

**STATE OF SOUTH DAKOTA**  
**Walter D. Miller, Governor**

**DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES**  
**Robert E. Roberts, Secretary**

**DIVISION OF GEOLOGICAL SURVEY**  
**C.M. Christensen, State Geologist**

**Open-File Report 66-UR**

**INVESTIGATION OF GROUND-WATER RESOURCES**  
**IN THE VICINITY OF HURLEY, SOUTH DAKOTA**

**by**

**Layne D. Schulz**

**Science Center**  
**University of South Dakota**  
**Vermillion, South Dakota**

**1993**

## CONTENTS

	Page
<b>INTRODUCTION</b> .....	1
<b>METHODS</b> .....	1
Drilling .....	1
Well construction .....	1
Well development and sampling .....	1
<b>RESULTS OF INVESTIGATION</b> .....	3
Geology .....	3
Bedrock .....	3
Glacial deposits .....	3
Parker-Centerville aquifer .....	3
Upper-Vermillion-Missouri aquifer .....	3
Hydrology .....	6
Bedrock aquifers .....	6
Upper-Vermillion-Missouri aquifer .....	6
Parker-Centerville aquifer .....	13
Comparison of water quality in the Hurley vicinity .....	13
<b>SUMMARY AND RECOMMENDATIONS</b> .....	13
<b>REFERENCES</b> .....	20

## FIGURES

1. Location of cross section A-A' and locations of test holes and observation wells drilled for this investigation .....	2
2. Geologic cross section A-A' .....	5
3. Locations of observation wells and Hurley's municipal well .....	7

<b>Figures -- continued.</b>	<b>Page</b>
4. Total dissolved solids and sulfate concentrations in the Upper-Vermillion-Missouri aquifer and Niobrara Formation .....	10
5. Hardness concentrations in the Upper-Vermillion-Missouri aquifer and Niobrara Formation .....	11
6. Iron and manganese concentrations in the Upper-Vermillion-Missouri aquifer and Niobrara Formation .....	12
7. Water-table contours for the Parker-Centerville aquifer .....	14
8. Total dissolved solids concentrations in the Parker-Centerville aquifer .....	15
9. Sulfate concentrations in the Parker-Centerville aquifer .....	16
10. Hardness concentrations in the Parker-Centerville aquifer .....	17
11. Iron concentrations in the Parker-Centerville aquifer .....	18
12. Manganese concentrations in the Parker-Centerville aquifer .....	19

### **TABLES**

1. Description of geologic units .....	4
2. Water elevations and saturated thickness .....	8
3. Comparison of water quality in the Hurley vicinity .....	9

### **APPENDICES**

A. Logs of test holes and observation wells .....	21
B. Chemical analyses of water samples .....	<b>Following</b> 32

## INTRODUCTION

The city of Hurley has a municipal well that is located in an unconfined surficial aquifer known as the Parker-Centerville aquifer (Tipton, 1957). Hurley's present water quality is poor and the municipal well has tested positive for iron bacteria. It is likely that the water-distribution system is also contaminated with the bacteria. Hurley's water-quality problem prompted the city's request of the South Dakota Geological Survey to delineate the areal extent and define the water quality of the aquifer material in the vicinity of Hurley.

The purpose of this investigation was to explore the area around Hurley for a potential water source. The results of the investigation, conducted by the South Dakota Geological Survey, are presented in this report. The investigation was financed by the South Dakota Geological Survey and the city of Hurley.

## METHODS

### Drilling

Six test-holes and 11 observation wells were completed for this investigation (fig. 1, app. A). Drilling was accomplished by using a forward mud rotary drill rig with a bit diameter of 5 inches. Samples were collected from the drill cuttings at 10-foot intervals and a lithologic log was written. The samples and the lithologic log were used to determine the suitability of the test hole for well construction.

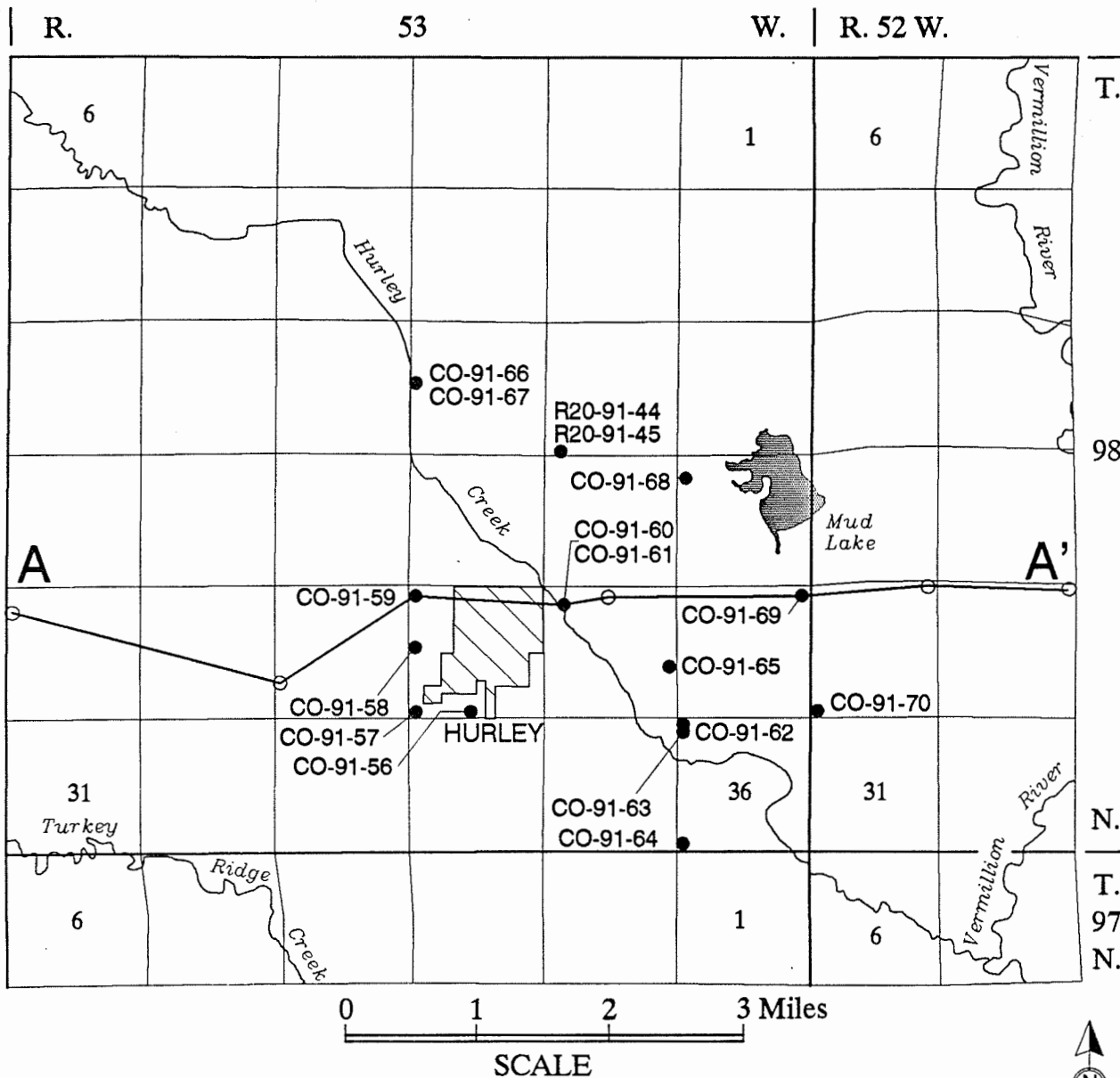
### Well Construction

Observation wells were constructed using 2-inch diameter, schedule 40, threaded, polyvinyl chloride (PVC) casing and screen. Screen length, well depth, and other well construction information are given in appendix A. Filter pack was placed through a tremie line to a depth that covered the entire screen and provided a factor for settlement around the screen. Bentonite grout was then placed in the remaining annular space from the top of the filter pack to a depth no less than 20 feet below ground surface. In those observation wells where the filter pack depth was above or near 20 feet below land surface, neat cement grout was placed directly on the filter pack with no bentonite grout added. After placement of the cement grout, a locking steel well protector was installed.

### Well Development and Sampling

Observation wells completed for this study were developed using a variety of methods depending on depth to water and rate of recharge to the well. All wells were pumped until the water temperature and conductivity had stabilized and the well water was clear.

Sampling procedures were consistent with the *South Dakota Geological Survey Water Sampling Manual* (Coker and others, 1988). A minimum of 3 well volumes of water were extracted before sampling occurred and the samples were collected using a laboratory cleaned teflon bailer.



- CO-91-70      Test hole or observation well drilled for this investigation. Letters and numbers are test-hole or well identifiers.
  
- Test hole or well not drilled for this project but used in the construction of cross section A - A'. Logs of test holes and wells are on file at the South Dakota Geological Survey.
  
- A      A'
   
 Line of cross section.



**Figure 1. Location of cross section A - A' and locations of test holes and observation wells drilled for this investigation.**

## RESULTS OF INVESTIGATION

### Geology

The geology around the city of Hurley consists of glacial deposits overlying older bedrock. Table 1 shows the geologic unit or formation names, their relative ages, and provides a brief description of each unit known to be present in the study area. Figure 2 shows the relative positions of the different units.

### Bedrock

The bedrock in the vicinity of Hurley consists of rocks deposited during a period of time known as the Cretaceous. These sediments include the Niobrara Formation, Carlile Shale, Greenhorn Limestone, Graneros Shale, and the Dakota Formation (table 1).

A bedrock highland or ridge cuts across the area from northwest to southeast. This ridge roughly extends from the city of Marion through Hurley and then toward the southeast (Lindgren and Hansen, 1990). This ridge consists of the Niobrara Formation with Carlile Shale present just below and off the shoulders of this bedrock highland (fig. 2). Other Cretaceous formations are present below the Carlile Shale but were beyond the scope of this investigation.

### Glacial Deposits

The glacial deposits are younger than the bedrock sediments and consist of till and outwash. Till is a heterogeneous mixture of clay, silt, sand, gravel, and boulders in a predominantly fine grained matrix of clay and silt. Outwash consists mainly of sand and gravel with minor amounts of clay and silt. Two outwash bodies have been recognized in the study area; one is known as the Parker-Centerville aquifer (Tipton, 1957) and the other is the Upper-Vermillion-Missouri aquifer (Hedges and others, 1982).

### PARKER-CENTERVILLE AQUIFER

The Parker-Centerville aquifer is composed of outwash and lies generally to the east of a northwest-southeast trending topographic highland extending through the city of Hurley. To the west of this topographic highland, the Parker-Centerville aquifer is absent. Near the western boundary of the Parker-Centerville aquifer, the sands and gravels are in direct contact with the Niobrara Formation. Farther toward the east, unweathered till is found directly below the aquifer material (fig. 2).

### UPPER-VERMILLION-MISSOURI AQUIFER

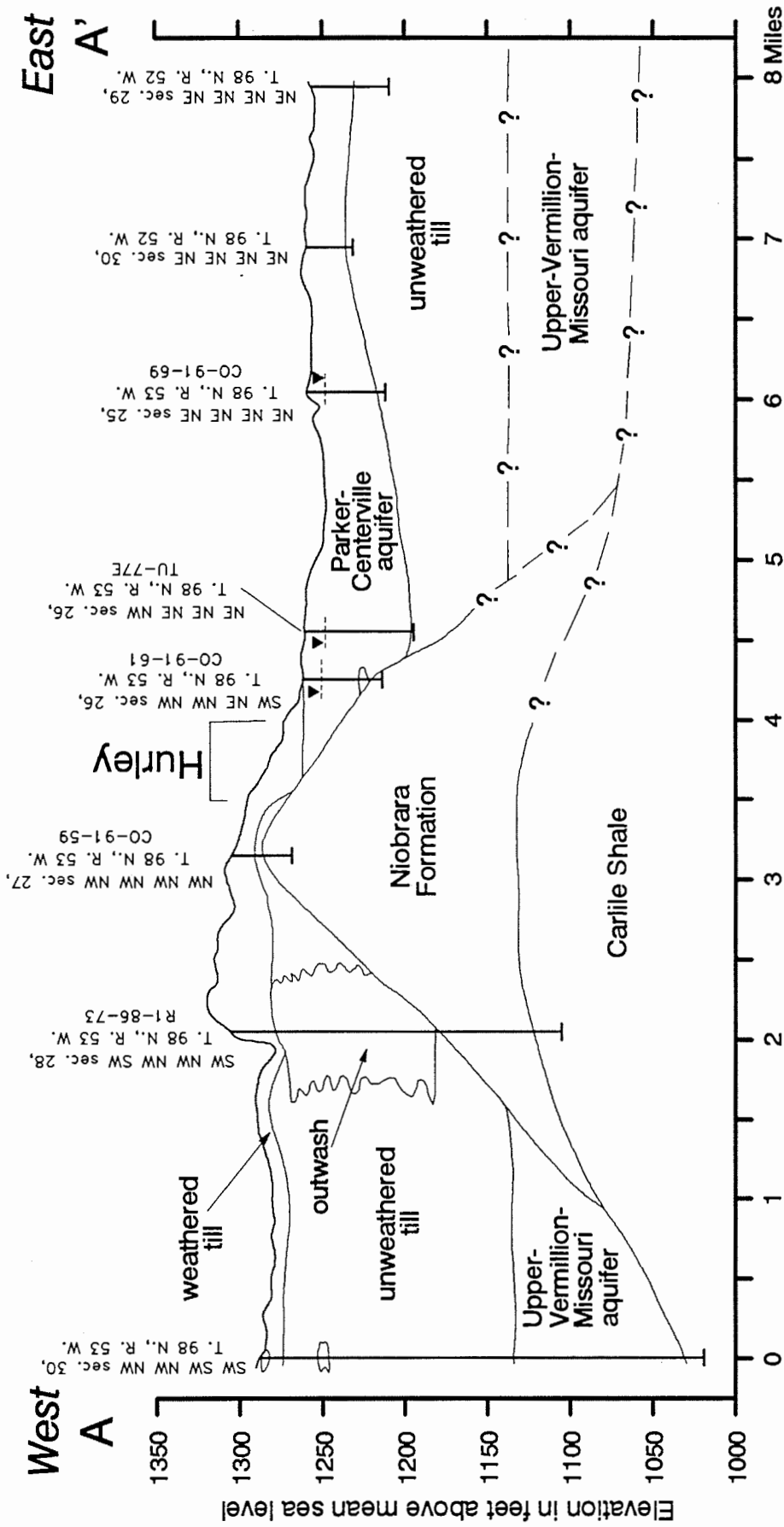
The Upper-Vermillion-Missouri aquifer is composed of outwash and lies below the Parker-Centerville aquifer (fig. 2). It was found to be present in test holes to the east, west, and north of

