Groundwater quality investigation of selected towns in Jefferson County, Wisconsin. [DNR-060] 1989?

Kenter, A.W.; Madison, Frederick William, 1937-
Madison, Wisconsin: Wisconsin Department of Natural Resources, 1989?

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Wisconsin Groundwater Management Practice Monitoring Project No. 53

GROUNDWATER
Wisconsin's buried treasure

Wisconsin Department of Natural Resources

GROUNDWATER QUALITY INVESTIGATION OF SELECTED TOWNS IN JEFFERSON COUNTY, WISCONSIN

A.W. Kenter and F.W. Madison

[1989 ?]

Study objectives
An evaluation by the Wisconsin Department of Natural Resources (DNR) concluded that Jefferson County had the highest per acre loadings of nitrogen in the state. Although these estimates were based on a variety of land uses, the largest sources of nitrogen inputs were thought to be agricultural fertilizers and animal waste. Outside of a few water-quality analyses from municipalities and private residences, little is known about the quality of groundwater in Jefferson County. The prime objective of this study was to assess the quality of groundwater in selected areas within the county with an emphasis on determining the nitrate concentrations in domestic wells.

Study area
Due to the time constraint placed on the study, six civil towns and half of a seventh were included in the sampling network (plate 1). These included the towns of: Lake Mills, Oakland, Farmington, Ixonia, Sullivan, Palmyra, and the northern half of Jefferson.

Water quality inventory
As a first step toward evaluating the quality of groundwater in the study area, well constructor's reports were screened for a possible match with the present owner of a property. Initial verification was aided by the use of plat books and a current county phone book. Letters were mailed to possible participants outlining the objective and scope of the project and inviting them to participate in the survey. The letters were then followed by a phone call to verify participation. A total of 231 homeowners were contacted. Of this total, 48 (21%) refused to participate or were unavailable at the time of sampling (sickness, seasonality of home/well, moving soon, etc.), leaving a total of 183 samples that were collected.

The exact locations of each well sampled were plotted on U.S. Geological Survey, 7.5 minute topographic quadrangles. When available, data from the well constructor's reports were also plotted on the topographic maps adjacent to the well location. This included date of well construction, specific capacity, static water level, depth of casing, and the driller's interpretation of the geology at the site. Sampling site locations were transferred to a 1:100,000 county base map (see plate 1); sample numbers are shown in plate 2.

The water quality inventory was conducted during the months of January, February, March, and April. Duplicate samples were taken at each location. One set of samples was tested for nitrate-nitrogen at the Wisconsin State Laboratory of Hygiene; the second set was analyzed for standard drinking water chemical parameters such as conductivity, hardness, chloride, iron, laboratory pH (table 1), alkalinity, and sulfate at a laboratory in the University of Wisconsin-Madison Soil Science Department.

Water table
The generalized water table map for Jefferson County (plate 3) is included in the series of 1:100,000 maps that accompany this report. This map was compiled from static water-level data taken from well constructor's reports as well as surface water points. The map was computer generated using a total of 1,174 water elevation points.

At any given point, the flow path of the groundwater will be controlled by the vertical gradients throughout the aquifer(s). The time frame and scope of this study did not permit the gathering of these data; therefore, the map is a generalized view of the regional flow of groundwater in the county.

The general direction of groundwater flow in any given area can be discerned from the contour lines on the map. Groundwater flow throughout the system will follow a gradient from areas of high potential to areas of low potential. This movement is from areas of groundwater recharge to areas of groundwater discharge. Steep gradients appear on the map in the area to the south of Lake Mills, with the Rock and Crawfish Rivers acting as major groundwater discharge sites. The low gradient region that lies between Lake Koshkonong and the Kettle Moraine is situated in a former lake basin where lacustrine silt and clay is the predominant sediment.

Water quality results

Results of the water quality inventory are given in appendix I and summary statistics in table 1.

A state and national standard of 10 mg/L of **nitrate** (NO_3-N) has been established for drinking water on the basis of the amount of nitrate that can cause methemoglobinemia, a potentially serious blood disorder in young infants. Greater levels of nitrate (the exact number is not known) can cause health problems for livestock. In most instances, it does not appear that the nitrate in the water is solely responsible for such problems, but rather that the problems result from the cumulative effects of nitrate in the water and the feed being used. Thirteen, or 7 percent, of the wells sampled in the study area had nitrate values in excess of the established standard. Major sources of nitrate are agricultural fertilizers, animal wastes, and septic system effluent. Of these 13 wells, five are shallow driven points or dug wells. Of the remaining eight wells, six are cased in limestone, one in sandstone, and one well does not have any construction data available.

As a part of the comprehensive groundwater legislation enacted by the state of Wisconsin, the DNR has established standards for drinking water for public and welfare and so-called Preventive Action Limits (PALs). PALs are values lower than those established as standards that are taken to mean that the quality of the groundwater has been affected and that remedial measures should be initiated to lessen those impacts if possible. The PAL for nitrate is 2 mg/L; 42 (23%) of the wells tested in the study exceed this value. The normal or natural background level for nitrate in groundwater is generally less than 0.2 mg/L. Nitrate concentrations from all wells varied from less than 5 mg/L to 30.5 mg/L. The average nitrate concentration in the 183 well sample population was 2.4 mg/L. The areal distribution of nitrate contamination is shown on plate 4.

Chloride (Cl) ions are unreactive; once they are in solution, they are usually unaffected by chemical processes as they percolate through the soil and underlying geologic material to the groundwater. Because the rocks that underlie the state are low in chloride, background levels in most of Wisconsin's groundwater are usually less than 5 mg/L. Levels much above that value suggest that land-use activities may be affecting groundwater. Major sources of chloride include road salt, chemical fertilizers, human and animal wastes, and discharges from home water softeners. The average value for chloride for all samples tested in the study was 24.7 mg/L. The standard for chloride in drinking water is 250 mg/L; this is based on taste, not on health effects.

Chloride concentrations are shown on plate 5 with sample locations.

Iron (Fe) occurs commonly in soils, glacial materials, and rocks in Wisconsin. It is also fairly common in groundwater even though most iron compounds are not very soluble in water. When iron is present in drinking water in amounts in excess of 0.3 mg/L, it can cause problems, such as staining porcelain fixtures. Amounts beyond those levels may require special treatment not only to reduce aesthetic, taste, and odor problems but also to alleviate problems with plumbing systems. Iron concentration ranged from less than the detection limit (<0.1 mg/L) to 5.2 mg/L. The majority of the wells sampled used a water softener to combat the iron problem in the region (plate 6).

