HYDROLOGY AND WATER QUALITY OF THE FOREST COUNTY POTAWATOMI INDIAN RESERVATION, WISCONSIN

By R.A. Lidwin and J.T. Krohelski

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BRUCE BABBITT, ***Secretary***

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, ***Director***

For additional information write to:

District Chief
U.S. Geological Survey
6417 Normandy Lane
Madison, WI 53719

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Multiply	***By***	***To obtain***
acre	0.004047	square kilometer
foot (ft)	0.3048	meter
foot per day (ft/d)	0.3048	meter per day
cubic foot per second (ft^3/s)	0.02832	cubic meter per second

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Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviated water-quality units used in this report: Chemical concentrations and water temperature are given in metric units. Chemical concentration is given in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is the same as for concentrations in parts per million.

Specific electrical conductance of water is expressed in microsiemens per centimeter at 25 degrees Celsius (µS/cm). This unit is equivalent to micromhos per centimeter at 25 degrees Celsius (µmho/cm), formerly used by the U.S. Geological Survey.

Radioactivity is expressed in picocuries per liter (pCi/L). A picocurie is one-trillionth (1×10^{-12}) the amount of radioactivity represented by a curie (Ci). A curie is the amount of radioactivity that yields 3.7×10^{10} radioactive disintegrations per second. A picocurie yields 2.22 disintegrations per minute.

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ABSTRACT

This report presents data from a study by the U.S. Geological Survey, in cooperation with the Forest County Potawatomi Community of Wisconsin, to document the hydrology and water quality of the Potawatomi Indian Reservation in southern Forest County. Data were collected from October 1981 through September 1987.

Glacial sand and gravel forms the primary aquifer on the reservation. This aquifer is unconfined, and its saturated thickness ranges from approximately 200 feet to zero feet in areas where the bedrock crops out. Horizontal hydraulic conductivity of the glacial deposits is estimated to range from 0.4 to 48 feet per day.

Three watersheds encompass the Reservation: The Wolf, the North Branch Oconto, and the Peshtigo. Estimates of base-flow discharge that will occur on the average once every 2 years for a 7-day period for Reservation streams range from 7.5 ft^3/s (cubic feet per second) for North Branch Oconto at Wabeno to 32 ft^3/s for the Rat River near Wabeno.

Ground water in the study area is a calcium magnesium bicarbonate type and is suitable for most uses. The ground water sampled during the study was slightly alkaline and moderately hard to very hard; median hardness was 135 mg/L (milligrams per liter) as calcium carbonate. Alkalinity of ground water ranged from 79 to 318 mg/L; median alkalinity was 123 mg/L as calcium carbonate.

With the exception of nitrate in water from one well sampled, constituent concentrations were less than the U.S. Environmental Protection Agency's Maximum Contaminant Levels (MCL's) for drinking water. Nitrate plus nitrite concentration was 15 mg/L as N, or 50 percent greater than the MCL, in one well located one-half mile northeast of Lake Lucerne.

Secondary Maximum Contaminant Levels (SMCL's) for iron were exceeded in water from two wells. In one of these two well waters, the manganese concentration equaled the SMCL.

Streams on the Reservation also contain a calcium magnesium bicarbonate type water. The stream waters are slightly alkaline and are considered soft to moderately hard; median hardness in stream samples was 56 mg/L as calcium carbonate. The alkalinity in stream samples ranged from 46 to 59 mg/L as calcium carbonate; the median value was 51 mg/L. Stream water is intermediate between hard, alkaline ground water and soft, acidic precipitation and surface runoff. Low but detectable concentrations of chromium, copper, iron, magnesium, mercury, and zinc were detected in most bottom-material samples.

Water quality of three lakes on the Reservation is variable and depends on the degree of connection with the ground-water system. In general, Bug Lake and Devils Lake are in poor hydraulic connection with the ground-water system, and their waters contain low concentrations of dissolved solids and alkalinity and low pH. King Lake is in good hydraulic connection with the ground-water system, and its waters contain higher concentrations of dissolved solids and alkalinity and higher pH than Bug and Devils Lakes.

INTRODUCTION

The Forest County Potawatomi Community of Wisconsin is concerned about the potential effects of proposed large-scale mining near the Potawatomi Indian Reservation. To address these concerns, the U.S. Geological Survey (USGS), in cooperation with the Community, conducted a hydrologic study of the Reservation. The objectives of the study were to characterize the ground-water hydrology and surface- and ground-water quality within the Potawatomi Indian Reservation.

Purpose and Scope

This report summarizes selected ground-water and surface-water data collected during the study. The report is not intended to be a comprehensive description of water resources of the Reservation, but rather it presents baseline water data for use by tribal planners and others in future site-specific investigations and studies concerned with long-term water-quality trends in the Reservation area.

Some data have been analyzed and interpreted; other data are presented in tabular form with minimal discussion. Data from test holes, seismic-refraction survey lines, and sampled and measured wells were used to compile water-table, saturated thickness, and bedrock-altitude maps. In situ displacement-recovery tests of nine observation wells were analyzed to estimate the hydraulic properties of the sand and gravel aquifer. Water samples from 22 wells, 4 streams, and 3 lakes were analyzed to describe chemical characteristics of water throughout the Reservation. The results of these analyses were interpreted and are also presented in tabular form.

Physical Setting

The Potawatomi Indian Reservation consists of noncontiguous parcels of land in southern Forest County, Wis. The total area of the Reservation, which includes tribally owned and allotted land, is 11,667 acres (Wisconsin Legislative Reference Bureau, 1986). Because the Reservation consists of noncontiguous parcels of land, a study area larger than the Reservation was adopted for this investigation. The study area and the location of Reservation lands within the study area are shown on plate 1.

The study area lies within the Northern Highland geographical province (Martin, 1965). The Northern Highland Province includes roughly the northern one-third of Wisconsin. Maximum elevation is 1,700 ft above sea level. Local topographic relief in the study area is about 200 ft. Approximately 80 to 85 percent of the Reservation area is forested with second-growth hardwoods. The remainder consist of wetlands and agricultural fields.

The geology of the study area consists of Precambrian crystalline bedrock and overlying glacial sediment. The Precambrian bedrock is part of the Canadian Shield and consists of a wide variety of igneous and metamorphic rocks (Greenberg and Brown, 1984). The bedrock surface gently slopes to the southeast over much of the study area (pl. 2); however, because of significant bedrock relief (as much as 360 ft) bedrock crops out in the southern and southeastern parts of the study area.

Glacial sediment is a result of deposition associated with the Langlade lobe of the Laurentide Ice Sheet. Glacial ice flowed from the northeast to the southwest as indicated by the long axis of drumlins (low rounded hills), which consist primarily of sand and gravel mantled by till. Two drumlins, one north of Lake Lucerne trending to the south and one in the south-central part of the study area trending to the southwest, are especially large (Simpkins and others, 1987). Landforms consisting of sand and gravel are associated with drumlins. Ice-contact features, such as kame terraces, generally abut drumlins and are always intermediate in altitude between the drumlins and outwash in valleys. Ice-contact features and outwash are comprised of high permeable sand and gravel, which form the local sand and gravel aquifer. Permeability of till is typically low (Freeze and Cherry, 1979, p. 29). Thickness of the glacial sediment varies from zero in bedrock-outcrop areas to approximately 340 ft west of Lake Lucerne.

Site-Identification Systems

Each stream station, lake site, and ground-water site mentioned in this report is assigned a unique identification number. The systems used by the USGS to assign identification numbers for stream sites and for lake and ground-water well sites differ, but both systems are based on geographic location.

An eight-digit "downstream-order number" is used for sites on streams. The first two digits denote the main drainage basin ("04" is assigned to the Lake Michigan Basin); the last six digits, which increase in downstream order, are unique to a specific site.

Lake and ground-water sites are identified by a unique 15-digit number that is a concatenation of the site's latitude and longitude and a two-digit sequence number. The sequence number is used to distinguish between sites with the same latitude-longitude designation. Each ground-water site is also identified by a local number based on the cadastral-survey system of the U.S. Government. The number consists of an abbreviation of the county name; the township, range and section; and a four-digit number assigned to the well. For example, site FR-34/15E/28-0579 is in Forest County (FR), township 34 north, range 15 east, section 28; its sequence number is 579. On plate 1, only the sequence number is used to identify ground-water sites.

