Water Quality of the Glacial-Outwash Aquifer in the Great Miami River Basin, Ohio

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ABSTRACT

The present water-quality conditions of the highly productive glacial-outwash aquifer in the Great Miami River basin of southwestern Ohio are documented by analyses of water from 98 sampling sites. Localized high concentrations of iron up to 5600 micrograms per liter, ammonia nitrogen as nitrogen up to 11 milligrams per liter, nitrite plus nitrate nitrogen as nitrogen up to 9.8 milligrams per liter, total organic carbon up to 71 milligrams per liter, and dissolved solids up to 1260 milligrams per liter were recorded. Chloride concentrations in the vicinity cf Dayton are higher than those of the surrounding area but do not exceed 100 milligrams per liter.

Changes in the chemical character of the water with time are apparent at some sites, but definitive trends are difficult to establish due to lack of consistent, documented data. Maps depicting the present distribution of dissolved solids, dissolved iron, dissolved manganese and total organic carbon are presented.

INTRODUCTION

This investigation deals specifically with the glacial-outwash aquifer in the valley of the Great Miami River in Miami, Montgomery, Warren, and Butler Counties of Ohio. The aquifer is the most productive ground-water source in the state. It is highly developed and requires artificial recharge in many areas to maintain the high rate of withdrawal. In the Dayton area alone pumpage was estimated at 162 million gallons ($6.116x10^8$ liters) per day in 1972 (Fidler, 1975). Increased demands for water by residential, commercial, and industrial users require more artificial recharge, and plans are in progress to fulfill these demands.

The water quality of a highly developed outwash aquifer that receives extensive induced recharge is susceptible to rapid degradation. In order to define areas where water-quality problems exist and to determine the rate at which a problem area is expanding, it is necessary to document the basic water-quality characteristics of the aquifer. The purpose of this report is to provide the results of a cooperative chemical-quality investigation conducted by the U.S. Geological Survey in cooperation with the Miami Conservancy District which documents the general water quality of the region.

PREVIOUS INVESTIGATIONS

Numerous reports (several of which are listed in Selected References) of investigations of the geology, hydrology, hydrogeology, and chemistry of the area have been published by the Miami Conservancy District, the U.S. Geological Survey, and the State of Ohio. Most of these reports contain chemical-quality data either as the main subject or as supplementary information. However, reports that emphasize chemical quality are either results of investigations of small areas or are limited to a specific aspect of water quality.

SITE SELECTION

Approximately 100 sampling sites were selected, the largest proportion within Montgomery County, to assure both areal and vertical distribution of wells representing a variety of water uses. Sites also were chosen on the basis of accessibility and probable long well life. Wells constituted all sampling sites except site 93 (fig. 1) which was a spring.

A few wells in the bedrock aquifers (denoted by footnote 3/, table 1) also were sampled for a qualitative comparison with water from the outwash aquifer.

Site locations and owner identification data are given in figure 1 and table 1, respectively. Results of chemical analyses are given in table 2.

SAMPLE COLLECTION AND ANALYSIS

Samples were collected between January and June 1976, preserved, and analyzed according to standard U.S. Geological Survey methods (Brown and others, 1970). All samples were pumped, as a pumped sample is generally more representative of water in an aquifer than a sample of standing water from a well casing, pump housing, or pressure tank.

Specific conductance, pH, temperature, and alkalinity were measured in the field and, where possible, water levels were measured. Other chemical constituents in table 2 were determined at the U.S. Geological Survey laboratory in Albany, New York.

PRESENT CONDITIONS

Specific Conductance

Specific conductance is a measure of the ability of a solution to carry a current, and varies with temperature and the type of ions in the solution. Natural waters generally exhibit a linear relationship between specific conductance and dissolved solids of the form; specific conductance (micromhos per centimeter at 25°C) x A = dissolved solids (mg/L) where A is a factor ranging in value from 0.5 to 1.0 (Hem, 1970). The mean values for specific conductance and dissolved solids of the samples in this study when substituted into this equation yielded a value for A of 0.57.

Specific conductance ranged from 483 micromhos at site 97 to 2,380 micromhos at site 90. The mean was 794 micromhos. Specific conductance seemed to be higher in the vicinity of the major industrial and population centers; and in localized rural areas of Miami County.

pH

The importance of the pH of raw public water supply is associated with its corrosive affect on plumbing fixtures, distribution lines, and water-treatment facilities as well as with its affect on water-treatment processes. Generally, corrosiveness of water increases with decreasing pH; however, highly alkaline water also may attack metal surfaces. The National Academy of Sciences (1972) recommends that the pH range for public water supplies be between 5.0 and 9.0.

pH values, which were fairly uniform throughout the study area, indicated that the ground water was slightly alkaline. The median pH was 7.3. The minimum was 7.0 at site 5 and the maximum was 8.6 at site 94.

Temperature

Temperature of ground water is usually uniform within an aquifer and normally fluctuates only slightly seasonally in shallow aquifers. For this reason, temperature may be used as an indicator of pollution as it was at site 90, where a temperature of 25°C was recorded. Site 90 is located in close proximity to the Miami County incinerator holding pond. This was the maximum observed temperature and over 10°C greater than the mean of 13.5°C; the second highest temperature was 18.0°C at site 1. Temperature was lowest, 10°C, at sites 57 and 67.

Silica

Silica in the presence of calcium and magnesium forms boiler scale. Most natural waters contain from 1 to 30 mg/L of silica (Hem, 1970). Silica concentrations were well within this range, with values ranging from 5.5 mg/L at site 57 to 20 mg/L at site 27. The mean was 11.1 mg/L.