Hardness of water is a measure of the dissolved calcium and magnesium that it contains. The water in Jefferson County is considered "very hard" with hardness concentrations from unsoftened wells ranging from 228 to 616 mg/L. The average hardness value for unsoftened well sampled is 343 mg/L. Concentrations and locations are plotted on plate 7.

Electrical conductivity is a measure of the ability of a solution to conduct an electric current. Pure water will not conduct a current, but water that contains dissolved solids, such as calcium, magnesium, and bicarbonate, will. These dissolved solids are common constituents of Wisconsin's groundwater; their amounts vary depending on the host material of the aquifer from which water is derived. Electrical conductivity values ranged from 400 μmhos/cm to 1710 μmhos/cm and are shown on plate 8.

pH values of 7 are considered to be neutral, those greater than 7 are alkaline, and those below 7 are acidic. Lab pH values, as reported in this study, are somewhat higher than values recorded immediately after a sample is taken because of chemical transformations that occur during transport and storage prior to analysis. When the pH is below 7 and the hardness below about 50, the water is corrosive and can be harmful to plumbing systems. It can also be a health hazard if lead-based solder was used in the plumbing system. Corrosive water may dissolve lead, which is toxic to humans and animals. People who have corrosive water should have it tested for lead content. Plate 9 shows the range of laboratory pH values in the study area.

A subset of the 183 wells sampled was analyzed for both alkalinity and sulfates. For 83 samples, the average alkalinity concentration is 272 mg/L while the average sulfate concentration is 51 mg/L.

Conclusions

The focus of this groundwater quality study was on nitrate concentrations in selected wells in Jefferson County. Nitrate is a relatively common contaminant because it can come from a variety of sources. Nitrate input into the groundwater is usually a direct result of man's activity. Potential sources include barnyard runoff, leaking septic systems or animal waste lagoons, and excess application of nitrogen fertilizers. Chemical data clearly suggest that current and past land-use activities are affecting groundwater quality. Elevated levels of NO_3-N and Cl found in many samples attest to this. Maps showing the spatial distribution of chemical values show areas in the study area where that degradation of groundwater quality is most apparent. Immediate consideration should be given to reviewing land-use activities in those areas and remedial measures to lessen those impacts should be developed.

Table 1. Summary statistics for water quality parameters test in Jefferson County water inventory.

COMPUTE ALL HARDNESS FROM JEFFERSON WHERE HARDNESS GT 100

HARDNESS	Count =	169
	Rows =	183
	Minimum =	228
	Maximum =	616
	Sum =	57918
	Average =	343
	Std Dev =	74
	Variance =	5506

COMPUTE ALL CONDUCT FROM JEFFERSON

CONDUCT	Count =	183
	Rows =	183
	Minimum =	400
	Maximum =	1710
	Sum =	121990
	Average =	667
	Std Dev =	206
	Variance =	42643

COMPUTE ALL LAB-PH FROM JEFFERSON

LAB-PH	Count =	183
	Rows =	183
	Minimum =	7.2
	Maximum =	8.5
	Sum =	1406.9
	Average =	7.687978
	Std Dev =	0.261287
	Variance =	0.068271

COMPUTE ALL ALKALINE FROM JEFFERSON

ALKALINE	Count =	83
	Rows =	83
	Minimum =	170
	Maximum =	400
	Sum =	22556
	Average =	272
	Std Dev	46
	Variance	2148

COMPUTE ALL SULFATE FROM JEFFERSON

SULFATE	Count =	83
	Rows =	83
	Minimum =	3
	Maximum =	125
	Sum =	4267
	Average =	51
	Std Dev =	25
	Variance =	639

COMPUTE ALL CHLORIDE FROM JEFFERSON

CHLORIDE	Count =	183
	Rows =	183
	Minimum =	0.05
	Maximum =	279
	Sum =	4514.55
	Average =	24.66967
	Std Dev =	38.20982
	Variance =	1459.991

COMPUTE ALL IRON FROM JEFFERSON

IRON	Count =	183
	Rows =	183
	Minimum	0.05
	Maximum	5.2
	Sum =	167.5
	Average =	0.915301
	Std Dev =	1.207099
	Variance =	1.457088

COMPUTE ALL NITRATE FROM JEFFERSON

NITRATE	Count =	183
	Rows =	183
	Minimum =	0.25
	Maximum =	30.5
	Sum =	434.5
	Average =	2.374317
	Std Dev =	4.990507
	Variance =	24.90516

APPENDIX I.

WELL NUMBER	CONDUCTIVITY	HARDNESS	NITRATE	CHLORIDE	IRON	LAB-PH
AO011	480	274	0.5	2.	0.1	8.3
AO012	560	300	0.5	12.	1.1	7.7
AO013	1400	100	0.6	180.	0.1	8.5
AO014	420	252	0.5	4.	5.2	7.8
AO015	450	256	0.5	1.	0.3	7.7
AO016	980	446	27.6	56.	0.2	8.5
AO017	700	356	19.8	21.	0.1	7.9
AO018	510	302	0.5	6.	0.5	7.9
AO019	400	228	0.5	6.	0.4	8.
AO020	540	288	0.5	7.	0.1	7.9
AO021	495	266	0.5	2.	3.2	7.8
AO022	700	4	0.5	9.	0.1	8.1
AO023	580	308	0.8	22.	0.2	7.8
AO024	700	294	7.5	64.	0.1	7.9
AO025	800	460	15.	34.	0.1	7.6
AO026	520	306	0.8	4.	0.1	7.9
AO027	900	516	13.8	56.	0.1	7.4
AO028	590	318	2.	11.	0.1	7.7
AO029	720	316	5.5	62.	0.1	8.
AO030	1280	584	21.6	116.	0.1	7.2
AO031	600	336	0.8	11.	0.9	7.7
AO032	480	266	0.5	9.	3.	8.1
AO033	430	258	0.5	1.	3.6	8.
AO034	630	250	0.5	51.	0.1	7.9
AO035	760	426	10.4	16.	0.1	7.5
AO036	600	350	0.5	5.	0.1	7.9
AO037	570	328	0.5	1.	0.1	7.6
AO038	520	306	2.1	6.	0.1	8.
AO039	620	332	3.9	16.	0.1	7.5
AO040	780	362	3.2	63.	0.1	7.5
AO041	610	28	0.5	29.	0.2	8.2
AO042	790	434	0.5	39.	1.4	7.6
AO043	580	322	0.5	16.	1.2	7.7
AO044	760	384	0.5	97.	2.4	7.8
AO045	730	24	0.5	1.	0.1	8.4
AO046	560	336	0.5	11.	3.2	8.3
AO047	470	254	0.5	1.	0.1	8.1
AO047	490	270	0.5	1.	4.9	7.9
AO048	520	300	0.5	1.	3.6	7.7
AO050	590	266	0.6	15.	0.1	7.7
AO051	920	24	0.5	20.	0.3	8.1
AO052	500	300	0.5	1.	0.9	7.7
AO053	1120	560	5.9	142.	0.1	7.3
AO054	550	312	0.5	4.	1.2	7.8
AO055	570	322	0.5	9.	1.6	7.9
AO056	700	40	0.5	4.	0.2	7.8
AO057	590	302	0.5	29.	0.7	7.4
AO058	760	416	0.5	52.	2.4	7.3
AO059	1095	376	3.2	168.	0.1	7.5
AO060	520	314	0.5	5.	1.6	8.
AO061	650	368	0.5	7.	1.1	7.5
AO062	650	368	0.5	9.	1.3	7.6
AO063	680	378	0.5	13.	0.2	8.3
AO064	720	410	0.5	13.	0.2	7.9

