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OPEN-FILE REPORT 86-UR

GROUND WATER INVESTIGATION OF THE VERMILLION EAST FORK AQUIFER FOR THE KINGBROOK RURAL WATER SYSTEM NEAR DE SMET, SOUTH DAKOTA

by

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INTRODUCTION

The investigation was conducted in June and July 1988 by the South Dakota Geological Survey, a program within the Department of Environment and Natural Resources, at the request of the Kingbrook Rural Water System. The investigation was financed by the Kingbrook Rural Water System, the East Dakota Water Development District, and the South Dakota Geological Survey.

The purpose of the investigation was to assist the Kingbrook Rural Water System in locating a new ground water supply. This report contains the results of the investigation that was conducted in the De Smet area (fig. 1). For this report, nitrate-nitrogen plus nitrite-nitrogen will be referred to simply as nitrate.

METHODS AND PROCEDURES

Drilling and Well Installation

Drilling occurred from June 22, 1988, through July 14, 1988. Twenty-nine test holes were drilled (fig. 2), 14 of which were completed as monitoring wells in the Vermillion East Fork aquifer. Lithologic logs, as well as geophysical logs recording single point resistivity and/or natural gamma, are on file at the South Dakota Geological Survey.

Monitoring wells were constructed using 2-inch diameter, schedule 80, threaded, polyvinyl chloride casing and screen. A filter pack is present around all well screens, up to at least 2 feet above the screen, and consists of a well sorted, coarse sand that was placed around the well screen. Bentonite grout was then pumped into the annular space around the outside of the casing to land surface. At a later date, after the bentonite had settled, the upper portion of the annular space was finished off with cement grout and finally topped with soil. Well completion data are on file at the South Dakota Geological Survey.

Surveying

The elevation of the top of the monitoring well casing and the land surface elevation next to each well were surveyed to the nearest 0.01 foot. The bench mark used as a datum was a U.S. Coast and Geodetic Survey bench mark located in section 28, T. 111 N., R. 56 W. The bench mark is stamped "De Smet 1934" and has an elevation of 1,753.661 feet above mean sea level.

Water Level Measurements

The depth to water in the monitoring wells was measured on three occasions (table 1) to the nearest 0.01 foot. Measurements were made using a plastic coated fiberglass reinforced tape measure with a concave shaped device attached to the end that makes an audible sound upon impact with the water.

Well Development and Water Sampling

All monitoring wells were developed by pumping with compressed air. A minimum of 130 well volumes was removed from each well during development.

Water samples were collected from 14 monitoring wells installed in the Vermillion East Fork aquifer for this investigation. Water samples from monitoring wells were collected using a bladder pump or, when that was not possible, with a bailer. A minimum of 2 well volumes of water was evacuated from each well before a sample was collected. Water quality analyses were performed by the South Dakota Geological Survey Basic and Analytical Studies Laboratory.

HYDROGEOLOGIC SETTING

General Geology

The surficial geology of the study area is derived from glaciation. The result of this glaciation was the deposition of material referred to as glacial drift composed of till and outwash. Till consists of a heterogeneous mixture of boulders, gravel, sand, clay, and silt. The till matrix is composed predominantly of clay and silt. Outwash consists primarily of sand and gravel that has been washed, sorted, and deposited by flowing meltwater. Varying amounts of less permeable materials (silt and clay) may be dispersed throughout the outwash matrix. These sand and gravel deposits (outwash) are often important aquifers.

The study area is underlain by till of late Pleistocene age that has been incised by an outwash channel. The surficial outwash in this area has been named the Vermillion East Fork aquifer. The Vermillion East Fork aquifer is the water source for the Kingbrook Rural Water System production wells, municipal wells, irrigation wells, and private domestic and stock wells.

Vermillion East Fork Aquifer

The Vermillion East Fork aquifer is an unconfined and surficial ground water system composed of fine sand to medium gravel, and limited to the flood plain of the East Fork Vermillion River (Lindgren and Hansen, 1993). The predominant grain size of the aquifer material was found to range from fine sand to very coarse gravel with some interbedded silt and clay layers. Ground water recharge to the Vermillion East Fork aquifer is from downward percolation of precipitation and is distributed downgradient via lateral inflow of water in transient storage.

PRESENT KINGBROOK RURAL WATER SYSTEM WATER SUPPLY

The Kingbrook Rural Water System's De Smet wellfield is located northwest of De Smet and the wells are completed in the Vermillion East Fork aquifer (fig. 2). The approximate depths of the wells range from 35 to 50 feet below ground level. At these well sites, the top of the sand and gravel is at a depth of 1 to 5 feet and the well screen is located near the base of the aquifer. Generally, the water quality in the Vermillion East Fork aquifer is fairly good, however, the water is considered fairly hard

to hard. The current production capacity of each well is approximately 150 to 175 gallons per minute. The Kingbrook Rural Water System estimated that an additional 500 gallons per minute would be needed to satisfy their near future requirements.

RESULTS OF INVESTIGATION

Two hydrostratigraphic cross sections, whose locations are shown on figure 3, illustrate the spatial distribution of sediments in the study area (figs. 4 and 5). The Vermillion East Fork aquifer is an unconfined aquifer composed of fine sand to very coarse gravel with some interbedded silt and clay layers. Till directly underlies the Vermillion East Fork aquifer. The sand and gravel unit (including the interbedded silt and clay layers) is 23 to 83 feet thick in the study area (fig. 6). On September 27, 1988, the saturated thickness of the Vermillion East Fork aquifer (fig. 6) varied from 13 feet in the northern portion of the study area to 69 feet in the southern portion of the study area. Depth to water is usually less than 25 feet below the ground surface. The water table surface slopes downward to the southeast (figs. 4, 5, and 7).