Iron (Dissolved)

Concentrations of iron greater than 300 ug/L cause staining of laundry and lavatory fixtures, precipitates in plumbing and degrades the general esthetic qualities of water (National Academy of Sciences, 1972). Figure 2 is a map depicting the areal distribution of iron in water from the aquifer. Iron concentrations varied widely, but were locally high. The maximum iron concentration, 5,600 ug/L,was observed at site 37, with a minimum of 0 ug/L at sites 22 and 39. The mean concentration was 810 ug/L.

Manganese (Dissolved)

Manganese precipitate causes problems similar to those of iron. Figure 3 is a map depicting the areal distribution of manganese in the water from the aquifer. Manganese concentrations were generally well below 200 ug/L, however, they were generally above the 50 ug/L maximum recommended by the National Academy of Sciences (1972) for drinking water. Concentrations ranged from 0 ug/L at numerous sites to 630 ug/L at site 5. The mean concentration was 97 ug/L.

Calcium and Magnesium

Calcium and magnesium combine with various anions to form boiler scale and also combine with fatty acids in soaps to form curd. The amount of calcium and magnesium presented generally governs the water hardness; which is discussed later in this report.

The mineralogic composition of the geologic formations of the area is responsible, in part, for the occurrence of significant quantities of both elements. Calcium concentrations ranged from 12 mg/L at site 94 to 160 mg/L at sites 17 and 67. The mean concentration was 93 mg/L. The range for magnesium was 13 mg/L at site 94 to 61 mg/L at site 67. The mean concentration was 36 mg/L.

Sodium

Because most samples exhibited low concentrations of sodium, and since sodium tends to be present in significant quantities in industrial waste and sewage effluent, sodium may be used as a pollution indicator. However, water softening also increases sodium concentration.

The high concentration at site 62, 120 mg/L, may be due to contamination by water-treatment reagents, despite precautionary measures. The high concentration (250 mg/L) at site 90, which does not have water-treatment apparatus, indicated water-quality problems. Sites 8, 31, 35, 38, 49, 94 and 98 exhibited high concentrations (greater than 50 mg/L), that may indicate pollutional stress. High sodium concentrations also were observed in the wells penetrating rock aquifers (footnote b, table 2). Concentration ranged from 3.8 mg/L (sites 7 and 79) to 250 mg/L (site 90). The mean was 25 mg/L.

Potassium

Potassium concentrations were low, possibly because potassium easily combines with weathering products, particularly clay minerals of hydrolyzate sediments. Potassium concentrations ranged from 0.7 mg/L at site 80 to 50 mg/L at site 90. The mean was 3.6 mg/L.

Sulfate

Sulfate ions in drinking water can affect taste as well as produce cathartic effects. The National Academy of Sciences (1972) indicates that a laxative effect can be experienced at low sulfate concentrations if the water is high in magnesium.

Sulfate concentrations were generally well below the 250 mg/L level recommended by the National Academy of Sciences, (1972) for public supply; however, the major industrial centers exhibited sulfate values slightly higher than the mean of 73 mg/L. Sulfate concentrations ranged from 1.2 mg/L at site 87 to 270 mg/L at site 35.

Chloride

The chief sources of chloride in natural waters are sedimentary rocks, industrial waste, and sewage effluent (Hem, 1970). Road salting and home water softeners also may contribute chloride concentration to the environment, (U.S. Environmental Protection Agency, 1971). Chloride concentration greatly in excess of 250 mg/L instill a salty taste to drinking water (National Academy of Sciences, 1972).

Chloride seems slightly higher south of Dayton and in localized areas of Butler and Miami Counties. However, concentrations were less than 250 mg/L at all but one site. The minimum (6.5 mg/L) occurred at site 33 and the maximum (520 mg/L) at site 90. The mean was 45 mg/L.

Hardness

Hardness of water is a property attributable to calcium and magnesium and is usually expressed in terms of mg/L of calcium carbonate. One of the widely accepted classification is, (Brown and others, 1970):

Hardness mg/L CaCO3	Classification
0-60	soft
61-120	moderately hard
121-180	hard
greater than 180	very hard

The ground water was generally very hard, and concentrations ranged from 84 mg/L at site 94 to 650 mg/L at sites 17 and 67. The mean was 377 mg/L.

Alkalinity

Alkalinity is primarily a function of the carbonate, bicarbonate, and(or) hydroxide content of the water; the alkalinity determination is normally taken as an indication of the concentration of these constituents. Such values are maximums and include other titratable weak-acid radicals if present. (Refer to the work of Barnes (1964), Langilier (1946), and Weber and Stumm (1963) for a further discussion of this topic.) Bicarbonate concentration ranged from 224 mg/L at site 1 to 558 mg/L at site 8. The mean was 370 mg/L. One sample, site 94, contained carbonate (13 mg/L).

According to techniques of Piper, Garrett, and others (1953), the water of the glacial-outwash aquifer within the study region generally was classified as a calcium-bicarbonate type with a few exceptions, the majority of which were located in Miami County.

Nitrogen

Sources of nitrogen in natural waters include the atmosphere, legumes, plant debris, fertilizers and waste products of both man and animals. Due to its high content in sewage, septic effluent, and chemical fertilizers; nitrogen is often used as an indicator of pollution by man.

Nitrogen under aerobic conditions is usually in the form of nitrate (NO3), which is the end product of aerobic decomposition of organic nitrogen. Nitrite (NO2) and ammonia (NH4+) are unstable under these conditions and are present normally in trace quantities only.

Under anaerobic conditions or in a reducing environment, nitrite and ammonia may be present in significant concentrations. Ammonia in high concentrations may indicate direct pollution with organic waste products. The high ammonia value at site 90 was probably due to such a situation.

