (till)
143-145	CLAY	Clay, silty, very sandy, dark olive gray, soft
145-150	CLAY	Clay, silty, sandy, pebbly, dark olive gray, hard (till)
150-151	CLAY	Clay, silty, sandy, pebbly, cobbles, dark olive gray
151-153	SAND	Sand, very fine and fine, silty, dark olive gray (outwash)
153-155	CLAY	Clay, silty, sandy, pebbly, cobbles, hard, olive gray (till)
155-161	SILT	Silt, very clayey, olive gray
161-165	SAND	Sand, very fine and fine, silty, olive gray (outwash)
165-172	SAND	Sand, very fine, very silty, olive gray (outwash)

172-196	CLAY	Clay, silty, sandy, pebbly, olive gray; sand, very fine, laminations from 178 to 187 feet (till)

136-053-06BAA
CRWD

Date Completed:	12/09/2006	Purpose:	Observation Well
L.S. Elevation (ft):	1063.5	Well Type:	2 in. - PVC
Depth Drilled (ft):	76	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	30-35		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Topsoil, sandy loam
1-6	SAND	Sand, very fine and fine, silty, light olive brown (5Y 5/6), oxidized (eolian)
6-14	SAND	Sand, very fine and fine, silty, moderate brown (5YR 4/4), mottles, oxidized (upper delta)
14-30	SAND	Sand, very fine and fine, silty, light olive gray (5Y 5/2), reduced (upper delta)
30-36	SAND	Sand, fine, silty, light olive gray, reduced (upper delta)
36-54	SILT	Silt, very clayey, olive gray (lower delta)
54-57	CLAY	Clay, very silty, olive gray (lower delta)
57-68	SILT	Silt, very clayey, olive gray (lower delta)
68-71	CLAY	Clay, silty, olive gray (lacustrine)
71-74	CLAY	Clay, very silty, olive gray (lacustrine)
74-76	CLAY	Clay, silty, olive gray (lacustrine)

136-053-07CCC
CRWD

Date Completed:	12/10/2006	Purpose:	Test Hole
L.S. Elevation (ft):	1065.6		
Depth Drilled (ft):	95		

Depth (ft)	Unit	Description
0-3	SILT	Silt, clayey, moderate olive brown (5Y 4/4), mottles, oxidized
3-8	SAND	Sand, very fine and fine, silty, light olive brown (5Y 5/6), mottles, oxidized (upper delta)
8-15	SAND	Sand, very fine and fine, silty, light olive gray, reduced (upper delta)
15-19	SILT	Silt, clayey, sandy, very fine, olive gray (lower delta)
19-42	SILT	Silt, very clayey, olive gray (lower delta)
42-55	CLAY	Clay, very silty, olive gray (lower delta)
55-75	CLAY	Clay, silty, olive gray (lacustrine)
75-80	CLAY	Clay, silty, few pebbles, olive gray (lacustrine)
80-91	CLAY	Clay, silty, sandy, pebbly, olive gray (till)
91-95	CLAY	Clay, very silty, olive gray

APPENDIX I: LITHOLOGIC DATA

136-053-08DDD
CRWD

Date Completed:	12/12/2006	Purpose:	Observation Well
L.S. Elevation (ft):	1062.2	Well Type:	2 in. - PVC
Depth Drilled (ft):	95	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	65-70		

Depth (ft)	Unit	Description
0-3	SILT	Silt, sandy, very fine, clayey, light olive brown (5Y 5/6), oxidized
3-9	SAND	Sand, very fine, silty, moderate brown (5YR 4/4), mottles, oxidized (eolian)
9-22	SAND	Sand, very fine and fine, silty, light olive gray (5Y 5/2), reduced (upper delta)
22-35	SAND	Sand, fine, silty, light olive gray (upper delta)
35-45	SAND	Sand, very fine and fine, silty, light olive gray (upper delta)
45-49	SAND	Sand, very fine and fine, silty, olive black (5Y 2/1), carbonaceous (upper delta)
49-56	SAND	Sand, very fine and fine, silty, olive gray (upper delta)
56-58	SILT	Silt, clayey, olive gray (upper delta)
58-63	SAND	Sand, very fine and fine, silty, olive gray (upper delta)
63-65	SILT	Silt, very clayey, olive gray (upper delta)
65-70	SAND	Sand, very fine, very silty, olive gray (upper delta)
70-82	SILT	Silt, very clayey, olive gray (lower delta)
82-84	SAND	Sand, very fine, very silty, olive gray (lower delta)
84-89	SILT	Silt, very clayey, olive gray (lower delta)
89-95	CLAY	Clay, silty, olive gray (lacustrine)

136-053-09AAA
NDDH

Date Completed:	07/26/2000	Purpose:	Observation Well
L.S. Elevation (ft):	1061.4	Well Type:	2 in. - PVC
Depth Drilled (ft):	15	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	5-15		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Topsoil
1-6	SAND	Sand, fine, brown
6-12	SAND	Sand, fine, gray
12-13	SAND	Sand, fine, clayey, gray
13-15	SAND	Sand, fine, gray

136-053-10BBB
CRWD

Date Completed:	12/07/2006	Purpose:	Observation Well
L.S. Elevation (ft):	1061.9	Well Type:	2 in. - PVC
Depth Drilled (ft):	115	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	45-55		

Depth (ft)	Unit	Description
0-4	SILT	Silt, sandy, very fine, clayey, brownish black (5YR 2/1), carbonaceous, oxidized
4-8	SAND	Sand, very fine and fine, silty, moderate brown (5YR 4/4), mottles, oxidized (upper delta)

8-33	SAND	Sand, very fine and fine, silty, olive gray (5Y 3/2), reduced (upper delta)
33-34	SAND	Sand, very fine and fine, silty, olive black (5Y 2/1), carbonaceous (upper delta)
34-47	SAND	Sand, very fine, silty, olive gray (uppr delta)
47-55	SAND	Sand, very fine and fine, silty, olive black, carbonaceous (upper delta)
55-65	SAND	Sand, very fine, silty, olive gray (upper delta)
65-66	SILT	Silt, very sandy, very fine, olive gray (upper delta)
66-70	SAND	Sand, very fine, silty, olive gray (upper delta)
70-75	SILT	Silt, very sandy, very fine, olive gray (lower delta)
75-83	SILT	Silt, clayey, slightly sandy, very fine, olive gray (lower delta)
83-85	CLAY	Clay, very silty, olive gray (lower delta)
85-95	SILT	Silt, clayey, sandy, very fine, olive gray (lower delta)
95-104	CLAY	Clay, very silty, olive gray (lower delta)
104-105	SILT	Silt, very sandy, very fine, olive gray (lower delta)
105-106	CLAY	Clay, very silty, olive gray (lower delta)
106-108	SILT	Silt, very sandy, olive gray (lower delta)
108-115	CLAY	Clay, firm, olive gray (lacustrine)

136-053-11DDD
NDDH

Date Completed:	07/26/2000	Purpose:	Observation Well
L.S. Elevation (ft):	1062.2	Well Type:	2 in. - PVC
Depth Drilled (ft):	15	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	5-15		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Topsoil
1-4	SAND	Sand, fine, brown
4-15	SAND	Sand, fine, gray

136-053-12ADD
CRWD

Date Completed:	12/10/2006	Purpose:	Observation Well
L.S. Elevation (ft):	1061.8	Well Type:	2 in. - PVC
Depth Drilled (ft):	116	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	50-55		

Depth (ft)	Unit	Description
0-5	SAND	Sand, very fine, silty, light olive brown (5Y 5/6), oxidized (eolian)
5-11	SAND	Sand, very fine, silty, moderate brown (5YR 4/4), mottles, oxidized (eolian)
11-18	SAND	Sand, very fine, silty, olive gray (5Y 3/2), reduced (eolian)
18-23	SILT	Silt, sandy, very fine, olive gray (upper delta)
23-25	SAND	Sand, very fine and fine, silty, light olive gray (5Y 5/2) (upper delta)
25-55	SAND	Sand, fine, silty, light olive gray; carbonaceous with detrital lignite from 48 to 50 ft (upper delta)
55-56	SAND	Sand, very fine, very silty, olive gray (upper delta)
56-66	SAND	Sand, very fine and fine, silty, olive gray (upper delta)
66-67	SILT	Silt, very sandy, very fine, olive gray (upper delta)
67-76	SAND	Sand, very fine and fine, silty, olive gray (upper delta)
76-81	SILT	Silt, very clayey, olive gray (upper delta)
81-84	SAND	Sand, very fine, very silty, olive gray (upper delta)
84-88	SAND	Sand, very fine, silty, olive gray (upper delta)

88-96	SILT	Silt, very clayey, olive gray (lower delta)
96-109	CLAY	Clay, silty, olive gray (lacustrine)
109-112	SAND	Sand, very fine, very silty, olive gray (lacustrine)
112-114	SILT	Silt, very clayey, olive gray (lacustrine)
114-115	CLAY	Clay, very silty, olive gray (lacustrine)
115-116	SILT	Silt, very clayey, olive gray (lacustrine)

136-053-14BBB
CRWD

Date Completed:	12/07/2006	Purpose:	Observation Well
L.S. Elevation (ft):	1062.3	Well Type:	2 in. - PVC
Depth Drilled (ft):	136	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	46-56		

Depth (ft)	Unit	Description
0-8	SAND	Sand, very fine, silty, light olive brown (5Y 5/6), oxidized (upper delta)
8-56	SAND	Sand, fine, silty, light olive gray (5Y 5/2), reduced (upper delta)
56-83	SAND	Sand, very fine, silty, olive gray (5Y 3/2), reduced (upper delta)
83-87	SILT	Silt, sandy, very fine, olive gray (upper delta)
87-90	SAND	Sand, very fine, silty, olive gray (upper delta)
90-96	SILT	Silt, sandy, very fine, olive gray (lower delta)
96-101	CLAY	Clay, very silty, olive gray (lower delta)
101-106	SILT	Silt, clayey, slightly sandy, very fine, olive gray (lower delta)
106-121	SILT	Silt, very clayey, olive gray (lower delta)
121-136	CLAY	Clay, firm, olive gray (lacustrine)

136-053-14CCC
CRWD

Date Completed:	12/06/2006	Purpose:	Observation Well
L.S. Elevation (ft):	1065.6	Well Type:	2 in. - PVC
Depth Drilled (ft):	176	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	66-76		

Depth (ft)	Unit	Description
0-5	SAND	Sand, very fine, silty, light olive brown (5Y 5/6), oxidized (eolian)
5-9	SAND	Sand, very fine and fine, silty, moderate brown (5YR 4/4), mottles, oxidized (upper delta)
9-24	SAND	Sand, fine, silty, light olive gray (5Y 6/4), reduced (upper delta)
24-51	SAND	Sand, very fine and fine, silty, dark olive gray (5Y 3/2), reduced (upper delta)
51-56	SAND	Sand, very fine and fine, silty, dark olive gray to olive black (5Y 2/1), reduced; interbedded silt and clay; carbonaceous (upper delta)
56-65	CLAY	Clay, silty, sllightly sandy, very fine, olive gray (upper delta)
65-76	SAND	Sand, fine, silty, clayey, olive gray (upper delta)
76-80	SILT	Silt, clayey, slightly sandy, very fine, olive gray (upper delta)
80-85	SAND	Sand, fine, silty, olive gray (upper delta)
85-95	CLAY	Clay, silty, olive gray (lower delta)
95-116	SILT	Silt, clayey, slightly sandy, very fine, olive gray; increasing clay with depth (lower delta)
116-136	CLAY	Clay, silty, olive gray; decreasing silt with depth (lacustrine)
136-146	SILT	Silt, clayey, olive gray (lacustrine)
146-160	CLAY	Clay, silty, olive gray; decreasing silt with depth (lacustrine)
160-176	CLAY	Clay, silty, sandy, pebbly, olive gray (till)

APPENDIX I: LITHOLOGIC DATA

136-053-15DDC
NDDH

Date Completed:	07/26/2000	Purpose:	Observation Well
L.S. Elevation (ft):	1064.6	Well Type:	2 in. - PVC
Depth Drilled (ft):	15	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	5-15		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Topsoil
1-10	SAND	Sand, fine, brown
10-15	SAND	Sand, fine, gray

136-053-21DDD
NDSWC 8467

Date Completed:	08/31/1972	Purpose:	Test Hole
L.S. Elevation (ft):	1062		
Depth Drilled (ft):	340		
Completion Info:			

Depth (ft)	Unit	Description
0-3	CLAY	Clay, silty, sandy, tan to gray, organic.
3-44	SAND	Sand, fine, gray, quartz, shale, lignite.
44-80	SILT	Silt, sandy, gray; interbedded fine sand.
80-264	TILL	Clay, silty, sandy, pebbly, gray, cohesive, plastic, slightly calcareous; gravel from 220 to 222 feet; rock at 222 feet; sand from 249 to 252 feet; interbedded sand from 252 to 262 feet (Till).
264-267	SAND	Sand, fine and medium.
267-274	TILL	Till, as above.
274-276	SAND & GRAVEL	Sand and gravel.
276-279	CLAY	Clay, silty, sandy, olive-gray to brownish-gray.
279-283	SAND	Sand, fine and medium.
283-300	CLAY	Clay, silty, sandy, olive-gray to brownish-gray.
300-323	TILL	Clay, silty, sandy, pebbly, olive-gray (Till).
323-340	SHALE	Shale, silty, brownish-gray, calcareous.