Water samples were collected from 14 monitoring wells installed in the Vermillion East Fork aquifer for this investigation. Table 2 and figure 8 indicate that in the study area, the quality of water in the Vermillion East Fork aquifer is generally good. In water collected from the monitoring wells, the total dissolved solids ranged in concentration from 354 (well CO-88-48) to 1080 (well CO-88-49) milligrams per liter (mg/L), hardness ranged in concentration from 270 (well CO-88-48) to 903 (well CO-88-49) mg/L, and iron ranged from less than 0.05 to 1.15 (well CO-88-39) mg/L. Figure 9 and table 2 illustrate that 13 of the 14 monitoring wells had nitrate concentrations below the drinking water standard for public water systems of 10 mg/L (U.S. Environmental Protection Agency, 1994). Water collected from monitoring well CO-88-49 had a nitrate concentration of 43.8 mg/L. This concentration is greatly above the drinking water standard of 10 mg/L and needs to be examined in more detail.

RECOMMENDATIONS AND SUMMARY

After the field work was completed and the data were analyzed, the following recommendations were made to the Kingbrook Rural Water System. An area of the Vermillion East Fork aquifer, near De Smet, that warrants further investigation is identified on figure 3. In this area, the sand and gravel (including the interbedded silt and clay layers) ranged in thickness from 23 feet to 71 feet and the saturated thickness ranged from 15 feet to 55 feet on September 27, 1988.

If the Vermillion East Fork aquifer is considered for development of a new water supply, it must be kept in mind that this aquifer is vulnerable to surface sources of contamination. Although the quality of water in the area identified for possible further investigation may be currently acceptable for municipal use, there is no guarantee that the quality might not degrade due to land use practices over the aquifer.

Prior to the installation of a production well, further test drilling, well installation, and water sampling should be performed in the area of interest to verify the extent, saturated thickness, and water quality of the aquifer. If the rural water system should decide to develop a wellfield, it is suggested that an aquifer test be conducted to assist in estimating long term water yield from the aquifer.

Recommendations on the pumping rate and well spacing will be based on the results of the aquifer test. Water samples should also be collected during the aquifer test for complete chemical analysis.

As of April 1997, the Kingbrook Rural Water System is utilizing water produced from eight wells installed in the Vermillion East Fork aquifer (fig. 2). Two wells are located in section 8, T. 111 N., R. 56 W., one well is located in section 17, T. 111 N., R. 56 W., one well is located in section 16, T. 111 N., R 56 W. and four wells are located in section 6, T. 111 N., R. 56 W.

REFERENCES

Lindgren, R.J., and Hansen, D.S., 1993, *Major aquifers in Hutchinson and Turner Counties, South Dakota*: South Dakota Geological Survey Information Pamphlet 45.

U.S. Environmental Protection Agency, 1994, *Drinking water regulations and health advisories*: November 1994.