Nitrite and nitrate as nitrogen were summed for this report. Concentrations of nitrogen were generally low and the few high values were randomly spaced indicating only localized problem areas.

Nitrite plus nitrate as nitrogen ranged from 0.0 mg/L at several sites to 9.8 mg/L at site 91. The mean was 1.3 mg/L. Ammonia as nitrogen ranged from 0.0 mg/L at numerous sites to 11 mg/L at site 90. The mean was 0.38 mg/L.

Dissolved Solids

Dissolved-solids data presented (DS sum, table 2) represent a summation of major anions and cations determined by laboratory analyses. Figure 4 is a map depicting the areal distribution of dissolved solids in the water from the aquifer. Dissolved solids were generally high in the entire region, and localized areas exhibited values above the 500 mg/L maximum recommended by the National Academy of Science (1972) as maximum for drinking water. Calculated dissolved solids ranged from 275 mg/L at site 97 to 1,260 mg/L at site 90. The mean was 453 mg/L.

Total Organic Carbon

Total organic carbon (TOC) is widely used as a measure of organic water quality in much the same way as specific conductance is used as a measure of dissolved solids. The determination of total organic carbon gives a better measure of organic matter present in aqueous solutions and(or) suspension than does chemical oxygen demand (Goerlitz and Brown, 1972).

Because only recently have extensive analyses been made of TOC in water, limited expertise exists in interpretation of results. The following tabulation presents a summary of expected levels of organic substances in ground water based on TOC determinations (J. A. Leenheer, oral communication, 1976):

TOC (mg/L)	Condition
0-5	low
5-10	moderate
10-25	high
greater than 25	very high

Figure 5 is a map depicting the areal distribution of total organic carbon in the water from the aquifer. TOC concentrations were generally low to moderate in the study area, although high to very high concentrations existed at sites, 90 (71 mg/L), 21 (31 mg/L), 17 (19 mg/L), 97 (14 mg/L), and 11 mg/L at sites 76 and 87. Concentrations ranged from 0.1 mg/L at site 70 to 71 mg/L at site 90. The mean was 5.2 mg/L.

Temporal Changes in Water Quality in the Aquifer

Comparison of current and past water analyses from particular wells indicated in some instances, a large variation in chemical character. At site 17 a comparison of analyses from 1964 (Spieker, 1968) and 1976 exhibit an almost two-fold increase in all properties. The most dramatic increase was sulfate — 40 mg/L in 1964 to 230 mg/L in 1976. Calcium and magnesium increased from 82 and 33 mg/L to 160 and 60 mg/L, respectively, and dissolved solids from 396 to 783 mg/L.

At site 42 analyses from 1958 and 1976 showed increases in specific conductance (675 to 910 micromhos), calcium (91 to 130 mg/L), chloride (10 to 61 mg/L), and sulfate (49 to 120 mg/L), (Norris and Speiker, 1966).

Lesser increases also were noted at several other sites, but definitive statements about the changes were not possible due to introduction of improved analytical methods and more sophisticated instrumentation.

Despite a large number of chemical analyses of groundwater samples from the region, consistent, long-term, chemical data generally were not available. Improved techniques and instrumentation, changes in sampling frequency, sites sampled, and properties determined were limiting factors in an evaluation of water quality trends. Therefore, trend analyses were not possible, however, the data adequately describe the current water quality conditions in the aquifer, and provide a base on which to develop trend analysis if selected sites are sampled over a period of time for similar constituents.

SUMMARY AND CONCLUSIONS

Water in the glacial-outwash aquifer in the basin was high in dissolved solids, hardness and, with some exceptions, iron. Locally, high concentrations of nitrogen, sodium, chloride, and total organic carbon indicated degradation of the water quality at some sites. As compared to rural areas, ground water in the vicinity of major industrial centers appeared to be slightly less desirable. Methods of waste disposal (landfills, sewage effluent, etc.) may be contributing to water-quality degradation in areas where pumping induces recharge to the aquifer.