TABLE 1. Description of geologic units

Geologic age from youngest to oldest	Geologic unit or Formation Name	Description <sup>1</sup>
Quaternary	Till	Heterogeneous mixture of clay, silt, sand, pebbles, and boulders in a predominantly fine grained matrix of clay and silt.
	Outwash	Mixture of sand and gravel with minor amounts of silt and clay. Includes the Parker-Centerville aquifer and Upper-Vermillion-Missouri aquifer on figure 2.
Cretaceous	Niobrara Formation	Medium- to dark-gray calcareous marl which weathers to light yellow in the upper section, and a gray chalky limestone which weathers white to cream-colored in the lower section.
	Carlile Shale	Medium-gray, noncalcareous, plastic, fissile shale.
	Greenhorn Limestone	Gray limestone, weathers light cream to white, fossiliferous.
	Graneros Shale	Medium- to dark-gray, noncalcareous, silty shale interbedded with thin silt and sand.
	Dakota Formation	Alternating beds of shale, siltstone, and sandstone.

<sup>1</sup> Modified from Christensen (1967)

# Figure 2. Geologic Cross Section A - A'.



SW NW NW SW sec. 28, T. 98 N., R. 53 W., CO-91-59

Well or test hole. The first two lines represent the legal location and, where present, the third line is the well identifier. All logs are on file at the South Dakota Geological Survey. See figure 1 for cross-section location.

SW NW NW SW sec. 28, T. 98 N., R. 53 W., R1-86-73

NW NW NW SW sec. 27, T. 98 N., R. 53 W., CO-91-59

SW NE NW NW sec. 26, T. 98 N., R. 53 W., CO-91-61

NE NE NE NE sec. 26, T. 98 N., R. 53 W., TU-77E

NE NE NE NE sec. 25, T. 98 N., R. 53 W., CO-91-69

NE NE NE NE sec. 30, T. 98 N., R. 52 W.

NE NE NE NE sec. 29, T. 98 N., R. 52 W.

Legend:

- Well or test hole. The first two lines represent the legal location and, where present, the third line is the well identifier. All logs are on file at the South Dakota Geological Survey. See figure 1 for cross-section location.
- Geologic contact. Dashed where approximate.
- Static water level. See table 2 for listing of water-elevation data.

See appendix A for legal-location format.

Vertical exaggeration = 50x



the city of Hurley (figs. 2 and 3). As with the Parker-Centerville aquifer, the Upper-Vermillion-Missouri aquifer is in direct contact with the Niobrara Formation and, additionally, the Carlile Shale.

## Hydrology

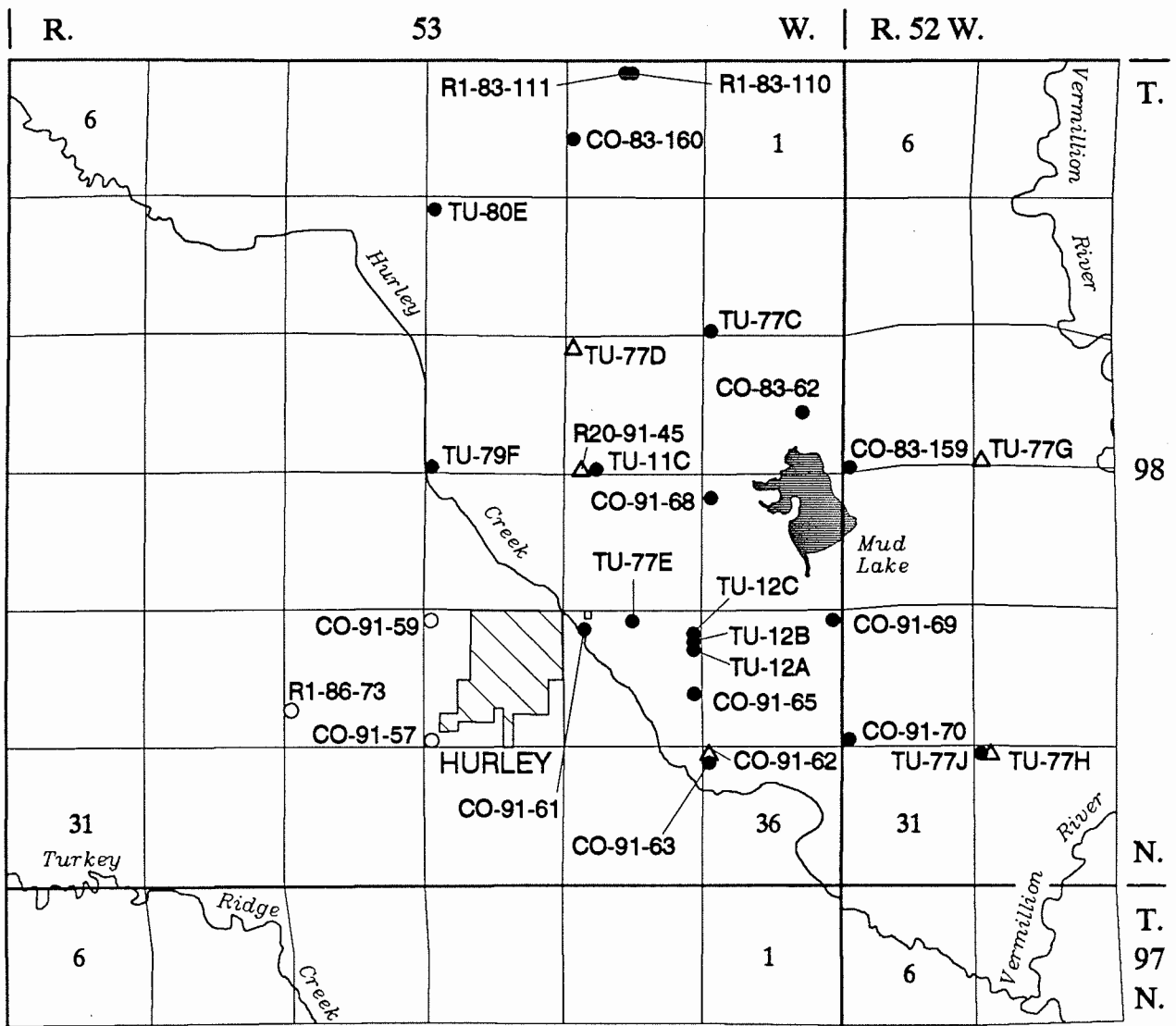
### Bedrock Aquifers

The Niobrara Formation and the Dakota Formation are two bedrock units that have the potential for yielding water near the city of Hurley. The Dakota Formation underlies the city of Hurley at a depth of approximately 400 feet below land surface and generally has a water quality that is inferior to the Parker-Centerville or Upper-Vermillion-Missouri aquifers. For these reasons, the Dakota Formation was not researched for this investigation. The Niobrara Formation has the potential for yielding useable amounts of water and many domestic wells have been completed in this formation. Near the city of Hurley, the Niobrara Formation has water elevations that are higher than those in the Parker-Centerville aquifer (table 2). As shown in figure 2, the Niobrara Formation and Parker-Centerville aquifer are in direct contact with each other. The difference in water elevations between the Niobrara Formation and Parker-Centerville aquifer suggests that water from the Niobrara Formation is discharging to the Parker-Centerville aquifer, at least in the area directly east of Hurley and near Hurley's municipal well which is located at NW NE NW NW sec. 26, T. 98 N., R. 53 W. (fig. 3). Three wells completed in the Niobrara Formation (fig. 3) were sampled for general chemical analysis. Analyses of water from these wells show a general poor water quality (table 3, app. B). Figures 4, 5, and 6 show the concentrations of total dissolved solids, sulfate, hardness, iron, and manganese in these three wells located just west of Hurley. The poor water quality of the Niobrara Formation and the possibility that water from the Niobrara Formation is discharging to the Parker-Centerville aquifer near Hurley's municipal well may contribute to Hurley's poor water quality problem.

### Upper-Vermillion-Missouri Aquifer

Water levels measured in wells completed in the Upper-Vermillion-Missouri aquifer show that this aquifer is under confined conditions. Approximate water elevations are shown in table 2 for the Upper-Missouri-Vermillion aquifer and are based on an approximation of ground-surface elevations using 7.5 minute topographic maps.

Water quality in the Upper-Vermillion-Missouri aquifer is generally better than that of the Niobrara Formation and worse in water quality than the Parker-Centerville aquifer (table 3, app. B). Figure 3 shows the well locations and figures 4, 5, and 6 show total dissolved solids, sulfate, hardness, iron, and manganese values for the Upper-Vermillion-Missouri aquifer. Total dissolved solids concentrations range from 736 to 2,090 milligrams per liter (mg/L) with an average of 1,382 mg/L. Sulfates range from 375 to 1,150 mg/L with an average of 705 mg/L. Hardness concentrations range from 496 to 1,373 mg/L with an average of 920 mg/L. Concentrations of iron range from less than 0.05 to 5.52 mg/L with an average of 1.57 mg/L. The concentrations of manganese range from 0.88 to 1.79 mg/L with an average of 1.40 mg/L.



0 1 2 3 Miles

SCALE



- TU-77E ● Observation well completed in the Parker-Centerville aquifer.
- CO-91-57 ○ Observation well completed in the Niobrara Formation.
- TU-77G ▲ Observation well completed in the Upper-Vermillion-Missouri aquifer.
- Hurley municipal well.

Letters and numbers are the well identifier.

**Figure 3. Locations of observation wells and Hurley's municipal well.**

**TABLE 2. Water elevations and saturated thickness**

Well Name	Legal Location <sup>1</sup>	Water Elevations <sup>2</sup>	Saturated Thickness <sup>3</sup>
<b><u>Parker-Centerville aquifer</u></b>			
CO-83-159	SW SW SW SW sec. 18, T. 98 N., R. 52 W.	1248	23
CO-91-70	SW SW SW SW sec. 30, T. 98 N., R. 52 W.	1245	35
TU-77J	NW NW NW NW sec. 32, T. 98 N., R. 52 W.	1244	21
TU-80E	NW NW NW NW sec. 10, T. 98 N., R. 53 W.	1273	24
TU-77C	SW SW SW SW sec. 12, T. 98 N., R. 53 W.	1251	22
TU-11C	SE SW SW SW sec. 14, T. 98 N., R. 53 W.	1244	--
TU-79F	SW SW SW SW sec. 15, T. 98 N., R. 53 W.	1259	28
CO-91-68	SW SW NW NW sec. 24, T. 98 N., R. 53 W.	1247	45
CO-91-69	NE NE NE NE sec. 25, T. 98 N., R. 53 W.	1249	43
TU-12A	SE SE NE NE sec. 26, T. 98 N., R. 53 W.	1246	--
TU-12B	SE SE NE NE sec. 26, T. 98 N., R. 53 W.	1246	--
TU-12C	SE SE NE NE sec. 26, T. 98 N., R. 53 W.	1247	--
TU-77E	NE NE NE NW sec. 26, T. 98 N., R. 53 W.	1248	63
CO-91-61	SW NE NW NW sec. 26, T. 98 N., R. 53 W.	1250	31
CO-91-65	SE NE NE SE sec. 26, T. 98 N., R. 53 W.	1249	52
CO-91-63	NW NW NW NW sec. 36, T. 98 N., R. 53 W.	1250	--
<b><u>Upper-Vermillion-Missouri aquifer</u></b>			
TU-77G	SW SW SW SW sec. 17, T. 98 N., R. 52 W.	1221	--
TU-77H	NW NW NW NW sec. 32, T. 98 N., R. 52 W.	1231	19
TU-77D	NW NW NW NW sec. 14, T. 98 N., R. 53 W.	1244	68
R20-91-45	SE SW SW SW sec. 14, T. 98 N., R. 53 W.	1254	56
CO-91-62	NW NW NW NW sec. 36, T. 98 N., R. 53 W.	1251	109
<b><u>Niobrara Formation</u></b>			
CO-91-59	NW NW NW NW sec. 27, T. 98 N., R. 53 W.	1279	--
CO-91-57	SW SW SW SW sec. 27, T. 98 N., R. 53 W.	1278	--
R1-86-73	SW NW NW SW sec. 28, T. 98 N., R. 53 W.	1274	--

<sup>1</sup> See appendix A for explanation of legal location format.