136-053-21DDD2
NDSWC 8467A

Date Completed:	08/31/1972	Purpose:	Observation Well-Destroyed
L.S. Elevation (ft):	1062	Well Type:	1.25 in. - PVC
Depth Drilled (ft):	60	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	38-41		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Topsoil.
1-3	CLAY	Clay, silty, sandy, yellowish-brown.
3-44	SAND	Sand, fine and medium, quartz, lignite.
44-60	CLAY	Clay, silty, sandy, olive-gray; interbedded sand.

APPENDIX I: LITHOLOGIC DATA

136-053-22BBB
CRWD

Date Completed:	12/13/2006	Purpose:	Observation Well
L.S. Elevation (ft):	1064.6	Well Type:	2 in. - PVC
Depth Drilled (ft):	95	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	59-64		

Depth (ft)	Unit	Description
0-3	SILT	Silt, sandy, very fine, clayey, light olive brown (5Y 5/6), oxidized
3-5	SAND	Sand, very fine, silty, light olive brown, oxidized (eolian)
5-8	SAND	Sand, very fine and fine, silty, moderate brown (5YR 4/4), mottles, oxidized (upper delta)
8-17	SAND	Sand, very fine and fine, silty, light olive gray (5Y 5/2), reduced (upper delta)
17-26	SAND	Sand, fine, silty, light olive gray (upper delta)
26-27	SAND	Sand, very fine and fine, silty, olive black (5Y 2/1) (upper delta)
27-35	SAND	Sand, fine, silty, olive gray; 6 inch silt lense at 34 ft (upper delta)
35-40	SAND	Sand, very fine, very silty, olive gray (upper delta)
40-44	SAND	Sand, very fine and fine, silty, olive gray (upper delta)
44-54	SAND	Sand, very fine, very silty, olive gray (upper delta)
54-55	SILT	Silt, clayey, olive gray (upper delta)
55-63	SAND	Sand, very fine, very silty, olive gray (upper delta)
63-64	SAND	Sand, very fine, silty, olive gray (upper delta)
64-65	SILT	Silt, very clayey, olive gray (upper delta)
65-67	SAND	Sand, very fine, very silty, olive gray (upper delta)
67-75	SILT	Silt, very clayey, olive gray (upper delta)
75-80	SAND	Sand, very fine and fine, silty, olive gray (upper delta)
80-95	SILT	Silt, very clayey, slightly sandy, very fine, olive gray (lower delta)

136-053-25AAA
NDSWC 2201

Date Completed:	10/08/1963	Purpose:	Test Hole
L.S. Elevation (ft):	1059		
Depth Drilled (ft):	189		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Topsoil, fine sandy loam, loose, black.
1-10	SAND	Sand, fine and medium, well sorted, rounded, moderately calcareous, oxidized; iron stained.
10-90	SAND	Sand, medium, dark greenish-gray, well sorted, rounded, quartz, igneous, carbonate, lignite, moderately calcareous, unoxidized; silty at 40, 60 and 90 feet.
90-130	SILT	Silt, olive-gray, soft, cohesive; clayey from 120 to 130 feet.
130-160	CLAY	Clay, silty, olive-gray.
160-180	SILT	Silt, olive-gray, soft, cohesive.
180-189	TILL	Clay, silty, sandy, pebbly, olive-gray, cohesive, slightly plastic, calcareous; occasional cobbles (Till).

APPENDIX I: LITHOLOGIC DATA

136-053-25AAA2
NDSWC 2201A

Date Completed:	10/08/1963	Purpose:	Observation Well-Destroyed
L.S. Elevation (ft):	1059	Well Type:	4 in. - PVC
Depth Drilled (ft):	63	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	58-63		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Topsoil, clay, silty, black.
1-63	SAND	Sand, fine and medium.

136-053-26ABAA
USGS

Date Completed:	05/19/1993	Purpose:	Observation Well
L.S. Elevation (ft):	1056.2	Well Type:	2 in. - PVC
Depth Drilled (ft):	20.1	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	15.1-19.5		

136-053-26BAB
USGS

Date Completed:		Purpose:	Observation Well
L.S. Elevation (ft):	1061	Well Type:	
Depth Drilled (ft):	12.21	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	5.66-10.66		

136-053-26BAB2
USGS

Date Completed:		Purpose:	Observation Well
L.S. Elevation (ft):	1061	Well Type:	
Depth Drilled (ft):	16.95	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	10.64-15.64		

136-053-29AAA
NDSWC 2207

Date Completed:	10/14/1963	Purpose:	Test Hole
L.S. Elevation (ft):	1066		
Depth Drilled (ft):	147		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Topsoil, very fine sandy loam, black.
1-6	SAND	Sand, very fine and fine, brown, well sorted, rounded, pitted (eolian).
6-10	CLAY	Clay, yellowish-gray, loosely consolidated, highly calcareous, oxidized; fractured.
10-60	SAND	Sand, fine and medium, moderate olive-brown, well sorted, rounded, quartz, shale, lignite, carbonate; dark greenish-gray, unoxidized at 15 feet; fine to coarse from 20 to 60 feet.
60-70	CLAY	Clay, silty, olive-gray, soft, cohesive, calcareous.
70-80	SAND	Sand, medium and coarse, well sorted, rounded.
80-90	CLAY	Clay, silty, olive-gray, soft, plastic, calcareous; silt, clayey with depth.

90-110	SILT	Silt, very sandy, loosely consolidated, calcareous.
110-130	CLAY	Clay, olive-gray, soft, plastic, sticky, slightly calcareous.
130-147	TILL	Clay, silty, sandy, pebbly, olive-gray, moderately cohesive; very pebbly from 140 to 147 feet (Till).

136-053-29AAA2
NDSWC 2207A

Date Completed:	10/14/1963	Purpose:	Observation Well - Destroyed
L.S. Elevation (ft):	1066	Well Type:	4 in. - PVC
Depth Drilled (ft):	63	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	13-23		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Topsoil, clay, silty, black.
1-6	SAND	Sand, very fine and fine, brown, well sorted, rounded, pitted (eolian).
6-63	SAND	Sand, fine to coarse; contains lignite.

136-053-31CCC
NDSWC 13497

Date Completed:	10/12/1995	Purpose:	Test Hole
L.S. Elevation (ft):	1065		
Depth Drilled (ft):	300		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Sandy loam, brown.
1-16	SAND	Sand, very fine and fine, increasing medium sand with depth, oxidized.
16-34	SAND	Sand, very fine to medium, reduced.
34-103	CLAY	Clay, very silty, olive gray (5Y 4/1), soft, sticky, slightly plastic; carbonate rock (drop stone) at 64 ft (lacustrine).
103-170	TILL	Clay, silty, sandy, pebbly, olive gray, slightly firm, slightly sticky, slightly plastic; occasional cobble; rock at 168 ft (till).
170-176	CLAY	Clay, brownish gray (5YR 4/1); probably bedrock block.
176-177	SAND	Sand, indurated; probably bedrock block.
177-210	TILL	Clay, silty, sandy, pebbly, olive gray, slightly firm, slightly sticky, slightly plastic; sand and gravel from 182 to 184; interbedded gravel, less than 1 ft beds, from 192 to 198 ft (till).
210-229	CLAY	Clay, olive gray.
229-230	ROCK	Rock.
230-234	CLAY	Clay, silty, sandy, pebbly, olive gray.
234-249	CLAY	Clay, olive gray.
249-300	SHALE	Clay, slightly silty, brownish black (5 YR 2/1), slightly firm, sticky, plastic, calcareous; waxy appearance; downard gradation to olive black (5Y 2/1), firm, noncalcareous by 290 ft (shale).

APPENDIX I: LITHOLOGIC DATA

136-053-31CCC2
NDSWC 13497B

Date Completed:	10/12/1995	Purpose:	Observation Well
L.S. Elevation (ft):	1065.5	Well Type:	2 in. - PVC
Depth Drilled (ft):	40	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	24-29		

Depth (ft)	Unit	Description
0-1	TOPSOIL	Sandy loam, brown.
1-16	SAND	Sand, very fine and fine, medium sand with depth, oxidized.
16-35	SAND	Sand, very fine to medium, reduced.
35-40	CLAY	Clay, silty, olive gray, soft, sticky, slightly plastic.

136-053-33ADD
NDSWC 8468

Date Completed:	08/01/1972	Purpose:	Observation Well
L.S. Elevation (ft):	1060	Well Type:	1.25 in. - PVC
Depth Drilled (ft):	140	Aquifer:	Sheyenne Delta
Screen Int. (ft.):	70-73		

Depth (ft)	Unit	Description
0-8	SAND	Sand, fine, silty, brown.
8-11	SILT	Silt, sandy, gray.
11-28	SAND	Sand, fine and medium, gray, quartz, shale.
28-30	SILT	Silt, clayey, sandy, gray.
30-37	SAND	Sand, medium, gray.
37-57	SILT	Silt, clayey, sandy, gray; interbedded sand from 37 to 48 feet; slightly sandy from 48 to 57 feet.
57-73	SAND	Sand, fine and medium, silty, gray.
73-95	SILT	Silt, clayey, slightly sandy, gray.
95-140	TILL	Clay, silty, sandy, pebbly, gray; very sandy, very pebbly from 95 to 97 feet (Till).

APPENDIX II: WATER-LEVEL DATA

136-052-03AAA2 **MP Elev (msl,ft)=1,051.30**
Sheyenne Delta Aquifer **SI (ft.)=23-26**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
11/20/95	2.15	1047.55	05/11/98	1.75	1047.95	05/17/01	1.64	1048.06
			07/14/98	1.34	1048.36	06/14/01	0.87	1048.83
04/30/96	1.30	1048.40	08/25/98	3.34	1046.36	07/20/01	1.41	1048.29
06/05/96	1.48	1048.22	10/13/98	2.99	1046.71	08/16/01	3.02	1046.68
07/16/96	3.58	1046.12	12/01/98	1.33	1048.37	09/13/01	4.03	1045.67
08/15/96	4.46	1045.24				09/19/01	3.70	1046.00
10/08/96	4.55	1045.15	05/24/99	1.72	1047.98	10/12/01	3.62	1046.08
12/09/96	4.31	1045.39	06/24/99	2.65	1047.05	11/14/01	6.68	1044.62
			07/22/99	3.73	1045.97	12/03/01	5.28	1046.02
05/29/97	1.60	1048.10	08/31/99	4.42	1045.28			
07/10/97	2.37	1047.33	10/05/99	2.60	1047.10	05/16/02	4.11	1047.19
08/14/97	4.27	1045.43	11/02/99	2.97	1046.73	06/27/02	5.17	1046.13
09/18/97	4.45	1045.25	12/07/99	3.49	1046.21	08/06/02	4.80	1046.50
10/16/97	4.01	1045.69				09/17/02	6.85	1044.45
11/20/97	4.41	1045.29	05/17/00	2.28	1047.42	11/05/02	7.09	1044.21
12/15/97	4.42	1045.28	08/17/00	3.39	1046.31			

136-052-06BBB2 **MP Elev (msl,ft)=1,058.34**
Sheyenne Delta Aquifer **SI (ft.)=40-43**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/15/96	5.59	1052.45	12/03/01	4.72	1053.32	07/11/06	6.82	1051.52
10/08/96	6.24	1051.80				08/07/06	6.55	1051.79
12/09/96	5.65	1052.39	05/16/02	4.06	1053.98	08/21/06	6.60	1051.74
			06/27/02	5.51	1052.53	09/06/06	5.13	1053.21
05/29/97	2.98	1055.06	08/06/02	8.93	1049.11	10/10/06	5.53	1052.81
07/10/97	4.06	1053.98	09/17/02	7.68	1050.36	11/06/06	5.72	1052.62
08/14/97	6.69	1051.35	11/05/02	6.48	1051.56	12/14/06	5.70	1052.64
09/18/97	6.82	1051.22	12/09/02	7.13	1050.91	12/21/06	7.03	1051.31
10/16/97	5.68	1052.36						
11/20/97	6.00	1052.04	05/06/03	3.90	1054.14	01/03/07	6.59	1051.75
12/15/97	5.68	1052.36	06/03/03	4.88	1053.16	05/15/07	3.42	1054.92
			07/08/03	4.97	1053.07	06/12/07	3.93	1054.41
05/11/98	3.27	1054.77	08/05/03	7.25	1050.79	07/17/07	4.58	1053.76
07/14/98	2.90	1055.14	09/02/03	8.30	1049.74	08/14/07	6.69	1051.65
08/25/98	5.85	1052.19	09/30/03	8.61	1049.43	09/11/07	6.39	1051.95
10/13/98	5.03	1053.01	11/03/03	8.36	1049.98	10/16/07	5.99	1052.35
12/01/98	2.99	1055.05	12/02/03	8.51	1049.83	11/13/07	5.82	1052.52
05/24/99	2.73	1055.31	05/04/04	7.12	1051.22	05/05/08	3.98	1054.36
06/24/99	3.50	1054.54	06/07/04	4.22	1054.12	06/03/08	3.84	1054.50
07/22/99	6.04	1052.00	07/13/04	4.54	1053.80	07/11/08	3.85	1054.49
08/31/99	6.01	1052.03	08/10/04	7.38	1050.96	08/04/08	6.50	1051.84
10/05/99	4.36	1053.68	08/31/04	8.13	1050.21	09/10/08	6.51	1051.83
11/02/99	4.62	1053.42	10/12/04	6.86	1051.48	10/06/08	4.99	1053.35
12/07/99	5.42	1052.62	11/08/04	4.79	1053.55	11/03/08	3.58	1054.76
			12/07/04	5.79	1052.55			
05/17/00	4.07	1053.97				05/18/09	2.84	1055.50
08/17/00	5.29	1052.75	04/12/05	4.45	1053.89	06/09/09	3.14	1055.20
11/27/00	3.18	1054.86	05/03/05	5.75	1052.59	07/14/09	4.21	1054.13
			06/01/05	5.37	1052.97	08/10/09	5.70	1052.64
05/17/01	2.54	1055.50	07/05/05	3.49	1054.85	09/15/09	4.99	1053.35