WELL NUMBER	CONDUCTIVITY	HARDNESS	NITRATE	CHLORIDE	IRON	LAB-PH
AO065	895	500	0.5	32.	1.7	7.7
AO066	800	444	0.5	41.	1.9	7.7
AO067	1710	572	1.4	279.	0.1	7.4
AO068	700	380	0.5	27.	0.8	7.7
AO069	600	318	0.5	14.	1.8	7.8
AO070	400	234	0.5	1.	1.6	8.
AO071	600	302	0.7	3.	0.1	7.5
AO072	500	284	0.5	1.	2.6	7.6
AO073	710	400	0.8	17.	0.1	7.5
AO074	700	382	0.5	34.	2.8	7.3
AO075	900	472	0.5	69.	1.2	7.6
AO076	580	326	0.5	6.	0.5	7.8
AO077	700	410	0.5	12.	0.4	7.4
AO078	590	314	0.5	8.	0.9	7.4
AO079	600	330	0.5	10.	0.1	7.5
AO081	480	26	0.5	1.	0.1	8.4
AO082	740	402	0.5	17.	1.3	7.8
AO083	610	346	0.5	18.	0.3	7.6
AO084	820	1	0.5	21.	0.1	7.9
AO085	690	384	0.5	21.	1.5	7.5
AO086	885	36	0.5	30.	0.2	7.6
AO087	700	382	0.5	9.	1.6	7.7
AO088	750	388	9.	38.	0.1	7.6
AO089	1000	420	19.2	32.	0.1	7.3
AO090	505	292	0.5	2.	0.5	7.6
AO091	990	504	8.2	35.	0.1	7.3
AO092	680	376	0.5	12.	1.2	7.4
AO093	800	440	0.5	26.	1.	7.5
AO094	600	324	0.5	16.	0.9	7.5
AO095	700	364	0.5	27.	0.6	7.6
AO096	590	314	0.5	3.	0.3	7.6
AO097	670	346	0.5	20.	1.1	7.4
AO098	600	342	0.5	8.	0.6	7.5
AO099	500	266	0.5	1.	0.3	7.8
AO100	940	480	9.8	57.	0.1	7.9
AO101	460	250	0.5	22.	3.9	7.7
AO102	700	386	0.5	13.	0.6	7.5
AO103	1330	524	22.1	95.	0.1	7.3
AO104	630	350	0.5	22.	1.	7.6
AO105	840	412	0.5	68.	0.2	7.7
AO106	580	322	0.5	11.	0.1	7.6
AO107	820	468	0.5	37.	0.5	7.5
AO108	700	384	8.2	21.	0.1	7.6
AO109	830	28	0.5	12.	0.1	8.
AO110	760	404	0.5	36.	0.4	7.5
AO111	720	406	1.8	19.	0.1	7.5
AO112	1100	476	0.5	160.	3.8	7.3
AO113	700	398	1.6	21.	0.2	7.6
AO114	620	288	0.5	10.	0.7	8.
AO115	660	360	0.5	29.	0.6	7.5
AO116	505	306	0.8	4.	5.	7.6
AO117	800	28	1.6	20.	0.1	8.1
AO118	530	294	0.5	9.	5.	7.7
AO119	600	330	0.5	13.	4.	7.4