<sup>2</sup> Water elevations are in feet above mean sea level and are based on an estimation of land-surface elevation from U.S. Geological Survey 7.5 minute series topographic maps for the Center Point (1970), Hurley (1968), Parker Southwest (1968), and Viborg (1968) quadrangles. Elevations are accurate to within plus or minus 5 feet. All water elevations were measured during July and August, 1991.

<sup>3</sup> Saturated thickness was calculated only where the well penetrated the entire aquifer and is presented in feet.

---

**TABLE 3. Comparison of water quality in the Hurley vicinity**

---

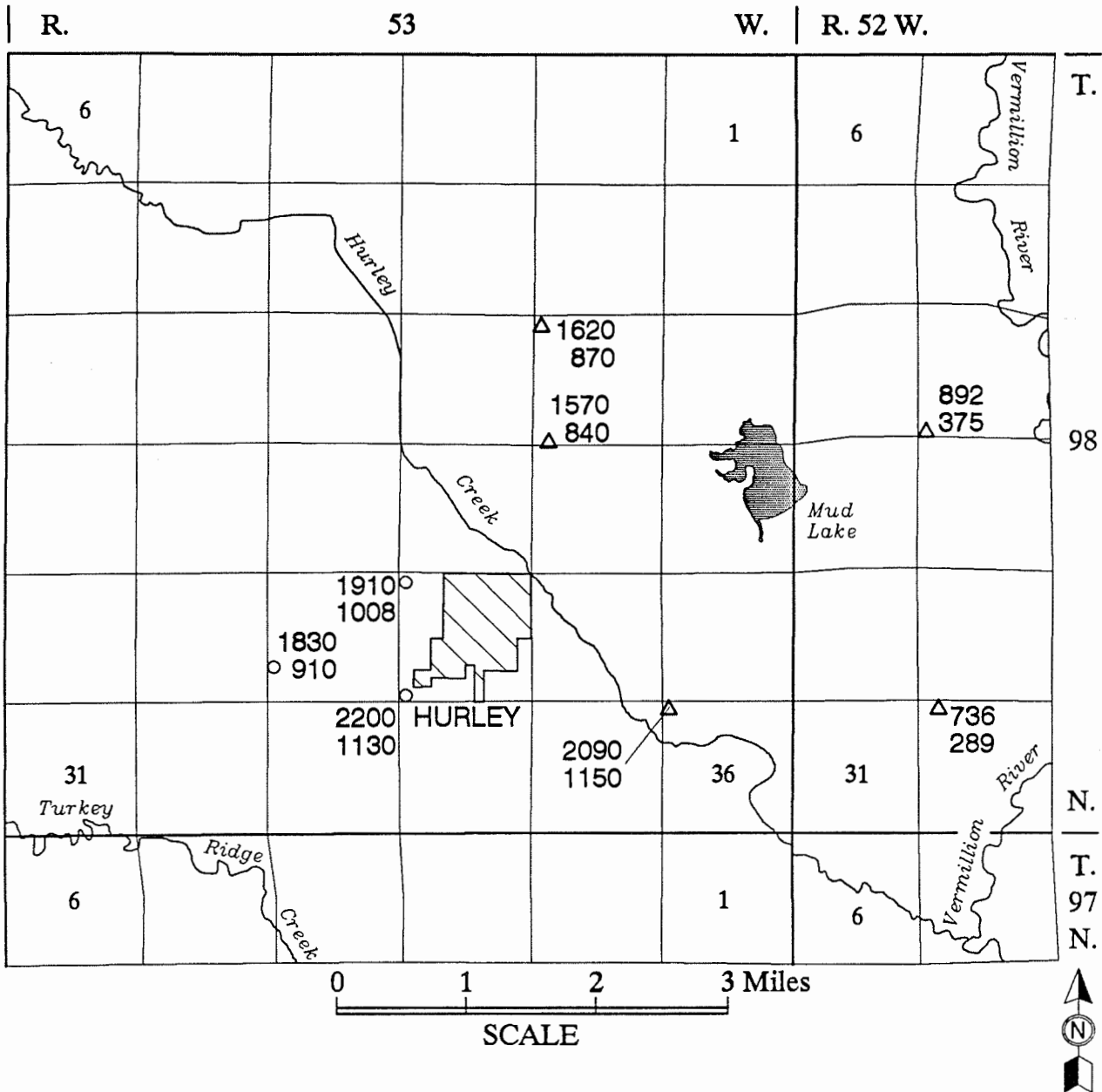
parameter and concentration in milligrams per liter

---

Iron	Manganese	Nitrate + nitrite as nitrogen	Sulfate	Total dissolved solids	Hardness as calcium carbonate
<b><u>Parker-Centerville aquifer</u></b>					
<i>average of 21 samples</i>					
1.30	0.95	1.28	558	1152	781
<i>Hurley municipal well</i>					
2.31	1.20	0.30	782	1558	1062
<i>CO-91-69</i>					
1.52	0.62	<0.04	236	815	630
<i>CO-91-70</i>					
0.94	0.42	<0.04	211	634	422
<b><u>Upper-Vermillion-Missouri aquifer</u></b>					
<i>average of 5 samples</i>					
1.57	1.40	<0.04	705	1382	920
<b><u>Niobrara Formation (bedrock)</u></b>					
<i>average of 3 samples</i>					
0.13	0.16	0.11	1016	1980	1263

---

See appendix B for a complete listing of analytical results.



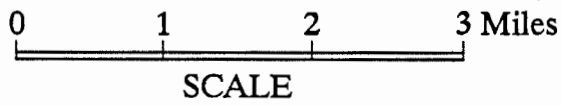
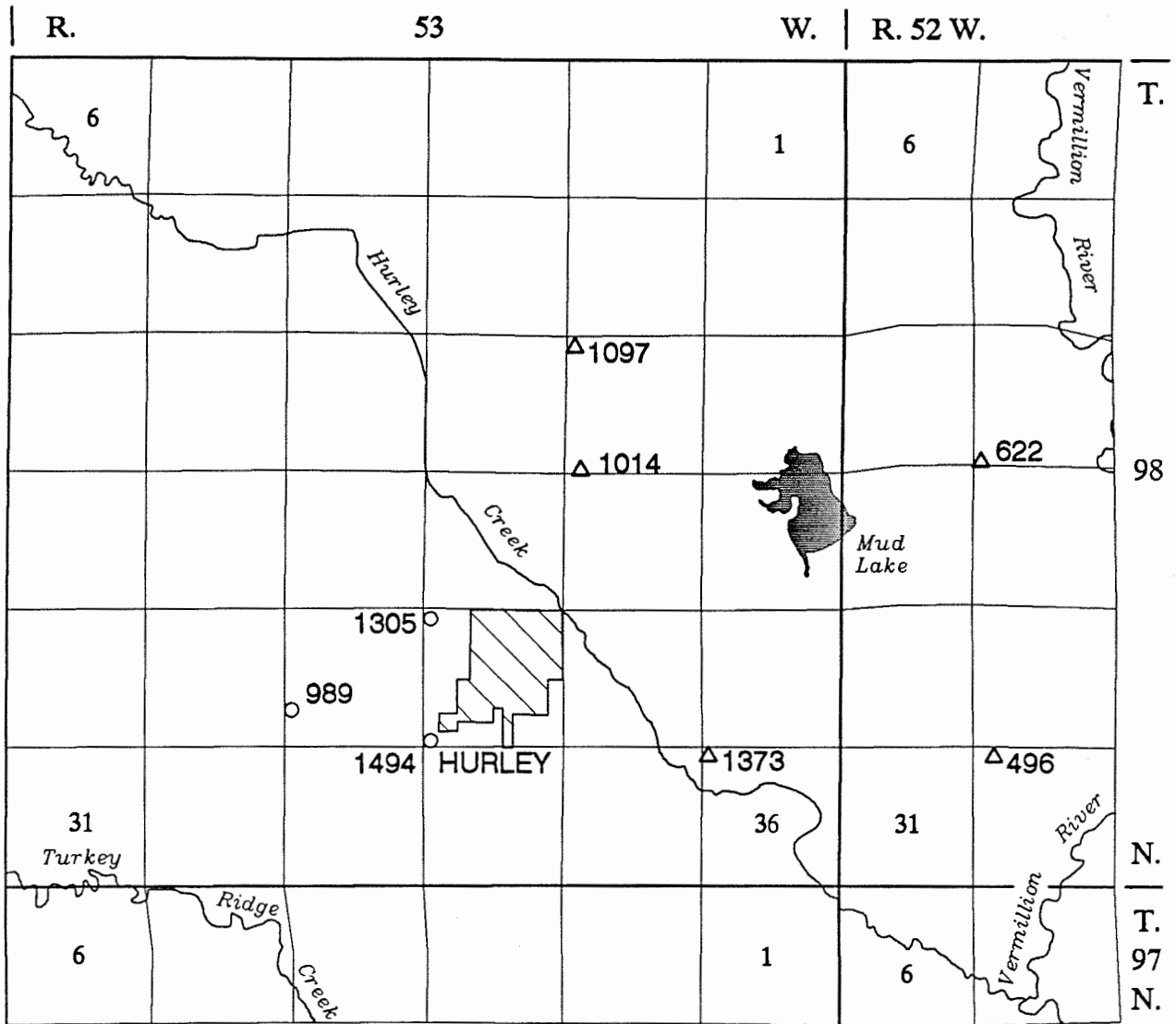
2200  
1130  
○ Observation well completed in the Niobrara Formation.

892  
375  
△ Observation well completed in the Upper-Vermillion-Missouri aquifer.

The upper number is the total dissolved solids concentration and the lower number is the sulfate concentration in milligrams per liter.

See appendix B for sample-collection date.

**Figure 4. Total dissolved solids and sulfate concentrations in the Upper-Vermillion-Missouri aquifer and Niobrara Formation.**



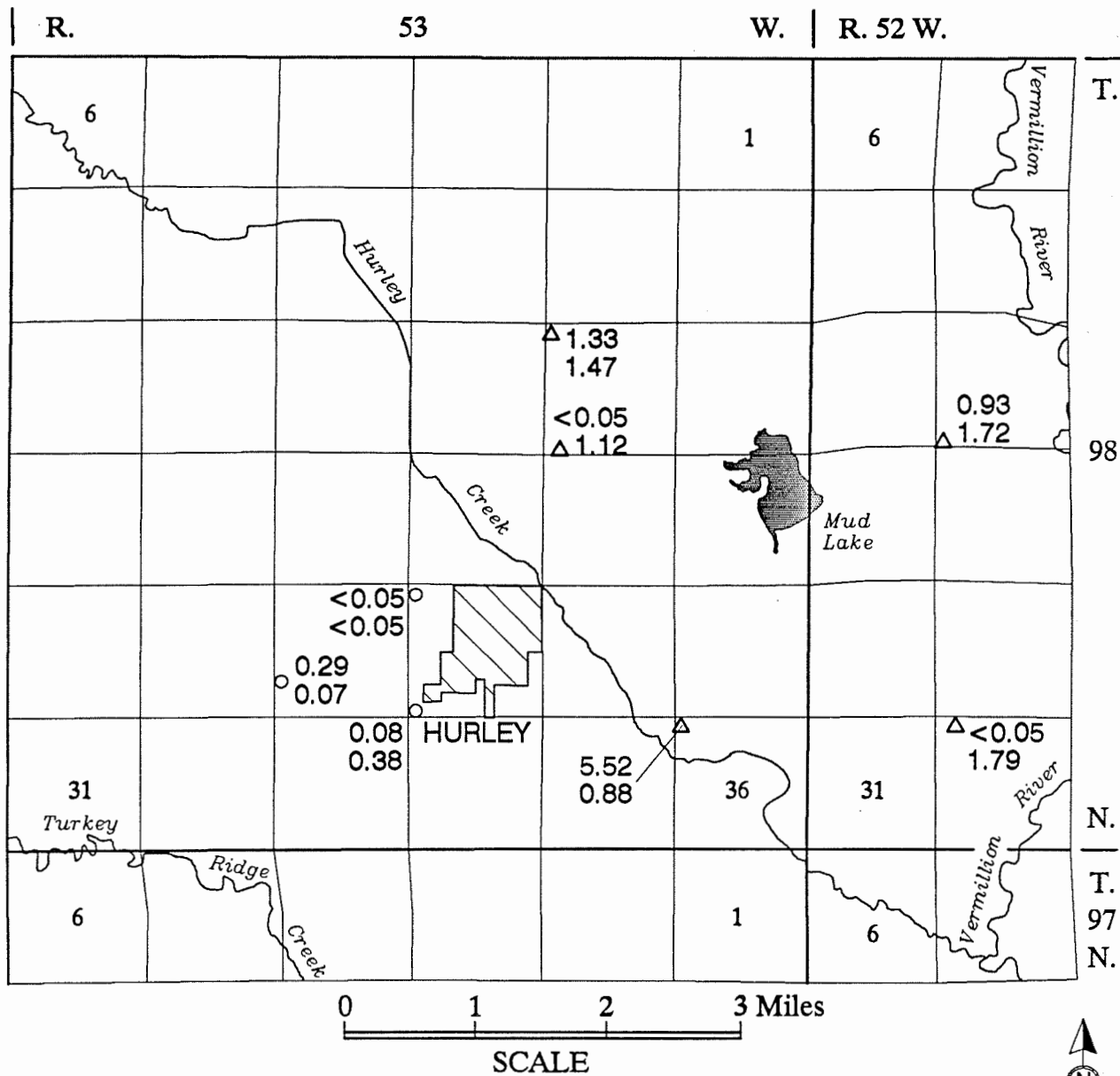
1305 ○ Observation well completed in the Niobrara Formation.