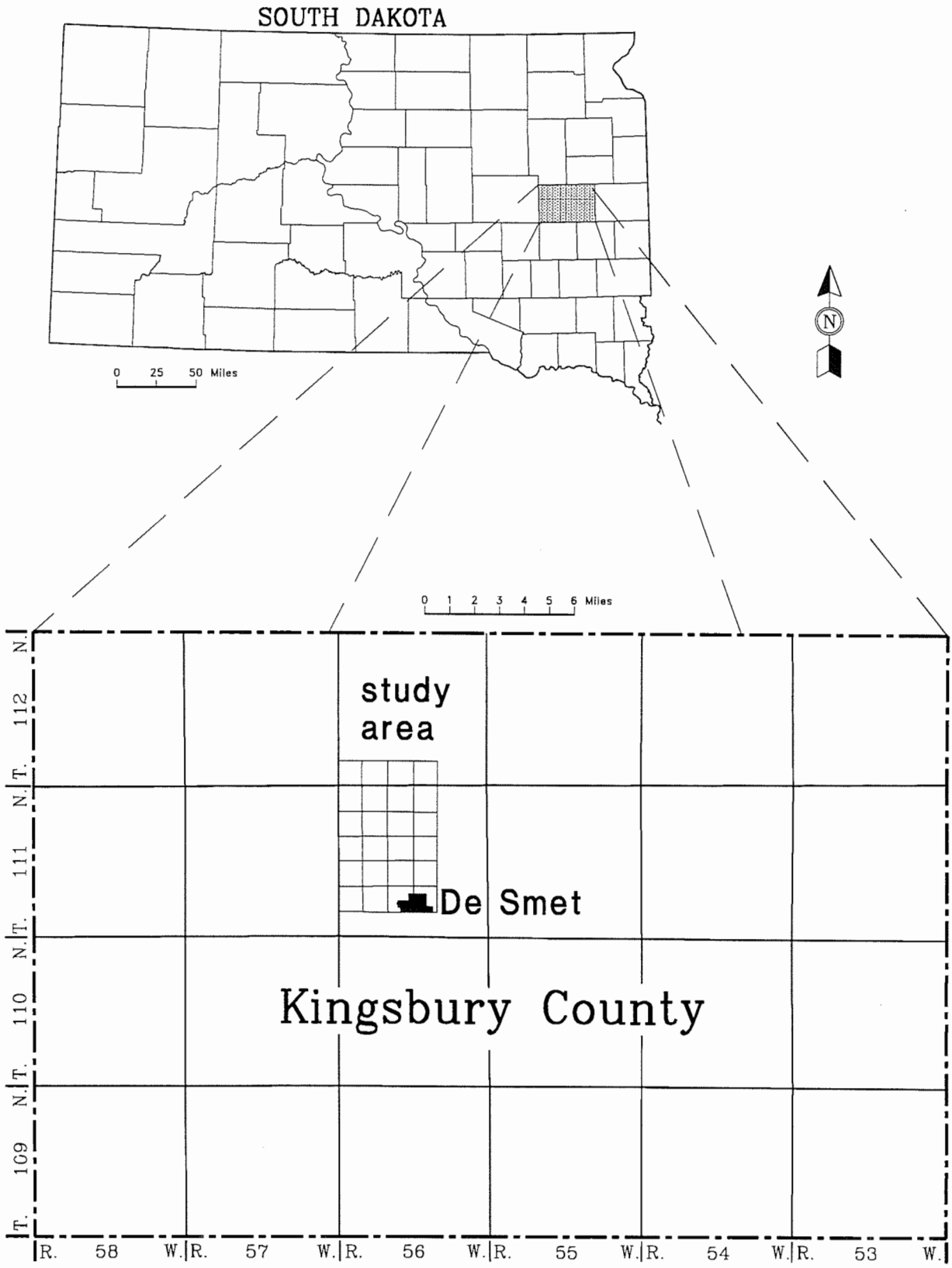
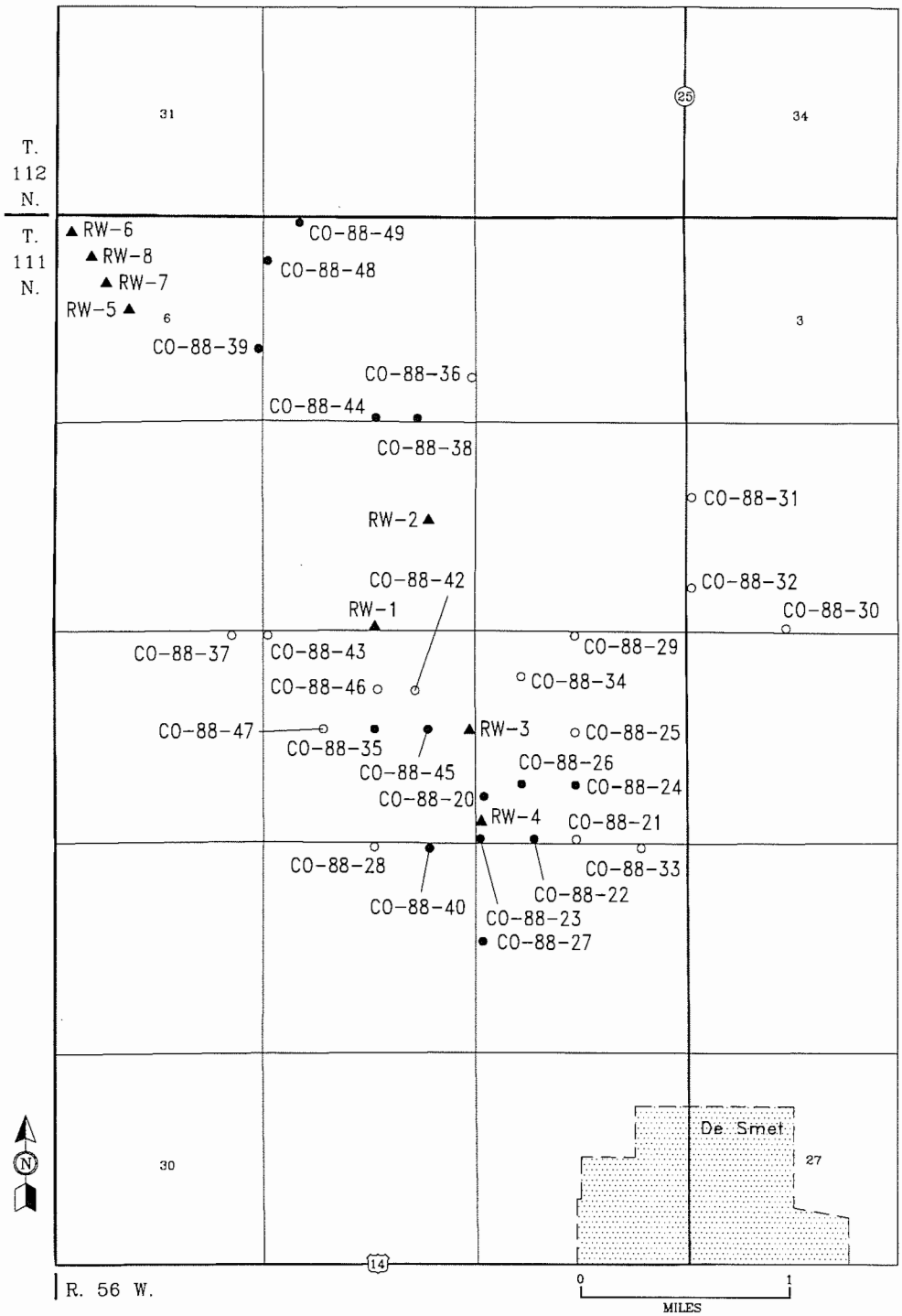


Figure 1. Location of the study area.