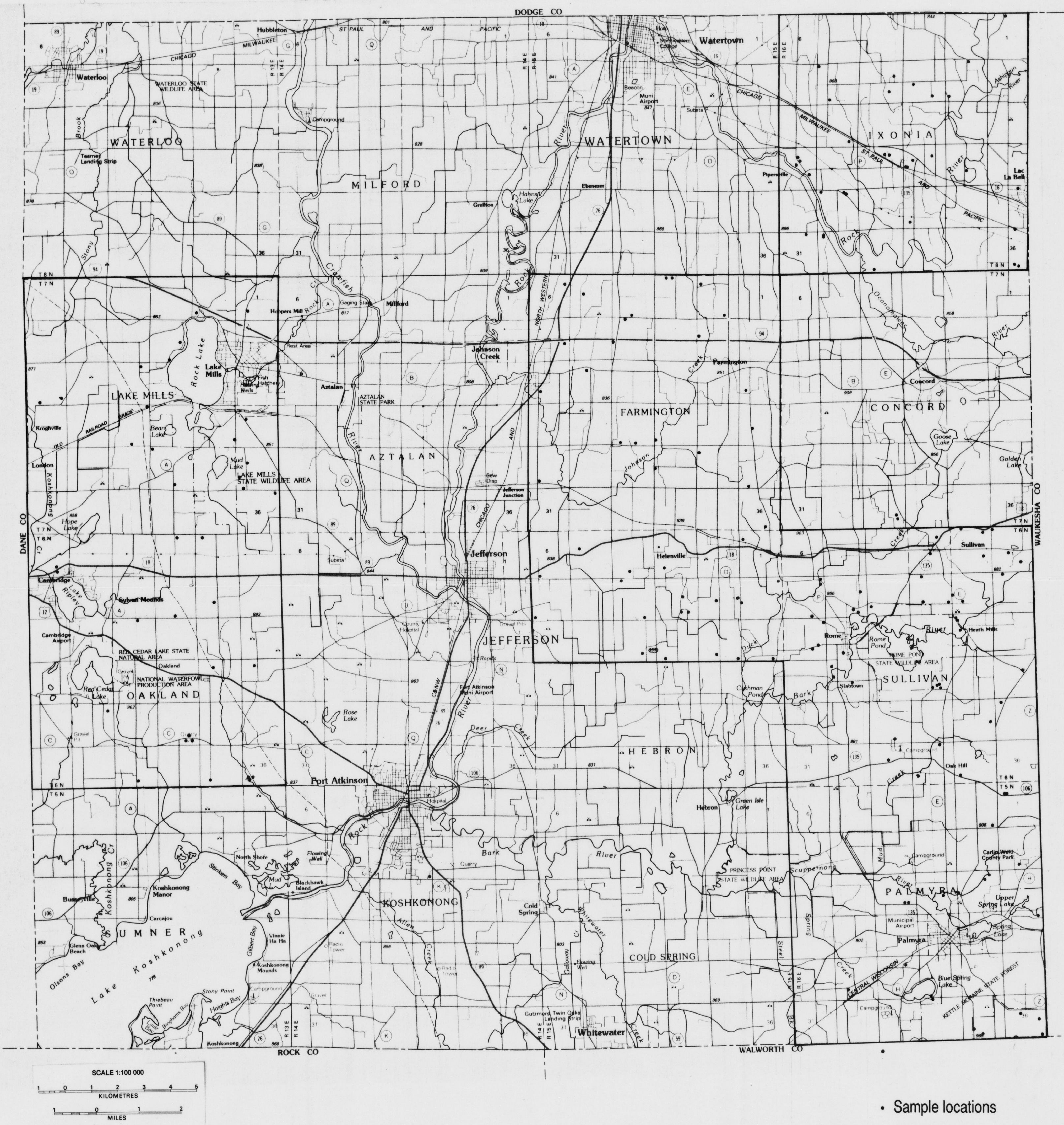
WELL NUMBER	CONDUCTIVITY	HARDNESS	NITRATE	CHLORIDE	IRON	LAB-PH
AO120	520	300	0.5	4.	1.3	7.5
AO121	610	350	0.5	8.	4.8	7.6
AO122	700	374	0.5	29.	0.8	7.7
AO123	460	256	0.6	3.	0.1	7.8
AO124	560	310	0.5	2.	0.8	7.7
AO125	700	374	0.5	9.	2.2	7.9
AO126	900	368	5.	87.	0.2	7.4
AO127	560	326	0.5	1.	0.2	7.5
AO128	1050	460	0.5	118.	1.6	7.4
AO129	1600	616	30.5	182.	0.1	7.7
AO130	620	354	1.3	10.	0.1	7.5
AO131	720	16	3.6	14.	0.1	7.8
AO132	640	4	0.5	2.	0.1	8.2
AO133	620	346	2.5	4.	0.1	7.5
AO134	400	232	0.5	1.	2.3	7.5
AO135	440	246	0.5	1.	1.4	7.4
AO136	400	228	2.4	2.	0.1	7.3
AO137	405	236	2.	2.	0.1	7.4
AO138	500	270	0.5	1.	0.9	7.6
AO139	630	350	6.5	15.	0.1	7.5
AO140	470	256	2.7	3.	0.1	7.5
AO141	700	392	0.5	10.	1.4	7.5
AO142	420	240	0.5	1.	1.6	7.9
AO143	450	252	0.5	1.	1.8	7.5
AO144	505	284	0.5	2.	1.3	7.6
AO145	600	338	0.5	25.	0.1	7.5
AO146	600	334	0.5	14.	4.	7.5
AO147	770	400	0.6	28.	0.2	7.5
AO148	470	266	0.5	1.	3.	7.5
AO149	410	250	1.5	2.	0.1	7.3
AO150	505	296	0.5	4.	1.3	7.3
AO151	600	340	7.4	15.	0.1	7.3
AO152	660	366	14.	24.	0.1	7.3
AO153	900	438	13.1	42.	0.1	7.2
AO154	550	308	0.5	1.	1.3	7.6
AO155	420	250	0.5	1.	0.6	7.5
AO156	580	324	0.7	3.	0.1	7.5
AO157	700	344	6.	34.	0.1	7.9
AO158	600	330	12.	11.	0.1	7.9
AO159	600	340	0.5	6.	0.9	7.7
AO160	910	412	0.5	82.	3.4	7.7
AO161	570	274	8.6	27.	0.1	8.2
AO162	460	262	0.5	3.	1.5	7.7
AO163	510	288	0.5	9.	0.8	7.5
AO164	505	288	0.5	4.	2.5	7.7
AO165	640	342	3.	16.	0.2	7.6
AO166	730	382	1.7	31.	0.1	7.6
AO167	720	256	0.5	18.	0.6	7.7
AO168	700	362	0.5	19.	0.1	7.7
AO169	730	386	0.5	23.	0.1	7.9
AO170	520	268	0.5	3.	2.8	7.9
AO171	750	6	0.5	9.	0.1	8.1
AO172	690	340	0.5	18.	0.1	7.8
AO173	510	262	0.5	4.	0.5	8.1

WELL NUMBER	CONDUCTIVITY	HARDNESS	NITRATE	CHLORIDE	IRON	LAB-PH
AO174	605	352	0.5	10.	0.7	7.9
AO175	600	324	0.5	12.	1.	7.9
AO176	695	362	2.9	20.	0.1	7.6
AO177	605	332	0.5	11.	1.4	8.
AO178	580	306	0.5	4.	0.8	7.8
AO179	430	250	0.5	3.	3.6	7.8
AO180	850	416	5.	38.	0.1	7.4
AO181	460	270	0.5	8.	0.3	7.8
AO182	650	302	10.3	18.	0.1	7.6
AO183	520	276	0.5	16.	3.	7.6
AO184	470	268	0.5	0.05	1.	7.7
AO185	470	258	0.5	4.	0.1	7.7
AO186	740	334	8.5	20.	0.1	7.8
AO187	640	336	0.5	11.	0.9	7.5
AO188	600	320	1.2	9.	0.1	7.3
AO189	530	298	0.5	1.	1.9	7.9
AO190	560	312	0.5	1.	1.6	7.8
AO191	1220	416	5.7	92.	0.1	7.6
AO192	950	348	9.7	111.	0.1	7.7
AO193	670	334	4.7	27.	0.1	7.4
BO061	695	366	0.5	10.	0.1	7.6

050885- Groundwater Quality Investigation of Selected Towns in Jefferson County, Wisconsin