496 △ Observation well completed in the Upper-Vermillion-Missouri aquifer.

The number is the hardness concentration in milligrams per liter.

See appendix B for sample-collection date.

**Figure 5. Hardness concentrations in the Upper-Vermillion-Missouri aquifer and Niobrara Formation.**



0.29  
0.07 ○ Observation well completed in the Niobrara Formation.

1.33  
1.47 △ Observation well completed in the Upper-Vermillion-Missouri aquifer.

The upper number is the iron concentration and the lower number is the manganese concentration in milligrams per liter.

See appendix B for sample-collection date.

**Figure 6. Iron and manganese concentrations in the Upper-Vermillion-Missouri aquifer and Niobrara Formation.**

## Parker-Centerville Aquifer

The Parker-Centerville aquifer is a surficial aquifer that covers approximately 72 square miles (Lindgren and Hansen, 1990). The saturated thickness was calculated only in the wells that penetrated the entire thickness of the Parker-Centerville aquifer and ranged from a low of 21 feet to a high of 63 feet with an average of 35 feet (table 2). Ground-water flow is generally from the northwest toward the southeast according to ground-water contours in figure 7. Ground-water flow is perpendicular to the ground-water contours. Water elevations are based on an approximation of ground-surface elevations using 7.5 minute topographic quadrangle maps.

Water quality in the Parker-Centerville aquifer varies, but generally has high iron, manganese, and total dissolved solids concentrations. Seventeen water samples were collected from this aquifer for general chemical analysis for this study. Analytical results for these samples collected in 1991 are presented in table 3 and appendix B along with other available data for the Parker-Centerville aquifer. Figure 3 shows the well locations and figures 8, 9, 10, 11, and 12 show the concentrations of total dissolved solids, sulfate, hardness, iron, and manganese in the Parker-Centerville aquifer. Total dissolved solids range from 629 to 2,850 mg/L with an average of 1,152 mg/L. Sulfate concentrations range from 211 to 1,650 mg/L with an average of 558 mg/L. Hardness concentrations range from 422 to 1,906 mg/L with an average of 781 mg/L. Iron ranges from less than 0.05 to 5.52 mg/L with an average of 1.30 mg/L. Manganese concentrations range from less than 0.05 to 4.71 mg/L with an average of 0.95 mg/L.

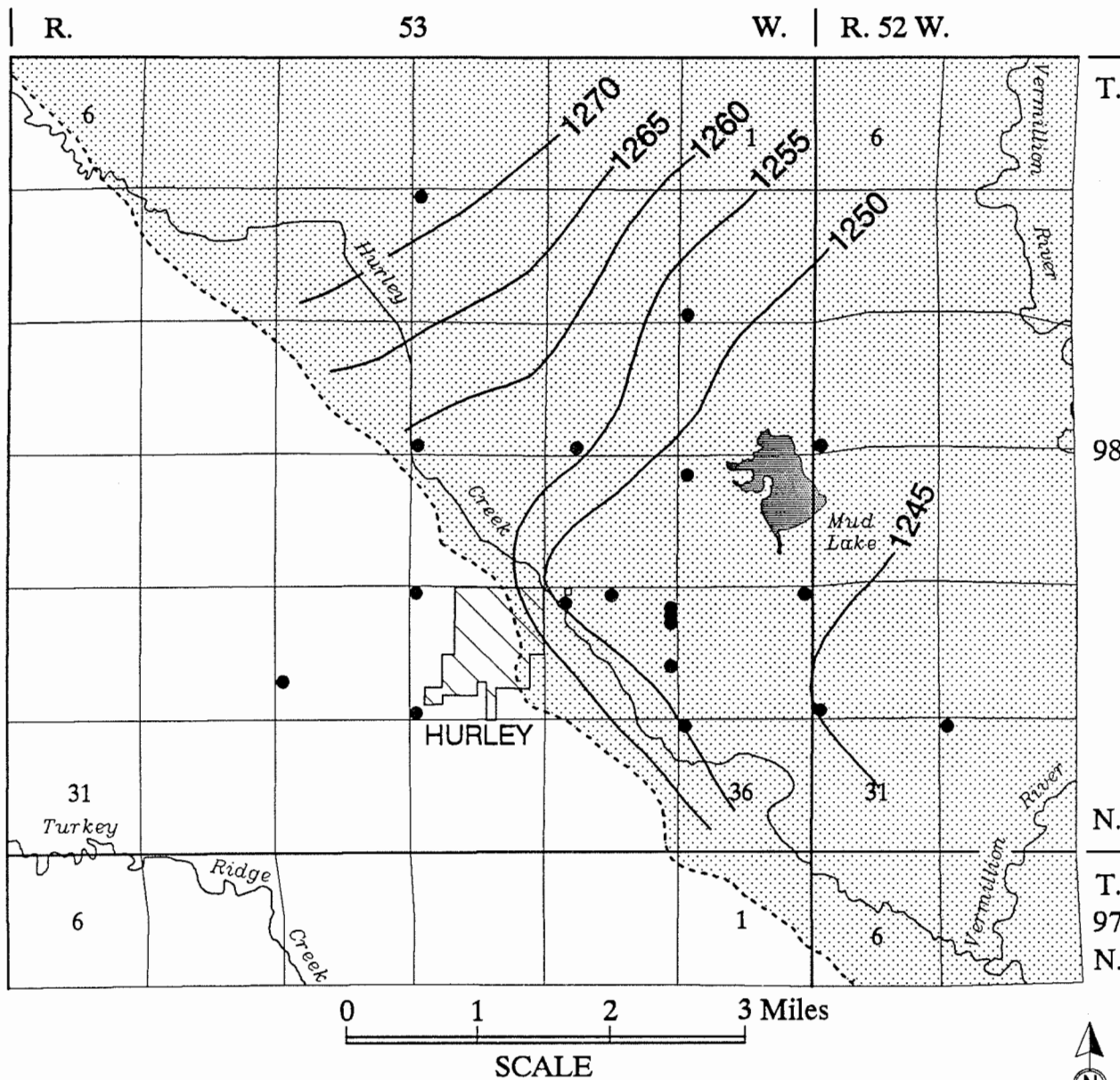
### Comparison of Water Quality in the Hurley Vicinity

Table 3 presents the average concentrations for various parameters for the different aquifers investigated in the Hurley vicinity. It also shows the water quality for the current Hurley municipal well and two other specific wells, CO-91-69 and CO-91-70, located 2 miles east of Hurley. These two wells east of Hurley have water quality slightly better than the average of other wells in the area. Water-quality data obtained from the city of Hurley show that the levels of total dissolved solids, sulfate, iron, and manganese exceed the secondary maximum contaminant levels set forth by the U.S. Environmental Protection Agency (see app. B for secondary maximum contaminant levels). Hurley's municipal well has also tested positive for iron bacteria which may cause discoloration, odor problems, clogging of piping, and reduced flow rates. A comparison of the quality of water between the different aquifers shows that the Parker-Centerville aquifer has the best overall water quality.

## SUMMARY AND RECOMMENDATIONS

The city of Hurley has a municipal water supply well that is located near the western boundary of the Parker-Centerville aquifer. The present water quality is poor and may be partly due to the influence of the Niobrara Formation which likely recharges the Parker-Centerville aquifer in the vicinity of the city's municipal well. Hurley's water supply does not violate any of the current national interim primary drinking water regulations set forth by the U.S. Environmental Protection Agency. Although Hurley's current water supply meets the primary drinking water standards, many secondary maximum contaminant levels are exceeded. These secondary drinking water regulations are suggested limits and not enforceable limits.





- Observation well used to determine water-table elevations.

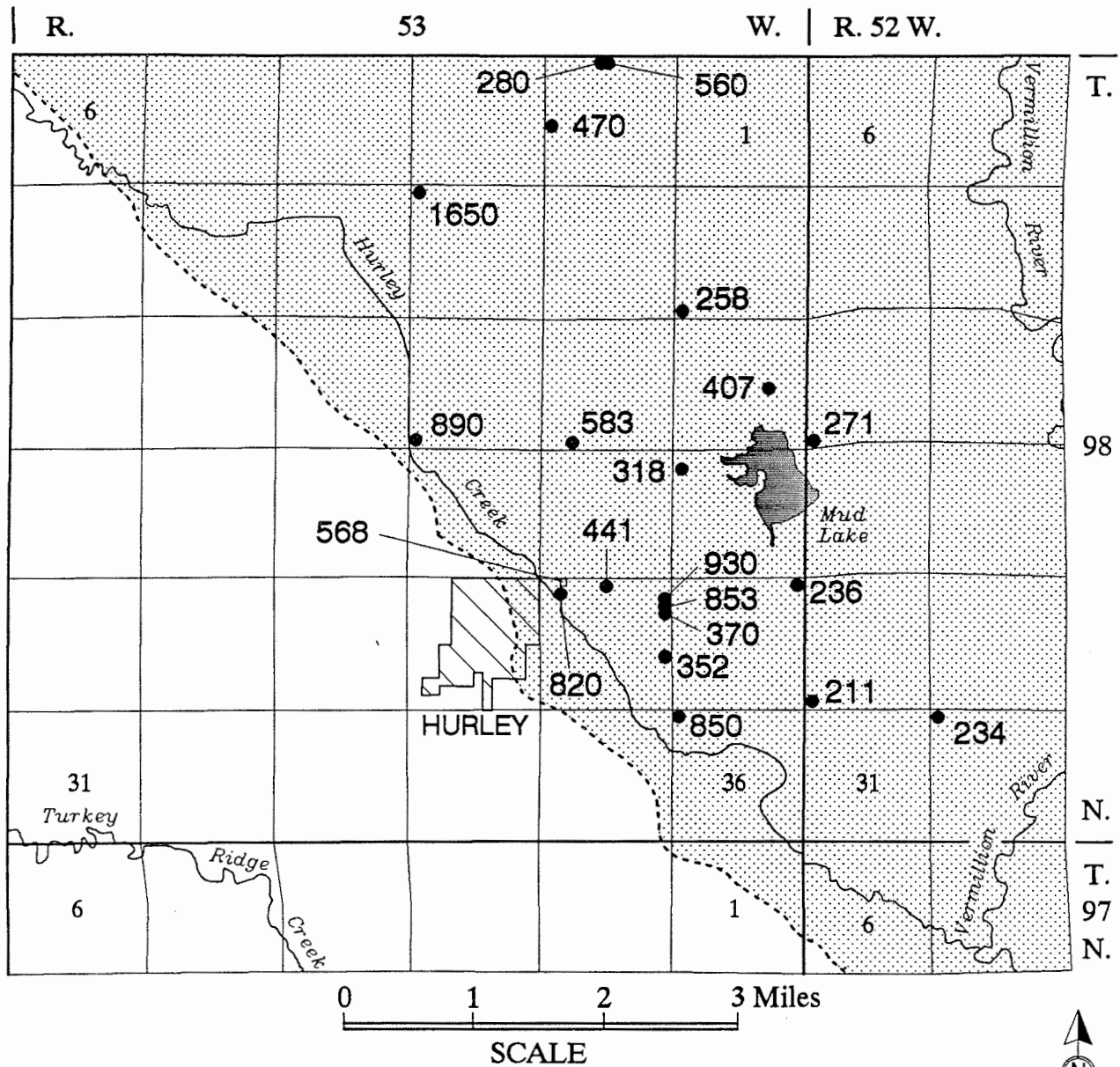
— 1270 Contour line connecting points of equal elevation during July - August, 1991. See table 2 for specific elevations. Elevations are in feet above mean sea level. Contour interval = 5 feet.

Approximate boundary and areal extent of the Parker-Centerville aquifer.