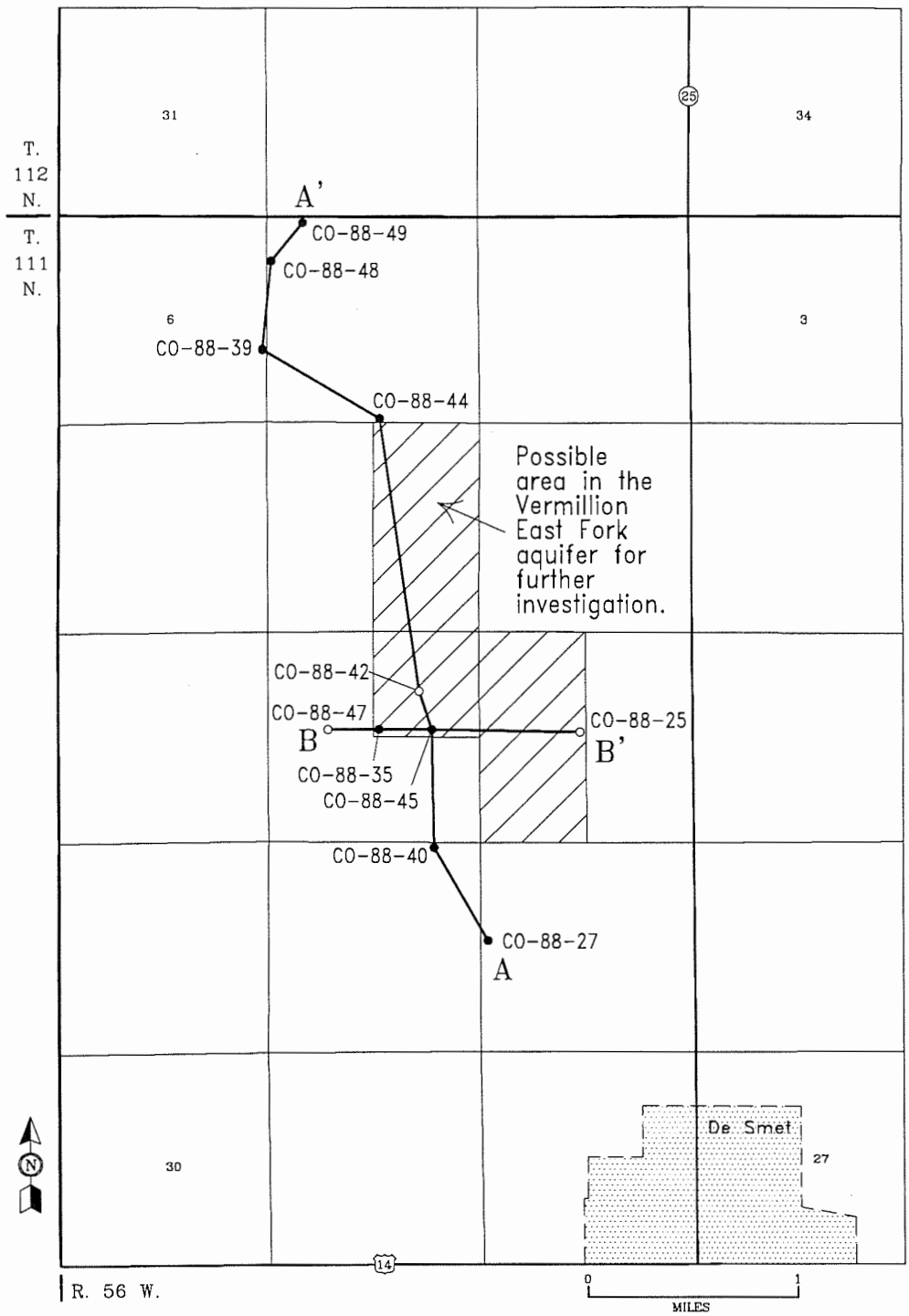
CO-88-26 ● Monitoring well

CO-88-33 ○ Test hole

Letters and numbers are the South Dakota Geological Survey test hole or well identifier.

RW-1 ▲ Kingbrook Rural Water System production well. Letters and number are rural water well designation.

Figure 2. Locations of test holes and monitoring wells.



CO-88-49 • Monitoring well

CO-88-42 ○ Test hole

Letters and numbers are the South Dakota Geological Survey test hole or well identifier.

B ○—○ B' Line of hydrogeologic cross section.

Figure 3. Locations of hydrogeologic cross sections.

Figure 4. Hydrogeologic cross section A-A'.