Groundwater Quality Investigation of Selected Townships in Jefferson County, Wisconsin

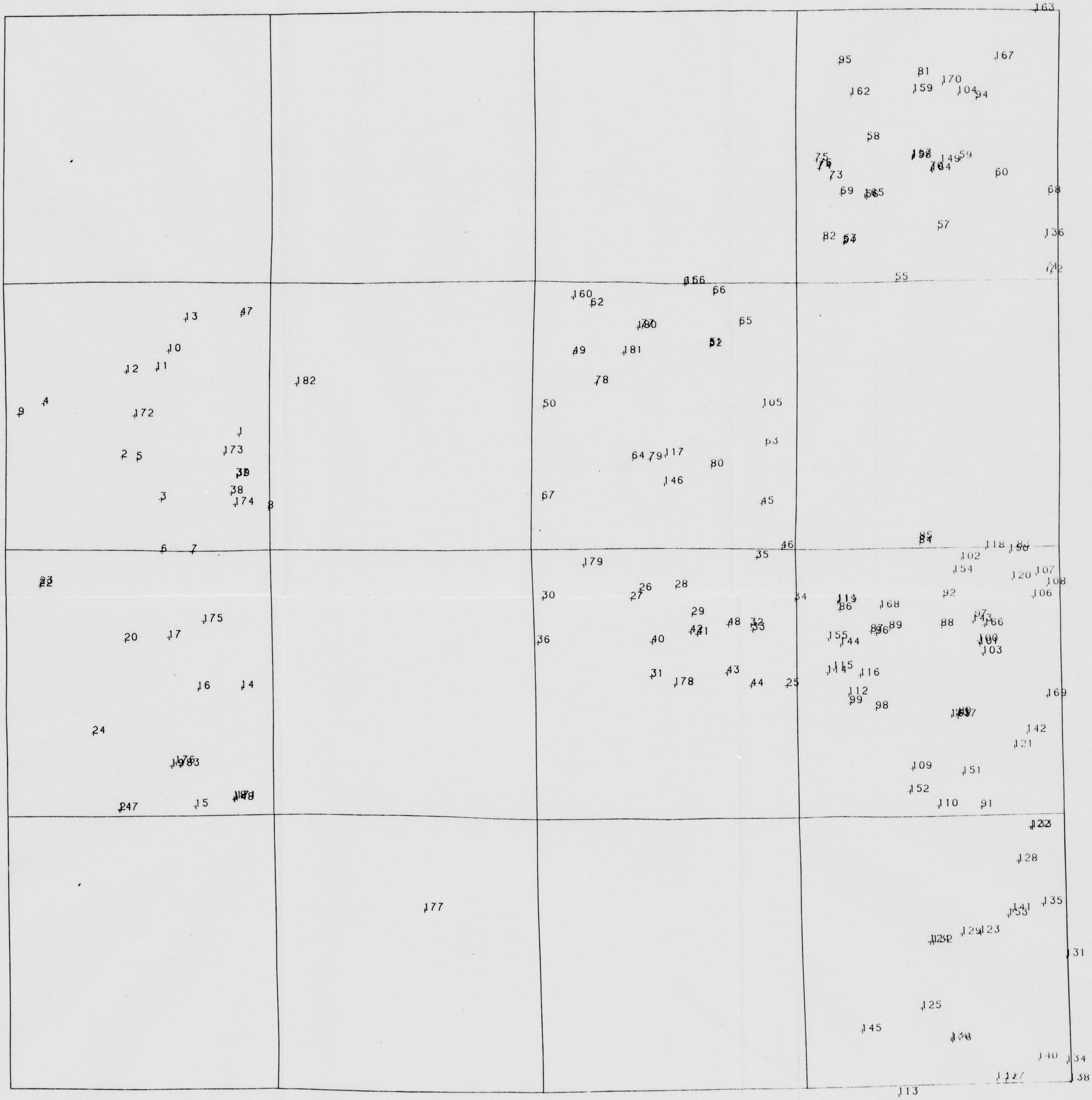
Plate 1



• Sample locations

Groundwater Quality Investigation of Selected Townships in Jefferson County, Wisconsin