Acknowledgments

The authors thank J.R. Holms, Mining Impact Coordinator of the Potawatomi Indian Reservation, for his help and information; Charles A. McCuddy, U.S. Bureau of Indian Affairs, for his help in activity coordination; and members of the Forest County Potawatomi Community for their interest and cooperation.

HYDROLOGY

The results and interpretation of data collected to describe ground- and surface-water hydrology are discussed below. Results of all analyses and measurements are listed in appendixes A and B.

Ground Water

Ground water is the source of all domestic water used in the southern Forest County area. Because the Precambrian bedrock yields only small quantities of ground water, most of the ground water is withdrawn from the sand and gravel aquifer in the study area. The aquifer lacks laterally extensive layers of poorly permeable material. As a result, the aquifer is unconfined, or under water-table conditions, throughout the study area.

The ground-water hydrology of the Reservation was investigated by means of several approaches. Water levels were measured, geologic data on 58 wells were analyzed (appendix A), and 9 seismic-refraction surveys (pl. 1) were used to define the water table and the saturated thickness of the sand and gravel aquifer. In addition, in situ displacement-recovery testing was done to estimate the horizontal hydraulic conductivity of the sand and gravel aquifer.

Water-Table Configuration and Saturated Thickness

The configuration of the water table in the study area is shown on plate 3. Generally, the configuration of the water table is similar to surface topography but somewhat subdued. The water table most closely resembles surface topography in areas of low permeability (areas mantled by till) because infiltrating recharge cannot dissipate as quickly as in areas of high permeability (areas mantled by sand and gravel). Within the areas of low permeability, closely spaced contours indicate a steep horizontal gradient in the water-table system (pl. 3). In contrast, widely spaced contours in areas of higher permeability indicate a slight horizontal gradient within the water-table system.

The water table is at or near the surface in the vicinity of some lakes and wetlands. In other parts of the study area, depth to the water table can be as great as 165 ft. Generally, ground water flows from topographic high areas to topographic low areas, where it discharges to streams, lakes, and wetlands. Generalized horizontal ground-water flow in the study area is shown on plate 3.

Areal differences in saturated thickness of the glacial sediment is shown on plate 4. Saturated thickness was calculated by subtracting bedrock-surface altitudes from associated water-table altitudes. Although saturated thickness ranges from zero (at bedrock outcrops) to approximately 200 ft in the study area, a 60- to 160-ft range predominates in and around the Reservation. Generally, areas of greatest saturated thickness of permeable materials are the best suited for water supply.

Aquifer Properties and Ground-Water Flow

Aquifers transmit water from recharge areas to discharge areas. The factors that affect the quantity of ground water transmitted are expressed in Darcy's Law:

$$Q = K \times A \times dh/dl \quad (1)$$

where

Q is the quantity of ground water per unit time,

K is the hydraulic conductivity of the aquifer,
A is the cross-sectional area (perpendicular to flow), and
dh/dl is the hydraulic gradient.

Hydraulic conductivity indicates the ability of an aquifer to transmit water. In this report, hydraulic conductivity is expressed in terms of feet per day (ft/d)[1]. A displacement-recovery test, or "slug" test, was used during this study to calculate horizontal hydraulic conductivity. In this test, a known quantity of water (or "slug") in a well is displaced, and subsequent recovery of the water level as a function of time is monitored (Bouwer and Rice, 1976). The local horizontal hydraulic conductivity in the immediate vicinity of the well can be calculated from the rate of recovery.

The horizontal hydraulic conductivities estimated during this study range from 0.4 to 48 ft/d; the geometric mean is 4.6 ft/d (appendix B). This variation is likely a result of the inhomogeneity of the sand and gravel aquifer at the local scale of the displacement-recovery tests. These hydraulic conductivities, however, are within the ranges for silty sand, till, and clean fine sand given by Freeze and Cherry (1979, p. 29).

The crystalline Precambrian bedrock is not a significant source of ground water in the study area. The hydraulic conductivity of the bedrock is largely dependent on the presence or absence of fractures within the bedrock. Although the amount of fracturing of the bedrock in the site area is not known, data collected by Dames and Moore (written commun., 1979) indicate that fracturing is not extensive and that hydraulic conductivities in bedrock are much lower than those in the sand and gravel aquifer. Estimated hydraulic conductivity of the bedrock ranges from 0.0003 to 0.03 ft/d.

Horizontal hydraulic gradients define the slope of the water table. Specifically, the slope is the change in water level divided by the horizontal distance. The water-table map (pl. 3) indicates that horizontal hydraulic gradients of a till unit and the sand and gravel aquifer are typically 0.019 ft/ft and 0.0075 ft/ft, respectively.

The rate of contaminant movement in aquifers is commonly approximated by calculating ground-water velocity, even though estimates of ground-water velocity do not account for contaminant-transport processes such as contaminant adsorption, decay, or dispersion (Freeze and Cherry, 1979, p. 75). Ground-water velocities are estimated by use of the following modified form of Darcy's Law:

$$v = K/n \times dh/dl \qquad (2)$$

where
v is the ground-water velocity,
K is the hydraulic conductivity of the aquifer,
n is the porosity of the aquifer, and
dh/dl is the hydraulic gradient.

The porosity of an aquifer is defined as the volume of void space in the aquifer divided by the total volume of the aquifer. Porosities commonly range from 40 to 70 percent, 25 to 50 percent, and 25 to 40 percent in clay, sand, and gravel, respectively (Freeze and Cherry, 1979, p. 37). If ground water is to move freely through an aquifer, however, the aquifer must be somewhat permeable. For example, porosities of clay deposits are high, but permeabilities are low. Thus, the water within clay deposits is not economically obtainable.

Two estimates of ground-water velocity were calculated for the sand and gravel aquifer by use of equation 2. Given a horizontal hydraulic conductivity of 48 ft/d (the highest estimated value from the slug tests), an average porosity of 25 percent, and an average horizontal hydraulic gradient of 0.0075 ft/ft, ground-water velocity is about 1.4 ft/d. Given a horizontal hydraulic conductivity of 0.4 ft/d (the lowest estimated value from slug tests), an average porosity of 35 percent and an average horizontal hydraulic gradient of 0.019 ft/ft, ground-water velocity is about 0.02 ft/d. It should be noted that stresses imposed on the ground-water system, such as pumping, can affect one or more of the variables used in these calculations, and ground-water velocities could differ from those reported here.

Surface Water

Forest County is part of the Lake Michigan drainage basin. Intermediate river basins encompassing the study area include the Fox-Wolf and the Menominee-Oconto-Peshtigo river basins. With-

[1]Feet per day is a mathematical reduction of cubic feet per day per square foot [$(ft^3/d)/ft^2$].

in these basins, the Wolf, the North Branch Oconto, and the Peshtigo are the three primary river systems that drain the Reservation (pl. 1).

Important sources of streamflow include precipitation that falls directly into streams, precipitation or snowmelt that flows overland into streams as direct runoff, and base flow. Base flow, which is derived largely from the discharge of ground water from aquifer systems to surface-water systems, is a major component of streamflow in the study area. Ground-water discharge can account for all streamflow during drought periods when there is no precipitation or during the winter when precipitation falls in the form of snow and surface-soil layers are frozen, limiting recharge to the underlying aquifer.

Base flow is commonly expressed by the value $Q_{7,2}$ or $Q_{7,10}$. For example, $Q_{7,2}$ is the base-flow discharge in cubic feet per second (ft^3/s) that will occur on the average once every 2 years for a 7-day period.

Base flow for streams that do not have gaging stations can be estimated using equations and methods developed by Holmstrom (1980).

Base-flow discharges for four sites on streams near stream-water quality sites are as follows:

Station number	Station name	Drainage area (mi^2)	$Q_{7,2}$ (ft^3/s)	$Q_{7,10}$ (ft^3/s)
04067900	Rat River near Wabeno	82.1	32	20
04067950	Otter Creek near Lakewood	32.1	18	13
04069690	North Branch Oconto at Wabeno	31.3	7.5	4.5
04069800	North Branch Oconto near Carter	58.2	17	12

The locations of these stations are shown on plate 1 except for Otter Creek near Lakewood, which is just east of the map border.