- ◻ Hurley municipal well

**Figure 7. Water-table contours for the Parker-Centerville aquifer.**





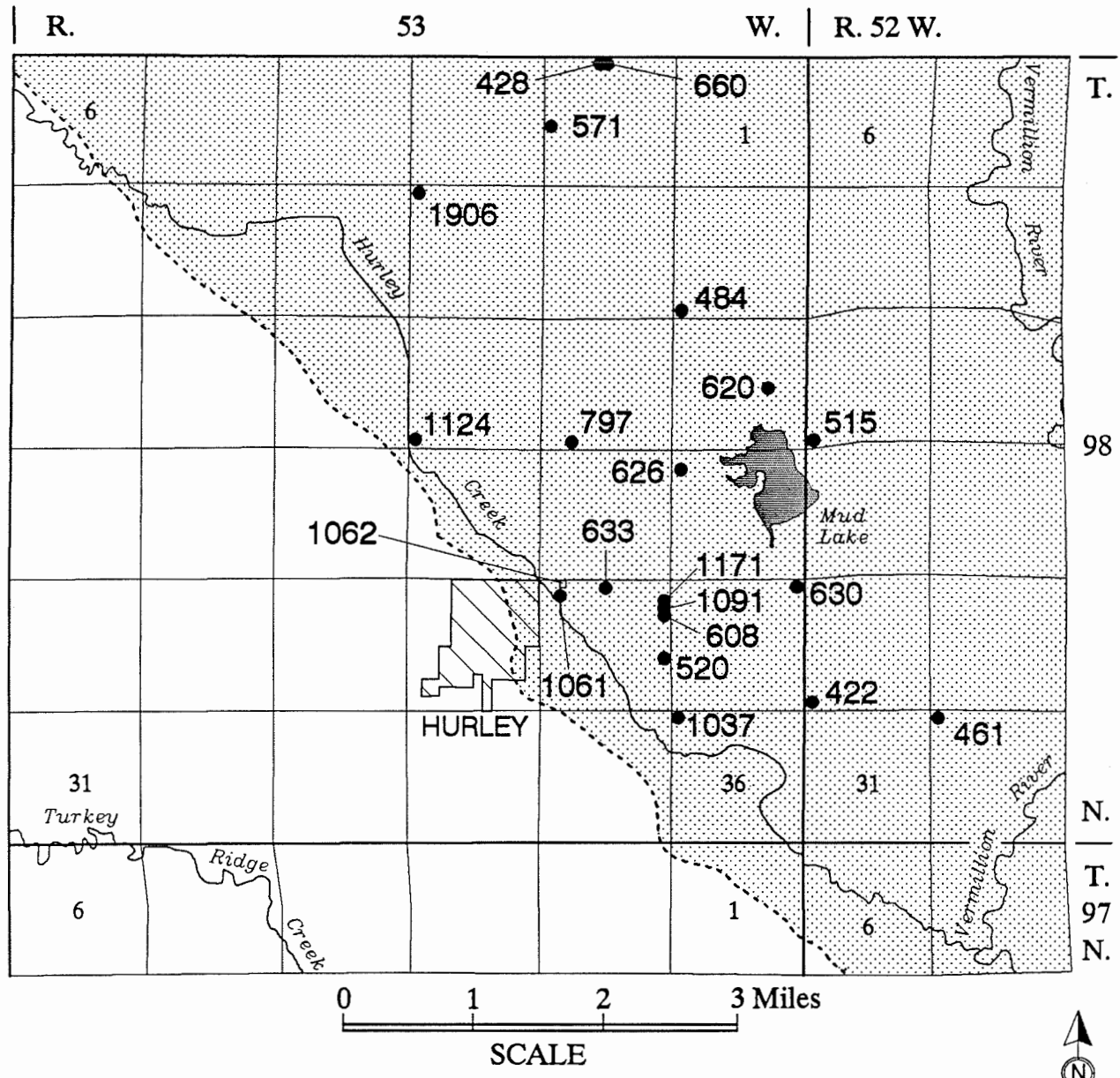
850 ● Observation well. Number is the concentration of sulfate in milligrams per liter.

568 ◻ Hurley municipal well.

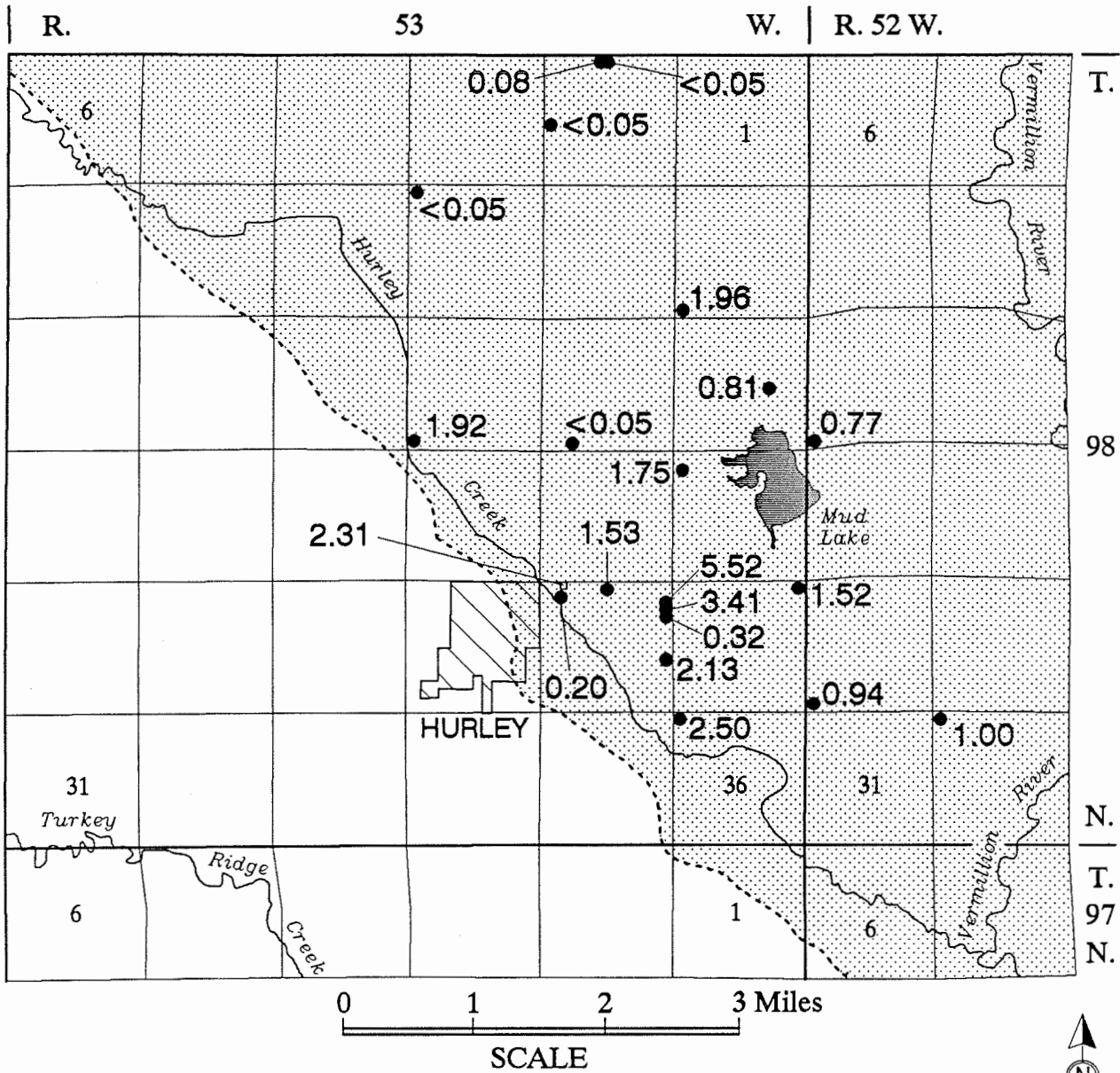
See appendix B for sample-collection date.

Approximate boundary and areal extent of the Parker-Centerville aquifer.

**Figure 9. Sulfate concentrations in the Parker-Centerville aquifer.**



**Figure 10. Hardness concentrations in the Parker-Centerville aquifer.**

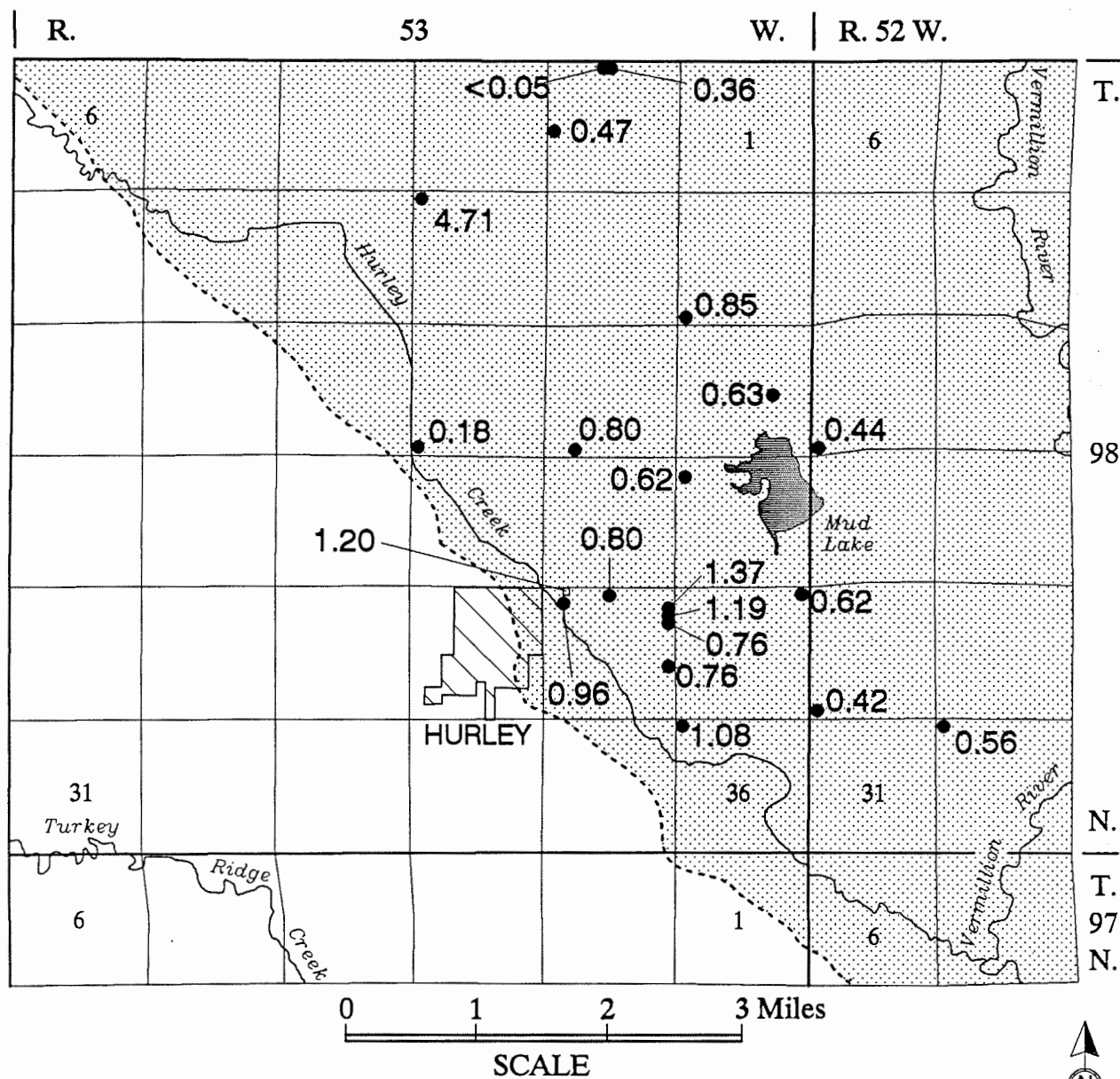


0.08 • Observation well. Number is the concentration of iron in milligrams per liter.  
 2.31 ◻ Hurley municipal well.

See appendix B for sample-collection date.


Approximate boundary and areal extent of the Parker-Centerville aquifer.

**Figure 11. Iron concentrations in the Parker-Centerville aquifer.**



0.36 ● Observation well. Number is the concentration of manganese in milligrams per liter.  
 1.20 ◻ Hurley municipal well.

See appendix B for sample-collection date.

 Approximate boundary and areal extent of the Parker-Centerville aquifer.

**Figure 12. Manganese concentrations in the Parker-Centerville aquifer.**

Based on the water-quality comparison, it can be generally stated that the Parker-Centerville aquifer has the best overall water quality of the aquifers investigated in the Hurley vicinity. One area of the Parker-Centerville aquifer located approximately 2 miles east of Hurley demonstrated better than average water quality, but still has iron, manganese, and total dissolved solids that are above the secondary maximum contaminant levels.

If the city of Hurley decides to develop an area in the Parker-Centerville aquifer or any other aquifer, it is recommended that the following be addressed before the final production well and water-distribution system are installed.

1. Site specific hydrogeologic exploration should be performed to better determine aquifer thickness and lithology, water levels, and water quality in the aquifer.
2. The potential impact of the Niobrara Formation on the quality and quantity of water should be considered.
3. An aquifer test should be performed to allow predictions of water yield from the aquifer.
4. The Department of Environment and Natural Resources (Division of Water Rights) should be contacted regarding a water-right permit.

## REFERENCES

- Christensen, C.M., 1967, Geology and water resources of Clay County, South Dakota: South Dakota Geological Survey Bulletin 19.
- Coker, M.K., Wilke, K., and Coker, M., 1988, South Dakota Geological Survey water sampling manual: South Dakota Geological Survey Internal Document.
- Hedges, L.S., Burch, S.L., Iles, D.L., Barari, R.A., and Schoon, R.A., 1982 Evaluation of ground-water resources, eastern South Dakota and upper Big Sioux River, South Dakota and Iowa; Task 2, Extent of aquifers: Prepared by the South Dakota Geological Survey for the U.S. Army Corps of Engineers, Contract DACW 45-80-C-0185.
- Lindgren, R.J., and Hansen, D.S., 1990, Water resources of Hutchinson and Turner Counties, South Dakota: U.S. Geological Survey Water-Resources Investigations Report 90-4093.
- Tipton, M.J., 1957, Geology and hydrology of the Parker-Centerville outwash: South Dakota Geological Survey Report of Investigations 82.
- U.S. Geological Survey, 1968, Surficial topography of the Hurley, South Dakota quadrangle: U.S. Geological Survey Topographic Map Series, scale 1:24,000.
- \_\_\_\_\_, 1968, Surficial topography of the Parker Southwest, South Dakota quadrangle: U.S. Geological Survey Topographic Map Series, scale 1:24,000.
- \_\_\_\_\_, 1968, Surficial topography of the Viborg quadrangle: U.S. Geological Survey Topographic Map Series, scale 1:24,000.
- \_\_\_\_\_, 1970, Surficial topography of the Center Point, South Dakota quadrangle: U.S. Geological Survey Topographic Map Series, scale 1:24,000.
- U.S. Environmental Protection Agency, 1985a, National interim primary drinking water regulations - maximum contaminant levels for inorganic chemicals: Code of Federal Regulations, Title 40, Part 141, Sections 141.11, and 141.15.
- \_\_\_\_\_, 1985b, National secondary drinking water regulations - secondary maximum contaminant levels: Code of Federal Regulations, Title 40, Part 143, Section 143.3.