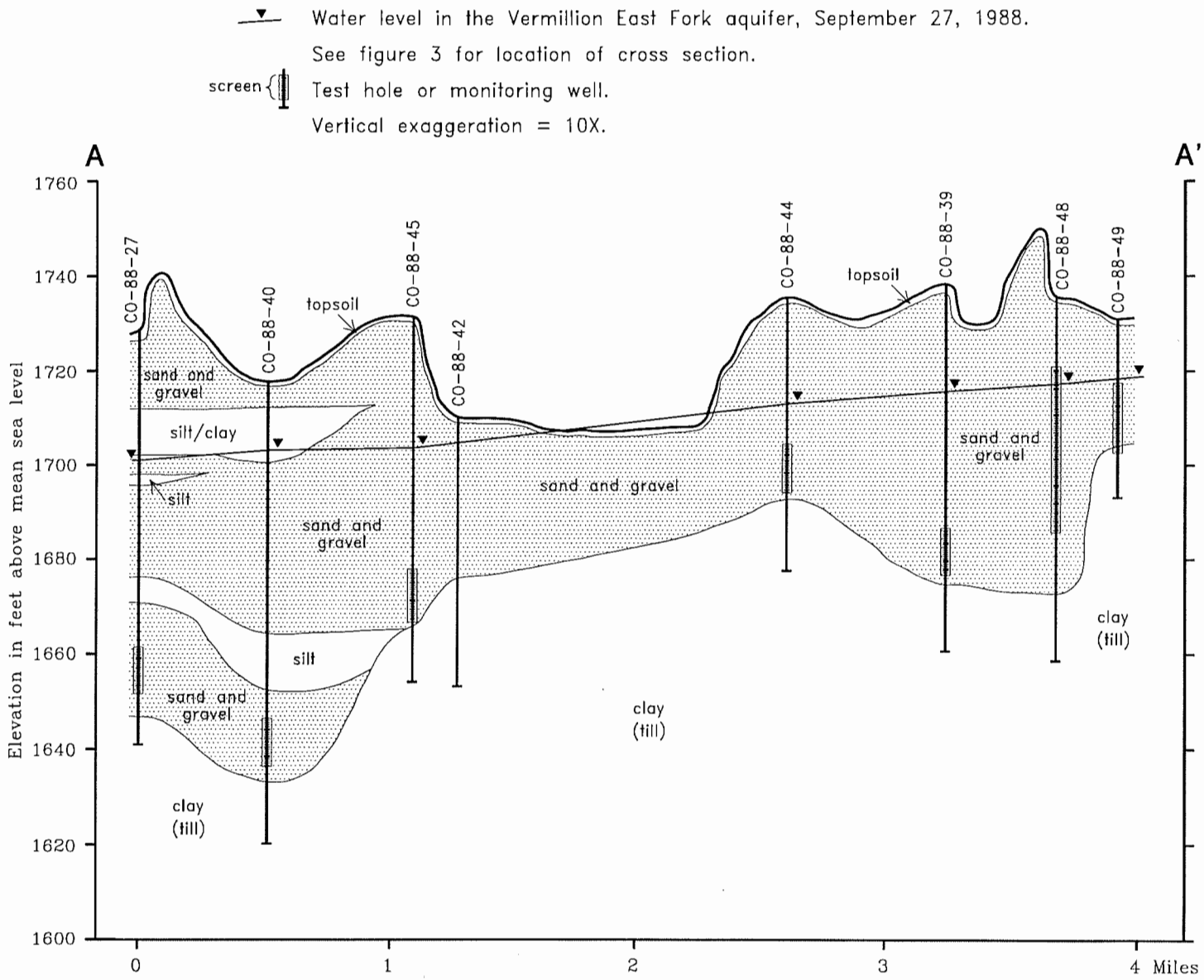


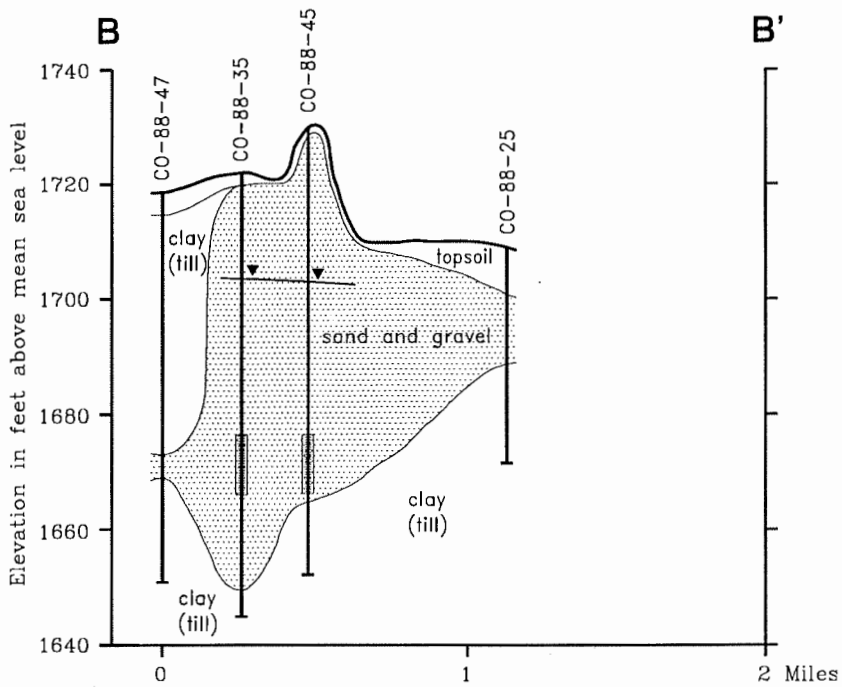
Figure 5. Hydrogeologic cross section B-B'.

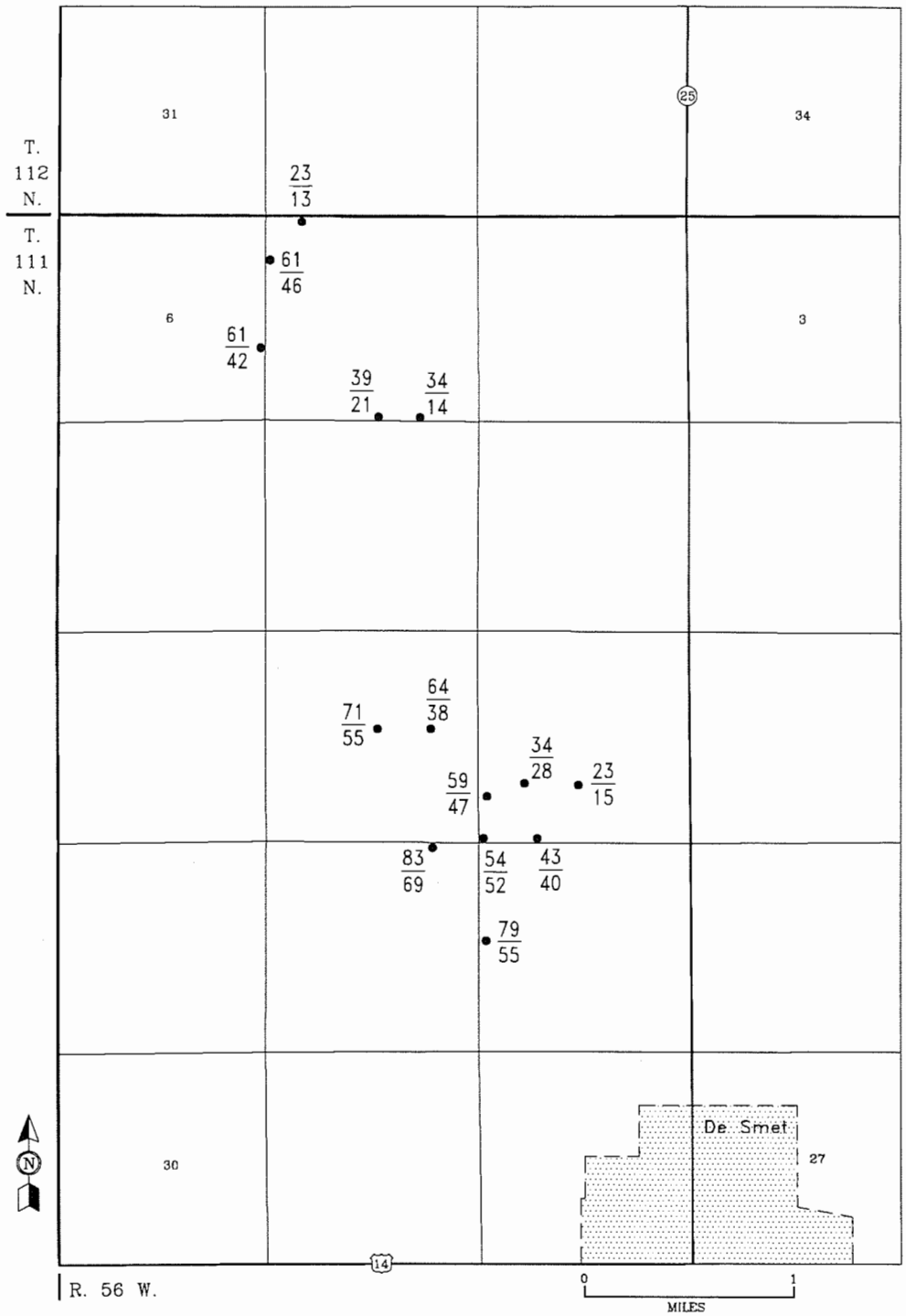
Water level in the Vermillion East Fork aquifer, September 27, 1988.