Lakes can be divided into three hydrologic types: (1) Lakes with at least one inlet and one outlet, (2) lakes with only an outlet, and (3) lakes without any inlet or outlet (Novitzki and Devaul, 1978). Lakes investigated in the study area were Bug Lake, Devils Lake, and King Lake. Bug Lake is classified as a lake without an inlet but with an intermittent outlet; Devils Lake and King Lake are classified as lakes without any inlet or outlet.

Lakes differ in degree of hydraulic connection to the surrounding ground-water system. It is difficult to assess the degree of such interaction through investigation of the physical system alone. Commonly, the degree of interconnection can be estimated only by examination of ground-water and lake-water chemistries. Results of analyses of samples from all three lakes and the ground-water system and a discussion of lake/ground-water interaction are presented in the next section.

WATER QUALITY

The results of analyses of water samples collected from ground-water and surface-water systems in the study area are discussed below. All water samples were collected in accordance with USGS standard practice (U.S. Department of the Interior, 1977) and were analyzed at the USGS National Water-Quality Laboratory in Denver, Colo. Specific conductance, temperature, and pH were measured in the field at the time of sample collection. Results of all analyses and measurements are listed in appendixes C-H.

Ground Water

Ground-water samples were collected from 17 domestic wells and from 5 observation wells installed by the USGS. Concentrations of major cations and anions in water from these 22 wells were determined to characterize the ground-water chemistry in the study area. In addition, nitrogen and trace-metal analyses were done on selected samples to identify possible areas of ground-water contamination.

Analytical results for ground-water samples from the sand and gravel aquifer are summarized in table 1. A modified Stiff diagram showing average major-ion concentrations (fig. 1) indicates that the predominant ground-water type is calcium magnesium bicarbonate. This water type, which is a result of dissolution of carbonate minerals, is the most prevalent water type in Wisconsin's ground water (Kammerer, 1984, p. 12, 20, 28, and 36).

pH, Alkalinity, and Hardness

The pH of ground-water samples collected in the study area ranged from 7.3 to 9.3, and the median pH was 8.1. Values of pH in this range are considered moderately basic.

Alkalinity of samples from the study area ranged from 79 to 318 mg/L as calcium carbonate, and the median was 123 mg/L as calcium carbonate. Kammerer (1981, p. 14) reported that typical alkalinities in Forest County ranged from 12 to 155 mg/L as calcium carbonate. The higher alkalinities measured during this study are thought to be a result of different aquifer mineralogy. Most of the 93 samples studied by Kammerer (1981, p. 14) were from the Mole Lake area; however, it is likely that the sand and gravel aquifer in the study area contains more carbonate material (limestone and dolomite) than it does in the Mole Lake area. Therefore, more carbonate is available for dissolution, and alkalinity concentrations are correspondingly higher.

The water-hardness classification of Durfor and Becker (1964) is used in this report:

Hardness range (mg/L as $CaCO_3$)	Hardness description
0 - 60	Soft
61 - 120	Moderately hard
121 - 180	Hard
Greater than 180	Very hard

The hardness of water samples from wells on the Reservation ranged from 79 to 490 mg/L as calcium carbonate, and the median hardness was 135 mg/L as calcium carbonate. Thus, ground water on the Reservation is considered moderately hard to very hard.

Table 1. *Summary of physical and chemical characteristics of water from wells on the Potawatomi Indian Reservation, 1982-83*

[Units are milligrams per liter unless otherwise indicated. µS/cm, microsiemens per centimeter at 25 degrees Celsius; < , less than]

Characteristic	Number of wells	Minimum	Maximum	Median
Specific conductance (µS/cm)	22	155	660	250
pH (units)	22	7.3	9.3	8.1
Hardness, as $CaCO_3$	21	79	490	135
Calcium, dissolved	21	20	110	30
Magnesium, dissolved	21	5.3	53	14
Sodium, dissolved	21	1.2	26	2.8
Potassium, dissolved	21	.4	3.7	.9
Alkalinity, as $CaCO_3$	21	79	318	123
Sulfate, dissolved	21	2.0	18	9.0
Chloride, dissolved	21	.6	78	2.6
Fluoride, dissolved	9	<.10	.80	.10
Silica, dissolved	20	2.4	17	14
Dissolved solids, residue at 180 degrees Celsius	21	107	595	149
Nitrate plus nitrite, as N, dissolved	17	<.10	15	.29

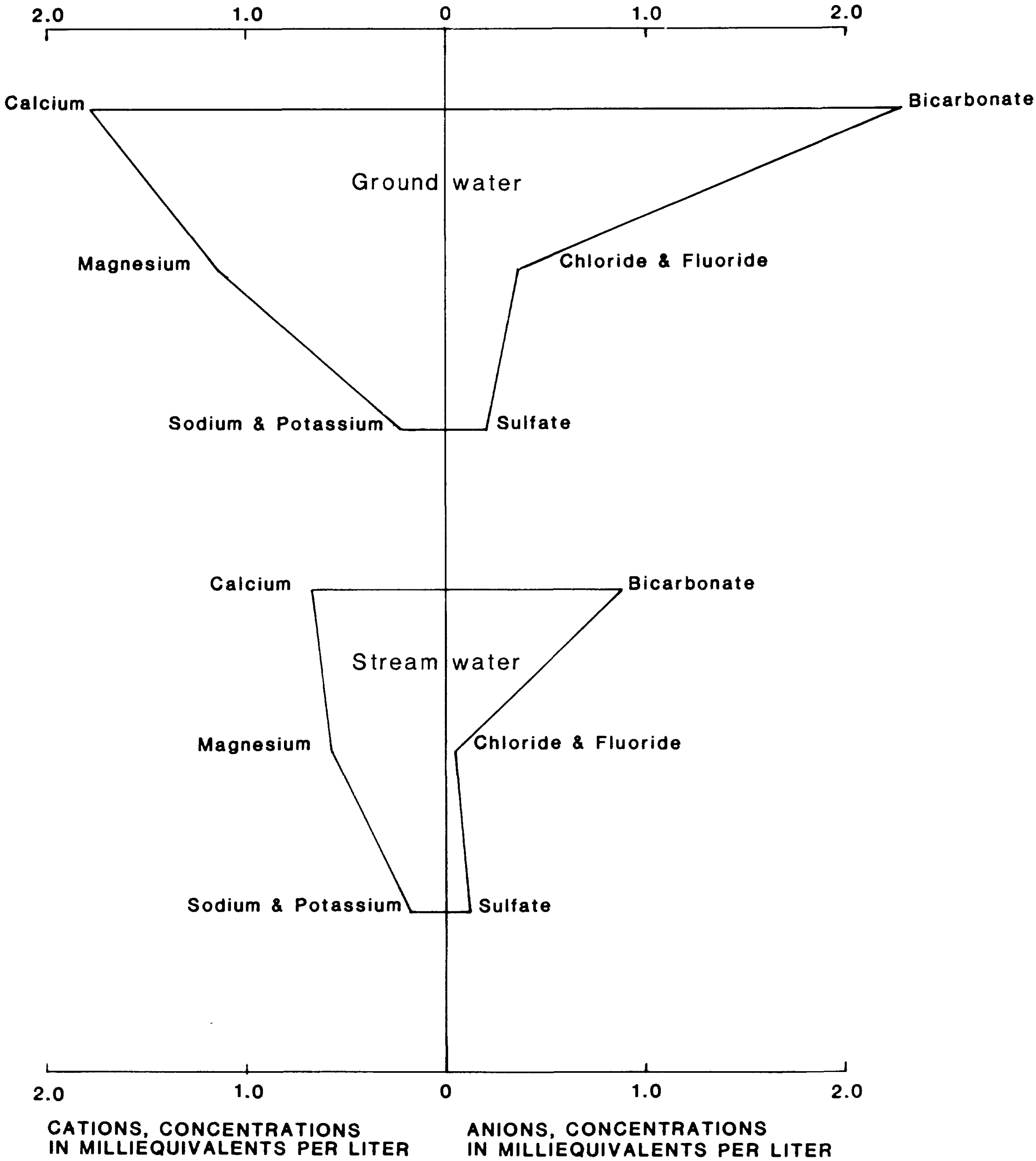

Figure 1. *Modified stiff diagram showing major-ion concentrations of ground water and stream water of the Potawatomi Reservation.*

Concentrations of Selected Constituents

Results of fluoride, nitrate-plus-nitrite, and metals analyses are summarized in tables 1 and 2. For comparison, the U.S. Environmental Protection Agency (USEPA) maximum contaminant levels (MCL's) and secondary maximum contaminant levels (SMCL's) for selected constituents and properties are shown in table 3. The USEPA levels are used to assess the suitability of ground water for use as drinking water.