06/14/01	2.42	1055.62	08/09/05	6.74	1051.60	10/13/09	3.55	1054.79
07/20/01	3.02	1055.02	09/06/05	3.93	1054.41	11/09/09	3.05	1055.29
08/16/01	5.53	1052.51	10/03/05	6.46	1051.88			
09/13/01	6.15	1051.89	11/08/05	5.61	1052.73	05/17/10	2.62	1055.72
09/19/01	5.40	1052.64				06/14/10	3.55	1054.79
10/12/01	3.58	1054.46	04/26/06	3.53	1054.81	07/19/10	3.46	1054.88
11/14/01	4.83	1053.21	06/06/06	4.61	1053.73			

136-052-07BBB **MP Elev (msl,ft)=1,063.11**
Sheyenne Delta Aquifer **SI (ft.)=5-15**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/14/06	8.05	1055.06				07/14/09	5.89	1057.22
12/21/06	8.36	1054.75	05/05/08	5.63	1057.48	08/10/09	6.70	1056.41
			06/03/08	5.91	1057.20	09/15/09	6.55	1056.56
01/03/07	7.96	1055.15	07/11/08	6.64	1056.47	10/13/09	4.76	1058.35
05/15/07	5.00	1058.11	08/04/08	8.51	1054.60	11/09/09	4.15	1058.96
06/12/07	5.87	1057.24	09/10/08	8.17	1054.94			
07/17/07	6.64	1056.47	10/06/08	7.33	1055.78	05/17/10	3.55	1059.56
08/14/07	8.48	1054.63	11/03/08	5.34	1057.77	06/14/10	4.48	1058.63
09/11/07	8.43	1054.68				07/19/10	4.64	1058.47
10/16/07	7.89	1055.22	05/18/09	3.69	1059.42	11/13/07	7.51	1055.60
06/09/09	4.04	1059.07						

136-052-09ADDD **MP Elev (msl,ft)=1,059.15**
Sheyenne Delta Aquifer **SI (ft.)=7.9-12.3**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/21/06	8.45	1050.70				07/14/09	7.07	1052.08
			05/05/08	6.18	1052.97	08/10/09	7.53	1051.62
01/03/07	8.75	1050.40	06/03/08	6.61	1052.54	09/15/09	8.15	1051.00
05/15/07	5.20	1053.95	07/11/08	6.32	1052.83	10/13/09	6.19	1052.96
06/12/07	5.54	1053.61	08/04/08	8.24	1050.91	11/09/09	5.03	1054.12
06/28/07	5.85	1053.30	09/10/08	8.36	1050.79			
07/17/07	6.72	1052.43	10/06/08	7.61	1051.54	05/17/10	3.99	1055.16
08/14/07	8.50	1050.65	11/03/08	5.34	1053.81	06/14/10	5.57	1053.58
09/11/07	8.73	1050.42				07/19/10	5.18	1053.97
10/16/07	8.58	1050.57	05/18/09	4.23	1054.92	11/13/07	8.10	1051.05
06/09/09	4.72	1054.43						

136-052-12CBB **MP Elev (msl,ft)=1,053.08**
Sheyenne Delta Aquifer **SI (ft.)=37-40**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
11/20/95	7.80	1045.28	09/13/01	8.40	1044.68	04/26/06	7.71	1045.37
			09/19/01	8.25	1044.83	06/06/06	8.01	1045.07
04/30/96	7.10	1045.98	10/12/01	7.57	1045.51	07/11/06	8.49	1044.59
06/05/96	7.45	1045.63	11/14/01	7.58	1045.50	08/07/06	8.86	1044.22
07/16/96	8.10	1044.98	12/03/01	7.60	1045.48	08/21/06	9.00	1044.08
08/15/96	8.30	1044.78				09/06/06	8.61	1044.47
09/25/96	8.72	1044.36	05/16/02	7.17	1045.91	10/10/06	8.47	1044.61
10/08/96	8.06	1045.02	06/27/02	8.26	1044.82	11/06/06	8.44	1044.64

12/09/96	7.96	1045.12	08/06/02	8.63	1044.45	12/14/06	8.42	1044.66
			09/17/02	9.01	1044.07	12/21/06	8.39	1044.69
05/29/97	6.88	1046.20	11/05/02	8.79	1044.29			
07/10/97	7.38	1045.70	12/09/02	8.79	1044.29	01/03/07	8.41	1044.67
08/14/97	8.10	1044.98				05/15/07	7.54	1045.54
09/18/97	7.89	1045.19	05/06/03	8.31	1044.77	06/12/07	7.52	1045.56
10/16/97	7.57	1045.51	06/03/03	8.30	1044.78	07/17/07	8.30	1044.78
11/20/97	7.71	1045.37	07/08/03	8.09	1044.99	08/14/07	8.80	1044.28
12/15/97	7.69	1045.39	08/05/03	8.74	1044.34	09/11/07	8.91	1044.17
			09/02/03	9.17	1043.91	10/16/07	8.57	1044.51
05/11/98	7.74	1045.34	09/30/03	9.36	1043.72	11/13/07	8.42	1044.66
07/14/98	7.41	1045.67	11/03/03	9.20	1043.88			
08/25/98	8.54	1044.54	12/02/03	9.09	1043.99	05/05/08	7.78	1045.30
10/13/98	8.02	1045.06				06/03/08	8.06	1045.02
12/01/98	7.49	1045.59	05/04/04	8.65	1044.43	07/11/08	7.96	1045.12
			06/07/04	7.73	1045.35	08/04/08	8.51	1044.57
05/24/99	7.58	1045.50	07/13/04	7.59	1045.49	09/10/08	8.50	1044.58
06/24/99	7.45	1045.63	08/10/04	8.54	1044.54	10/06/08	8.39	1044.69
07/22/99	7.87	1045.21	08/31/04	8.82	1044.26	11/03/08	7.68	1045.40
08/31/99	8.17	1044.91	10/12/04	7.92	1045.16			
10/05/99	7.93	1045.15	11/08/04	7.71	1045.37	05/18/09	7.05	1046.03
11/02/99	7.93	1045.15	12/07/04	8.25	1044.83	06/09/09	7.51	1045.57
12/07/99	7.75	1045.33				07/14/09	8.10	1044.98
			04/12/05	7.97	1045.11	08/10/09	8.29	1044.79
05/17/00	6.87	1046.21	05/03/05	8.13	1044.95	09/15/09	8.54	1044.54
08/17/00	8.34	1044.74	06/01/05	8.12	1044.96	10/13/09	7.79	1045.29
11/27/00	7.45	1045.63	07/05/05	7.21	1045.87	11/09/09	7.31	1045.77
			08/09/05	8.61	1044.47			
05/17/01	7.02	1046.06	09/06/05	7.64	1045.44	05/17/10	6.74	1046.34
06/14/01	5.97	1047.11	10/03/05	8.43	1044.65	05/24/10	7.03	1046.05
07/20/01	5.81	1047.27	11/08/05	8.27	1044.81	08/16/01	7.98	1045.10

136-052-14CBBC **MP Elev (msl,ft)=1,059.66**
Sheyenne Delta Aquifer **Sl (ft.)=6.6-11**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/21/06	10.12	1049.54				07/14/09	7.78	1051.88
			05/05/08	7.74	1051.92	08/10/09	8.34	1051.32
01/03/07	10.15	1049.51	06/03/08	8.20	1051.46	09/15/09	9.29	1050.37
05/15/07	7.02	1052.64	07/11/08	8.23	1051.43	10/13/09	7.25	1052.41
06/12/07	7.12	1052.54	08/04/08	9.77	1049.89	11/09/09	6.28	1053.38
06/28/07	7.52	1052.14	09/10/08	10.05	1049.61			
07/17/07	8.44	1051.22	10/06/08	9.96	1049.70	05/17/10	5.90	1053.76
08/14/07	10.07	1049.59	11/03/08	7.57	1052.09	06/14/10	7.44	1052.22
09/11/07	10.58	1049.08				07/19/10	7.79	1051.87
10/16/07	9.92	1049.74	05/18/09	5.80	1053.86	11/13/07	9.60	1050.06
06/09/09	6.17	1053.49						

136-052-15DCC **MP Elev (msl,ft)=1,059.04**
Sheyenne Delta Aquifer **Sl (ft.)=39-44**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/21/06	8.24	1050.80				06/09/09	4.64	1054.40
			05/05/08	5.88	1053.16	07/14/09	5.99	1053.05
01/03/07	8.04	1051.00	06/03/08	5.25	1053.79	08/10/09	6.04	1053.00
05/15/07	4.98	1054.06	07/11/08	5.82	1053.22	09/15/09	6.60	1052.44

06/12/07	5.38	1053.66	08/04/08	7.49	1051.55	10/13/09	5.41	1053.63
07/17/07	6.00	1053.04	09/10/08	7.81	1051.23	11/09/09	4.90	1054.14
08/14/07	7.79	1051.25	10/06/08	7.44	1051.60			
09/11/07	8.15	1050.89	11/03/08	5.56	1053.48	05/17/10	4.61	1054.43
10/16/07	7.81	1051.23				06/14/10	5.59	1053.45
11/13/07	7.44	1051.60	05/18/09	4.01	1055.03	07/19/10	5.30	1053.74

136-052-17DAD **MP Elev (msl,ft)=1,059.94**
Sheyenne Delta Aquifer **SI (ft.)=77-82**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/15/06	6.06	1053.88				07/14/09	3.68	1056.26
12/21/06	6.51	1053.43	05/05/08	3.96	1055.98	08/10/09	3.42	1056.52
			06/03/08	3.23	1056.71	09/15/09	4.72	1055.22
01/03/07	6.08	1053.86	07/10/08	4.49	1055.45	10/13/09	3.02	1056.92
05/15/07	3.23	1056.71	08/04/08	5.87	1054.07	11/09/09	2.63	1057.31
06/12/07	3.20	1056.74	09/10/08	5.70	1054.24			
07/17/07	3.70	1056.24	10/06/08	4.24	1055.70	05/17/10	1.90	1058.04
08/14/07	5.76	1054.18	11/03/08	3.18	1056.76	06/14/10	2.79	1057.15
09/11/07	5.75	1054.19				07/19/10	2.70	1057.24
10/16/07	5.71	1054.23	05/18/09	2.02	1057.92	11/13/07	5.59	1054.35
06/09/09	2.49	1057.45						

136-052-19DCB **MP Elev (msl,ft)=1,058.62**
Undefined Aquifer **SI (ft.)=215-230**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/14/06	19.68	1038.94	10/16/07	19.51	1039.11	11/03/08	19.32	1039.30
12/21/06	19.68	1038.94	11/13/07	19.48	1039.14			
						06/09/09	18.61	1040.01
01/03/07	19.50	1039.12	05/05/08	19.55	1039.07	07/14/09	18.61	1040.01
05/15/07	19.32	1039.30	06/03/08	19.48	1039.14	09/15/09	18.81	1039.81
06/12/07	19.26	1039.36	07/10/08	19.39	1039.23	10/13/09	18.72	1039.90
07/17/07	19.28	1039.34	08/04/08	19.57	1039.05	11/09/09	18.53	1040.09
08/14/07	19.50	1039.12	09/10/08	19.63	1038.99	09/11/07	19.60	1039.02
10/06/08	19.58	1039.04						

136-052-19DCB2 **MP Elev (msl,ft)=1,058.57**
Sheyenne Delta Aquifer **SI (ft.)=75-90**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/14/06	8.32	1050.25	10/16/07	7.85	1050.72	11/03/08	6.27	1052.30
12/21/06	8.37	1050.20	11/13/07	7.81	1050.76			
						06/09/09	3.18	1055.39
01/03/07	8.34	1050.23	05/05/08	7.28	1051.29	07/14/09	4.72	1053.85
05/15/07	6.06	1052.51	06/03/08	7.27	1051.30	09/15/09	5.67	1052.90
06/12/07	5.92	1052.65	07/10/08	7.11	1051.46	10/13/09	4.48	1054.09
07/17/07	6.60	1051.97	08/04/08	7.68	1050.89	11/09/09	3.79	1054.78
08/14/07	7.73	1050.84	09/10/08	7.60	1050.97	09/11/07	7.90	1050.67
10/06/08	7.73	1050.84						