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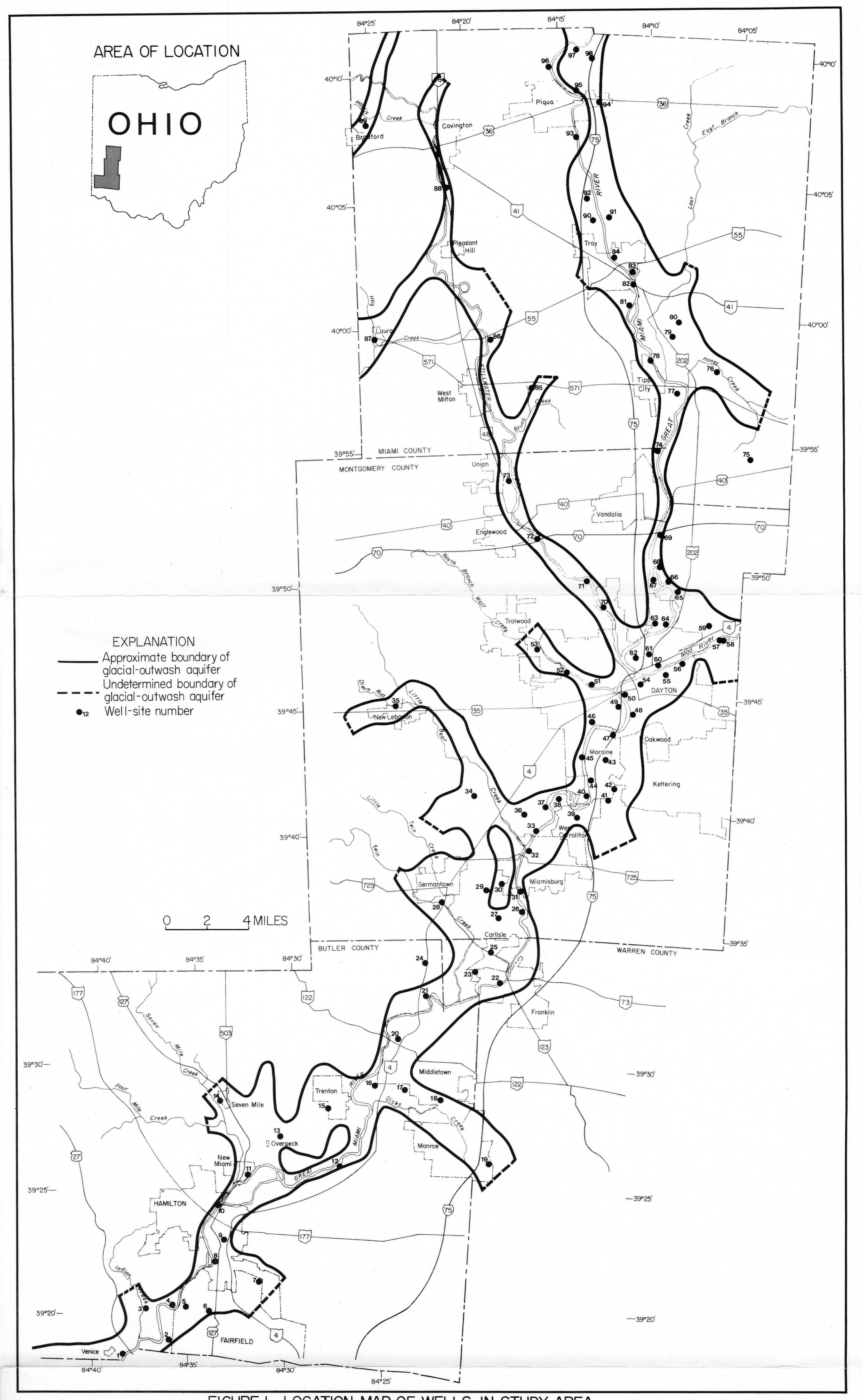

FIGURE 1.--LOCATION MAP OF WELLS IN STUDY AREA.