With the exception of one well about one-half mile northeast of Lake Lucerne, no wells sampled in this study yielded water in which ion concentrations exceeded the MCL's listed in table 3. The sample from the well near Lake Lucerne contained 15 mg/L of nitrate as nitrogen--a concentration 50 percent higher than the MCL of 10 mg/L as N. Because elevated nitrate concentrations in ground water may indicate contamination from septic drainfields or animal wastes, the well was resampled for fecal coliform bacteria (an indicator of fecal contamination). No fecal coliform bacteria were found in the sample.

Iron concentrations in water from two wells exceeded the USEPA's SMCL. One of these well waters also contained manganese concentration that equaled the SMCL. Although iron and manganese do not pose health risks, high concentrations of these constituents can result in objectional taste and staining of fixtures and laundry.

Radiochemical Activity

Radiochemical analyses were also done on samples collected from the study area. Concentrations of radionuclides can be expressed either in terms of activities of specific radionuclides (radon or radium) or as a gross activity of specific radioactive particles (commonly alpha or beta particles).

Total gross alpha particle activity ranged from <3.1 to <9.2 pCi/L as uranium in samples collected from 14 wells during this study. Presently, the USEPA has established an MCL of 15 pCi/L for gross alpha-particle activity in drinking water (U.S. Environmental Protection Agency, 1990). Radon activity ranged from 89 to 2,510 pCi/L, and the median radon activity in water from seven wells sampled during this study was 391 pCi/L (appendix E). An MCL for the activity of radon in water has not been promulgated at this time.

Surface Water

Surface-water samples were collected from four streams (at five sites) and from three lakes on the Reservation. Results of major cation and anion analyses were used to characterize the surface-water chemistry. In addition, bottom materials collected from four streams were analyzed for trace elements, and water samples collected from the three lakes were analyzed for metal ions. Results of all analyses are listed in appendixes F-H. Results of the stream-water analyses are summarized in figure 1 and in tables 4 and 5.

Streams

The shape of the surface-water Stiff diagram in figure 1 is similar to that of the ground-water Stiff diagram. The similarity indicates that surface water also is of the calcium magnesium bicarbonate type. The concentrations of the major constituents in the surface water, however, are less than the corresponding concentrations in the ground water. This is likely due to dilution of the ground-water runoff component of streamflow by precipitation and surface runoff.

pH, Alkalinity and Hardness

The pH of the streams sampled ranged from 7.2 to 8.0, and the median pH was 7.4. The pH values of streams measured during this study are within the range of values reported by Hem (1985, p. 64) for surface waters not affected by contamination. It should be noted that these values are lower than those for ground water sampled in this study. This difference may be a result of microbiological factors or a result of the mixing of acidic precipitation and ground water.

Alkalinity measured in the stream samples from the study area ranged from 46 to 59 mg/L as calcium carbonate, and the median was 51 mg/L as calcium carbonate. As with pH, alkalinity of stream water was lower than that for ground water because the mixing of precipitation and ground water.

The mixing of ground water with dilute precipitation will also reduce the calcium and magnesium concentration, thus reducing hardness. Hardness in stream samples collected during this study ranged from 50 to 63 mg/L as calcium carbonate, and the median was 56 mg/L as calcium carbonate.

Table 2. *Summary of trace-constituent analyses of water from wells on the Potawatomi Indian Reservation, 1982-83*

[All sample analyses are for dissolved constituents; units are micrograms per liter; <, less than]

Constituent	Number of wells	Concentration of constituent		
		Minimum	Maximum	Median
Arsenic	5	1	4	3
Barium	4	15	46	29
Cadmium	4	<1	4	2
Chromium	4	10	20	10
Copper	4	<10	30	<10
Iron	4	<3	6,500	305
Lead	4	<10	10	<10
Manganese	4	11	380	120
Mercury	5	<.1	<.1	<.1
Selenium	4	<1	<1	<1
Silver	5	<1.0	<1.0	<1.0
Zinc	5	35	230	100

Table 3. *Summary of selected U.S. Environmental Protection Agency drinking-water regulations*

[From U.S. Environmental Protection Agency, 1990. All units are milligrams per liter unless otherwise specified. Dashes (--) indicate not applicable.]

Constituent or property	Maximum contaminant level	Secondary maximum contaminant level
Arsenic	0.050	--
Barium	1.0	--
Cadmium	.010	--
Chromium	.050	--
Lead	.050	--
Mercury	.002	--
Selenium	.010	--
Silver	.050	--
Fluoride	4.0	--
Nitrate (as nitrogen)	10	--
Radionuclides, gross alpha particle activity (picocuries per liter)	15	--
Chloride	--	250
Copper	--	1
Iron	--	.3
Manganese	--	.05
pH (units)	--	6.5-8.5
Sulfate	--	250
Total dissolved solids	--	500
Zinc	--	5

Table 4. *Summary of physical and chemical characteristics of water from streams on the Potawatomi Indian Reservation, 1982-83*

[Units are milligrams per liter unless otherwise indicated; values are based on five samples at base flow; μS/cm, microsiemens per centimeter at 25 degrees Celsius; <, less than]

Characteristic	Minimum	Maximum	Median
Specific conductance (μS/cm)	95	115	110
pH (units)	7.2	7.6	7.4
Hardness, total as $CaCO_3$	50	63	56
Calcium, dissolved	12	15	13
Magnesium, dissolved	4.9	6.3	5.6
Sodium, dissolved	1.1	1.8	1.3
Potassium, dissolved	.5	1.0	.8
Alkalinity, as $CaCO_3$	46	59	51
Sulfate, dissolved	6.0	11	10
Chloride, dissolved	1.0	2.0	1.1
Fluoride, dissolved	<.10	.10	<.10
Silica, dissolved	4.1	6.1	4.9
Dissolved solids, residue at 180 degrees Celsius	77	108	94

Table 5. *Summary of trace-element analyses of bottom material from streams on the Potawatomi Indian Reservation, 1982-83*

[Units are micrograms per gram; <, less than]

Constituent	Minimum	Maximum	Median
Arsenic	<1	<1	<1
Cadmium	<1	<1	<1
Chromium	3	6	4
Copper	2	5	4
Iron	690	4,700	1,100
Lead	<10	<10	<10
Manganese	29	630	96
Mercury	<.01	.01	.01
Nickel	<10	<10	<10
Zinc	6	30	8

The median hardness is less than half of that for ground water, and it would be described as soft to moderately hard on the basis of the classification of Durfor and Becker (1964).

Concentrations of Selected Constituents

Concentrations of selected trace elements in bottom materials were determined for four streams at five sites. Results of the bottom-material analyses are summarized in table 4. Chromium, copper, iron, manganese, mercury, and zinc were detected in the samples. Although there are no regulations regarding the maximum allowable metal concentration in sediments, it is thought that these bottom-material concentrations correspond to much lower dissolved and (or) suspended concentrations in stream water that do not pose a threat to the aquatic plant and animal communities in the study area.

Lakes

Water samples from three lakes on the Reservation were analyzed for major cations and anions to help delineate the degree of surface-water/ground-water interaction. These data are also important in characterizing the lake-water type and providing a baseline for monitoring any future changes to lake-water chemistry. Lake-water samples were also analyzed for metals (appendix H).

On the basis of the analytical data, Bug Lake and Devils Lake are thought to be in poor hydraulic connection with the surrounding ground-water system. This poor connection is evidenced by low pH and low concentrations of alkalinity and dissolved solids. These lakes apparently receive most of their water from direct precipitation and surface runoff. In addition, Devils Lake is bordered by a bog area typical of hydrologic settings where ground water is not a significant source of water (Mitsch and Gosselink, 1986, p. 301).

King Lake is thought to be in good hydraulic connection with the surrounding ground-water system, as evidenced by its much higher pH and concentration of alkalinity and much higher concentration of dissolved solids.

Results of analyses indicate nondetectable or otherwise low concentrations of metals in water from all three lakes.