APPENDIX II: WATER-LEVEL DATA

136-052-19DCB3 **MP Elev (msl,ft)=1,058.56**
Sheyenne Delta Aquifer **SI (ft.)=50-55**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/14/06	8.10	1050.46	10/16/07	7.55	1051.01	11/03/08	6.01	1052.55
12/21/06	8.16	1050.40	11/13/07	7.59	1050.97			
						06/09/09	3.15	1055.41
01/03/07	8.10	1050.46	05/05/08	6.97	1051.59	07/14/09	4.01	1054.55
05/15/07	5.91	1052.65	06/03/08	6.78	1051.78	09/15/09	5.69	1052.87
06/12/07	5.87	1052.69	07/10/08	7.02	1051.54	10/13/09	4.20	1054.36
07/17/07	6.27	1052.29	08/04/08	7.53	1051.03	11/09/09	3.57	1054.99
08/14/07	7.56	1051.00	09/10/08	7.30	1051.26	09/11/07	7.62	1050.94
10/06/08	7.23	1051.33						

136-052-19DCD **MP Elev (msl,ft)=1,056.46**
Sheyenne Delta Aquifer **SI (ft.)=40-55**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/21/06	7.72	1048.74	11/13/07	7.19	1049.27			
						05/18/09	0.89	1055.57
01/03/07	7.77	1048.69	05/05/08	6.92	1049.54	06/09/09	1.44	1055.02
05/15/07	5.50	1050.96	06/03/08	6.90	1049.56	07/14/09	3.26	1053.20
06/12/07	5.37	1051.09	07/10/08	6.41	1050.05	08/10/09	5.54	1050.92
07/17/07	5.65	1050.81	08/04/08	6.84	1049.62	09/15/09	5.13	1051.33
08/14/07	6.75	1049.71	09/10/08	7.29	1049.17	10/13/09	4.16	1052.30
09/11/07	7.29	1049.17	10/06/08	7.35	1049.11	11/09/09	3.46	1053.00
10/16/07	7.37	1049.09	11/03/08	5.98	1050.48			

136-052-19DDC **MP Elev (msl,ft)=1,058.01**
Sheyenne Delta Aquifer **SI (ft.)=0-51**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/21/06	9.34	1048.67	10/16/07	8.95	1049.06	11/03/08	7.59	1050.42
			11/13/07	8.77	1049.24			
01/03/07	9.39	1048.62				05/18/09	2.39	1055.62
05/15/07	7.03	1050.98	05/05/08	8.48	1049.53	06/09/09	3.11	1054.90
06/12/07	6.88	1051.13	06/03/08	8.51	1049.50	07/14/09	4.81	1053.20
06/28/07	7.00	1051.01	07/10/08	7.95	1050.06	09/15/09	6.66	1051.35
07/17/07	7.30	1050.71	08/04/08	8.36	1049.65	10/13/09	5.75	1052.26
08/14/07	8.27	1049.74	09/10/08	8.88	1049.13	11/09/09	5.11	1052.90
09/11/07	8.82	1049.19	10/06/08	8.97	1049.04			

136-052-21DCCC **MP Elev (msl,ft)=1,060.57**
Sheyenne Delta Aquifer **SI (ft.)=9.9-14.3**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/21/06	10.48	1050.09				07/14/09	6.81	1053.76
			05/05/08	8.88	1051.69	08/10/09	6.89	1053.68

01/03/07	10.52	1050.05	06/03/08	8.75	1051.82	09/15/09	7.33	1053.24
05/15/07	7.86	1052.71	07/10/08	8.16	1052.41	10/13/09	6.11	1054.46
06/12/07	7.34	1053.23	08/04/08	9.05	1051.52	11/09/09	5.51	1055.06
06/28/07	7.32	1053.25	09/10/08	9.50	1051.07			
07/17/07	8.05	1052.52	10/06/08	9.78	1050.79	05/17/10	5.03	1055.54
08/14/07	9.18	1051.39	11/03/08	8.10	1052.47	06/14/10	6.39	1054.18
09/11/07	9.68	1050.89				07/19/10	6.56	1054.01
10/16/07	9.37	1051.20	05/18/09	5.64	1054.93	11/13/07	9.15	1051.42
06/09/09	5.69	1054.88						

136-052-22CCC **MP Elev (msl,ft)=1,057.81**
Sheyenne Delta Aquifer **SI (ft.)=38-41**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
11/20/95	6.98	1050.83	09/13/01	6.56	1051.25			
			09/19/01	6.30	1051.51	04/26/06	5.78	1052.03
04/30/96	7.27	1050.54	10/12/01	5.45	1052.36	06/06/06	5.84	1051.97
06/05/96	5.75	1052.06	11/14/01	6.28	1051.53	07/11/06	7.23	1050.58
07/16/96	6.90	1050.91	12/03/01	6.42	1051.39	08/07/06	8.15	1049.66
08/15/96	7.73	1050.08				08/21/06	8.44	1049.37
10/08/96	8.34	1049.47	05/16/02	5.81	1052.00	09/06/06	8.00	1049.81
12/09/96	8.35	1049.46	06/27/02	6.53	1051.28	10/10/06	8.67	1049.14
			08/06/02	7.32	1050.49	11/06/06	8.76	1049.05
05/29/97	4.92	1052.89	09/17/02	8.28	1049.53	12/14/06	8.90	1048.91
07/10/97	5.89	1051.92	11/05/02	8.73	1049.08	12/21/06	8.97	1048.84
08/14/97	5.29	1052.52	12/09/02	8.88	1048.93			
09/18/97	7.73	1050.08				01/03/07	9.01	1048.80
10/16/97	7.56	1050.25	05/06/03	8.53	1049.28	05/15/07	6.47	1051.34
11/20/97	7.94	1049.87	06/03/03	7.56	1050.25	06/12/07	5.85	1051.96
12/15/97	8.05	1049.76	07/08/03	7.20	1050.61	07/17/07	6.31	1051.50
			08/05/03	8.12	1049.69	08/14/07	7.53	1050.28
05/11/98	6.43	1051.38	09/02/03	8.96	1048.85	09/11/07	8.13	1049.68
07/14/98	3.04	1054.77	09/30/03	9.51	1048.30	10/16/07	8.06	1049.75
08/25/98	6.50	1051.31	11/03/03	9.80	1048.01	11/13/07	7.88	1049.93
10/13/98	6.34	1051.47	12/02/03	9.95	1047.86			
12/01/98	4.83	1052.98				05/05/08	7.31	1050.50
			05/04/04	9.47	1048.34	06/03/08	7.25	1050.56
05/24/99	4.98	1052.83	06/07/04	8.32	1049.49	07/10/08	6.71	1051.10
06/24/99	5.39	1052.42	07/13/04	8.03	1049.78	08/04/08	7.43	1050.38
07/22/99	6.33	1051.48	08/10/04	8.71	1049.10	09/10/08	7.90	1049.91
08/31/99	6.78	1051.03	08/31/04	9.13	1048.68	10/06/08	8.21	1049.60
10/05/99	5.66	1052.15	10/12/04	8.70	1049.11	11/03/08	6.86	1050.95
11/02/99	6.03	1051.78	11/08/04	8.02	1049.79			
12/07/99	6.47	1051.34	12/07/04	8.14	1049.67	05/18/09	3.33	1054.48
						06/09/09	3.91	1053.90
05/17/00	5.59	1052.22	04/12/05	8.79	1049.02	07/14/09	5.14	1052.67
08/17/00	6.91	1050.90	05/03/05	8.15	1049.66	08/10/09	5.39	1052.42
11/27/00	5.23	1052.58	06/01/05	8.08	1049.73	09/15/09	5.88	1051.93
			07/05/05	5.71	1052.10	10/13/09	4.78	1053.03
05/17/01	3.11	1054.70	08/09/05	7.19	1050.62	11/09/09	3.47	1054.34
06/14/01	3.09	1054.72	09/06/05	6.80	1051.01			
07/20/01	3.50	1054.31	10/03/05	7.51	1050.30	05/17/10	2.45	1055.36
08/16/01	6.06	1051.75	11/08/05	7.18	1050.63	05/24/10	2.43	1055.38

APPENDIX II: WATER-LEVEL DATA

136-052-22DDD2 **MP Elev (msl,ft)=1,051.72**
Sheyenne Delta Aquifer **SI (ft.)=33-38**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
01/03/96	5.93	1045.79	08/22/06	7.33	1044.39	09/10/08	6.85	1044.87
			12/21/06	7.51	1044.21	10/06/08	7.00	1044.72
06/18/99	4.51	1047.21				11/03/08	5.39	1046.33
08/19/99	5.47	1046.25	01/03/07	7.43	1044.29			
			05/15/07	4.84	1046.88	05/18/09	3.58	1048.14
10/11/05	5.07	1046.65	06/12/07	5.23	1046.49	06/09/09	3.68	1048.04
11/08/05	5.49	1046.23	07/17/07	5.63	1046.09	07/14/09	4.99	1046.73
12/12/05	5.57	1046.15	08/14/07	6.79	1044.93	07/27/09	5.50	1046.22
12/22/05	5.57	1046.15	09/11/07	6.97	1044.75	08/10/09	5.10	1046.62
			10/16/07	7.12	1044.60	09/15/09	6.06	1045.66
01/18/06	5.19	1046.53	11/13/07	6.89	1044.83	10/13/09	4.72	1047.00
03/07/06	5.70	1046.02				11/09/09	4.01	1047.71
04/26/06	4.39	1047.33	05/05/08	5.54	1046.18			
05/22/06	4.30	1047.42	06/03/08	5.94	1045.78	05/17/10	3.18	1048.54
07/07/06	6.17	1045.55	07/11/08	5.73	1045.99	06/14/10	4.28	1047.44
07/27/06	6.73	1044.99	08/04/08	6.79	1044.93	07/19/10	4.33	1047.39

136-052-29BBB **MP Elev (msl,ft)=1,063.26**
Sheyenne Delta Aquifer **SI (ft.)=47-50**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
11/20/95	15.63	1047.63	08/16/01	13.03	1050.23	10/03/05	16.43	1046.83
			09/13/01	14.14	1049.12	11/08/05	16.39	1046.87
04/30/96	13.76	1049.50	09/19/01	14.75	1048.51			
06/05/96	12.40	1050.86	10/12/01	14.60	1048.66	04/26/06	14.41	1048.85
07/16/96	14.55	1048.71	11/14/01	12.70	1050.56	06/06/06	14.57	1048.69
08/15/96	15.33	1047.93	12/03/01	12.68	1050.58	07/11/06	15.70	1047.56
10/08/96	16.16	1047.10				08/07/06	14.54	1048.72
12/09/96	15.78	1047.48	05/16/02	13.49	1049.77	08/21/06	16.80	1046.46
			06/27/02	15.50	1047.76	09/06/06	16.78	1046.48
05/29/97	11.32	1051.94	08/06/02	15.26	1048.00	10/10/06	17.09	1046.17
07/10/97	12.93	1050.33	09/17/02	16.20	1047.06	11/06/06	17.13	1046.13
08/14/97	13.96	1049.30	11/05/02	16.42	1046.84	12/14/06	16.95	1046.31
09/18/97	14.72	1048.54	12/09/02	16.74	1046.52	12/21/06	16.90	1046.36
10/16/97	15.18	1048.08						
11/20/97	15.15	1048.11	05/06/03	16.63	1046.63	01/03/07	16.91	1046.35
12/15/97	15.27	1047.99	06/03/03	16.40	1046.86	05/15/07	15.13	1048.13
			07/08/03	15.85	1047.41	06/12/07	15.54	1047.72
05/11/98	13.88	1049.38	08/05/03	16.56	1046.70	07/17/07	15.90	1047.36
07/14/98	9.86	1053.40	09/02/03	17.36	1045.90	08/14/07	16.62	1046.64
08/25/98	12.18	1051.08	09/30/03	17.60	1045.66	09/11/07	16.89	1046.37
10/13/98	12.91	1050.35	11/03/03	17.88	1045.38	10/16/07	17.08	1046.18
12/01/98	11.25	1052.01	12/02/03	17.69	1045.57	11/13/07	16.98	1046.28
05/24/99	9.90	1053.36	05/04/04	17.42	1045.84	05/05/08	16.87	1046.39
06/24/99	11.70	1051.56	06/07/04	17.62	1045.64	06/03/08	16.87	1046.39
07/22/99	12.27	1050.99	07/13/04	16.75	1046.51	07/10/08	16.18	1047.08
08/31/99	12.51	1050.75	08/10/04	17.40	1045.86	08/04/08	16.82	1046.44
10/05/99	11.70	1051.56	08/31/04	18.03	1045.23	09/10/08	17.22	1046.04
11/02/99	11.94	1051.32	10/12/04	17.91	1045.35	10/06/08	17.29	1045.97
12/07/99	12.83	1050.43	11/08/04	17.85	1045.41	11/03/08	15.83	1047.43
			12/07/04	17.41	1045.85			