Base from Ohio Department of Transportation

Table 1.--Site Identification and Description of Wells in Ohio

Site number	Latitude-longitude	Owner	Depth[1] (ft)	Use[2]	Water-quality sampling date
1	3918390843814	Bu-1012 Wade Hill Concrete Products at Ross	--	Ind	5-20-76
2	3919080843609	Bu-14 Miami Conservancy District near Hamilton	56	Obs	3-24-76
3	3920190843722	Bu-1010 Southwest Butler County Water Association well #1 near Ross	86	PS	2-26-76
4	3920300843600	Bu-66 Miami Conservancy District near Ross	25	Obs	3-24-76
5	3920270843507	Bu-1009 City of Fairfield well #3 at Fairfield	176	PS	2-26-76
6	3920150843355	Bu-1008 City of Hamilton well #11 at Hamilton	203	PS	2-26-76
7	3921340843329	Bu-162 Bobmeyer Road Landfill at Hamilton	103	Dcm	2-26-76
8	3922100843408	Bu-1002 Hamilton Sewage Treatment at Hamilton	48.5	Ind	3-15-76
9	3923100843317	Bu-1011 Hamilton Die Cast well #1 at Hamilton	--	Ind	3-16-76
10	3924500843330	Bu-36 Champion Paper Company well #4 at Hamilton	180	Ind	2-25-76
11	3925400843200	Bu-1001 Armco Steel (New Miami) well #10 at Hamilton	176.3	Ind	2-25-76
12	3926080842727	Bu-144 Nicolet Incorporated well #3 near Hamilton	--	Ind	2-24-76
13	3927400843023	Bu-1007 Hickory Flats Church near Hamilton	41	Dcm	2-25-76
14	3928090843325	Bu-1014 Village of Sevensmile well #1 at Sevensile	65	PS	2-25-76
15	3928300842737	Bu-1013 City of Trenton well #3 at Trenton	78	PS	2-24-76
16	3929260842535	Bu-1003 Mecco Concrete at Middletown	--	Dcm	2-23-76
17	3929240842341	Bu-1015 Armco Steel well #35 at Middletown	226	Ind	3-22-76
18	3929560842204	Bu-1016 Armco Steel well #36 at Middletown	--	Ind	3-22-76
19	3926210841924	W-1003 City of Monroe well #3 at Monroe	145	PS	2-24-76
20	3931200842420	Bu-1000 Middletown Water Works well #1 at Middletown	35.5	PS	2-24-76
21	3932540842252	Bu-1005 Posst Town School at Middletown	68	Inst	2-23-76
22	3933310841837	W-106 City of Franklin well #6 at Franklin	88	PS	2-06-76
23	3931000842007	W-1000 Thomas Kidwell Duncan Road near Carlisle	45	Dcm	2-05-76
24[3]	3933490842253	Bu-1006 A. Ferguson Ora Lane near Middletown	75	Dcm	2-05-76
25	3935020841924	W-1001 Holman Central Street (SR 123) at Carlisle	--	Dcm	2-05-76
26	3936290841724	Mt-962 Dayton Power & Light C.H. Hutchings Station well #2 near Miamisburg	105	Ind	2-05-76
27	3935220841838	Mt-914 Pearson Farmington Road near Miamisburg	--	Dcm	4-09-76
28	3936550842155	Mt-1010 R. Swartz Main Street at Germantown	65	Dcm	2-05-76
29	3937380841942	Mt-923 B.E. Shade Jamaica Road near Germantown	85	Dcm	2-05-76
30[3]	3937400841842	Mt-920 J. Hart Lower Miamisburg Road near Miamisburg	95	Dcm	2-05-76
31	3937240841729	Mt-912 Monsanto Mound Laboratory well #3 at Miamisburg	80	Ind	2-06-76
32	3935300841707	Mt-63 Box Board Company well #1 (south) at Miamisburg	95	Ind	2-06-76
33	3939420841637	Mt-1016 H. Johnson Upper River Road at Miamisburg	30	Dcm	4-09-76
34	3940500842007	Mt-924 E. Hoffsinger South Lebanon Church Road near Miamisburg	67	Dcm	4-08-76
35	3944580842259	Mt-1000 Village of New Lebanon well #3 at New Lebanon	202	PS	5-11-76
36	3940280841724	Mt-1012 L.D. Winkler Soldiers Home Road near Miamisburg	68	Dcm	4-08-76
37	3940410841604	Mt-708 Hilltop Concrete at West Carrollton	168	Dcm	2-04-76
38	3940560841525	Mt-705 T. Tyson Hydraulic Road at West Carrollton	61	Dcm	2-04-76
39	3941200841451	Mt-770 City of West Carrollton well #3 at West Carrollton	91	PS	2-04-76
40	3940580841400	Mt-1002 Montgomery County Sanitation well #14 at Dayton	160	PS	1-30-76
41	3940480841307	Mt-591 Siebenthaler Nursery at Dayton	94	Irr	2-04-76
42	3941270841243	Mt-592 Montgomery County Sanitation well #2 at Dayton	201	PS	1-30-76
43	3942000841256	Mt-580 Ancle Incorporated at Dayton	60	Ind	1-30-76
44	3941480841301	Mt-647 Montgomery County Recharge Facility at Dayton	73	Obs	2-03-76
45	3942480841356	Mt-1017 Dayton Sewage Plant well #DY-81 at Dayton	40	Obs	5-18-76
46	3944500841313	Mt-336 Monsanto Chemical Laboratory north well at Dayton	121	AC	1-29-76
47	3947300841244	Mt-523 Dayton Power and Light F.M. Tait Station well #4 at Dayton	158	Pcw	1-29-76
48	3944360841134	Mt-420 National Cash Register River well at Dayton	171	Ind	1-29-76