SUMMARY

The study area in southern Forest County, Wis., includes the dispersed parcels of land that comprise the Potawatomi Indian Reservation. The area consists of unconsolidated glacial material overlying largely impermeable Precambrian crystalline bedrock. The unconsolidated sediments are as much as 340 ft thick, but they are absent in areas where bedrock crops out at the surface.

Most water used for domestic purposes in the study area is ground water. Because the Precambrian bedrock is not a significant source of ground water, glacial sand and gravel forms the primary aquifer on the Reservation. The aquifer is unconfined, and its saturated thickness ranges from approximately 200 ft (in areas where the glacial deposits are relatively thick) to zero feet (in areas where the bedrock crops out). A range of 60 to 160 ft of saturated thickness is common in and around the Reservation. Horizontal hydraulic conductivity of the sand and gravel deposits was analyzed by means of in situ displacement-recovery (slug) tests. The estimated horizontal hydraulic conductivity ranges from 0.4 to 48 ft/d; the geometric mean is 4.6 ft/d. Because ground-water withdrawals from till in the study area are not economically feasible, the hydraulic conductivity of the till was not investigated.

The horizontal hydraulic gradient, or slope, of the water table ranges from 0.0075 ft/ft in the sand and gravel areas of the study site to 0.019 ft/ft in the till areas. Estimates of ground-water velocities within the glacial deposits are about 1.4 ft/d in the sand and gravel deposits and about 0.02 ft/d in the tills.

Reservation lands lie within three surface-water basins: the Wolf, the North Branch Oconto, and the Peshtigo. Estimates of base-flow discharge that will occur on the average once every 2 years for a 7-day period for Reservation streams range from 7.5 ft^3/s for the North Branch Oconto at Wabeno to 32 ft^3/s for the Rat River near Wabeno.

The ground water in the study area is a calcium magnesium bicarbonate type. This ion assemblage is the most common water type in Wisconsin. The ground water sampled during the study was moderately hard to very hard and slightly alkaline; median hardness was 135 milligrams per liter as calcium carbonate. Alkalinity ranged from 79 to 318 mg/L; median alkalinity was 123 mg/L as calcium carbonate.

Concentrations of selected constituents in ground water, with the exception of nitrate at one well sampled, were less than USEPA MCL's for drinking water. At that one well, the nitrate plus nitrite concentration of 15 mg/L as N exceeded the MCL of 10 mg/L as N. Gross alpha-particle activity, a byproduct of radioactive decay, ranged from <3.1 to <9.2 pCi/L--values less than the USEPA MCL of 15 pCi/L. Radon concentrations ranged from 89 to 2,510 pCi/L. The SMCL for iron was exceeded in two wells; in water from one well, the SMCL for manganese was equaled.

Water in streams on the Reservation is also of the calcium magnesium bicarbonate type; this similarity in water type indicates considerable surface-water/ground-water interaction in the study area. Sampled streams contain soft to moderately hard, slightly alkaline water. Median hardness in samples collected during the study was 56 mg/L as calcium carbonate. Alkalinity in the streams ranged from 46 mg/L to 59 mg/L, and median alkalinity was 51 mg/L as calcium carbonate.

Trace-element concentrations in bottom materials of five stream sites were mostly below detection. Some detectable concentrations of chromium, copper, iron, magnesium, mercury, and zinc were found.

Dissolved-solids concentrations in the three lakes studied on the Reservation are variable and depend on the degree of connection with the ground-water system. In general, Bug Lake and Devils Lake are in poor hydraulic connection to the ground-water system; water from these lakes has low concentrations of dissolved solids and alkalinity, and low pH. King Lake, however, is in good hydraulic connection with the ground-water system; water from King Lake contains higher concentrations of dissolved solids and alkalinity, and a higher pH.

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APPENDIXES

Appendix A. *Water-level and well-construction data for domestic and observation wells in the sand and gravel aquifer*

[Data on depth of well and screen length are from well-construction reports. Wells are domestic unless otherwise indicated. --, no data available]

Local well number	Water-level measurement date	Land-surface altitude (feet above sea level)	Water-level altitude (feet above sea level)	Depth of well (feet)	Screen length (feet)
FR-34/15E/28-0579	--	1,570	--	96	10
FR-34/15E/28-0580	--	1,510	--	95	14
FR-36/13E/35-0582	--	1,875	--	331	3
FR-36/13E/35-0586	06-08-82	1,800	1,642	243	6
FR-36/13E/36-0592	--	1,770	--	151	--
FR-36/13E/29-0585	--	1,870	--	253	3
[1] FR-36/13E/14-0567	11-03-81	1,650	1,608	63	5
FR-36/13E/26-0575	06-08-82	1,715	1,615	118	--
[1] FR-36/13E/26-0568	11-03-81	1,680	1,638	58	10
FR-36/13E/34-0584	--	1,830	--	216	3
FR-36/13E/35-0581	--	1,755	1,594	165	4
FR-36/13E/36-0574	--	1,780	--	228	6
FR-36/13E/35-0463	--	1,870	--	--	--
FR-35/13E/03-0412	06-22-76	1,650	1,643	30	--
FR-35/13E/03-0413	08-07-73	1,665	1,648	43	2
FR-35/13E/02-0569	--	1,710	--	38	--
FR-35/13E/10-0406	08-31-65	1,665	1,632	75	3
FR-35/13E/10-0419	06-06-72	1,690	1,635	70	--
FR-35/13E/10-0424	05-29-69	1,665	1,631	64	3
FR-35/13E/14-0403	10-09-74	1,655	1,638	30	--
FR-35/14E/17-0439	07-25-69	1,675	1,610	115	11
FR-35/14E/03-0434	07-20-76	1,620	1,570	59	2
FR-35/14E/02-0066	06-21-67	1,620	1,609	113	--
FR-35/14E/03-0440	09-09-71	1,610	1,597	77	--
FR-35/15E/06-0095	12-02-67	1,580	1,557	63	--
FR-35/15E/05-0429	09-04-70	1,570	1,544	72	--
FR-35/14E/12-0436	10-09-75	1,570	1,547	55	--
FR-35/15E/07-0430	05-10-73	1,600	1,548	82	--
FR-35/14E/14-0435	08-27-55	1,630	1,605	60	4
FR-35/15E/18-0431	10-09-72	1,580	1,545	114	--
FR-35/15E/17-0075	01-01-65	1,610	1,553	100	5
FR-35/14E/25-0065	12-11-67	1,620	1,579	141	3
[1] FR-35/15E/32-0596	11-04-81	1,570	1,564	21	3
FR-34/15E/05-0063	11-11-67	1,670	1,535	241	--
FR-34/15E/18-0459	--	1,600	--	--	--

Appendix A. *Water-level and well-construction data for domestic and observation wells in the sand and gravel aquifer*--Continued

Local well number	Water-level measurement date	Land-surface altitude (feet above sea level)	Water-level altitude (feet above sea level)	Depth of well (feet)	Screen length (feet)
FR-34/15E/08-0372	12-03-64	1,550	1,500	114	--
FR-34/15E/16-0578	--	1,555	--	43	8
FR-34/15E/28-0589	--	1,560	1,500	74	--
FR-34/15E/28-0588	--	1,560	1,492	110	--
FR-34/15E/33-0074	08-15-66	1,580	1,490	220	--
FR-34/15E/28-0375	03-20-72	1,470	1,450	46	4
FR-35/15E/09-0011	06-16-65	1,540	1,462	124	11
FR-35/15E/15-0067	06-26-67	1,480	1,460	56	--
FR-35/15E/22-0577	06-09-82	1,595	1,502	146	3
FR-35/15E/28-0576	--	1,545	--	129	3
[1]FR-35/15E/23-0565	11-03-81	1,480	1,471	27	5
[1]FR-35/15E/36-0566	11-03-81	1,430	1,421	22	--
FR-34/15E/10-0587	--	1,510	--	61	2
[1]FR-34/15E/10-0652	05-27-82	1,490	1,480	11	3
FR-34/15E/10-0373	10-25-74	1,480	1,440	120	3
FR-34/15E/12-0061	06-22-67	1,450	1,395	116	4
FR-35/13E/34-0227	--	1,630	--	36	--
FR-35/16E/18-0069	09-28-66	1,400	1,395	45	5
FR-35/16E/18-0068	09-26-66	1,400	1,386	54	5
[1]FR-35/16E/24-0570	11-04-81	1,310	1,294	20	3
[1]FR-35/16E/34-0571	11-04-81	1,360	1,354	22	3
[1]FR-34/16E/16-0572	11-04-81	1,320	1,313	23	3
[1]FR-34/16E/24-0573	11-04-81	1,340	1,281	82	3

[1] U.S. Geological Survey observation well constructed for this study.