See figure 3 for location of cross section.

screen Test hole or monitoring well.

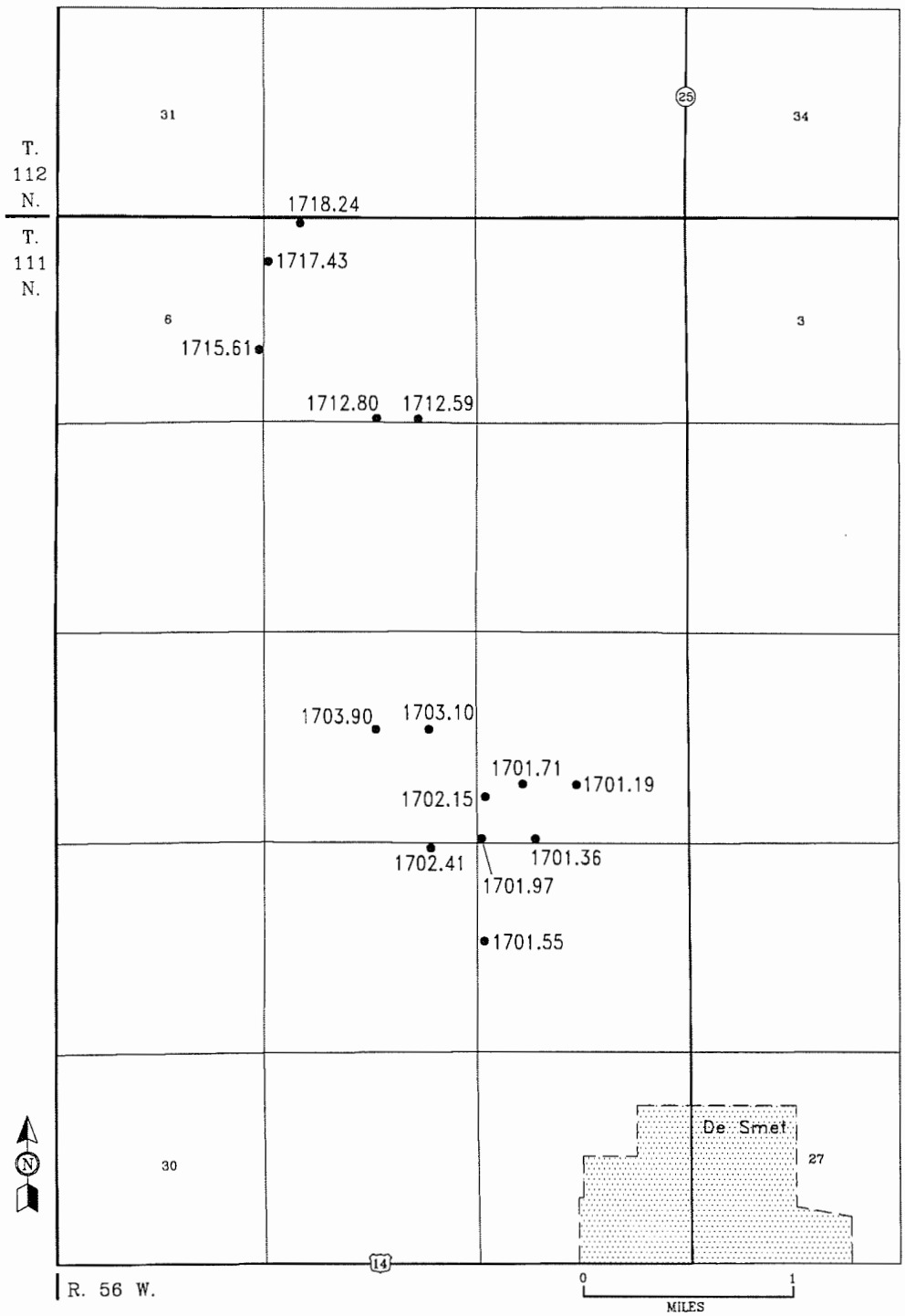
Vertical exaggeration = 10X.





71/55 • Monitoring well. Upper number is thickness of the sand and gravel and lower number is saturated thickness, in feet, on September 27, 1988.

Figure 6. Sand and gravel thickness and saturated thickness of the Vermillion East Fork aquifer.



1703.90 • Monitoring well. Number is elevation of water table in feet above mean sea level.

Figure 7. Water table elevations in the Vermillion East Fork aquifer on September 27, 1988.