49	3944490841230	Mt-1008 Standard Register at Dayton	129	AC	5-11-76
50	3944500841146	Mt-823 Dayton Power & Light Longworth Station Layne well at Dayton	140	Pcw	5-11-76
51	3945470841354	Mt-313 Dayton Tire & Rubber well #2 at Dayton	195	Ind	5-11-76
52	3946190841454	Mt-363 Darling Company at Dayton	60	Ind	4-09-76
53	3947200841626	Mt-1018 Wysong Gravel Wolf Creek Pike at Dayton	69	Ind	4-09-76
54	3947100841111	Mt-884 Delco Products First Street well #8 at Dayton	126	Ind	5-11-76
55	3946090841007	Mt-1005 City of Dayton well #47 at Dayton	123	PS	1-27-76
56	3946300840856	Mt-1004 City of Dayton well #46 at Dayton	85	PS	1-27-76
57[4]	3947210840713	Mt-1013 City of Dayton well #12 at Dayton	65	PS	1-27-76
58[4]	3947210840713	Mt-1014 City of Dayton well #34 at Dayton	161	PS	1-27-76
59	3947520840743	Mt-1022 Mad River Schools Stebbins High School #B-42 at Dayton	147	Obs	5-18-76
60	3944400840907	Mt-217 Dayton Rust Proof well #2 at Dayton	141	Ind	2-03-76
61	3947180840958	Mt-208 Burdox Company at Dayton	220	Ind	5-12-76
62	3947030841040	Mt-211 Chrysler Air Temp Boiler House well at Dayton	89	Ind	1-28-76
63	3948090841031	Mt-1011 City of Dayton well #I-2 at Dayton	152	Ind	1-27-76
64	3948100840951	Mt-1003 City of Dayton well #13 at Dayton	26	PS	1-27-76
65	3949190840908	Mt-279 Ohio Suburban Water Company well #3 at Dayton	59	PS	1-28-76
66	3950060840931	Mt-257 Powell Road Landfill Powell Road at Dayton	--	Dcm	1-29-76
67	3950130841030	Mt-1008 Unknown owner Redavanky Lane near Miami Villa	--	Dcm	1-29-76
68	3951010841010	Mt-1009 Van Shaik Big Hap Road at Miami Villa	51	Dcm	1-29-76
69	3951440841001	Mt-72 Ohio Suburban Water Company near Vandalia	120	Obs	3-23-76
70	3951400841253	Mt-1019 Colgus Investments Shoup Mill Road at Dayton	45	Dcm	4-09-76
71	3950150841346	Mt-282 Delscamp Philadelphia Drive at Dayton	--	Dcm	1-29-76
72	3951420841612	Mt-1006 City of Englewood South well #1 at Englewood	128	PS	3-16-76
73	3953520841746	Mt-1020 Village of Union well #1 at Union	100	PS	3-16-76
74	3955220840958	Mt-1007 Valley Concrete Corporation near Vandalia	--	Ind	3-02-76
75[3]	3955040840511	Mi-1001 Bethel Township School South SR 201 near Tipp City	100	Inst	3-03-76
76	3958020840641	Mi-1000 T. Tidd Hufy Road near Tipp City	58	Dcm	3-03-76
77	3957340840857	Mi-1005 City of Tipp City well #5 at Tipp City	92	PS	3-03-76
78	3958360840109	Mi-1006 H. Moulton Crane Road at Tipp City	45	Dcm	3-03-76
79	3959340840928	Mi-19 T-3 I.W. Howard Trojan Farms South Childrens Home Road near Troy	62	Dcm	3-03-76
80	3959380840910	Mi-1008 R. Treon South Knoop Road near Troy	--	Dcm	3-03-76
81	4000490841145	Mi-1009 B. S. Reed Towpath Road at Troy	20	Dcm	3-03-76
82	4001360841123	Mi-1007 Dinner Bell Foods well #1 at Troy	--	Ind	3-04-76
83	4002080841129	Mi-44 City of Troy well #4 at Troy	83	PS	3-04-76
84	4002390841220	Mi-1020 City of Troy old well #1 at Troy	155	PS	3-04-76
85	3957500841655	Mi-1019 C. Searcey Kessler-Fredrick Road near West Milton	84	Dcm	4-15-76
86	3959380841854	Mi-1018 J. Cluney Kessler-Fredrick Road near Ludlow Falls	--	Dcm	4-14-76
87	3959380842445	Mi-1017 Village of Laura well #1 at Laura	110	PS	3-30-76
88[3]	4005200842059	Mi-1016 Dayton Boys Club Boys Acres well North SR 48 near Covington	--	Inst	3-30-76
89	4008180842536	Mi-1015 Village of Bradford well #1 at Bradford	65	PS	3-30-76
90	4004240841331	Mi-1014 Miami County Incinerator Factory well at Troy	86	Ind	3-04-76
91	4004460841237	Mi-1010 Peoples Gas Service Company West Eldean Road near Troy	60	Dcm	3-04-76
92	4005130841332	Mi-1011 Dettmer Hospital South well near Troy	--	Inst	3-05-76
93[4]	4007150841410	Mi-1013 E. Easton North County Road 25A near Piqua	--	Dcm	4-15-76
94	4008560841246	Mi-1004 Wooly Wash at Piqua	199	Fire	3-05-76
95	4009240840930	Mi-1003 Ernst Gravel Company Lockington Road at Piqua	60	Dcm	3-05-76
96[3]	4010340841540	Mi-39 City of Piqua at Piqua	302	None	3-23-76
97	4011030841431	Mi-1002 A. Wilson North Lockington Road near Piqua	120	Dcm	3-05-76
98	4010540841301	Mi-1012 Piqua Country Club Maintenance Building well near Piqua	130	Irr	4-14-76