Appendix B. *Horizontal hydraulic conductivity, well-construction data, and brief description of geologic materials at observation wells*

[ft, feet]

Local well number	Horizontal hydraulic conductivity (feet per day)	Depth of observation well (feet)	Screen length (feet)	Lithology from test boring		
FR-35/15E/23-0565	0.4	27	3.0	0-3	ft	silt and clay
				3-8	ft	silt and clay with coarse gravel
				8-18	ft	sand and gravel
				18-23	ft	fine sand with gravel
				23-28	ft	clay and sand
FR-35/15E/36-0566	48	22	3.0	0-18	ft	fine sand with very coarse gravel
				13-18	ft	coarse sand with some gravel
				18-23	ft	coarse sand
FR-36/13E/14-0567	1.6	63	1.3	0-3	ft	clay
				3-13	ft	clay and silt
				13-30	ft	sand
				30-43	ft	sand and clay
				43-58	ft	clay
				58-63	ft	sand and clay
FR-36/13E/26-0568	1.5	58	3.0	0-13	ft	silt and clay
				13-18	ft	sand and gravel
				18-53	ft	sand
				53-58	ft	silt and sand
FR-35/16E/24-0570	1.3	20	3.0	0-3	ft	silt and sand
				3-23	ft	fine sand with gravel
FR-35/16E/34-0571	9.2	22	3.0	0-4	ft	silt and sand
				4-24	ft	silt and coarse sand
FR-34/16E/16-0572	24	23	3.0	0-13	ft	sand and gravel
				13-18	ft	silt and coarse sand
				18-23	ft	coarse sand
FR-34/16E/24-0573	8.0	82	1.3	0-43	ft	sand and gravel
				43-48	ft	medium sand
				48-83	ft	fine sand
FR-35/15E/32-0596	8.6	21	3.0	0-23	ft	clay with lenses of sand and gravel

Appendix C. *Physical and chemical characteristics of water from wells on the Potawatomi Indian Reservation*

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; °C, degrees Celsius; --, no data available; <, less than. The five digit number ending each column heading is the parameter code used in the U.S. Geological Survey's Water Data Storage and Retrieval System.]

Local identifier	Site number	Date	Time	Depth of well, total (feet) (72008)	Depth to bottom of sample interval (feet) (72016)	Depth to top of sample interval (feet) (72015)	Elevation of land-surface datum (feet above NGVD) (72000)	Specific conductance (µS/cm) (00095)
FR-36/13E/35-0581	452331088495201	08-09-82	1010	165.00	165	161	1,755	615
FR-34/15E/28-0579	452405088380701	08-10-82	0830	96.00	96	86	1,570	540
FR-34/15E/28-0588	452408088380201	05-17-83	1300	110.00	--	--	1,560	205
FR-36/15E/28-0589	452425088380601	05-17-83	1100	74.00	--	--	1,560	510
FR-34/15E/28-0580	452459088375501	08-10-82	0900	95.00	95	81	1,510	280
[1] FR-34/16E/24-0573	452509088255601	08-31-82	1130	83.00	--	--	1,340	155
[1] FR-34/16E/16-0572	452515088294001	08-31-82	1030	23.00	--	--	1,320	165
FR-34/15E/16-0578	452536088380401	05-17-83	1000	43.00	--	--	1,555	660
FR-34/15E/10-0587	452651088362801	08-10-82	1005	61.00	61	59	1,510	270
[1] FR-35/16E/34-0571	452802088290901	08-31-82	1245	24.00	--	--	1,360	195
FR-35/15E/28-0576	452932088364801	08-09-82	1525	129.00	129	126	1,545	250
[1] FR-35/15E/23-0565	452934088345101	08-31-82	0915	27.00	--	--	1,480	210
FR-35/15E/22-0577	453004088364001	08-09-82	1445	146.00	146	143	1,595	250
FR-36/13E/35-0463	453327088493301	08-09-82	1005	35.00	--	--	1,870	230
FR-36/13E/35-0582	453327088493302	08-08-83	1500	331.00	--	--	1,875	190
FR-36/13E/35-0586	453333088495201	08-09-82	0915	243.00	243	237	1,800	280
FR-36/13E/34-0584	453345088505401	08-09-82	1400	216.00	216	213	1,830	255
FR-36/13E/36-0574	453350088490301	08-09-82	1135	228.00	228	222	1,780	280
FR-36/13E/36-0592	453354088490701	05-17-83	0840	151.00	--	--	1,770	165
FR-36/13E/27-0585	453401088513401	08-09-82	1335	253.00	253	250	1,870	240
[1] FR-36/13E/26-0568	453412088494301	08-30-82	1415	58.00	--	--	1,680	210
FR-36/13E/26-0575	453421088494701	08-09-82	1210	118.00	--	--	1,715	210
		08-08-83	1545	118.00	--	--	1,715	280

Appendix C. *Physical and chemical characteristics of water from wells on the Potawatomi Indian Reservation*--Continued

Local identifier	pH (standard units) (00400)	Temperature, water, (degrees Celsius) (00010)	Hardness, total (mg/L as $CaCO_3$) (00900)	Calcium, dissolved (mg/L as Ca) (00915)	Magnesium, dissolved (mg/L as Mg) (00925)	Sodium, dissolved (mg/L as Na) (00930)	Potassium, dissolved (mg/L as K (00935)
FR-36/13E/35-0581	7.8	9.5	300	66	33	4.5	0.70
FR-34/15E/28-0579	7.9	9.5	250	58	25	6.3	1.4
FR-34/15E/28-0588	8.6	8.0	120	30	10	6.8	1.5
FR-36/15E/28-0589	7.7	9.5	350	80	37	8.6	2.0
FR-34/15E/28-0580	7.8	10.0	130	31	13	3.1	.80
[1] FR-34/16E/24-0573	9.3	10.0	84	20	8.3	1.8	.80
[1] FR-34/16E/16-0572	7.5	10.5	79	23	5.3	1.7	.90
FR-34/15E/16-0578	7.3	11.5	490	110	53	26	3.7
FR-34/15E/10-0587	8.0	8.0	140	31	14	2.5	1.6
[1] FR-35/16E/34-0571	7.3	10.0	98	26	8.0	1.2	1.2
FR-35/15E/28-0576	8.2	10.0	120	27	12	2.9	1.5
[1] FR-35/15E/23-0565	8.1	8.5	120	27	12	2.8	2.0
FR-35/15E/22-0577	8.2	9.0	120	28	12	3.2	1.3
FR-36/13E/35-0463	8.0	10.0	130	28	14	1.9	.50
FR-36/13E/35-0582	8.4	15.0	--	--	--	--	--
FR-36/13E/35-0586	8.1	9.5	150	32	17	1.9	.50
FR-36/13E/34-0584	8.0	9.5	120	28	13	2.4	.60
FR-36/13E/36-0574	8.1	9.5	140	31	15	1.9	.40
FR-36/13E/36-0592	7.9	13.5	130	29	14	3.2	.80
FR-36/13E/27-0585	8.2	9.5	130	29	14	2.3	.60
[1] FR-36/13E/26-0568	7.6	9.0	160	37	17	4.9	2.5
FR-36/13E/26-0575	8.1	9.0	150	33	16	2.1	.50
	8.2	--	--	--	--	--	--