05/17/00	12.49	1050.77				05/18/09	11.04	1052.22
08/17/00	13.71	1049.55	04/12/05	17.39	1045.87	06/09/09	11.87	1051.39
11/27/00	13.33	1049.93	05/03/05	17.22	1046.04	07/14/09	13.65	1049.61
			06/01/05	16.83	1046.43	08/10/09	14.54	1048.72
05/17/01	10.48	1052.78	07/05/05	15.26	1048.00	09/15/09	15.13	1048.13
06/14/01	11.51	1051.75	08/09/05	15.84	1047.42	10/13/09	14.98	1048.28
07/20/01	12.32	1050.94	09/06/05	15.97	1047.29			

136-052-29BBB2 **MP Elev (msl,ft)=1,063.78**
Undefined Aquifer **SI (ft.)=212-217**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/27/09	24.92	1038.86				06/14/10	24.32	1039.46
11/09/09	25.00	1038.78	05/17/10	24.25	1039.53	07/19/10	24.28	1039.50

136-052-29BBB3 **MP Elev (msl,ft)=1,063.68**
Sheyenne Delta Aquifer **SI (ft.)=49-54**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/27/09	15.05	1048.63				06/14/10	12.19	1051.49
11/09/09	15.14	1048.54	05/17/10	10.63	1053.05	07/19/10	12.62	1051.06

136-052-29DDD **MP Elev (msl,ft)=1,056.08**
Sheyenne Delta Aquifer **SI (ft.)=67-70**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
11/20/95	22.08	1034.00	07/22/99	22.47	1033.61			
			08/31/99	22.34	1033.74	05/06/03	20.64	1035.44
04/30/96	22.00	1034.08	10/05/99	18.48	1037.60	06/03/03	20.48	1035.60
06/05/96	21.40	1034.68	11/02/99	18.41	1037.67	07/08/03	30.10	1025.98
07/16/96	21.34	1034.74	12/07/99	18.38	1037.70	08/05/03	38.28	1017.80
08/27/96	21.86	1034.22				09/02/03	37.25	1018.83
10/08/96	21.72	1034.36	05/17/00	18.27	1037.81	09/30/03	22.22	1033.86
12/09/96	21.34	1034.74	08/17/00	38.61	1017.47	11/03/03	21.80	1034.28
			11/27/00	18.81	1037.27	12/02/03	21.66	1034.42
05/29/97	21.34	1034.74						
07/10/97	21.25	1034.83	05/17/01	17.76	1038.32	05/04/04	21.48	1034.60
08/14/97	21.42	1034.66	06/14/01	17.54	1038.54	06/07/04	21.28	1034.80
09/18/97	21.59	1034.49	07/20/01	19.49	1036.59	07/13/04	21.61	1034.47
10/16/97	21.59	1034.49	08/16/01	18.16	1037.92	08/10/04	23.63	1032.45
11/20/97	21.52	1034.56	09/13/01	18.34	1037.74	08/31/04	22.51	1033.57
12/15/97	21.55	1034.53	10/12/01	18.27	1037.81	10/12/04	21.94	1034.14
			11/14/01	18.36	1037.72	11/08/04	21.71	1034.37
05/11/98	21.36	1034.72	12/03/01	18.42	1037.66	12/07/04	21.50	1034.58
07/14/98	20.00	1036.08						
08/25/98	20.13	1035.95	05/16/02	18.80	1037.28	04/12/05	21.30	1034.78
10/13/98	19.73	1036.35	06/27/02	19.43	1036.65	05/03/05	21.25	1034.83
12/01/98	19.34	1036.74	08/06/02	23.42	1032.66	06/01/05	21.22	1034.86
			09/17/02	20.65	1035.43	07/05/05	20.54	1035.54
05/24/99	17.93	1038.15	11/05/02	20.38	1035.70	06/24/99	22.34	1033.74
12/09/02	20.40	1035.68						

APPENDIX II: WATER-LEVEL DATA

136-052-29DDD2 **MP Elev (msl,ft)=1,055.42**
Sheyenne Delta Aquifer **SI (ft.)=58-63**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/09/05	30.75	1024.67				10/06/08	21.24	1034.18
09/01/05	20.25	1035.17	01/03/07	20.55	1034.87	11/03/08	20.62	1034.80
09/06/05	20.72	1034.70	05/15/07	20.02	1035.40			
10/03/05	20.52	1034.90	06/12/07	19.87	1035.55	05/18/09	18.69	1036.73
11/08/05	20.20	1035.22	07/17/07	22.02	1033.40	06/09/09	18.59	1036.83
			08/14/07	21.81	1033.61	07/14/09	18.41	1037.01
04/26/06	19.52	1035.90	09/11/07	21.51	1033.91	08/10/09	19.90	1035.52
06/06/06	19.22	1036.20	10/16/07	20.88	1034.54	09/15/09	19.78	1035.64
07/11/06	36.82	1018.60	11/13/07	20.69	1034.73	10/13/09	19.18	1036.24
08/07/06	36.46	1018.96				11/09/09	18.83	1036.59
09/06/06	21.60	1033.82	05/05/08	20.53	1034.89			
10/10/06	20.91	1034.51	06/03/08	20.47	1034.95	05/17/10	17.19	1038.23
11/06/06	20.71	1034.71	07/10/08	27.61	1027.81	06/14/10	17.08	1038.34
12/14/06	20.61	1034.81	08/04/08	36.37	1019.05	07/19/10	17.05	1038.37
12/21/06	20.62	1034.80	09/10/08	21.81	1033.61			

136-052-30DDD **MP Elev (msl,ft)=1,058.02**
Sheyenne Delta Aquifer **SI (ft.)=52-55**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
11/20/95	15.48	1042.54	09/13/01	11.92	1046.10	11/08/05	14.62	1043.40
			09/19/01	11.88	1046.14			
04/30/96	15.92	1042.10	10/12/01	11.86	1046.16	04/26/06	13.80	1044.22
06/05/96	14.39	1043.63	11/14/01	12.13	1045.89	06/06/06	13.54	1044.48
07/16/96	14.70	1043.32				07/11/06	14.02	1044.00
08/15/96	14.94	1043.08	05/16/02	12.28	1045.74	08/07/06	14.14	1043.88
10/08/96	15.31	1042.71	06/27/02	12.92	1045.10	08/21/06	14.42	1043.60
			08/06/02	13.08	1044.94	09/06/06	14.55	1043.47
05/29/97	13.50	1044.52	09/17/02	13.47	1044.55	10/10/06	14.70	1043.32
07/10/97	13.84	1044.18	11/05/02	13.83	1044.19	11/06/06	14.88	1043.14
08/14/97	14.20	1043.82	12/09/02	14.00	1044.02	12/14/06	15.07	1042.95
09/18/97	14.33	1043.69				12/21/06	14.91	1043.11
10/16/97	14.56	1043.46	05/06/03	14.71	1043.31			
11/20/97	14.68	1043.34	06/03/03	14.04	1043.98	01/03/07	15.19	1042.83
12/15/97	14.78	1043.24	07/08/03	13.56	1044.46	05/15/07	14.16	1043.86
			08/05/03	14.05	1043.97	06/12/07	14.21	1043.81
05/11/98	13.84	1044.18	09/02/03	14.38	1043.64	07/17/07	14.17	1043.85
07/14/98	11.94	1046.08	09/30/03	14.69	1043.33	08/14/07	14.52	1043.50
08/25/98	12.70	1045.32	11/03/03	14.93	1043.09	09/11/07	14.79	1043.23
10/13/98	12.95	1045.07	12/02/03	15.12	1042.90	10/16/07	14.93	1043.09
						11/13/07	15.03	1042.99
05/24/99	11.42	1046.60	05/04/04	15.46	1042.56			
06/24/99	11.92	1046.10	06/07/04	15.26	1042.76	05/05/08	15.38	1042.64
07/22/99	12.18	1045.84	07/13/04	15.21	1042.81	06/03/08	15.29	1042.73
08/31/99	12.13	1045.89	08/10/04	15.48	1042.54	07/10/08	14.41	1043.61
10/05/99	11.59	1046.43	08/31/04	15.65	1042.37	08/04/08	14.72	1043.30
11/02/99	11.80	1046.22	10/12/04	15.64	1042.38	09/10/08	14.98	1043.04
12/07/99	12.05	1045.97	11/08/04	15.48	1042.54	10/06/08	15.04	1042.98
			12/07/04	15.27	1042.75	11/03/08	14.12	1043.90
05/17/00	11.90	1046.12						
08/17/00	12.56	1045.46	04/12/05	15.63	1042.39	05/18/09	12.54	1045.48
11/27/00	11.74	1046.28	05/03/05	15.72	1042.30	06/09/09	12.76	1045.26

			06/01/05	15.85	1042.17	07/14/09	12.75	1045.27
05/17/01	10.94	1047.08	07/05/05	14.32	1043.70	08/10/09	13.10	1044.92
06/14/01	10.93	1047.09	08/09/05	14.49	1043.53	09/15/09	13.38	1044.64
07/20/01	10.90	1047.12	09/06/05	14.39	1043.63	10/13/09	13.17	1044.85
08/16/01	11.42	1046.60	10/03/05	14.48	1043.54			

136-052-30DDD2 **MP Elev (msl,ft)=1,054.30**
Sheyenne Delta Aquifer **Sl (ft.)=50-53**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/27/09	9.65	1044.65				06/14/10	8.20	1046.10
11/09/09	9.50	1044.80	05/17/10	7.90	1046.40	07/19/10	8.25	1046.05

136-052-32CDB1 **MP Elev (msl,ft)=1,048.34**
Sheyenne Delta Aquifer **Sl (ft.)=87-90**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
11/20/95	15.03	1034.11	09/19/01	11.45	1037.69	06/06/06	12.54	1035.80
			10/12/01	11.68	1037.46	07/11/06	12.48	1035.86
04/30/96	14.71	1034.43	11/14/01	11.93	1037.21	08/07/06	12.74	1035.60
06/05/96	14.16	1034.98	12/03/01	11.98	1037.16	08/21/06	12.85	1035.49
07/16/96	14.00	1035.14				09/06/06	12.98	1035.36
08/15/96	14.00	1035.14	05/16/02	12.73	1036.41	10/10/06	13.16	1035.18
10/08/96	14.37	1034.77	06/27/02	12.78	1036.36	11/06/06	13.35	1034.99
12/09/96	14.70	1034.44	08/06/02	12.84	1036.30	12/14/06	13.50	1034.84
			09/17/02	12.99	1036.15	12/21/06	13.56	1034.78
05/29/97	13.38	1035.76	11/05/02	13.28	1035.86			
07/10/97	13.31	1035.83	12/09/02	13.44	1035.70	01/03/07	13.56	1034.78
08/14/97	13.36	1035.78				05/15/07	13.48	1034.86
09/18/97	13.57	1035.57	05/06/03	14.16	1034.98	06/12/07	13.22	1035.12
10/16/97	13.89	1035.25	06/03/03	14.20	1034.94	07/17/07	13.11	1035.23
11/20/97	14.02	1035.12	07/08/03	13.87	1035.27	08/14/07	13.14	1035.20
12/15/97	14.08	1035.06	08/05/03	13.60	1035.54	09/11/07	13.31	1035.03
			09/02/03	13.84	1035.30	10/16/07	13.55	1034.79
05/11/98	13.87	1035.27	09/30/03	14.16	1034.98	11/13/07	13.67	1034.67
07/14/98	12.27	1036.87	11/03/03	14.29	1034.85			
08/25/98	12.14	1037.00	12/02/03	14.39	1034.75	05/05/08	14.30	1034.04
10/13/98	12.59	1036.55				06/03/08	14.31	1034.03
12/01/98	12.20	1036.94	05/04/04	14.80	1034.34	07/10/08	13.51	1034.83
			06/07/04	14.88	1034.26	08/04/08	13.48	1034.86
05/24/99	11.88	1037.26	07/13/04	14.93	1034.21	09/10/08	13.61	1034.73
06/24/99	11.69	1037.45	08/10/04	14.97	1034.17	10/06/08	13.75	1034.59
07/22/99	11.75	1037.39	08/31/04	15.03	1034.11	11/03/08	13.44	1034.90
08/31/99	11.91	1037.23	10/12/04	15.10	1034.04			
10/05/99	11.69	1037.45	11/08/04	15.15	1033.99	05/18/09	11.95	1036.39
11/02/99	11.70	1037.44	12/07/04	14.94	1034.20	06/09/09	11.90	1036.44
12/07/99	11.91	1037.23				07/14/09	11.83	1036.51
			04/12/05	14.95	1034.19	08/10/09	11.92	1036.42
05/17/00	12.07	1037.07	05/03/05	15.09	1034.05	09/15/09	12.13	1036.21
08/17/00	12.13	1037.01	06/01/05	15.16	1033.98	10/13/09	12.31	1036.03
11/27/00	12.42	1036.72	07/05/05	14.09	1035.05	11/09/09	12.31	1036.03
			08/09/05	13.80	1035.34			
05/17/01	11.54	1037.60	09/06/05	13.86	1035.28	05/17/10	10.82	1037.52
06/14/01	11.25	1037.89	10/03/05	13.88	1035.26	06/14/10	10.66	1037.68
07/20/01	11.00	1038.14	11/08/05	13.17	1035.17	07/19/10	10.69	1037.65