Plate 2



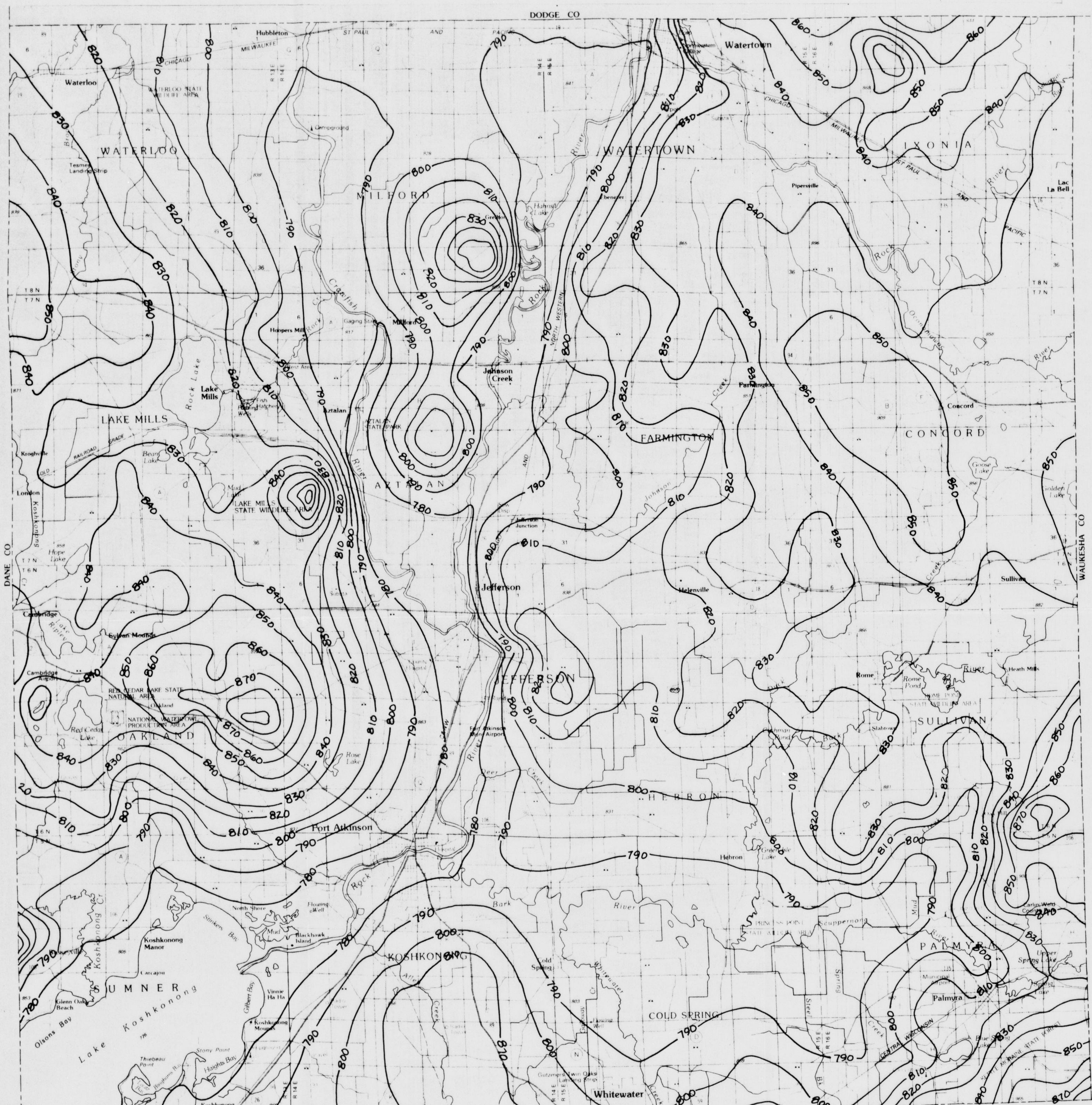
SCALE 1:100 000

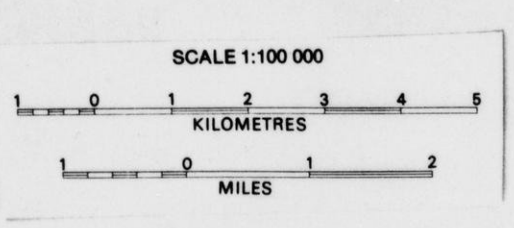
1 0 1 2 3 4 5
KILOMETRES

1 0 1 2
MILES

Sample numbers

· Location and number of sampled well

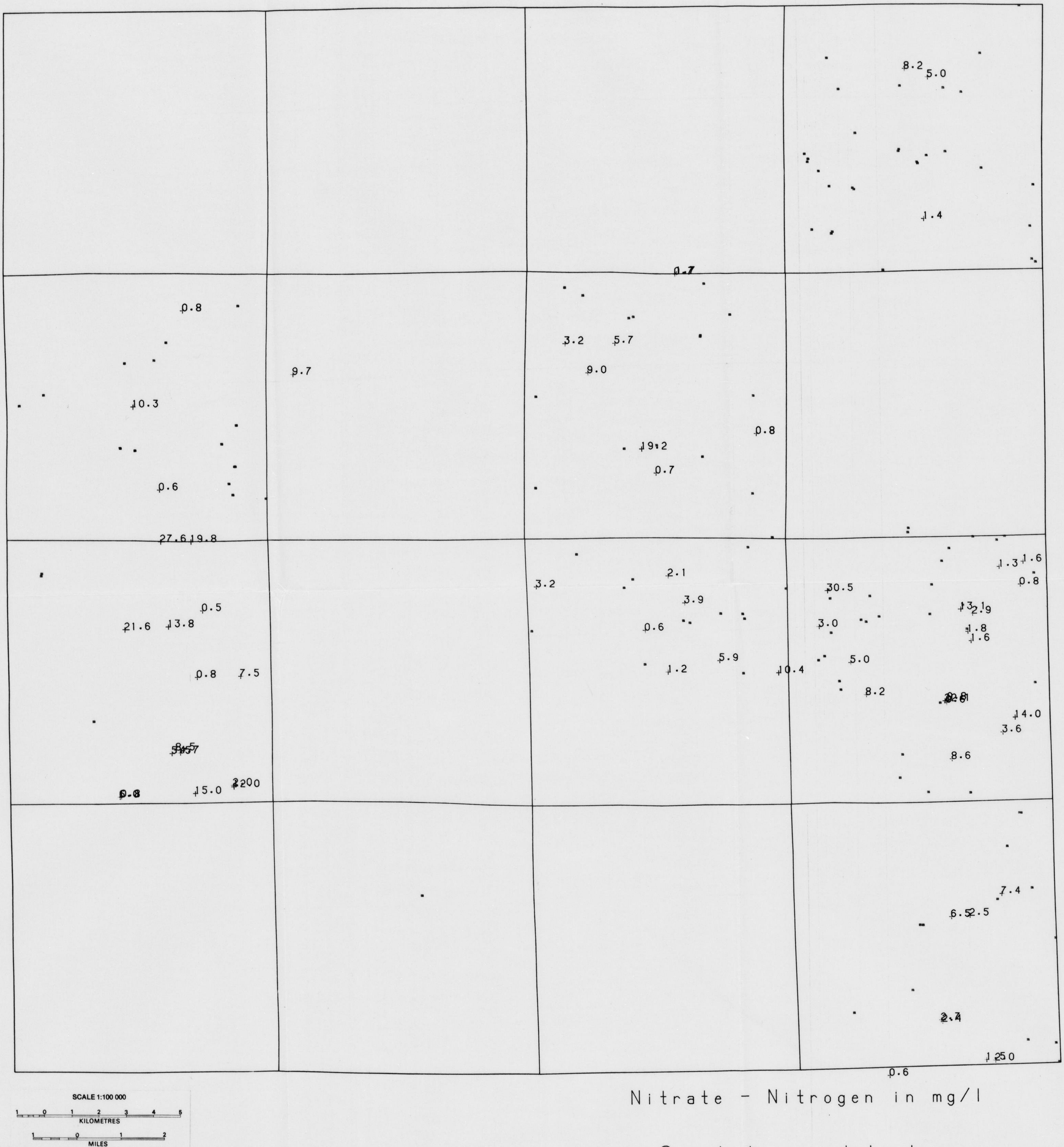




Water table map (contour interval, 10 feet)

Groundwater Quality Investigation of Selected Townships in Jefferson County, Wisconsin

Plate 4



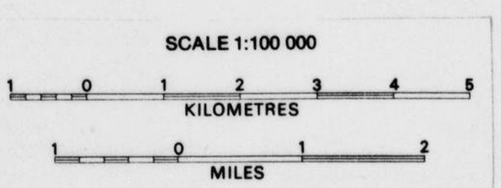
Nitrate - Nitrogen in mg/l

- · Sampled - no detect
- ⁺ Location and concentration less than 10 mg/l
- + Location and concentration greater than 10 mg/l