[1] For depth in meters multiply ft by 0.3048.
[2] Explanation of abbreviations: AC - air conditioning; Dom - domestic; Fire - fire protection; Ind - industrial; Inst - institution supply; Irr - irrigation; Obs - observation; PS - public supply; Pcw - power generation.
[3] Wells in bedrock aquifers.
[4] Spring.

Table 2.--Water-quality data from wells a/

Site No.	Temp. °C	pH	HCO3 mg/L	CO3 mg/L	Cl mg/L	SO4 mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Spec. Cond. Micro-mhos	D.S. SUM mg/L	SiO2 mg/L	Fe ug/L	Mn ug/L	Total NO2+NO3-N mg/L	Total NH4-N mg/L	Total Org. Car. mg/L	Hard. as CaCO3 mg/L
1	18.0	7.6	224	0	16	59	69	25	8.1	2.3	535	392	6.8	20	0	1.3	.01	5.4	280
2	12.0	7.4	342	0	21	67	100	30	13	2.8	745	425	9.5	70	10	2.1	.01	2.0	370
3	14.0	7.4	300	0	29	51	84	25	11	2.7	605	367	6.4	10	0	2.2	.02	5.9	310
4	16.0	7.4	265	0	41	87	85	24	29	4.0	700	412	9.6	1000	110	.03	.04	6.5	310
5	14.0	7.0	359	0	29	62	92	29	13	2.3	670	416	11	100	630	.09	.02	2.6	350
6	13.0	7.3	386	0	17	49	94	29	11	2.3	660	410	12	70	270	1.2	.02	3.8	350
7	14.0	7.5	344	0	15	74	96	27	3.8	1.2	635	398	9.8	880	260	.03	.14	5.2	350
8	13.0	7.1	558	0	47	110	130	41	69	9.5	1170	702	13	130	500	.39	3.9	4.4	490
9	14.5	7.1	395	0	43	100	129	40	20	3.0	510	536	11	370	390	.85	.03	8.6	460
10	16.0	7.2	384	0	39	96	100	32	25	3.5	600	502	11	20	10	1.4	.02	--	380
11	16.0	7.4	363	0	46	61	80	29	24	3.1	625	445	8.0	10	0	3.4	.04	8.8	320
12	13.0	7.2	475	0	50	61	88	57	27	3.0	660	535	9.0	30	30	1.2	.04	8.3	450
13	14.0	7.4	349	0	15	47	88	32	6.2	1.6	630	395	9.6	20	0	5.2	.00	7.1	350
14	13.0	7.4	362	0	29	65	92	29	11	2.4	470	422	8.6	10	0	2.8	.02	3.0	350
15	13.0	7.1	395	0	47	40	100	36	23	2.1	750	490	11	20	0	8.1	.01	5.7	400
16	13.0	7.2	342	0	31	52	76	30	19	4.0	640	392	8.4	170	10	.52	.41	3.3	310
17	14.0	7.2	448	0	55	230	160	60	33	2.5	1190	783	15	5400	60	.02	.96	19.0	650
18	14.0	7.3	386	0	71	110	120	43	18	1.5	960	570	13	900	20	.02	1.8	3.0	480
19	13.0	7.2	380	0	23	27	80	28	12	1.0	625	375	14	2200	30	.04	.51	5.8	320
20	14.0	7.3	308	0	19	140	92	31	12	4.5	710	493	11	220	390	1.2	.03	2.5	360
21	14.5	7.2	436	0	27	57	100	40	11	2.6	800	475	11	10	0	2.5	.00	31	410
22	14.0	7.2	354	0	32	56	88	29	10	2.0	720	420	10	0	20	1.5	.01	4.5	340
23	12.5	7.2	398	0	26	45	88	35	15	2.0	720	446	11	20	10	6.2	.01	2.8	360
24b/	14.0	7.3	376	0	39	42	52	24	60	11	720	425	7.8	20	0	.96	.29	6.2	230
25	14.0	7.2	--	0	28	50	90	37	7.2	1.4	650	--	11	50	0	5.1	.05	4.8	390
26	13.0	7.3	375	0	72	53	86	30	46	3.7	820	488	11	690	110	.12	.08	6.5	340
27	12.0	7.3	379	0	28	40	87	41	7.2	1.0	720	413	20	1700	20	.01	.10	.5	390
28	12.0	7.2	377	0	19	43	100	29	5.8	1.3	660	416	8.6	210	0	5.3	.04	7.1	370
29	13.5	7.4	352	0	14	53	87	34	9.6	1.6	630	407	14	230	90	.04	.12	7.7	360
30b/	14.0	7.4	420	0	25	49	65	34	42	9.3	1050	634	8.3	30	10	.03	.04	4.9	430
31	14.0	7.1	425	0	190	65	120	43	87	4.1	1200	737	9.9	30	30	1.7	.54	.7	480
32	13.5	7.2	460	0	51	100	110	42	43	3.4	940	592	12	2700	180	.05	.53	2.5	450
33	13.0	7.4	312	0	6.5	41	80	33	5.1	1.0	615	356	11	30	10	5.3	.03	3.3	340
34	13.0	7.4	365	0	13	24	80	36	5.3	1.0	650	360	19	2000	20	.03	.03	5.6	350
35	13.5	7.5	368	0	35	270	110	48	72	2.6	1120	737	15	1700	90	.03	1.1	2.6	470
36	12.0	7.6	368	0	7.4	52	73	34	27	1.9	695	395	16	1600	40	.01	.64	5.4	320
37	14.5	7.4	410	0	19	80	96	39	11	1.5	740	469	14	5600	330	.03	.21	3.2	400
38	17.0	7.6	256	0	82	59	64	27	59	1.8	720	435	15	1000	160	.03	.08	1.9	270
39	15.0	7.1	392	0	36	120	100	41	23	2.7	850	530	12	0	70	.55	.01	2.7	420
40	13.5	7.1	452	0	47	170	130	48	26	3.0	1000	662	14	830	280	.01	.26	.8	520
41	13.0	7.2	352	0	50	54	86	34	28	2.3	740	443	6.9	20	10	1.5	.01	4.2	360
42	13.5	7.2	421	0	61	120	130	44	19	1.8	910	601	14	30	220	.99	.01	.4	510
43	13.5	7.3	542	0	97	140	150	52	49	2.4	1200	774	16	570	110	.01	.03	.8	590
44	13.0	7.5	267	0	41	83	88	23	29	1.9	700	409	8.2	2100	140	.01	.78	1.1	310
45	14.0	7.0	473	0	42	76	110	44	37	12	575	609	12	30	150	5.2	2.8	6.3	490
46	14.0	7.3	371	0	59	110	100	35	39	4.7	840	543	11	150	110	.26	.09	3.4	390
47	14.0	7.3	368	0	45	130	110	43	26	3.3	650	553	14	150	330	.01	.16	2.4	450
48	14.5	7.2	355	0	81	140	120	43	32	3.4	1010	643	15	20	130	1.9	.00	2.8	460
49	16.0	7.2	381	0	87	140	110	45	53	17	1110	665	10	240	90	3.3	.02	4.6	460