08/16/01	11.07	1038.07				09/13/01	11.45	1037.69
04/26/06	13.78	1034.56						

136-053-02ABB **MP Elev (msl,ft)=1,062.90**
Sheyenne Delta Aquifer **Sl (ft.)=9-19**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/14/06	8.52	1054.38				07/14/09	7.27	1055.63
12/21/06	8.76	1054.14	05/05/08	6.19	1056.71	08/10/09	7.90	1055.00
			06/03/08	5.78	1057.12	09/15/09	7.57	1055.33
01/03/07	8.36	1054.54	07/11/08	6.01	1056.89	10/13/09	5.72	1057.18
05/15/07	5.73	1057.17	08/04/08	8.24	1054.66	11/09/09	5.04	1057.86
06/12/07	5.92	1056.98	09/10/08	8.05	1054.85			
07/17/07	6.45	1056.45	10/06/08	7.17	1055.73	05/17/10	4.83	1058.07
08/14/07	8.73	1054.17	11/03/08	5.38	1057.52	06/14/10	6.31	1056.59
09/11/07	8.35	1054.55				07/19/10	5.81	1057.09
10/16/07	7.94	1054.96	05/18/09	5.04	1057.86	11/13/07	7.76	1055.14
06/09/09	5.38	1057.52						

136-053-02DAA **MP Elev (msl,ft)=1,065.56**
Sheyenne Delta Aquifer **Sl (ft.)=46-51**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/15/06	10.42	1055.14				07/14/09	8.51	1057.05
12/21/06	10.56	1055.00	05/05/08	8.03	1057.53	08/10/09	8.50	1057.06
			06/03/08	8.57	1056.99	09/15/09	8.91	1056.65
01/03/07	10.36	1055.20	07/11/08	8.08	1057.48	10/13/09	7.23	1058.33
05/15/07	6.90	1058.66	08/04/08	9.91	1055.65	11/09/09	6.44	1059.12
06/12/07	7.69	1057.87	09/10/08	10.55	1055.01			
07/17/07	8.58	1056.98	10/06/08	9.93	1055.63	05/17/10	6.26	1059.30
08/14/07	9.91	1055.65	11/03/08	7.35	1058.21	06/14/10	7.98	1057.58
09/11/07	9.77	1055.79				07/19/10	8.08	1057.48
10/16/07	9.49	1056.07	05/18/09	6.43	1059.13	11/13/07	9.31	1056.25
06/09/09	7.32	1058.24						

136-053-03AAA **MP Elev (msl,ft)=1,063.93**
Sheyenne Delta Aquifer **Sl (ft.)=50-60**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/14/06	9.08	1054.85				07/14/09	6.83	1057.10
12/21/06	9.21	1054.72	05/05/08	7.17	1056.76	08/10/09	7.70	1056.23
			06/03/08	7.09	1056.84	09/15/09	8.46	1055.47
01/03/07	9.15	1054.78	07/11/08	6.73	1057.20	10/13/09	7.15	1056.78
05/15/07	6.35	1057.58	08/04/08	7.94	1055.99	11/09/09	6.53	1057.40
06/12/07	6.50	1057.43	09/10/08	8.97	1054.96			
07/17/07	7.24	1056.69	10/06/08	8.35	1055.58	05/17/10	4.81	1059.12
08/14/07	9.01	1054.92	11/03/08	6.84	1057.09	06/14/10	6.40	1057.53
09/11/07	9.80	1054.13				07/19/10	6.70	1057.23
10/16/07	9.10	1054.83	05/18/09	5.21	1058.72	11/13/07	8.48	1055.45
06/09/09	6.03	1057.90						

APPENDIX II: WATER-LEVEL DATA

136-053-04BBB **MP Elev (msl,ft)=1,061.72**
Sheyenne Delta Aquifer **SI (ft.)=32-42**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/14/06	6.65	1055.07				07/14/09	4.48	1057.24
12/21/06	6.71	1055.01	05/05/08	3.19	1058.53	08/10/09	5.12	1056.60
			06/03/08	3.07	1058.65	09/15/09	5.96	1055.76
01/03/07	6.50	1055.22	07/11/08	3.08	1058.64	10/13/09	3.75	1057.97
05/15/07	3.52	1058.20	08/04/08	5.43	1056.29	11/09/09	2.74	1058.98
06/12/07	3.80	1057.92	09/10/08	5.43	1056.29			
07/17/07	3.27	1058.45	10/06/08	4.87	1056.85	05/17/10	1.96	1059.76
08/14/07	6.27	1055.45	11/03/08	3.07	1058.65	06/14/10	3.36	1058.36
09/11/07	6.31	1055.41				07/19/10	2.59	1059.13
10/16/07	5.91	1055.81	05/18/09	2.48	1059.24	11/13/07	5.80	1055.92
06/09/09	2.70	1059.02						

136-053-06BAA **MP Elev (msl,ft)=1,066.25**
Sheyenne Delta Aquifer **SI (ft.)=30-35**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/14/06	10.15	1056.10	05/05/08	7.30	1058.95	07/14/09	7.10	1059.15
12/21/06	10.14	1056.11	06/03/08	7.14	1059.11	08/10/09	8.05	1058.20
			07/11/08	6.21	1060.04	09/15/09	8.61	1057.64
01/03/07	10.20	1056.05	08/04/08	8.55	1057.70	10/13/09	6.81	1059.44
06/12/07	6.89	1059.36	09/10/08	9.25	1057.00	11/09/09	5.49	1060.76
07/17/07	7.15	1059.10	10/06/08	9.07	1057.18			
08/14/07	9.03	1057.22	11/03/08	6.57	1059.68	05/17/10	4.30	1061.95
10/16/07	9.53	1056.72				06/14/10	6.40	1059.85
11/13/07	9.09	1057.16	05/18/09	4.61	1061.64	07/19/10	5.13	1061.12
			06/09/09	5.14	1061.11			

136-053-08DDD **MP Elev (msl,ft)=1,065.00**
Sheyenne Delta Aquifer **SI (ft.)=65-70**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/21/06	7.68	1057.32				07/14/09	2.83	1062.17
			05/05/08	4.91	1060.09	08/10/09	3.45	1061.55
01/03/07	7.42	1057.58	06/03/08	3.67	1061.33	09/15/09	4.18	1060.82
05/15/07	3.67	1061.33	07/11/08	3.78	1061.22	10/13/09	3.34	1061.66
06/12/07	4.89	1060.11	08/04/08	6.26	1058.74	11/09/09	2.84	1062.16
07/17/07	3.75	1061.25	09/10/08	6.35	1058.65			
08/14/07	6.28	1058.72	10/06/08	4.96	1060.04	06/14/10	2.66	1062.34
09/11/07	6.01	1058.99	11/03/08	3.62	1061.38	07/19/10	2.84	1062.16
10/16/07	5.97	1059.03				11/13/07	5.86	1059.14
06/09/09	2.56	1062.44						

APPENDIX II: WATER-LEVEL DATA

136-053-09AAA **MP Elev (msl,ft)=1,064.61**
Sheyenne Delta Aquifer **SI (ft.)=5-15**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/15/06	8.88	1055.73				07/14/09	5.54	1059.07
12/21/06	8.96	1055.65	05/05/08	5.94	1058.67	08/10/09	6.90	1057.71
			06/03/08	6.46	1058.15	09/15/09	7.44	1057.17
01/03/07	8.89	1055.72	07/11/08	6.19	1058.42	10/13/09	5.73	1058.88
05/15/07	5.63	1058.98	08/04/08	7.71	1056.90	11/09/09	5.08	1059.53
06/12/07	6.45	1058.16	09/10/08	8.20	1056.41			
07/17/07	6.67	1057.94	10/06/08	7.69	1056.92	05/17/10	3.71	1060.90
08/14/07	8.50	1056.11	11/03/08	5.60	1059.01	06/14/10	4.58	1060.03
09/11/07	8.62	1055.99				07/19/10	4.71	1059.90
10/16/07	8.54	1056.07	05/18/09	4.16	1060.45	11/13/07	8.17	1056.44
06/09/09	4.47	1060.14						

136-053-10BBB **MP Elev (msl,ft)=1,064.50**
Sheyenne Delta Aquifer **SI (ft.)=45-55**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/15/06	8.82	1055.68				07/14/09	5.79	1058.71
12/21/06	8.95	1055.55	05/05/08	6.00	1058.50	08/10/09	7.15	1057.35
			06/03/08	6.31	1058.19	09/15/09	7.42	1057.08
01/03/07	8.79	1055.71	07/11/08	6.07	1058.43	10/13/09	5.63	1058.87
05/15/07	5.87	1058.63	08/04/08	7.75	1056.75	11/09/09	5.12	1059.38
06/12/07	6.71	1057.79	09/10/08	8.18	1056.32			
07/17/07	6.31	1058.19	10/06/08	7.39	1057.11	05/17/10	3.74	1060.76
08/14/07	8.35	1056.15	11/03/08	5.62	1058.88	06/14/10	4.69	1059.81
09/11/07	8.44	1056.06				07/19/10	4.83	1059.67
10/16/07	8.50	1056.00	05/18/09	4.39	1060.11	11/13/07	8.13	1056.37
06/09/09	4.80	1059.70						

136-053-11DDD **MP Elev (msl,ft)=1,065.49**
Sheyenne Delta Aquifer **SI (ft.)=5-15**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/15/06	8.61	1056.88				07/14/09	6.31	1059.18
12/21/06	8.75	1056.74	05/05/08	7.31	1058.18	08/10/09	7.85	1057.64
			06/03/08	6.97	1058.52	09/15/09	7.81	1057.68
01/03/07	8.67	1056.82	07/11/08	6.73	1058.76	10/13/09	6.74	1058.75
05/15/07	6.05	1059.44	08/04/08	7.79	1057.70	11/09/09	5.59	1059.90
06/12/07	6.52	1058.97	09/10/08	8.63	1056.86			
07/17/07	7.28	1058.21	10/06/08	8.20	1057.29	05/17/10	4.25	1061.24
08/14/07	8.40	1057.09	11/03/08	6.56	1058.93	06/14/10	5.20	1060.29
09/11/07	8.82	1056.67				07/19/10	5.52	1059.97
10/16/07	8.95	1056.54	05/18/09	4.60	1060.89	11/13/07	8.56	1056.93
06/09/09	5.33	1060.16						

APPENDIX II: WATER-LEVEL DATA

136-053-12ADD **MP Elev (msl,ft)=1,064.50**
Sheyenne Delta Aquifer **SI (ft.)=50-55**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/15/06	9.02	1055.48	11/13/07	8.57	1055.93	08/10/09	6.58	1057.92
12/21/06	9.27	1055.23				09/15/09	6.79	1057.71
			05/05/08	7.28	1057.22	10/13/09	5.57	1058.93
01/03/07	9.04	1055.46	06/03/08	6.65	1057.85	11/09/09	5.12	1059.38
05/15/07	6.36	1058.14	09/10/08	8.90	1055.60			
06/12/07	6.57	1057.93	10/06/08	8.04	1056.46	05/17/10	4.29	1060.21
07/17/07	7.15	1057.35	11/03/08	6.45	1058.05	06/14/10	4.89	1059.61
08/14/07	9.10	1055.40				07/19/10	4.91	1059.59
09/11/07	9.24	1055.26	06/09/09	4.83	1059.67	10/16/07	9.06	1055.44
07/14/09	5.59	1058.91						

136-053-14BBB **MP Elev (msl,ft)=1,064.91**
Sheyenne Delta Aquifer **SI (ft.)=46-56**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/14/06	7.88	1057.03	11/13/07	7.13	1057.78	05/18/09	3.08	1061.83
12/21/06	8.04	1056.87				06/09/09	3.58	1061.33
			05/05/08	5.19	1059.72	07/14/09	5.20	1059.71
01/03/07	7.78	1057.13	06/03/08	4.52	1060.39	08/10/09	6.16	1058.75
05/15/07	4.72	1060.19	07/11/08	4.97	1059.94	09/15/09	6.18	1058.73
06/12/07	5.01	1059.90	08/04/08	7.00	1057.91	10/13/09	4.69	1060.22
07/17/07	5.64	1059.27	09/10/08	7.59	1057.32	11/09/09	3.73	1061.18
08/14/07	7.58	1057.33	10/06/08	7.08	1057.83			
09/11/07	7.92	1056.99	11/03/08	5.23	1059.68	06/14/10	5.39	1059.52
10/16/07	7.61	1057.30				07/19/10	5.28	1059.63