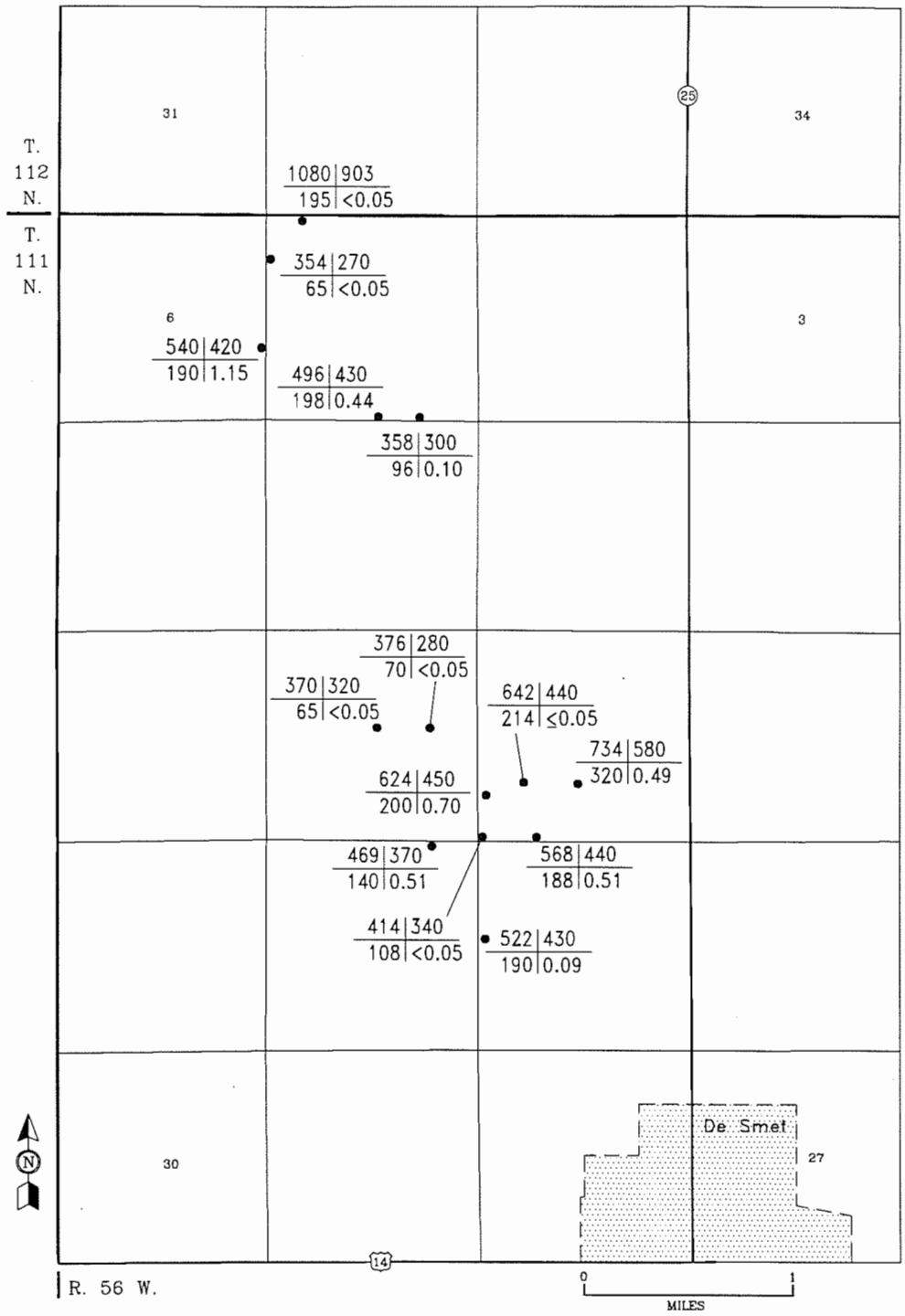
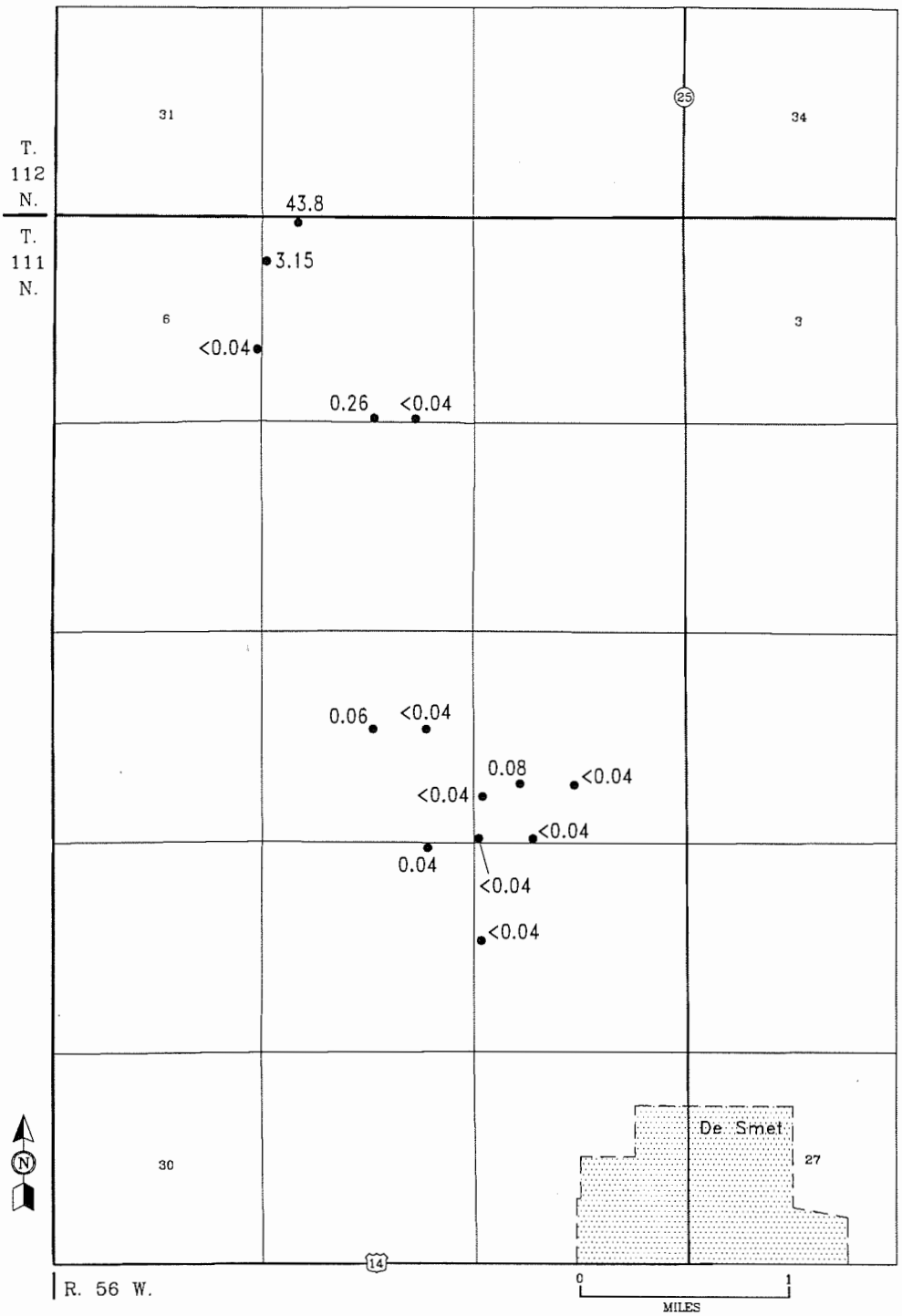


Figure 8. Selected water quality parameters and concentrations in the Vermillion East Fork aquifer.