## APPENDIX A

### Logs of test holes and observation wells

#### LEGAL LOCATION and LOCATION

The logs are listed by smallest township number, then the smallest range number, the smallest section number and then by quarter section. NE = A; NW = B; SW = C; SE = D. A comparison of **LEGAL LOCATION** and **LOCATION** is as follows. A **LEGAL LOCATION** of NW $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 29, T. 98 N., R. 53 W. is the same as a **LOCATION** of 098N-53W-29CADB. If the smallest quarter section in the **LOCATION** is followed by a number, this indicates that more than one log may exist for that particular location.

#### LATITUDE and LONGITUDE

The format is DD.MMSS where **D** is degrees, **M** is minutes, and **S** is seconds.

#### DRILLING COMPANY

**SDGS** is an abbreviation for South Dakota Geological Survey.

#### TOTAL DRILL HOLE DEPTH, SCREEN LENGTH, TOTAL CASING AND SCREEN and CASING STICK-UP

The numbers are presented in feet.

#### SCREEN TYPE and CASING TYPE

**PVC** is an abbreviation for polyvinyl chloride. **MFG.** is an abbreviation for manufactured and indicates a product that is commercially available. **SLOT** is the size, in inches, of the openings on the screen. **SCH.** is an abbreviation for schedule and refers to casing thickness.

#### CASING TOP ELEVATION and GROUND SURFACE ELEVATION

The numbers are presented in feet above mean sea level. **T** - the elevation was estimated from a 7.5 minute series topographic map.

#### CASING DIAMETER

The numbers are presented in inches.



County: TURNER  
 Legal Location: SW SW SW SW sec. 30, T. 98 N., R. 52 W.  
 Latitude: 43.1619  
 Land Owner:  
 Project: HURLEY CITY STUDY  
 Drilling Company: SDGS  
 Driller: D. JACOBSON  
 Geologist: L. SCHULZ  
 Date Drilled: 07-23-1991  
 Ground Surface Elevation: 1252 T  
 Total Drill Hole Depth: 47  
 Water Rights Well:  
 Other Well Name:  
 Basin: VERMILLION  
 Management Unit:  
 Screen Type: PVC, MFG., SLOT SIZE 0.018  
 Casing Type: PVC  
 Casing Top Elevation: 1254 T  
 Casing Stick-up: 2.00  
 Well Maintenance Date:  
 USGS Hydrological Unit Code: 10170102  
 Electric Log Information:  
   Spontaneous Potential:  
   Natural Gamma:  
   Samples:

Location: 098N-52W-30CCCC  
 Longitude: 97.0231  
  
 Driller's Log:  
 Geologist's Log: X  
 Drilling Method: ROTARY  
  
 Test Hole Number: CO-91-70  
 SDGS Well Name: CO-91-70  
  
 Aquifer: PARKER-CENTERVILLE  
  
 Screen Length: 10.0  
 Casing Diameter: 2.0  
  
 Total Casing and Screen: 40.0  
  
 Single Point Resistivity:  
 Extra:

Well Information: Well screened from 38 to 28 feet. Filter pack from 38 to 26 feet.  
 Neat cement grout from 26 feet below ground surface to ground level. One steel  
 well protector installed.

0	-	2	Topsoil
2	-	42	Sand and gravel, brown to orange-brown, very coarse sand, very coarse to cobble gravel; clean (outwash)
42	-	47	Clay, gray, silty, sandy, pebbly; unoxidized (till)

\* \* \* \*

County: TURNER  
 Legal Location: SE SW SW SW sec. 14, T. 98 N., R. 53 W.  
 Latitude: 43.1802  
 Land Owner:  
 Project: HURLEY CITY STUDY  
 Drilling Company: SDGS  
 Driller: D. IVERSON  
 Geologist: L. SCHULZ  
 Date Drilled: 07-16-1991  
 Ground Surface Elevation: 1268 T  
 Total Drill Hole Depth: 177  
 USGS Hydrological Unit Code: 10170102  
 Electric Log Information:  
   Spontaneous Potential:  
   Natural Gamma: X  
   Samples:

Location: 098N-53W-14CCCD  
 Longitude: 97.0450  
  
 Driller's Log:  
 Geologist's Log: X  
 Drilling Method: ROTARY  
  
 Test Hole Number: R20-91-44  
  
 Single Point Resistivity: X  
 Extra:

0	-	1	Topsoil
---	---	---	---------

1	-	27	Sand and gravel, brown, medium to coarse
27	-	30	Gravel, brown, medium
30	-	66	Clay, gray, silty, sandy, pebbly; unoxidized (till)
66	-	122	Sand, brown, medium-grained
122	-	144	Clay, gray, silty, sandy, pebbly; many chalk pebbles, calcareous (till)
144	-	170	Sand and gravel, brown, medium sand, coarse gravel; some clay(?), many chalk pebbles
170	-	177	Clay, white to light-gray; calcareous, this interval reported by driller to be chalk, unable to verify with E-Log (Niobrara Formation?)

\* \* \* \*

County: TURNER  
 Legal Location: SE SW SW SW sec. 14, T. 98 N., R. 53 W.  
 Latitude: 43.1802  
 Land Owner:  
 Project: HURLEY CITY STUDY  
 Drilling Company: SDGS  
 Driller: D. IVERSON  
 Geologist: L. SCHULZ  
 Date Drilled: 07-17-1991  
 Ground Surface Elevation: 1268 T  
 Total Drill Hole Depth: 107  
 Water Rights Well:  
 Other Well Name:  
 Basin: VERMILLION  
 Management Unit:  
 Screen Type: PVC, MFG., SLOT SIZE 0.020  
 Casing Type: PVC, SCH. 80  
 Casing Top Elevation: 1270 T  
 Casing Stick-up: 2.00  
 Well Maintenance Date:  
 USGS Hydrological Unit Code: 10170102  
 Electric Log Information:  
 Spontaneous Potential:  
 Natural Gamma:  
 Samples:

Location: 098N-53W-14CCCD 1  
 Longitude: 97.0450  
 Driller's Log:  
 Geologist's Log: X  
 Drilling Method: ROTARY  
 Test Hole Number: R20-91-45  
 SDGS Well Name: R20-91-45  
 Aquifer: UPPER-VERMILLION-MISSOURI  
 Screen Length: 5.0  
 Casing Diameter: 2.0  
 Total Casing and Screen: 108.0  
 Single Point Resistivity:  
 Extra:

Well Information: Well screened from 106 to 101 feet below land surface. Filter pack from 106 to 90 feet below land surface. Bentonite grout placed from 90 to 20 feet below land surface. Neat cement grout from 20 feet to ground level. One steel well protector installed.

0	-	1	Topsoil
1	-	30	Sand and gravel, brown, medium to coarse sand, medium to cobble gravel (outwash)
30	-	65	Clay, gray, silty, sandy, pebbly; unoxidized (till)
65	-	100	Sand, brown, medium-grained
100	-	107	Sand and gravel, brown, medium to coarse sand, coarse to cobble gravel

\* \* \* \*

County: TURNER  
 Legal Location: SW SW SW NW sec. 15, T. 98 N., R. 53 W.  
 Latitude: 43.1827  
 Land Owner:  
 Project: HURLEY CITY STUDY  
 Drilling Company: SDGS

Location: 098N-53W-15BCCC  
 Longitude: 97.0606

Driller: D. JACOBSON  
Geologist: L. SCHULZ  
Date Drilled: 07-23-1991  
Ground Surface Elevation: 1273 T  
Total Drill Hole Depth: 39  
USGS Hydrological Unit Code: 10170102  
Electric Log Information:  
Spontaneous Potential:  
Natural Gamma:  
Samples:

Driller's Log:  
Geologist's Log: X  
Drilling Method: ROTARY

Test Hole Number: CO-91-66

Single Point Resistivity:  
Extra:

0	-	3	Topsoil
3	-	6	Clay, brown to dark-brown, silty, sandy, pebbly; calcareous (till)
6	-	19	Sand and gravel, brown, fine to medium sand, coarse gravel; clean
19	-	23	Clay, gray, silty, sandy, pebbly; unoxidized, calcareous (till)
23	-	39	Unknown; lost circulation, poor return; possible Niobrara Formation(?) or Carlile Shale(?) toward bottom of hole

Lost circulation at 23 feet; end depths may not be accurate; redrilled 15 feet from original test site.

\* \* \* \* \*

County: TURNER  
Legal Location: SW SW SW NW sec. 15, T. 98 N., R. 53 W.  
Latitude: 43.1827  
Land Owner:  
Project: HURLEY CITY STUDY  
Drilling Company: SDGS  
Driller: D. JACOBSON  
Geologist: L. SCHULZ  
Date Drilled: 07-23-1991  
Ground Surface Elevation: 1273 T  
Total Drill Hole Depth: 57  
USGS Hydrological Unit Code: 10170102  
Electric Log Information:  
Spontaneous Potential:  
Natural Gamma:  
Samples:

Location: 098N-53W-15BCCC 1

Longitude: 97.0606

Driller's Log:  
Geologist's Log: X  
Drilling Method: ROTARY

Test Hole Number: CO-91-67

Single Point Resistivity:  
Extra:

0	-	3	Topsoil
3	-	6	Clay, tan-brown, silty, sandy, pebbly; oxidized (till)
6	-	29	Sand and gravel, brown, fine to coarse sand, coarse gravel; fairly clean, clay layer from 20 to 22 feet
29	-	48	Clay, gray, silty, sandy, pebbly; unoxidized, calcareous (till)
48	-	57	Clay, light-gray to gray, sandy; many small black specks in the clay; siltstone layer from 51 to 54 feet (Niobrara Formation or Carlile Shale?)

\* \* \* \* \*

County: TURNER  
Legal Location: SW SW NW NW sec. 24, T. 98 N., R. 53 W.  
Latitude: 43.1751  
Land Owner:  
Project: HURLEY CITY STUDY  
Drilling Company: SDGS

Location: 098N-53W-24BBCC

Longitude: 97.0343

Driller: D. JACOBSON  
Geologist: L. SCHULZ  
Date Drilled: 07-23-1991  
Ground Surface Elevation: 1255 T  
Total Drill Hole Depth: 50  
Water Rights Well:  
Other Well Name:  
Basin: VERMILLION  
Management Unit:  
Screen Type: PVC, MFG., SLOT SIZE 0.018  
Casing Type: PVC, SCH. 40  
Casing Top Elevation: 1257 T  
Casing Stick-up: 2.00  
Well Maintenance Date:  
USGS Hydrological Unit Code: 10170102  
Electric Log Information:  
Spontaneous Potential:  
Natural Gamma:  
Samples:

Driller's Log:  
Geologist's Log: X  
Drilling Method: ROTARY  
  
Test Hole Number: CO-91-68  
SDGS Well Name: CO-91-68  
  
Aquifer:  
  
Screen Length: 10.0  
Casing Diameter: 2.0  
  
Total Casing and Screen: 44.0  
  
Single Point Resistivity:  
Extra:

Well Information: Well screened from 42 to 32 feet below land surface. Filter pack from 42 to 28 feet below land surface. Bentonite grout 28 feet to surface. Neat cement grout placed through tremie line from 11 feet to ground level. One steel well protector installed.

0	-	3	Topsoil
3	-	6	Sand, brown, fine to coarse; clean
6	-	48	Sand and gravel, brown, coarse sand, medium to coarse gravel; clean
48	-	50	Clay, gray, silty, very sandy, pebbly; unoxidized (till)

\* \* \* \*

County: TURNER  
Legal Location: NE NE NE NE sec. 25, T. 98 N., R. 53 W.  
Latitude: 43.1711  
Land Owner:  
Project: HURLEY CITY STUDY  
Drilling Company: SDGS  
Driller: D. JACOBSON  
Geologist: L. SCHULZ  
Date Drilled: 07-23-1991  
Ground Surface Elevation: 1257 T  
Total Drill Hole Depth: 47  
Water Rights Well:  
Other Well Name:  
Basin: VERMILLION  
Management Unit:  
Screen Type: PVC, MFG., SLOT SIZE 0.018  
Casing Type: PVC, SCH. 40  
Casing Top Elevation: 1259 T  
Casing Stick-up: 2.00  
Well Maintenance Date:  
USGS Hydrological Unit Code: 10170102  
Electric Log Information:  
Spontaneous Potential:  
Natural Gamma:

Location: 098N-53W-25AAAA 1  
Longitude: 97.0232  
  
Driller's Log:  
Geologist's Log: X  
Drilling Method: ROTARY  
  
Test Hole Number: CO-91-69  
SDGS Well Name: CO-91-69  
  
Aquifer: PARKER-CENTERVILLE  
  
Screen Length: 10.0  
Casing Diameter: 2.0  
  
Total Casing and Screen: 43.0  
  
Single Point Resistivity:  
Extra:

Samples:

Well Information: Well screened from 41 to 31 feet below land surface. Filter pack from 41 to 25 feet below land surface. Neat cement grout placed through tremie line from 25 feet below land surface to ground level. One steel well protector installed.