136-053-14CCC **MP Elev (msl,ft)=1,068.57**
Sheyenne Delta Aquifer **SI (ft.)=66-76**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/15/06	11.20	1057.37				07/14/09	8.04	1060.53
12/21/06	11.28	1057.29	05/05/08	9.10	1059.47	08/10/09	8.86	1059.71
			06/03/08	8.98	1059.59	09/15/09	8.72	1059.85
01/03/07	11.20	1057.37	07/11/08	8.89	1059.68	10/13/09	7.70	1060.87
05/15/07	8.01	1060.56	08/04/08	10.11	1058.46	11/09/09	6.97	1061.60
06/12/07	8.37	1060.20	09/10/08	10.74	1057.83			
07/17/07	9.07	1059.50	10/06/08	10.57	1058.00	05/17/10	6.27	1062.30
08/14/07	10.35	1058.22	11/03/08	8.73	1059.84	06/14/10	7.34	1061.23
09/11/07	10.69	1057.88				07/19/10	7.44	1061.13
10/16/07	10.89	1057.68	05/18/09	6.59	1061.98	11/13/07	10.52	1058.05
06/09/09	6.91	1061.66						

APPENDIX II: WATER-LEVEL DATA

136-053-15DDC **MP Elev (msl,ft)=1,067.89**
Sheyenne Delta Aquifer **SI (ft.)=5-15**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/15/06	10.00	1057.89				07/14/09	6.70	1061.19
12/21/06	10.02	1057.87	05/05/08	7.91	1059.98	08/10/09	7.65	1060.24
			06/03/08	7.70	1060.19	09/15/09	7.51	1060.38
01/03/07	10.01	1057.88	07/11/08	7.65	1060.24	10/13/09	6.43	1061.46
05/15/07	6.91	1060.98	08/04/08	8.90	1058.99	11/09/09	5.64	1062.25
06/12/07	7.13	1060.76	09/10/08	9.72	1058.17			
07/17/07	7.82	1060.07	10/06/08	9.56	1058.33	05/17/10	4.75	1063.14
08/14/07	9.17	1058.72	11/03/08	7.61	1060.28	06/14/10	6.25	1061.64
09/11/07	9.69	1058.20				07/19/10	6.49	1061.40
10/16/07	9.76	1058.13	05/18/09	5.11	1062.78	11/13/07	9.38	1058.51
06/09/09	5.42	1062.47						

136-053-22BBB **MP Elev (msl,ft)=1,067.18**
Sheyenne Delta Aquifer **SI (ft.)=59-64**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/15/06	8.62	1058.56				07/14/09	4.80	1062.38
12/21/06	8.78	1058.40	05/05/08	6.02	1061.16	08/10/09	5.52	1061.66
			06/03/08	4.67	1062.51	09/15/09	5.89	1061.29
01/03/07	8.60	1058.58	07/11/08	5.26	1061.92	10/13/09	4.53	1062.65
05/15/07	5.52	1061.66	08/04/08	7.21	1059.97	11/09/09	3.66	1063.52
06/12/07	5.91	1061.27	09/10/08	7.76	1059.42			
07/17/07	5.59	1061.59	10/06/08	7.35	1059.83	05/17/10	2.63	1064.55
08/14/07	7.59	1059.59	11/03/08	5.70	1061.48	06/14/10	3.19	1063.99
09/11/07	7.92	1059.26				07/19/10	3.63	1063.55
10/16/07	7.75	1059.43	05/18/09	3.13	1064.05	11/13/07	7.43	1059.75
06/09/09	3.48	1063.70						

136-053-26ABAA **MP Elev (msl,ft)=1,057.20**
Sheyenne Delta Aquifer **SI (ft.)=15.1-19.5**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/14/06	12.16	1045.04				07/14/09	8.94	1048.26
12/21/06	12.16	1045.04	05/05/08	11.47	1045.73	08/10/09	9.51	1047.69
			06/03/08	11.33	1045.87	09/15/09	10.08	1047.12
01/03/07	12.23	1044.97	07/11/08	10.84	1046.36	10/13/09	9.28	1047.92
05/15/07	9.93	1047.27	08/04/08	11.32	1045.88	11/09/09	8.58	1048.62
06/12/07	10.03	1047.17	09/10/08	11.89	1045.31			
07/17/07	10.72	1046.48	10/06/08	11.73	1045.47	05/17/10	6.71	1050.49
08/14/07	11.33	1045.87	11/03/08	10.54	1046.66	06/14/10	7.78	1049.42
09/11/07	11.76	1045.44				07/19/10	8.11	1049.09
10/16/07	11.94	1045.26	05/18/09	7.76	1049.44	11/13/07	11.91	1045.29
06/09/09	8.29	1048.91						

APPENDIX II: WATER-LEVEL DATA

136-053-26BAB **MP Elev (msl,ft)=1,062.80**
Sheyenne Delta Aquifer **SI (ft.)=5.66-10.66**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/14/06	8.50	1054.30				07/14/09	5.53	1057.27
12/21/06	8.55	1054.25	05/05/08	7.60	1055.20	08/10/09	6.00	1056.80
			06/03/08	7.54	1055.26	09/15/09	6.37	1056.43
01/03/07	8.61	1054.19	07/11/08	7.18	1055.62	10/13/09	5.55	1057.25
05/15/07	6.21	1056.59	08/04/08	7.71	1055.09	11/09/09	4.70	1058.10
06/12/07	6.48	1056.32	09/10/08	8.13	1054.67			
07/17/07	7.09	1055.71	10/06/08	7.92	1054.88	05/17/10	3.03	1059.77
08/14/07	7.78	1055.02	11/03/08	6.73	1056.07	06/14/10	4.47	1058.33
09/11/07	8.17	1054.63				07/19/10	4.63	1058.17
10/16/07	8.31	1054.49	05/18/09	3.98	1058.82	11/13/07	8.20	1054.60
06/09/09	4.70	1058.10						

136-053-26BAB2 **MP Elev (msl,ft)=1,062.40**
Sheyenne Delta Aquifer **SI (ft.)=10.64-15.64**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
12/14/06	8.05	1054.35				07/14/09	5.06	1057.34
12/21/06	8.07	1054.33	05/05/08	7.14	1055.26	08/10/09	5.48	1056.92
			06/03/08	7.07	1055.33	09/15/09	5.91	1056.49
01/03/07	8.12	1054.28	07/11/08	6.71	1055.69	10/13/09	5.08	1057.32
05/15/07	5.73	1056.67	08/04/08	7.24	1055.16	11/09/09	4.24	1058.16
06/12/07	6.02	1056.38	09/10/08	7.66	1054.74			
07/17/07	6.62	1055.78	10/06/08	7.45	1054.95	05/17/10	2.56	1059.84
08/14/07	7.31	1055.09	11/03/08	6.27	1056.13	06/14/10	4.00	1058.40
09/11/07	7.71	1054.69				07/19/10	4.16	1058.24
10/16/07	7.85	1054.55	05/18/09	3.51	1058.89	11/13/07	7.73	1054.67
06/09/09	4.23	1058.17						

136-053-29AAA2 **MP Elev (msl,ft)=1,067.20**
Sheyenne Delta Aquifer **SI (ft.)=13-23**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)

136-053-31CCC2 **MP Elev (msl,ft)=1,067.47**
Sheyenne Delta Aquifer **SI (ft.)=24-29**

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
11/20/95	7.24	1060.23	09/13/01	7.28	1060.19	04/26/06	6.86	1060.61
			10/12/01	6.95	1060.52	06/06/06	6.66	1060.81
04/30/96	6.46	1061.01	11/14/01	7.04	1060.43	07/11/06	8.00	1059.47
06/05/96	6.51	1060.96	12/03/01	7.06	1060.41	08/07/06	9.21	1058.26
07/16/96	7.52	1059.95				09/06/06	9.99	1057.48
08/27/96	8.50	1058.97	05/16/02	6.44	1061.03	10/10/06	9.86	1057.61
09/25/96	9.16	1058.31	06/27/02	7.50	1059.97	11/06/06	9.73	1057.74

APPENDIX II: WATER-LEVEL DATA

10/08/96	9.03	1058.44	08/06/02	8.36	1059.11	12/14/06	9.70	1057.77
			09/17/02	9.39	1058.08	12/21/06	9.72	1057.75
05/29/97	5.27	1062.20	11/05/02	9.19	1058.28			
07/10/97	6.68	1060.79	12/09/02	9.20	1058.27	01/03/07	9.69	1057.78
08/14/97	7.78	1059.69				05/15/07	7.30	1060.17
09/18/97	8.42	1059.05	05/06/03	8.64	1058.83	06/12/07	7.32	1060.15
10/16/97	8.04	1059.43	06/03/03	7.65	1059.82	07/17/07	7.98	1059.49
11/20/97	7.87	1059.60	07/08/03	7.56	1059.91	08/14/07	8.66	1058.81
12/15/97	7.86	1059.61	08/05/03	8.72	1058.75	09/12/07	8.98	1058.49
			09/02/03	9.73	1057.74	10/16/07	8.85	1058.62
05/11/98	6.63	1060.84	09/30/03	10.09	1057.38	11/13/07	8.71	1058.76
07/14/98	4.58	1062.89	11/03/03	9.93	1057.54			
08/25/98	6.40	1061.07	12/02/03	9.88	1057.59	05/05/08	8.13	1059.34
10/13/98	6.65	1060.82				06/03/08	8.02	1059.45
12/01/98	5.16	1062.31	05/04/04	9.12	1058.35	07/10/08	7.70	1059.77
			06/07/04	8.42	1059.05	08/04/08	8.44	1059.03
05/24/99	4.07	1063.40	07/13/04	8.45	1059.02	09/10/08	9.39	1058.08
06/23/99	4.68	1062.79	08/10/04	9.36	1058.11	10/06/08	9.05	1058.42
07/22/99	5.58	1061.89	08/31/04	9.81	1057.66	11/03/08	7.64	1059.83
08/31/99	5.82	1061.65	10/12/04	9.35	1058.12			
10/05/99	4.86	1062.61	11/08/04	8.75	1058.72	05/18/09	4.77	1062.70
11/02/99	4.93	1062.54	12/07/04	8.39	1059.08	06/09/09	5.26	1062.21
12/07/99	5.19	1062.28				07/14/09	5.40	1062.07
			04/12/05	8.39	1059.08	08/11/09	6.32	1061.15
05/17/00	4.68	1062.79	05/03/05	8.28	1059.19	09/15/09	6.90	1060.57
07/20/00	4.80	1062.67	06/01/05	8.25	1059.22	10/13/09	6.08	1061.39
08/17/00	6.45	1061.02	07/05/05	6.99	1060.48	11/09/09	5.27	1062.20
11/27/00	5.35	1062.12	08/09/05	8.39	1059.08			
			08/29/05	8.60	1058.87	05/17/10	3.31	1064.16
05/17/01	4.05	1063.42	09/06/05	8.66	1058.81	06/14/10	3.98	1063.49
06/14/01	3.85	1063.62	10/03/05	8.75	1058.72	07/19/10	4.41	1063.06
07/20/01	4.68	1062.79	11/08/05	8.68	1058.79	08/16/01	6.14	1061.33