Local identifier	Alkalinity, laboratory (mg/L as $CaCO_3$) (90410)	Sulfate, dissolved (mg/L as SO_4) (00945)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Solids, residue, at 180°C dissolved (mg/L) (70300)	Nitrogen, $NO_3 + NO_2$, dissolved (mg/L as N) (00631)
FR-36/13E/35-0581	221	10	25	--	14	388	15.0
FR-34/15E/28-0579	147	18	59	--	15	346	4.40
FR-34/15E/28-0588	121	2.0	5.0	.80	10	136	--
FR-36/15E/28-0589	242	14	78	.10	15	420	--
FR-34/15E/28-0580	112	6.0	11	--	13	161	.660
[1] FR-34/16E/24-0573	79	7.0	1.6	.10	2.4	107	<.100
[1] FR-34/16E/16-0572	83	8.0	2.1	.10	3.9	114	.430
FR-34/15E/16-0578	318	18	53	.10	17	595	--
FR-34/15E/10-0587	123	14	.60	--	11	156	<.100
[1] FR-35/16E/34-0571	111	5.0	1.8	.10	14	146	<.100
FR-35/15E/28-0576	113	12	.80	--	14	127	<.100
[1] FR-35/15E/23-0565	103	11	.70	.10	16	131	.110
FR-35/15E/22-0577	114	13	1.0	--	13	142	.150
FR-36/13E/35-0463	122	7.0	.70	--	13	127	.270
FR-36/13E/35-0582	--	--	--	--	--	--	--
FR-36/13E/35-0586	142	6.0	1.0	--	13	151	.250
FR-36/13E/34-0584	117	8.0	3.2	--	13	149	.290
FR-36/13E/36-0574	133	6.0	1.3	--	14	149	.800
FR-36/13E/36-0592	125	12	1.8	.10	14	154	--
FR-36/13E/27-0585	122	9.0	2.9	--	12	140	.300
[1] FR-36/13E/26-0568	144	8.0	9.9	<.10	16	202	.370
FR-36/13E/26-0575	131	12	2.6	--	13	170	1.30
	--	--	--	--	--	--	--

[1] U.S. Geological Survey observation well constructed for this study.

Appendix D. *Trace-constituent analyses of water from wells on the Potawatomi Indian Reservation*

[All concentrations are in micrograms per liter; --, no data available; <, less than. The five digit number ending each column heading is the parameter code used in the U.S. Geological Survey's Water Data Storage and Retrieval System.]

Local identifier	Site number	Date	Time	Arsenic, total (µg/L as As) (01002)	Arsenic, dis-solved (µg/L as As) (01000)	Barium, total recov-erable (µg/L as Ba) (01007)	Barium, dis-solved (µg/L as Ba) (01005)	Cadmium, total recov-erable (µg/L as Cd) (01027)	Cadmium, dis-solved (µg/L as Cd) (01025)	Chromium, total recov-erable (µg/L as Cr) (01034)	Chromium, dis-solved (µg/L as Cr) (01030)	Copper, total recov-erable (µg/L as Cu) (01042)	Copper, dis-solved (µg/L as Cu) (01040)
FR-34/15E/28-0588	452408088380201	05-17-83	1300	1	--	<100	--	2	--	10	--	7	--
FR-36/15E/28-0589	452425088380601	05-17-83	1100	1	--	100	--	1	--	20	--	110	--
[1] FR-34/16E/24-0573	452509088255601	08-31-82	1130	--	1	--	18	--	<1.0	--	10	--	<10
[1] FR-34/16E/16-0572	452515088294001	08-31-82	1030	--	1	--	15	--	2.0	--	10	--	30
FR-34/15E/16-0578	452536088380401	05-17-83	1000	1	--	200	--	3	--	10	--	72	--
[1] FR-35/16E/34-0571	452802088290901	08-31-82	1245	--	4	--	46	--	2.0	--	10	--	<10
[1] FR-35/15E/23-0565	452934088345101	08-31-82	0915	--	3	--	29	--	<1.0	--	--	--	--
FR-36/13E/36-0592	453354088490701	05-17-83	0840	1	--	<100	--	1	--	10	--	520	--
[1] FR-36/13E/26-0568	453412088494301	08-30-82	1415	--	2	--	29	--	4.0	--	20	--	<10

Local identifier	Iron, total recov-erable (µg/L as Fe) (01045)	Iron, dis-solved (µg/L as Fe) (01046)	Lead, total recov-erable (µg/L as Pb) (01051)	Lead, dis-solved (µg/L as Pb) (01049)	Manga-nese, total recov-erable (µg/L as Mn) (01055)	Manga-nese, dis-solved (µg/L as Mn) (01056)	Mercury, total recov-erable (µg/L as Hg) (71900)	Mercury, dis-solved (µg/L as Hg) (71890)	Selenium, total (µg/L as Se) (01147)	Sele-nium, dis-solved (µg/L as Se) (01145)	Silver, total recov-erable (µg/L as Ag) (01077)	Silver, dis-solved (µg/L as Ag) (01075)	Zinc, total recov-erable (µg/L as Zn) (01092)	Zinc, dis-solved (µg/L as Zn) (01090)
FR-34/15E/28-0588	800	--	12	--	20	--	<0.10	--	1	--	1	--	240	--
FR-36/15E/28-0589	60	--	9	--	10	--	<.10	--	1	--	<1	--	60	--
[1]FR-34/16E/24-0573	--	<3	--	<10	--	11	--	<.1	--	<1	--	<1.0	--	230
[1]FR-34/16E/16-0572	--	160	--	10	--	45	--	<.1	--	<1	--	<1.0	--	100
FR-34/15E/16-0578	40	--	10	--	50	--	<.10	--	1	--	<1	--	140	--
[1]FR-35/16E/34-0571	--	6,500	--	10	--	380	--	<.1	--	<1	--	<1.0	--	220
[1]FR-35/15E/23-0565	--	--	--	--	--	320	--	<.1	--	<1	--	<1.0	--	27
FR-36/13E/36-0592	50	--	7	--	<10	--	<.10	--	1	--	1	--	180	--
[1]FR-36/13E/26-0568	--	450	--	<10	--	120	--	<.1	--	<1	--	<1.0	--	35

[1]U.S. Geological Survey observation well constructed for this study.

Appendix E. *Radioactive-particle analyses of water from wells on the Potawatomi Indian Reservation*

[µg/L, micrograms per liter; pCi/L, picocuries per liter; --, no data available; <, less than. The five digit number ending each column heading is the parameter code used in the U.S. Geological Survey's Water Data Storage and Retrieval System.]

Local identifier	Site number	Date	Time	Gross alpha, total (µg/L as U-NAT) (80029)	Gross alpha, dis-solved (µg/L as U-NAT) (80030)	Gross alpha, sus-pended, total (µg/L as U-NAT) (80040)	Gross beta, total (pCi/L as CS-137) (03519)	Gross beta, dis-solved (pCi/L as CS-137) (03515)	Gross beta, sus-pended, total (pCi/L as CS-137) (03516)	Gross beta, total (pCi/L as SR/YT-90) (80049)	Gross beta, dis-solved (pCi/L as SR/YT-90) (80050)	Gross beta, sus-pended, total (pCi/L as SR/YT-90) (80060)	Radon 222, dis-solved (pCi/L) (82305)
FR-36/13E/35-0581	452331088495201	08-09-82	1010	<9.2	--	--	<5.0	--	--	<4.7	--	--	--
FR-34/15E/28-0579	452405088380701	08-10-82	0830	<7.8	--	--	<4.0	--	--	<3.8	--	--	--
FR-34/15E/28-0580	452459088375501	08-10-82	0900	<3.4	--	--	<1.9	--	--	<1.9	--	--	--
FR-34/15E/10-0587	452651088362801	08-10-82	1005	<3.8	--	--	<1.8	--	--	<1.7	--	--	121
[1]FR-35/16E/34-0571	452802088290901	08-31-82	1245	--	<4.0	44	--	2.1	18	--	2.0	17	--
FR-35/15E/28-0576	452932088364801	08-09-82	1525	<3.9	--	--	1.8	--	--	1.7	--	--	--
FR-35/15E/22-0577	453004088364001	08-09-82	1445	<3.3	--	--	<1.6	--	--	<1.6	--	--	258
FR-36/13E/35-0463	453327088493301	08-09-82	1005	<3.1	--	--	1.8	--	--	1.7	--	--	2,510
FR-36/13E/35-0582	453327088493302	08-08-83	1500	--	--	--	--	--	--	--	--	--	960
FR-36/13E/35-0586	453333088495201	08-09-82	0915	<3.8	--	--	<1.9	--	--	<1.8	--	--	--
FR-36/13E/34-0584	453345088505401	08-09-82	1400	<3.5	--	--	<1.6	--	--	<1.6	--	--	--
FR-36/13E/36-0574	453350088490301	08-09-82	1135	<3.9	--	--	<1.7	--	--	<1.7	--	--	89
FR-36/13E/27-0585	453401088513401	08-09-82	1335	<3.4	--	--	<1.7	--	--	<1.6	--	--	--
[1]FR-36/13E/26-0568	453412088494301	08-30-82	1415	--	<3.6	46	--	2.5	48	--	2.4	46	--
FR-36/13E/26-0575	453421088494701	08-09-82	1210	<4.0	--	--	<1.9	--	--	<1.8	--	--	391
		08-08-83	1545	--	--	--	--	--	--	--	--	--	465

[1]U.S. Geological Survey observation well constructed for this study.