0 - 43 Sand and gravel, brown to orange-brown, coarse sand, medium to coarse gravel; clean  
43 - 47 Clay, gray to black, silty, sandy, gravelly; unoxidized (till)

\* \* \* \*

County: TURNER  
Legal Location: SW NE NW NW sec. 26, T. 98 N., R. 53 W.  
Latitude: 43.1706  
Land Owner:  
Project: HURLEY CITY STUDY  
Drilling Company: SDGS  
Driller: D. JACOBSON  
Geologist: L. SCHULZ  
Date Drilled: 07-06-1991  
Ground Surface Elevation: 1260 T  
Total Drill Hole Depth: 47  
USGS Hydrological Unit Code: 10170102  
Electric Log Information:  
Spontaneous Potential:  
Natural Gamma:  
Samples:

Location: 098N-53W-26BBAC  
Longitude: 97.0443  
Driller's Log:  
Geologist's Log: X  
Drilling Method: ROTARY  
Test Hole Number: CO-91-60

0 - 3 Topsoil  
3 - 33 Sand and gravel, brown, fine to coarse sand, medium to coarse gravel;  
fairly clean  
33 - 40 Clay, gray, silty, sandy, pebbly; unoxidized, calcareous (till)  
40 - 47 Clay and silt, light-gray; gritty, greasy, many small black specks in the cuttings  
(Niobrara Formation)

\* \* \* \*

County: TURNER  
Legal Location: SW NE NW NW sec. 26, T. 98 N., R. 53 W.  
Latitude: 43.1706  
Land Owner:  
Project: HURLEY CITY STUDY  
Drilling Company: SDGS  
Driller: D. JACOBSON  
Geologist: L. SCHULZ  
Date Drilled: 07-06-1991  
Ground Surface Elevation: 1260 T  
Total Drill Hole Depth: 37  
Water Rights Well:  
Other Well Name:  
Basin: VERMILLION  
Management Unit:  
Screen Type: PVC, MFG., SLOT SIZE 0.018  
Casing Type: PVC, SCH. 40  
Casing Top Elevation: 1263 T

Location: 098N-53W-26BBAC 1  
Longitude: 97.0443  
Driller's Log:  
Geologist's Log: X  
Drilling Method: ROTARY  
Test Hole Number: CO-91-61  
SDGS Well Name: CO-91-61  
Aquifer: PARKER-CENTERVILLE  
Screen Length: 10.0  
Casing Diameter: 2.0

Casing Stick-up: 3.00  
Well Maintenance Date:  
USGS Hydrological Unit Code: 10170102  
Electric Log Information:  
Spontaneous Potential:  
Natural Gamma:  
Samples:

Total Casing and Screen: 29.0

Single Point Resistivity:  
Extra:

Well Information: Well screened from 26 to 16 feet below land surface. Filter pack from 26 to 15 feet below land surface. Neat cement grout placed through tremie line from 16 feet below land surface to ground level. One steel well protector installed.

0	-	3	Topsoil
3	-	34	Sand and gravel, brown to orange-brown, fine to coarse sand, coarse to cobble gravel; clean
34	-	37	Clay, gray, silty, sandy, pebbly; unoxidized (till)

\* \* \* \*

County: TURNER  
Legal Location: SE NE NE SE sec. 26, T. 98 N., R. 53 W.  
Latitude: 43.1642  
Land Owner:  
Project: HURLEY CITY STUDY  
Drilling Company: SDGS  
Driller: D. JACOBSON  
Geologist: L. SCHULZ  
Date Drilled: 07-17-1991  
Ground Surface Elevation: 1258 T  
Total Drill Hole Depth: 47  
Water Rights Well:  
Other Well Name:  
Basin: VERMILLION  
Management Unit:  
Screen Type: PVC, MFG., SLOT SIZE 0.018  
Casing Type: PVC, SCH. 40  
Casing Top Elevation: 1261 T  
Casing Stick-up: 3.00  
Well Maintenance Date:  
USGS Hydrological Unit Code: 10170102  
Electric Log Information:  
Spontaneous Potential:  
Natural Gamma:  
Samples:

Location: 098N-53W-26DAAD

Longitude: 97.0345

Driller's Log:  
Geologist's Log: X  
Drilling Method: ROTARY

Test Hole Number: CO-91-65  
SDGS Well Name: CO-91-65

Aquifer: PARKER-CENTERVILLE

Screen Length: 10.0  
Casing Diameter: 2.0

Total Casing and Screen: 51.0

Single Point Resistivity:  
Extra:

Well Information: Well screened from 48 to 38 feet below land surface. Filter pack from 48 to 33 feet below land surface. Bentonite grout from 33 feet to land surface. Neat cement grout placed through tremie line from 20 feet below land surface to ground level. One steel well protector installed.

0	-	3	Topsoil
3	-	55	Sand and gravel, brown to brown-gray, fine to coarse sand, medium to coarse gravel; clean
55	-	57	Clay, light-gray, silty; some sand, many small black specks in the clay, calcareous (Niobrara Formation?)

\* \* \* \*

County: TURNER  
 Legal Location: NW NW NW NW sec. 27, T. 98 N., R. 53 W.  
 Latitude: 43.1709  
 Land Owner:  
 Project: HURLEY CITY STUDY  
 Drilling Company: SDGS  
 Driller: D. JACOBSON  
 Geologist: L. SCHULZ  
 Date Drilled: 07-15-1991  
 Ground Surface Elevation: 1304 T  
 Total Drill Hole Depth: 37  
 Water Rights Well:  
 Other Well Name:  
 Basin: VERMILLION  
 Management Unit:  
 Screen Type: PVC, MFG., SLOT SIZE 0.018  
 Casing Type: PVC, SCH. 40  
 Casing Top Elevation: 1307 T  
 Casing Stick-up: 3.00  
 Well Maintenance Date:  
 USGS Hydrological Unit Code: 10170102  
 Electric Log Information:  
 Spontaneous Potential:  
 Natural Gamma:  
 Samples:

Location: 098N-53W-27BBBB  
 Longitude: 97.0606

Driller's Log:  
 Geologist's Log: X  
 Drilling Method: ROTARY

Test Hole Number: CO-91-59  
 SDGS Well Name: CO-91-59

Aquifer: NIOBRARA

Screen Length: 10.0  
 Casing Diameter: 2.0

Total Casing and Screen: 39.0

Single Point Resistivity:  
 Extra:

Well Information: Well screened from 36 to 26 feet below land surface. Filter pack from 36 to 24 feet below land surface. Bentonite grout placed from 24 feet to ground surface. Neat cement grout placed from 12 feet below land surface to ground level. One steel well protector installed.

0	-	11	Clay, tan-white to brown, silty, sandy, pebbly; oxidized, many chalk pebbles (till)
11	-	14	Clay, brown-gray, silty, sandy, pebbly; partly oxidized, much chalk, calcareous (till)
14	-	20	Clay, gray, silty, sandy, pebbly; unoxidized, calcareous (till)
20	-	37	Silt, cream to white; highly calcareous (Niobrara Formation)

\* \* \* \*

County: TURNER  
 Legal Location: SW SW SW NW sec. 27, T. 98 N., R. 53 W.  
 Latitude: 43.1645  
 Land Owner:  
 Project: HURLEY CITY STUDY  
 Drilling Company: SDGS  
 Driller: D. JACOBSON  
 Geologist: L. SCHULZ  
 Date Drilled: 07-13-1991  
 Ground Surface Elevation: 1302 T  
 Total Drill Hole Depth: 37  
 USGS Hydrological Unit Code: 10170102  
 Electric Log Information:  
 Spontaneous Potential:  
 Natural Gamma:  
 Samples:

Location: 098N-53W-27BCCC  
 Longitude: 97.0606

Driller's Log:  
 Geologist's Log: X  
 Drilling Method: ROTARY

Test Hole Number: CO-91-58

Single Point Resistivity:  
 Extra:

0 - 18	Clay, tan-brown, silty, sandy, pebbly; oxidized, many chalk pebbles (till)
18 - 24	Clay, gray, silty, sandy, pebbly; unoxidized, calcareous (till)
24 - 37	Clay and silt, light-gray; highly calcareous (Niobrara Formation)

\* \* \* \*

County: TURNER	Location: 098N-53W-27CCCC
Legal Location: SW SW SW SW sec. 27, T. 98 N., R. 53 W.	
Latitude: 43.1618	Longitude: 97.0606
Land Owner:	
Project: HURLEY CITY STUDY	
Drilling Company: SDGS	
Driller: D. JACOBSON	Driller's Log:
Geologist: L. SCHULZ	Geologist's Log: X
Date Drilled: 07-15-1991	Drilling Method: ROTARY
Ground Surface Elevation: 1306 T	
Total Drill Hole Depth: 37	Test Hole Number: CO-91-57
Water Rights Well:	SDGS Well Name: CO-91-57
Other Well Name:	
Basin: VERMILLION	Aquifer:
Management Unit:	
Screen Type: PVC, MFG., SLOT SIZE 0.018	Screen Length: 10.0
Casing Type: PVC, SCH. 40	Casing Diameter: 2.0
Casing Top Elevation: 1309 T	
Casing Stick-up: 3.00	Total Casing and Screen: 38.0
Well Maintenance Date:	
USGS Hydrological Unit Code: 10170102	
Electric Log Information:	Single Point Resistivity:
Spontaneous Potential:	Extra:
Natural Gamma:	
Samples:	

Well Information: Well screened from 35 to 25 feet below land surface. Filter pack from 35 to 23 feet below land surface. Bentonite from 23 feet to land surface. Neat cement grout placed through tremie line from 25 feet below land surface to ground level. One steel well protector installed.

0 - 16	Clay, tan-brown, silty, sandy, pebbly; oxidized, many chalk pebbles (till)
16 - 17	Clay, gray, silty, sandy, pebbly; unoxidized, calcareous (till)
17 - 25	Clay, cream-white; highly calcareous (Niobrara Formation)
25 - 37	Clay, gray; soft, highly calcareous (Niobrara Formation)

\* \* \* \*

County: TURNER	Location: 098N-53W-27CDDD
Legal Location: SE SE SE SW sec. 27, T. 98 N., R. 53 W.	
Latitude: 43.1618	Longitude: 97.0532
Land Owner:	
Project: HURLEY CITY STUDY	
Drilling Company: SDGS	
Driller: D. JACOBSON	Driller's Log:
Geologist: L. SCHULZ	Geologist's Log: X
Date Drilled: 07-15-1991	Drilling Method: ROTARY
Ground Surface Elevation: 1296 T	
Total Drill Hole Depth: 47	Test Hole Number: CO-91-56



Water Rights Well:  
Other Well Name:  
Basin: VERMILLION  
Management Unit:  
Screen Type: PVC, MFG., SLOT SIZE 0.018  
Casing Type: PVC, SCH. 40  
Casing Top Elevation: 1298 T  
Casing Stick-up: 2.60  
Well Maintenance Date:  
USGS Hydrological Unit Code: 10170102  
Electric Log Information:  
Spontaneous Potential:  
Natural Gamma:  
Samples:

SDGS Well Name: CO-91-56

Aquifer:

Screen Length: 10.0  
Casing Diameter: 2.0

Total Casing and Screen: 48.0

Single Point Resistivity:  
Extra:

Well Information: Well screened from 45 to 35 feet below land surface. Filter pack from 45 to 35 feet below land surface. Bentonite grout from 35 feet to land surface. Neat cement grout placed through tremie line from 21 feet below land surface to ground level. One steel well protector installed.

0	-	16	Clay, tan-orange-brown, silty, sandy, pebbly; oxidized, many chalk pebbles, calcareous (till)
16	-	18	Clay, white-gray, silty; calcareous; may be a small boulder of chalk(?)
18	-	24	Clay, dark-brown, silty, sandy; calcareous
24	-	46	Sand and gravel, orange-brown, coarse sand, coarse gravel; fairly clean
46	-	47	Siltstone, gray; highly calcareous (Niobrara Formation)

\* \* \* \* \*

County: TURNER  
Legal Location: NW NW NW NW sec. 36, T. 98 N., R. 53 W.  
Latitude: 43.1617  
Land Owner:  
Project: HURLEY CITY STUDY  
Drilling Company: SDGS  
Driller: D. JACOBSON  
Geologist: L. SCHULZ  
Date Drilled: 07-16-1991  
Ground Surface Elevation: 1255 T  
Total Drill Hole Depth: 117  
Water Rights Well:  
Other Well Name:  
Basin: VERMILLION  
Management Unit:  
Screen Type: PVC, MFG., SLOT SIZE 0.018  
Casing Type: PVC, SCH. 40  
Casing Top Elevation: 1258 T  
Casing Stick-up: 3.00  
Well Maintenance Date:  
USGS Hydrological Unit Code: 10170102  
Electric Log Information:  
Spontaneous Potential:  
Natural Gamma:  
Samples:

Location: 098N-53W-36BBBB

Longitude: 97.0343

Driller's Log:  
Geologist's Log: X  
Drilling Method: ROTARY

Test Hole Number: CO-91-62  
SDGS Well Name: CO-91-62

Aquifer: UPPER-VERMILLION-MISSOURI

Screen Length: 15.0  
Casing Diameter: 2.0

Total Casing and Screen: 92.0

Single Point Resistivity:  
Extra:

Well Information: Well screened from 89 to 74 ft below land surface. Filter pack from 89 to 72 ft below land surface. Neat cement grout placed through tremie line from 17 ft below land surface to ground level. One steel well protector installed. Hole collapsed around well at 11 ft. No bentonite grout was placed around the well.