Groundwater Quality Investigation of Selected Townships in Jefferson County, Wisconsin

Plate 5

Chloride concentration in mg/l

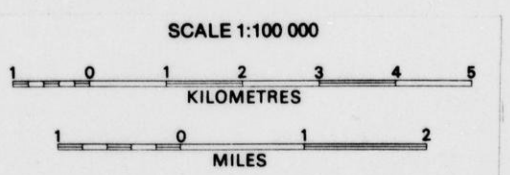


+ Location and concentration

* > DL (> 1 mg/L)

Groundwater Quality Investigation of Selected Townships in Jefferson County, Wisconsin

Plate 6



Ferrous iron in mg/l

· Location and concentration

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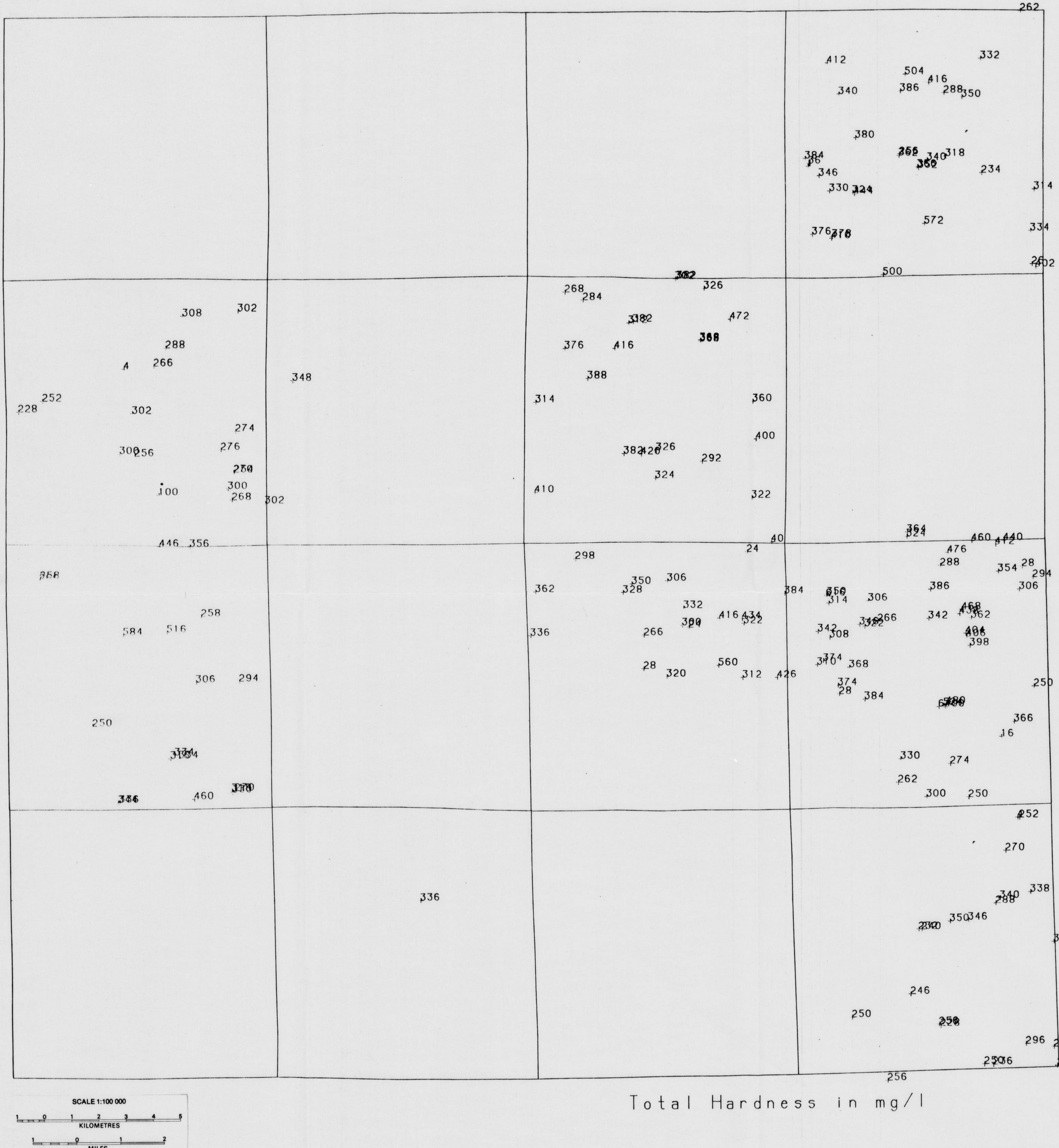
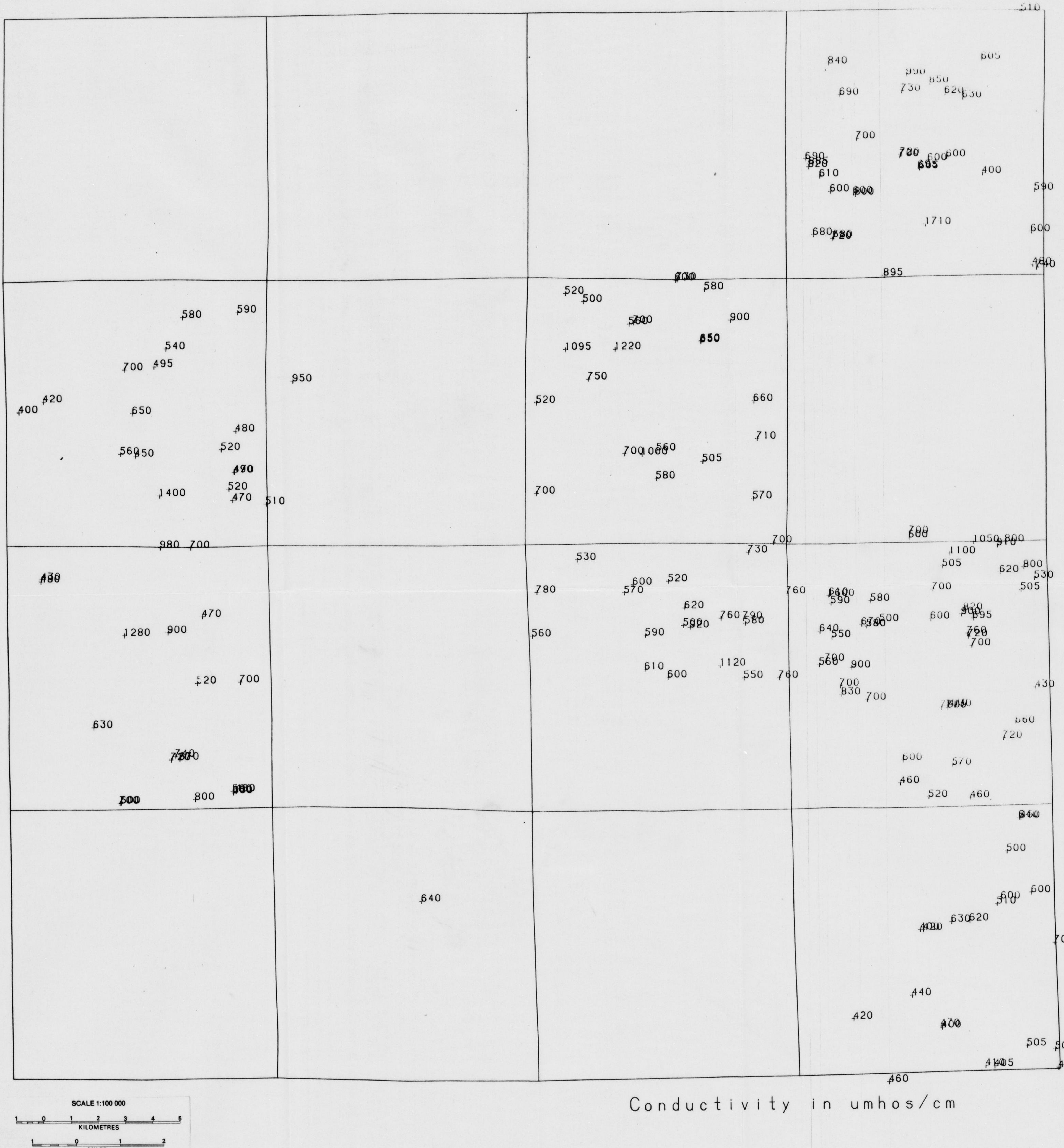
Plate 7