Appendix F. *Physical and chemical characteristics of water from streams on the Potawatomi Indian Reservation*

[ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; dashes (--), no data available; <, less than. The five digit number ending each column heading is the parameter code used in the U.S. Geological Survey's Water Data Storage and Retrieval System.]

Site name	Site number	Date	Time	Elevation of land-surface datum (feet above NGVD) (72000)	Gage height (feet) (00065)	Discharge, instantaneous (ft^3/s) (00061)	Specific conductance (µS/cm) (00095)	pH (standard units) (00400)	Temperature, water (°C) (00010)	Oxygen, dissolved (mg/L) (00300)
Rat River at Valley Lake Road near Wabeno, Wis.	04067907	05-24-83	1100	1,310	--	369	105	7.4	12.5	8.9
Otter Creek at Indian Market Road near Wabeno, Wis.	04067930	05-24-83	0815	1,440	--	3.85	115	7.3	11.0	9.0
Otter Creek at Bay Shore Road near Wabeno, Wis.	04067940	05-23-83	1740	1,300	6.08	74.9	95	7.4	17.0	9.0
North Branch Oconto River at Highway C near Wabeno, Wis.	04069730	05-24-83	1340	1,500	--	77.0	115	7.6	13.5	9.0
Torpee Creek at Highway 32 near Wabeno, Wis.	04069770	05-23-83	1415	1,510	.26	39.2	110	7.2	13.0	7.2

Site name	Calcium, dissolved (mg/L as Ca) (00915)	Magnesium, dissolved (mg/L as Mg) (00925)	Sodium, dissolved (mg/L as Na) (00930)	Potassium, dissolved (mg/L as K) (00935)	Alkalinity, laboratory (mg/L as $CaCO_3$) (90410)	Sulfate, dissolved (mg/L as SO_4) (00945)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Solids, residue at 180°C, dissolved (mg/L) (70300)
Rat River at Valley Lake Road near Wabeno, Wis.	13	5.4	1.5	0.80	48	11	1.5	<.10	5.5	77
Otter Creek at Indian Market Road near Wabeno, Wis.	14	6.0	1.2	1.0	56	9.9	1.1	<.10	6.1	103
Otter Creek at Bay Shore Road near Wabeno, Wis.	12	4.9	1.1	.70	46	10	1.0	.10	4.1	108
North Branch Oconto River at Highway C near Wabeno, Wis.	15	6.3	1.8	.90	59	10	2.0	<.10	4.9	94
Torpee Creek at Highway 32 near Wabeno, Wis.	13	5.6	1.3	.50	51	6.0	1.0	.10	4.3	87

Appendix G. *Trace-constituent analyses of bottom material from streams on the Potawatomi Indian Reservation*

[All concentrations in micrograms per gram; --, no data available; <, less than. The five digit number ending each column heading is the parameter code used in the U.S. Geological Survey's Water Data Storage and Retrieval System.]

Site name	Site number	Date	Time	Arsenic, total in bottom material (µg/g as As) (01003)	Cadmium, recoverable from bottom material (µg/g as Cd) (01028)	Chromium, recoverable from bottom material (µg/g as Cr) (01029)	Cobalt, recoverable from bottom material (µg/g as Co) (01038)	Copper, recoverable from bottom material (µg/g as Cu) (01043)
Rat River at Valley Lake Road near Wabeno, Wis.	04067907	05-24-83	1100	<1	<1	3	<10	4
Otter Creek at Indian Market Road near Wabeno, Wis.	04067930	05-24-83	0815	<1	<1	6	<10	4
Otter Creek at Bay Shore Road near Wabeno, Wis.	04067940	05-23-83	1740	<1	<1	4	<10	4
North Branch Oconto River at Highway C near Wabeno, Wis.	04069730	05-24-83	1340	<1	<1	5	<10	2
Torpee Creek at Highway 32 near Wabeno, Wis.	04069770	05-23-83	1415	<1	<1	4	<10	5

Site name	Iron, recoverable from bottom material (µg/g as Fe) (01170)	Lead, recoverable from bottom material (µg/g as Pb) (01052)	Manganese, recoverable from bottom material (µg/g as Mn) (01053)	Mercury, recoverable from bottom material (µg/g as Hg) (71921)	Nickel, recoverable from bottom material (µg/g as Ni) (01068)	Zinc, recoverable from bottom material (µg/g as Zn) (01093)
Rat River at Valley Lake Road near Wabeno, Wis.	4,700	<10	630	.01	<10	6
Otter Creek at Indian Market Road near Wabeno, Wis.	1,300	<10	29	.01	<10	30
Otter Creek at Bay Shore Road near Wabeno, Wis.	920	<10	96	.01	<10	6
North Branch Oconto River at Highway C near Wabeno, Wis.	690	<10	180	<.01	<10	8
Torpee Creek at Highway 32 near Wabeno, Wis.	1,100	<10	34	<.01	<10	8

Appendix H. *Physical and chemical characteristics of water from lakes on the Potawatomi Indian Reservation*

[°C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; --, no data available; <, less than. The five digit number ending each column heading is the parameter code used in the U.S. Geological Survey's Water Data Storage and Retrieval System.]

Site name	Site number	Date	Time	Elevation of land-surface datum (feet above NGVD) (72000)	Gage height (feet) (00065)	Specific conductance (µS/cm) (00095)	pH (standard units) (00400)	Temperature, water (°C) (00010)	Calcium, dissolved (mg/L as Ca) (00915)	Magnesium, dissolved (mg/L as Mg) (00925)	Sodium, dissolved (mg/L as Na) (00930)
King Lake near Wabeno, Wis.	452516088254001	05-25-83	0850	1,278	7.02	170	7.8	13.0	21	8.1	1.3
Devils Lake near Crandon, Wis.	453300088500001	05-24-83	1720	1,730	9.05	<50	4.7	15.0	1.5	.48	.20
Bug Lake near Crandon, Wis.	453442088493501	05-25-83	1115	1,730	10.00	<50	6.0	13.0	1.8	.63	.90

Site name	Potassium, dissolved (mg/L as K) (00935)	Alkalinity, laboratory (mg/L as $CaCO_3$) (90410)	Sulfate, dissolved (mg/L as SO_4) (00945)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Solids, residue, at 180°C dissolved (mg/L) (70300)	Arsenic, total (µg/L as As) (01002)	Barium, total recoverable (µg/L as Ba (01007)	Cadmium, total recoverable (µg/L as Cd) (01027)
King Lake near Wabeno, Wis.	0.70	86	6.0	1.0	<.10	0.23	83	1	<100	<1
Devils Lake near Crandon, Wis.	.90	3.0	4.0	.50	<.10	.36	20	1	<100	<1
Bug Lake near Crandon, Wis.	.90	5.0	5.5	1.9	<.10	.15	13	1	<100	1

Site name	Chromium, total recoverable (µg/L as Cr) (01034)	Copper, total recoverable (µg/L as Cu) (01042)	Iron, total recoverable (µg/L as Fe) (01045)	Lead, total recoverable (µg/L as Pb) (01051)	Manganese, total recoverable (µg/L as Mn) (01055)	Mercury, total recoverable (µg/L as Hg) (71900)	Nickel, total recoverable (µg/L as Ni) (01067)	Selenium, total (µg/L as Se) (01147)	Silver, total recoverable (µg/L as Ag) (01077)	Zinc, total recoverable (µg/L as Zn) (01092)
King Lake near Wabeno, Wis.	10	5	90	<1	<10	0.70	1	<1	<1	20
Devils Lake near Crandon, Wis.	10	3	310	1	60	<.10	<1	<1	<1	20
Bug Lake near Crandon, Wis.	20	6	110	1	10	.30	2	<1	<1	50

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