APPENDIX III: GROUNDWATER CHEMISTRY DATA

Location	Date	Top SI	Field EC	Lab EC	Field pH	Lab pH	TDS	Temp	Calcium	Magnesium	Potassium	Sodium	Bicarbonate	Sulfate	Chloride	Nitrate	Iron	Manganese	Arsenic
		(feet)	(um/cm)	(um/cm)			(mg/L)	(C)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
13605203AAA2	7/24/73	23		545		8.0	324		62.0	35.0	2.0	4.3	353.0	19.0	3.0	1.0	0.0	0.6	
13605203AAA2	6/14/78	23	535	524		8.1	304	15.0	69.0	26.0	2.1	3.9	302.0	25.0	4.9	1.0	0.7	0.5	
13605203AAA2	8/15/96	23	420	450		7.9	291		68.0	24.0	4.8	4.8	259.0	53.0	6.2	1.0	0.1	0.4	
13605203AAA2	9/19/01	23	567	605	7.4	6.6	366		71.0	31.0	2.7	8.0	244.0	110.0	14.0	6.1	2.4	0.6	
13605206BBB2	6/14/78	40	580	571		7.4	329	10.0	82.0	23.0	2.5	5.3	373.0	1.2	1.8	1.0	1.1	0.4	
13605206BBB2	8/15/96	40	440	486		8.1	292		75.0	25.0	2.9	8.5	351.0	3.0	2.0	1.0	1.2	0.4	
13605206BBB2	9/19/01	40	495	515	7.2	7.7	292		70.0	23.0	2.6	7.5	324.0	26.0	1.5	0.2	0.7	0.4	
13605206BBB2	8/21/06	40	750	766		7.7	475		106.0	31.9	3.9	7.2	411.0	51.0	19.4	<0.09	2.5	0.6	
13605206BBB2	12/14/06	40	721	723	7.7	7.5	448	9.1	94.8	27.6	3.8	5.8	383.0	57.6	20.0	<0.09	4.7	0.5	4.0
13605207BBB	12/14/06	5	1930	1990	7.5	7.4	1230	9.0	109.0	117.0	3.1	167.0	1170.0	230.0	20.2	<0.09	2.4	1.0	12.3
13605209ADDD	6/28/07	8	918	965		7.7	598		87.5	47.6	8.6	53.7	638.0	27.4	5.6	<0.09	0.4	0.6	10.3
13605212CBB	8/15/96	37	650	725		8.1	470		130.0	31.0	7.0	12.0	572.0	3.0	1.8	1.0	1.5	0.4	
13605212CBB	9/19/01	37	757	792	7.3	7.4	467		120.0	33.0	6.6	12.0	562.0	11.0	0.0	0.1	6.4	0.4	
13605212CBB	8/21/06	37	758	793		7.8	492		115.0	30.7	7.1	11.0	534.0	7.9	0.7	<0.09	0.3	0.3	
13605212CBB	12/14/06	37	652	634	7.8	7.3	393	11.5	70.2	29.4	7.7	11.2	443.0	4.2	0.8	0.2	10.1	0.2	27.0
13605214CBBC	6/28/07	7	820	858		7.2	532		115.0	35.4	1.6	12.9	482.0	71.6	8.6	0.1	0.4	1.2	2.1
13605215DCC	12/21/06	39	558	580	5.4	7.4	360	9.3	70.5	21.8	4.7	9.6	346.0	26.3	5.9	0.1	1.3	0.4	24.2
13605217DAD	12/15/06	77	635	660	7.9	7.4	409	8.3	82.4	18.5	6.5	18.6	402.0	34.4	1.7	<0.09	0.5	0.5	46.7
13605219DCB	12/14/06	215	2800	2910	8.1	7.4	1800	8.9	156.0	42.3	15.9	357.0	314.0	725.0	359.0	<0.09	0.3	0.5	13.0
13605219DCB2	12/14/06	75	919	941	8.0	7.2	583	8.3	112.0	26.1	11.3	46.4	484.0	119.0	3.6	<0.09	0.8	0.6	82.3
13605219DCB3	12/14/06	50	533	550	8.2	7.4	341	8.4	66.7	20.9	4.3	8.1	344.0	21.7	0.9	<0.09	0.7	0.4	27.3
13605219DCD	12/21/06	40	495	515	5.5	7.4	319	10.1	68.3	18.1	2.1	6.0	291.0	42.4	1.0	0.1	1.5	0.5	14.9
13605219DDC	6/28/07	40	513	528		7.5	327		70.5	19.4	1.8	6.7	274.0	52.9	3.0	<0.09	3.0	0.5	8.5
13605221DCCC	6/28/07	10	563	599		7.4	371		84.6	21.3	<1	5.6	357.0	23.7	7.0	<0.09	<0.05	0.2	<1
13605222CCC	8/15/96	38	600	624		7.9	406		110.0	30.0	4.5	14.0	482.0	4.0	1.6	1.0	2.4	0.8	
13605222CCC	9/19/01	38	673	710	7.5	7.4	410		100.0	30.0	4.1	14.0	494.0	11.0	0.0	0.1	6.9	0.7	
13605222CCC	8/21/06	38	686	708		7.9	439		95.3	27.7	4.7	12.7	479.0	9.8	0.7	<0.09	1.5	0.9	

APPENDIX III: GROUNDWATER CHEMISTRY DATA

Location	Date	Top SI	Field EC	Lab EC	Field pH	Lab pH	TDS	Temp	Calcium	Magnesium	Potassium	Sodium	Bicarbonate	Sulfate	Chloride	Nitrate	Iron	Manganese	Arsenic
		(feet)	(um/cm)	(um/cm)			(mg/L)	(C)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
13605222CCC	12/14/06	38	716	706	7.6	7.3	438	9.3	92.0	25.6	4.8	11.7	476.0	9.3	0.9	<0.09	5.3	0.9	23.6
13605222DDD2	10/8/63	33		570		7.8	332		74.0	23.0	4.0	9.2	293.0	55.0		1.0	0.5		
13605222DDD2	8/19/99	33	516	579	7.5	7.4	333		80.0	23.0	3.0	6.0	299.0	66.0	3.4	0.1	3.4	0.5	
13605222DDD2	7/15/04	33		590		7.4	321		81.0	23.0	3.5	5.2	370.0	22.8	1.7		3.3	0.6	12.1
13605222DDD2	7/27/09	33	540	566		7.5	351		86.2	24.3	4.1	7.3	353.0	18.6	1.3	0.8	0.1	0.1	
13605225CCB5	8/22/72	60		334		7.2	207		36.0	9.5	3.7	16.0	156.0	40.0	0.0	1.0	0.1	0.7	
13605229BBB	8/25/83	47	538	490	6.9	7.9	304	10.0	60.0	24.0	3.0	9.0	278.0	39.0	2.5	1.0	0.5	0.3	4.0
13605229BBB	8/15/96	47	440	463		8.0	293		74.0	24.0	2.0	6.3	324.0	20.0	2.8	1.0	2.1	0.3	
13605229BBB	9/19/01	47	383	385	7.7	7.2	206		50.0	19.0	1.2	5.5	226.0	16.0	0.0	0.1	2.5	0.2	
13605229BBB	8/21/06	47	431	448		7.8	278		55.8	20.4	2.0	3.9	259.0	27.4	1.6	<0.09	0.6	0.3	
13605229BBB	12/14/06	47	443	445	8.2	7.3	276	9.8	55.1	19.2	2.0	3.3	256.0	27.7	1.6	<0.09	4.1	0.2	3.7
13605229BBB2	10/27/09	212	2830	2900		7.4	1800		188.0	48.8	18.6	399.0	331.0	721.0	355.0	0.1	0.7	0.5	25.8
13605229BBB3	10/27/09	49	472	489		7.2	303		71.3	23.4	2.4	5.4	275.0	35.3	2.5	<0.09	1.8	0.3	<5
13605229DDD2	9/1/05	58	477	498	8.0	7.6	269	10.8	59.8	16.2	2.6	15.0	287.0	29.8	2.0	<0.09	0.3	0.8	11.8
13605229DDD2	12/14/06	58	464	467	7.9	7.5	290	9.0	66.0	15.3	2.0	4.1	289.0	25.7	1.6	<0.09	0.6	0.9	6.1
13605230DDD	8/15/96	52	520	551		8.0	358		97.0	23.0	3.3	9.9	416.0	13.0	1.7	1.0	2.9	0.4	
13605230DDD	9/19/01	52	565	603	7.5	7.8	331		77.0	25.0	2.8	10.0	415.0	12.0	0.0	0.1	0.0	0.1	
13605230DDD	8/21/06	52	592	623		7.9	386		87.1	22.7	3.5	9.1	409.0	9.8	0.5	<0.09	1.3	0.5	
13605230DDD	12/14/06	52	607	627	8.3	7.8	389	8.9	84.7	20.8	3.4	8.3	415.0	9.4	0.5	<0.09	2.1	0.5	8.3
13605230DDD2	10/27/09	50	606	625		7.4	388		99.3	23.8	4.2	12.4	396.0	13.9	1.1	0.4	3.4	0.6	<5
13605232CDB1	8/15/96	87	456	476		7.9	313		89.0	19.0	2.0	1.6	315.0	40.0	1.8	1.0	2.5	0.5	
13605232CDB1	9/19/01	87	519	554	7.6	7.6	312		86.0	19.0	0.8	2.5	295.0	52.0	5.4	0.1	0.9	0.5	
13605232CDB1	8/21/06	87	534	562		8.0	348		83.9	18.9	1.5	<3	271.0	69.6	6.2	<0.09	0.1	0.5	
13605232CDB1	12/14/06	87	551	561	7.9	7.3	348	9.6	81.0	17.8	1.3	<3	277.0	71.3	5.2	<0.09	1.5	0.5	4.7
13605235DDD	8/23/72	47		521		7.3	326		81.0	17.0	1.8	5.0	330.0	10.0	0.0	5.3	4.1	1.4	
13605302ABB	12/14/06	9	552	564	7.8	7.4	350	9.7	66.1	23.3	1.7	7.8	258.0	80.9	9.4	<0.09	0.5	0.6	3.2
13605302DAA	12/15/06	46	644	652	7.9	7.4	404	8.3	82.2	26.6	4.6	9.7	438.0	17.7	1.6	<0.09	2.0	0.4	5.2
13605303AAA	12/14/06	50	749	762	7.5	7.3	472	8.8	98.7	26.0	5.3	16.5	500.0	13.3	0.9	<0.09	1.0	0.6	51.1

APPENDIX III: GROUNDWATER CHEMISTRY DATA

Location	Date	Top SI	Field EC	Lab EC	Field pH	Lab pH	TDS	Temp	Calcium	Magnesium	Potassium	Sodium	Bicarbonate	Sulfate	Chloride	Nitrate	Iron	Manganese	Arsenic
		(feet)	(um/cm)	(um/cm)			(mg/L)	(C)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
13605304BBB	12/14/06	32	1106	1120	7.2	7.1	694	8.2	139.0	41.4	9.1	36.4	676.0	103.0	2.1	<0.09	3.2	0.4	81.3
13605306BAA	12/14/06	30	1130	1120	7.0	7.1	694	9.4	131.0	45.5	7.5	44.0	643.0	135.0	1.9	<0.09	4.1	0.5	40.7
13605308DDD	12/21/06	65	1124	1180	5.4	7.4	732	11.2	142.0	38.3	10.6	51.7	753.0	56.4	3.7	0.3	1.2	0.4	95.6
13605309AAA	12/15/06	5	4430	4680	8.0	7.5	2900	8.0	637.0	253.0	11.2	260.0	1100.0	2150.0	172.0	<0.09	4.8	1.4	19.9
13605310BBB	12/15/06	45	1824	1900	7.7	7.2	1180	7.6	177.0	91.4	19.0	116.0	1140.0	202.0	5.3	<0.09	6.0	0.3	37.3
13605311DDD	12/15/06	5	506	523	8.1	7.5	324	9.2	73.1	16.2	<1	4.2	288.0	52.9	2.4	0.8	0.1	0.3	<1
13605312ADD	12/15/06	50	1305	1340	7.7	7.3	831	8.3	137.0	63.9	8.6	62.4	967.0	19.8	2.2	<0.09	4.0	0.3	52.0
13605314BBB	12/14/06	46	488	511	9.6	7.6	317	8.6	67.6	16.8	3.7	3.9	325.0	10.1	0.7	<0.09	0.1	0.1	39.9
13605314CCC	12/15/06	66	481	499	8.2	7.6	309	7.9	60.9	15.6	6.3	8.7	314.0	11.5	0.8	<0.09	0.1	0.2	23.1
13605315DDC	12/15/06	5	678	700	7.9	7.4	434	9.1	90.1	23.9	1.1	5.1	218.0	139.0	32.9	<0.09	0.2	0.7	<1
13605321DDD2	4/6/77	38	540	541	7.8	8.4	322	8.0	76.0	19.0	2.4	9.6	345.0	6.6	3.0	1.0	2.3	0.6	
13605322BBB	12/15/06	59	598	622	7.9	7.4	386	7.7	75.1	18.5	7.5	16.2	381.0	17.3	0.8	<0.09	0.2	0.4	64.4
13605325AAA2	4/6/77	58	400	443	8.0	8.6	270	7.5	65.0	19.0	1.2	3.4	261.0	20.0	2.2	1.0	0.3	0.4	
13605325AAA2	7/22/81	58	365	423		8.1	258	13.0	59.0	18.0	1.1	7.1	265.0	21.0	1.2	1.0	0.0	0.3	
13605326ABAA	12/14/06	15	508	515	8.9	7.5	319	10.3	65.3	18.2	<1	4.0	197.0	100.0	12.7	0.1	0.1	0.4	9.6
13605326BAB	12/14/06	6	355	365	9.2	7.8	226	9.3	50.9	10.6	<1	<3	191.0	5.0	0.9	30.7	0.0	0.0	<1
13605326BAB2	12/14/06	11	550	565	9.0	7.4	350	10.1	71.4	20.7	<1	3.7	257.0	59.5	9.3	19.1	0.0	0.2	<1
13605329AAA2	10/15/63	13		539		7.9	332		74.0	21.0	1.0	5.0	249.0	75.0			0.7		
13605329AAA2	4/5/77	13	500	480	8.0	8.5	291	7.5	69.0	19.0	0.6	3.7	251.0	31.0	8.4	1.0	0.3	0.7	
13605331CCC2	10/26/95	24	392	441		8.0	254	8.4	64.0	17.0	1.7	3.5	257.0	36.0	2.3	1.0	1.0	0.6	
13605331CCC2	7/20/00	24	398	421	8.3	7.6	233		64.0	15.0	1.6	5.0	237.0	28.0	0.0	0.1	1.8	0.6	
13605331CCC2	8/29/05	24	384	411		7.4	220		54.9	13.8	1.9	5.2	231.0	27.2	1.3	<0.09	1.6	0.5	
13605331CCC2	12/14/06	24	405	403	6.6	7.5	250	8.9	55.0	13.2	2.0	<3	239.0	26.2	1.5	<0.09	1.6	0.5	4.6