<0.04 • Monitoring well. Number is nitrate concentration in milligrams per liter.

Figure 9. Nitrate concentrations in the Vermillion East Fork aquifer.

Table 1. Water levels in monitoring wells

Well name	Date	Depth to water below casing top (feet)	Casing top elevation above mean sea level (feet)	Water elevation above mean sea level (feet)
CO-88-49	07/13/88	14.26	1733.16	1718.90
	07/19/88	14.27		1718.89
	09/27/88	14.92		1718.24
CO-88-48	07/13/88	17.79	1736.29	1718.50
	07/19/88	17.79		1718.50
	09/27/88	18.86		1717.43
CO-88-44	07/13/88	20.85	1734.91	1714.06
	07/19/88	20.99		1713.92
	09/27/88	22.11		1712.80
CO-88-38	07/13/88	23.27	1737.11	1713.84
	07/19/88	23.37		1713.74
	09/27/88	24.52		1712.59
CO-88-39	07/13/88	21.92	1738.51	1716.59
	07/19/88	22.12		1716.39
	09/27/88	22.90		1715.61
CO-88-24	07/13/88	11.56	1713.49	1701.93
	07/19/88	11.75		1701.74
	09/27/88	12.30		1701.19
CO-88-26	07/13/88	11.55	1714.22	1702.67
	07/19/88	11.71		1702.51
	09/27/88	12.51		1701.71
CO-88-20	07/13/88	15.61	1718.93	1703.32
	07/19/88	15.74		1703.19
	09/27/88	16.78		1702.15
CO-88-23	07/13/88	8.03	1711.22	1703.19
	07/19/88	8.15		1703.07
	09/27/88	9.25		1701.97
CO-88-22	07/13/88	8.08	1710.30	1702.22
	07/19/88	8.26		1702.04
	09/27/88	8.94		1701.36
CO-88-35	07/13/88	18.29	1723.99	1705.70
	07/19/88	18.50		1705.49
	09/27/88	20.09		1703.90
CO-88-45	07/13/88	27.50	1732.11	1704.61
	07/19/88	27.69		1704.42
	09/27/88	29.01		1703.10
CO-88-40	07/13/88	15.80	1719.50	1703.70
	07/19/88	15.96		1703.54
	09/27/88	17.09		1702.41
CO-88-27	07/13/88	27.45	1730.07	1702.62
	07/19/88	27.61		1702.46
	09/27/88	28.52		1701.55

Table 2. Chemical analyses of water samples

Well name	Date collected	Well depth[2]	Conduc-tivity[3]	Parameters[1] with concentrations in milligrams per liter												
				HCO_3	Ca	Cl	F	Fe	K	Mg	Mn	Na	NO_3-N + NO_2-N	SO_4	TDS	Hardness as $CaCO_3$
				--	--	250[4]	2.4[5]	0.3[4]	--	--	0.05[4]	--	10[5]	250[4]	500[4]	--
CO-88-49	07/18/88	30.5	1776	586	177	121	0.40	<0.05	6.7	112	0.09	42	43.8	195	1080	903
CO-88-48	07/18/88	51.5	628	304	61	10	0.45	<0.05	4.7	28	0.10	34	3.15	65	354	270
CO-88-44	07/13/88	41.5	831	283	104	12	0.11	0.44	3.5	42	0.59	14	0.26	198	496	430
CO-88-38	07/08/88	42.2	605	275	77	2.6	0.10	0.10	3.9	26	0.44	10	<0.04	96	358	300
CO-88-39	07/11/88	61.2	847	327	98	3.8	0.15	1.15	6.8	42	0.88	26	<0.04	190	540	420
CO-88-24	07/06/88	23.8	1107	380	148	5.4	0.14	0.49	7.0	50	1.11	33	<0.04	320	734	580
CO-88-26	06/29/88	38.0	935	367	112	7.5	0.21	≤0.05	6.5	39	1.04	37	0.08	214	642	440
CO-88-20	06/29/88	58.9	903	373	117	2.4	0.25	0.70	6.2	38	0.80	28	<0.04	200	624	450
CO-88-23	06/29/88	59.2	661	310	85	3.9	0.10	<0.05	5.6	30	0.54	14	<0.04	108	414	340
CO-88-22	06/29/88	43.8	874	362	110	2.7	0.13	0.51	6.8	40	0.63	30	<0.04	188	568	440
CO-88-35	07/07/88	55.7	647	344	80	5.0	0.37	<0.05	4.6	28	0.50	20	0.06	65	370	320
CO-88-45	07/14/88	64.2	618	31	72	5.0	0.20	<0.05	5.4	25	0.46	26	<0.04	70	376	280

Table 2 - continued.

Well name	Date collected	Well depth[2]	Conductivity[3]	Parameters[1] with concentrations in milligrams per liter												
				HCO_3	Ca	Cl	F	Fe	K	Mg	Mn	Na	NO_3-N + NO_2-N	SO_4	TDS	Hardness as $CaCO_3$
				--	--	250[4]	2.4[5]	0.3[4]	--	--	0.05[4]	--	10[5]	250[4]	500[4]	--
CO-88-40	07/12/88	80.8	766	336	96	2.4	0.24	0.51	5.6	32	0.54	22	0.04	140	469	370
CO-88-27	07/06/88	76.7	867	350	113	2.4	0.27	0.09	6.5	35	0.65	25	<0.04	190	522	430

[1] **HCO_3** - bicarbonate; **Ca** - calcium; **Cl** - chloride; **F** - fluoride; **Fe** - iron; **K** - potassium; **Mg** - magnesium; **Mn** - manganese; **Na** - sodium; **NO_3-N + NO_2-N** - nitrate as nitrogen + nitrite as nitrogen; **SO_4** - sulfate; **TDS** - total dissolved solids; **Hardness as $CaCO_3$** - hardness as calcium carbonate.

[2] Well depth is presented in feet below casing top.

[3] Conductivity is presented in micromhos per centimeter.

[4] U.S. Environmental Protection Agency (1994). Secondary maximum contaminant levels. Recommended limits.

[5] U.S. Environmental Protection Agency (1994). Maximum contaminant levels. Enforceable limits.