0 - 3	Topsoil
3 - 112	Sand and gravel, brown, coarse sand, coarse gravel; clean, much coal
112 - 117	Clay, light-gray to gray, silty; highly calcareous (Niobrara Formation)

\* \* \* \*

County: TURNER	Location: 098N-53W-36BBBB 1
Legal Location: NW NW NW NW sec. 36, T. 98 N., R. 53 W.	
Latitude: 43.1617	Longitude: 97.0343
Land Owner:	
Project: HURLEY CITY STUDY	
Drilling Company: SDGS	
Driller: D. JACOBSON	Driller's Log:
Geologist: L. SCHULZ	Geologist's Log: X
Date Drilled: 07-17-1991	Drilling Method: ROTARY
Ground Surface Elevation: 1255 T	
Total Drill Hole Depth: 37	Test Hole Number: CO-91-63
Water Rights Well:	SDGS Well Name: CO-91-63
Other Well Name:	
Basin: VERMILLION	Aquifer: PARKER-CENTERVILLE
Management Unit:	
Screen Type: PVC, MFG., SLOT SIZE 0.018	Screen Length: 10.0
Casing Type: PVC, SCH. 40	Casing Diameter: 2.0
Casing Top Elevation: 1257 T	
Casing Stick-up: 2.00	Total Casing and Screen: 35.0
Well Maintenance Date:	
USGS Hydrological Unit Code: 10170102	
Electric Log Information:	
Spontaneous Potential:	Single Point Resistivity:
Natural Gamma:	Extra:
Samples:	

Well Information: Well screened from 33 to 23 feet below land surface. Filter pack from 33 to 20 feet below land surface. Neat cement grout placed through tremie line from 19 feet to ground level. One steel well protector installed.

0 - 2	Topsoil
2 - 37	Sand and gravel, brown, coarse sand, coarse gravel; clean

\* \* \* \*

County: TURNER	Location: 098N-53W-36CCCC
Legal Location: SW SW SW SW sec. 36, T. 98 N., R. 53 W.	
Latitude: 43.1527	Longitude: 97.0342
Land Owner:	
Project: HURLEY CITY STUDY	
Drilling Company: SDGS	
Driller: D. JACOBSON	Driller's Log:
Geologist: L. SCHULZ	Geologist's Log: X
Date Drilled: 07-17-1991	Drilling Method: ROTARY

Ground Surface Elevation: 1284 T  
Total Drill Hole Depth: 57  
USGS Hydrological Unit Code: 10170102

Test Hole Number: CO-91-64

Electric Log Information:

Spontaneous Potential:

Natural Gamma:      Extra:

Single Point Resistivity:

Samples:

0	-	23	Clay, tan-brown to dark-brown, silty, sandy, pebbly; many chalk pebbles (till)
23	-	35	Clay, gray, very silty, sandy, pebbly; unoxidized (till)
35	-	44	Sand and gravel, brown, fine to coarse sand, medium to coarse gravel
44	-	49	Clay, cream-white, silty; highly calcareous (Niobrara Formation)
49	-	57	Clay, gray and cream-white; alternating layers of chalk and shale (Niobrara Formation)

\* \* \* \*

APPENDIX B. Chemical analyses of water samples

Legal Location	Well Name	Date Collected	Well Depth <sup>2</sup>	Conduc-tivity <sup>3</sup>	Field pH	Concentration in milligrams per liter <sup>1</sup>													
						Alk-T	HCO <sub>3</sub>	Ca	Cl	F	Fe	K	Mg	Mn	Na	NO <sub>3</sub> -N + NO <sub>2</sub> -N	SO <sub>4</sub>	TDS	Hardness as CaCO <sub>3</sub>
									250 <sup>4</sup>	2.4 <sup>5</sup>	0.3 <sup>4</sup>	---	---	0.05 <sup>4</sup>	----	10 <sup>5</sup>	250 <sup>4</sup>	500 <sup>4</sup>	----
<b>PARKER-CENTERVILLE AQUIFER</b>																			
SW SW SW SW sec. 18, T. 98 N., R. 52 W.	CO-83-159	07-29-91	40	952	7.35	248	302	122	20.0	0.23	0.77	3.6	51	0.44	10.0	<0.04	271	740	515
SW SW SW SW sec. 30, T. 98 N., R. 52 W.	CO-91-70	07-29-91	40	916	7.51	272	332	98	25.0	0.25	0.94	5.5	43	0.42	35.0	<0.04	211	634	422
NW NW NW NW sec. 32, T. 98 N., R. 52 W.	TU-77J	08-20-91	23	848	7.25	244	297	112	11.0	0.19	1.00	3.1	44	0.56	6.7	<0.04	234	629	461
NE NE NE NW sec. 02, T. 98 N., R. 53 W.	R1-83-110	08-24-83	43	1370	---	200	244	157	13.0	0.29	<0.05	7.1	65	0.36	60.0	<0.05	560	998	660
NE NE NE NW sec. 02, T. 98 N., R. 53 W.	R1-83-111	09-14-83	22	955	---	200	244	99	10.0	0.34	0.08	3.5	44	<0.05	52.0	14.80	280	720	428
SW SW SW NW sec. 02, T. 98 N., R. 53 W.	CO-83-160	09-26-83	41	1398	---	240	293	133	11.0	0.28	<0.05	7.8	58	0.47	93.0	<0.05	470	1010	571
NW NW NW NW sec. 10, T. 98 N., R. 53 W.	TU-80E	07-30-91	28	2860	7.00	396	483	460	4.6	0.38	<0.05	12.0	184	4.71	44.0	0.04	1650	2850	1906
SW SW SW SW sec. 12, T. 98 N., R. 53 W.	TU-77C	08-20-91	45	873	7.30	238	290	123	13.0	0.12	1.96	4.7	43	0.85	4.2	<0.04	258	664	484
NE NE NW SE sec. 13, T. 98 N., R. 53 W.	CO-83-62	08-24-83	38	1130	---	220	268	143	18.0	0.13	0.81	3.9	64	0.63	14.0	<0.05	407	790	620
SE SW SW SW sec. 14, T. 98 N., R. 53 W.	TU-11C	07-23-91	20	1414	7.25	214	261	197	18.0	0.21	<0.05	5.5	74	0.80	24.0	11.00	583	1190	797
SW SW SW SW sec. 15, T. 98 N., R. 53 W.	TU-79F	07-23-91	40	1830	6.98	317	386	356	15.0	0.52	1.92	10.0	57	0.18	30.0	<0.04	890	1650	1124
SW SW NW NW sec. 24, T. 98 N., R. 53 W.	CO-91-68	07-30-91	44	1290	7.29	290	354	147	88.0	0.24	1.75	4.6	63	0.62	35.0	<0.04	318	920	626
NE NE NE NE sec. 25, T. 98 N., R. 53 W.	CO-91-69	07-29-91	43	1180	7.28	452	551	145	19.0	0.26	1.52	5.8	65	0.62	31.0	<0.04	236	815	630
SE SE NE NE sec. 26, T. 98 N., R. 53 W.	TU-12A	07-24-91	19	1077	7.42	262	319	138	8.8	0.35	0.32	3.7	64	0.76	10.0	0.56	370	855	608
SE SE NE NE sec. 26, T. 98 N., R. 53 W.	TU-12B	07-24-91	29	1776	7.16	281	343	259	4.9	0.20	3.41	5.3	108	1.19	16.0	<0.04	853	1600	1091
SE SE NE NE sec. 26, T. 98 N., R. 53 W.	TU-12C	07-24-91	38	1833	7.22	298	363	286	3.8	0.23	5.52	5.5	111	1.37	25.0	<0.04	930	1700	1171
NE NE NE NW sec. 26, T. 98 N., R. 53 W.	TU-77E	08-20-91	45	1170	7.08	253	308	153	12.0	0.25	1.53	5.5	61	0.80	22.0	<0.04	441	942	633
NW NE NW NW sec. 26, T. 98 N., R. 53 W.	Hurley Municipal Well	11-27-89	44	1768	7.02	296	361	294	19.9	0.42	2.31	10.5	79.8	1.20	31.2	0.3	782	1558	1062
SW NE NW NW sec. 26, T. 98 N., R. 53 W.	CO-91-61	07-30-91	29	1840	7.11	318	388	283	20.0	0.31	0.20	12.0	86	0.96	34.0	0.09	820	1580	1061

Appendix B - continued.

Legal Location	Well Name	Date Collected	Well Depth <sup>2</sup>	Conduc-tivity <sup>3</sup>	Field pH	Concentration in milligrams per liter <sup>1</sup>													
						Alk-T	HCO <sub>3</sub>	Ca	Cl	F	Fe	K	Mg	Mn	Na	NO <sub>3</sub> -N + NO <sub>2</sub> -N	SO <sub>4</sub>	TDS	Hardness as CaCO <sub>3</sub>
									250 <sup>4</sup>	2.4 <sup>5</sup>	0.3 <sup>4</sup>	---	---	0.05 <sup>4</sup>	----	10 <sup>5</sup>	250 <sup>4</sup>	500 <sup>4</sup>	----
SE NE NE SE sec. 26, T. 98 N., R. 53 W.	CO-91-65	07-23-91	51	1044	7.14	230	280	144	18.0	0.48	2.13	6.0	39	0.76	31.0	<0.04	352	807	520
SE SE SE SW sec. 27, T. 98 N., R. 53 W.	CO-91-56	07-23-91	48	1740	6.89	340	414	300	2.9	0.37	0.74	5.3	69	2.39	24.0	0.04	728	1490	1033
NW NW NW NW sec. 36, T. 98 N., R. 53 W.	CO-91-63	07-24-91	35	1908	7.09	277	338	280	26.0	0.35	2.5	9.4	82	1.08	47.0	<0.04	850	1600	1037
<b>UPPER VERMILION MISSOURI AQUIFER</b>																			
SW SW SW SW sec. 17, T. 98 N., R. 52 W.	TU-77G	08-20-91	166	1160	7.17	319	389	160	2.5	0.23	0.93	6.2	54	1.72	24.0	<0.04	375	892	622
NW NW NW NW sec. 32, T. 98 N., R. 52 W.	TU-77H	08-20-91	74	989	7.25	288	351	131	2.9	0.31	<0.05	6.8	41	1.79	26.0	<0.04	289	736	496
NW NW NW NW sec. 14, T. 98 N., R. 53 W.	TU-77D	07-30-91	206	1880	7.56	303	369	268	4.2	0.22	1.33	6.5	104	1.47	25.0	<0.04	870	1620	1097
SE SW SW SW sec. 14, T. 98 N., R. 53 W.	R20-91-45	07-23-91	108	1766	7.51	264	322	246	21.0	0.26	<0.05	9.0	97	1.12	46.0	<0.04	840	1570	1014
NW NW NW NW sec. 36, T. 98 N., R. 53 W.	CO-91-62	07-24-91	92	2232	6.92	358	436	385	8.3	0.44	5.52	14.0	100	0.88	52.0	<0.04	1150	2090	1373
<b>NIobrara FORMATION (BEOROCK)</b>																			
NW NW NW NW sec. 27, T. 98 N., R. 53 W.	CO-91-59	07-30-91	39	2130	6.72	408	497	409	3.7	0.66	<0.05	6.5	69	<0.05	32.0	0.25	1008	1910	1305
SW SW SW SW sec. 27, T. 98 N., R. 53 W.	CO-91-57	07-30-91	38	2390	6.76	481	586	440	11.0	0.47	0.08	8.0	96	0.38	40.0	0.05	1130	2200	1494
SW NW NW SW sec. 28, T. 98 N., R. 53 W.	R1-86-73	07-31-91	203	2120	7.73	442	539	269	5.0	0.69	0.29	27.0	77	0.07	147.0	<0.04	910	1830	989

<sup>1</sup> All concentrations are listed in milligrams per liter. **Alk-T** - total alkalinity; **HCO<sub>3</sub>** - bicarbonate; **Ca** - calcium; **Cl** - chloride; **F** - fluoride; **Fe** - iron; **K** - potassium; **Mg** - magnesium; **Mn** - manganese; **Na** - sodium; **NO<sub>3</sub>-N + NO<sub>2</sub>-N** - nitrate + nitrite as nitrogen; **SO<sub>4</sub>** - sulfate; **TDS** - total dissolved solids; **Hardness as CaCO<sub>3</sub>** - hardness as calcium carbonate.

<sup>2</sup> Well depth is presented in feet below top of casing.

<sup>3</sup> Numbers are presented in micromhos.

<sup>4</sup> National secondary drinking water regulations-secondary maximum contaminant levels (U.S. Environmental Protection Agency, 1985b).

<sup>5</sup> National interim primary drinking water regulations-maximum contaminant levels for inorganic chemicals (U.S. Environmental Protection Agency, 1985a).