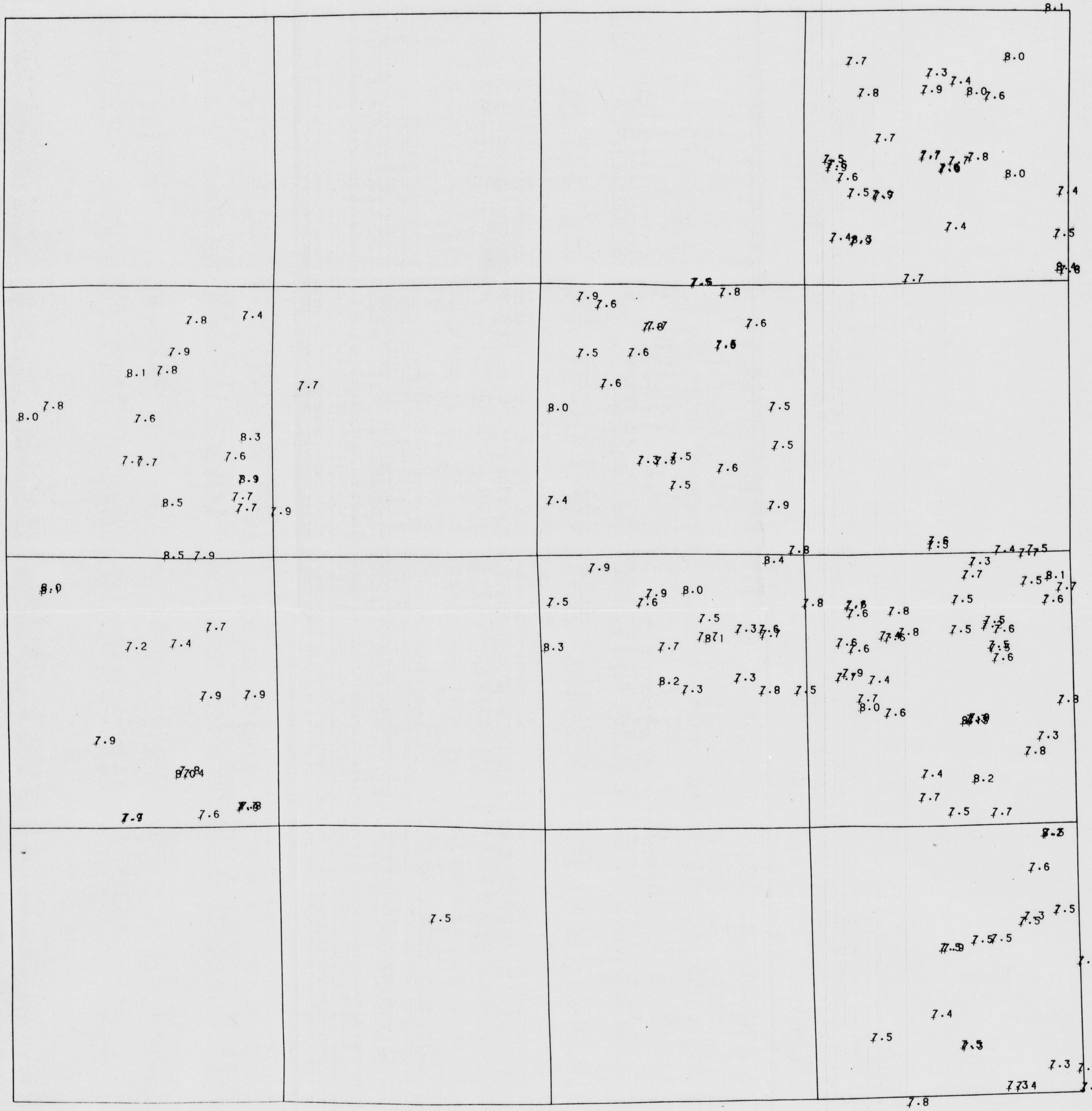
Total Hardness in mg/l

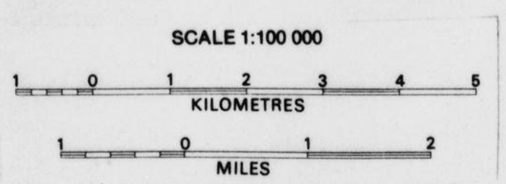
· Location and concentration



Conductivity in umhos/cm

· Location and concentration





Laboratory Measurement of pH

· Location and concentration