50	13.0	7.3	364	0	51	97	110	35	26	2.9	810	519	15	70	290	.49	.02	2.7	420
51	15.0	7.4	388	0	40	75	93	43	24	1.9	835	487	16	1900	50	.02	.51	1.1	410
52	15.0	7.6	338	0	16	59	74	35	14	1.5	670	374	16	1600	30	.01	.06	2.9	330
53	14.0	7.5	319	0	82	50	80	34	4.1	1.1	625	399	15	1800	30	8.8	.08	.6	340
54	14.0	7.4	392	0	34	50	91	30	36	3.2	840	480	13	20	10	.03	.03	2.4	400
55	15.0	7.2	407	0	74	99	110	42	40	3.9	950	592	12	20	240	2.2	.01	5.7	450
56	12.0	7.6	251	0	42	77	78	32	22	4.1	690	415	7.4	10	0	1.9	.11	7.7	330
57	10.0	7.5	298	0	32	68	72	34	17	2.4	610	384	5.5	10	0	1.5	.00	4.2	320
58	13.0	7.2	397	0	21	97	110	37	9.7	1.5	720	448	14	1600	300	.01	.13	6.1	400
59	13.5	7.3	289	0	33	69	98	39	7.2	1.4	720	414	17	1800	160	.03	.20	.3	360
60	14.0	7.5	298	0	30	69	76	32	11	1.5	610	381	13	1200	50	.04	.12	.7	320
61	13.0	7.4	350	0	10	34	74	34	9.7	1.5	610	354	16	1200	60	.08	.27	1.0	320
62	16.0	7.1	430	0	59	54	74	34	120	3.6	880	574	12	1100	20	.24	.14	2.4	320
63	13.5	7.1	432	0	46	92	110	43	28	2.7	675	551	12	1100	80	.69	.14	2.3	450
64	12.5	7.3	347	0	33	70	96	36	15	2.0	720	415	11	660	70	.04	.04	1.6	390
65	12.5	7.3	389	0	34	69	98	34	20	2.4	720	460	9.5	450	110	.29	.03	2.4	380
66	12.5	7.3	385	0	45	52	80	43	19	2.6	750	443	11	670	190	.01	.03	2.0	380
67	10.0	7.2	416	0	200	120	160	61	29	2.3	1380	794	11	5500	110	.01	.06	1.8	650
68	11.0	7.3	373	0	81	140	120	35	3.8	3.4	1010	620	11	230	80	.01	.03	.3	470
69	12.0	7.3	361	0	25	56	96	37	10	1.7	735	422	16	2100	50	.05	.05	2.2	390
70	13.5	7.4	320	0	19	97	110	35	9.3	2.1	695	391	10	20	0	1.0	.02	.1	330
71	11.0	7.2	404	0	57	49	98	37	31	1.9	825	491	8.0	60	10	2.2	.03	1.1	400
72	12.5	7.3	314	0	19	49	79	30	31	1.7	730	411	11	350	30	.21	.04	6.1	360
73	12.0	7.3	315	0	33	53	92	33	23	1.3	695	396	8.4	20	0	1.6	.01	.7	370
74	12.0	7.1	460	0	38	78	110	36	18	1.7	640	492	10	20	0	.60	.21	4.2	420
75b/	14.5	7.2	429	0	8.4	60	84	46	4.9	1.0	725	435	8.9	30	0	2.3	.01	5.8	400
76	14.0	7.2	424	0	9.2	52	90	39	4.4	1.1	715	421	14	2200	40	.01	.03	11	390
77	15.0	7.2	359	0	20	64	90	33	7.2	1.6	655	406	11	1500	40	.01	.10	6.7	360
78	14.5	7.1	351	0	29	48	93	34	13	1.5	730	423	9.0	10	0	4.8	.01	8.1	370
79	13.0	7.3	331	0	13	77	82	36	3.8	.8	620	388	11	4400	30	.01	.04	5.9	350
80	13.0	7.3	381	0	9.5	58	88	37	4.2	.7	665	402	14	2300	20	.03	.14	6.6	370
81	11.5	7.3	354	0	16	80	98	36	7.5	1.6	750	460	7.6	30	0	8.7	.02	7.3	390
82	--	7.4	376	0	22	53	80	32	20	2.1	700	408	12	980	50	.02	.25	6.2	340
83	12.0	7.5	368	0	17	56	74	36	15	1.8	650	397	14	940	30	.03	.42	9.8	330
84	13.5	7.5	368	0	17	35	88	35	15	2.3	780	480	9.4	950	150	.19	.52	4.0	360
85	13.5	7.4	336	0	19	68	84	35	8.6	1.9	700	396	12	2000	20	.01	.05	5.2	410
86	13.0	7.6	286	0	87	1.6	64	30	35	5.1	740	374	7.3	950	40	.02	1.4	1.6	280
87	13.0	7.8	346	0	19	1.2	35	24	57	2.1	600	324	12	440	10	.02	2.5	11	190
88b/	14.0	7.4	415	0	180	69	51	22	220	12.0	1400	768	7.2	70	20	.02	8.1	1.9	220
89	12.0	7.2	426	0	64	160	140	52	32	1.8	1100	677	15	1900	120	.01	.30	7.4	560
90	25.0	7.3	410	0	520	36	140	50	250	50	2380	1260	16	1600	530	.01	11	71	490
91	14.0	7.5	311	0	25	58	88	32	10	2.6	710	421	8.8	20	0	9.8	.02	5.3	350
92	13.0	7.4	369	0	61	95	110	39	34	1.8	660	497	9.5	50	0	5.4	.00	5.7	390
93c/	12.0	7.4	302	0	15	66	89	31	5.2	1.8	675	375	6.5	20	0	2.6	.09	5.4	350
94	13.5	8.6	291	13	6.9	8.3	12	13	60	40	538	320	18	10	0	1.3	.01	7.3	84
95	13.5	7.4	266	0	25	69	72	28	9.3	1.8	590	347	8.7	60	50	.38	.02	17	300
96b/	12.0	7.4	478	0	220	8.4	52	35	200	19	1450	782	8.8	680	10	.11	1.8	1.3	270
97	11.5	7.8	309	0	10	1.9	30	17	49	1.7	463	275	11	510	10	.04	1.0	14	150
98	12.0	7.3	346	0	100	100	110	32	64	2.4	1040	589	8.0	1100	30	.01	.04	1.3	410

a/ Explanation of symbols and abbreviations used in table headings:

Symbol	Explanation	Symbol	Explanation
Temp. °C	Temperature in degrees Celsius	Spec. Cond. Micromhos	Specific conductance in micromhos at 25°C (degrees Celsius)
pH	pH units	D.S. SUM	Dissolved Solids, Sum of constituents
HCO3	Bicarbonate	SiO2	Silica
CO3	Carbonate	Fe	Iron
Cl	Chloride	Mn	Manganese
SO4	Sulfate	Total NO2+NO3-N	Total Nitrite plus Nitrate as Nitrogen
Ca	Calcium	Total NH4-N	Total Ammonia Nitrogen as Nitrogen
Mg	Magnesium	Total Org. Car.	Total organic carbon
Na	Sodium	Hard as CaCO3	Hardness as Calcium Carbonate
K	Potassium		

b/ Wells in bedrock aquifers.
c/ Spring.