

Prepared in cooperation with the
PRAIRIE BAND POTAWATOMI NATION

Quality of Water on the Prairie Band Potawatomi Reservation, Northeastern Kansas, May 2001 Through August 2003



Scientific Investigations Report 2004–5243

Front cover: Old hand pump on Prairie Band Potawatomi Reservation (photograph taken by Gregory P. Wold, Biologist, Prairie Band Potawatomi Nation, Mayetta, Kansas).

Back cover: Study personnel collecting ground-water sample from Potawatomi Reservation (photograph taken by Pat Finnegan, U.S. Geological Survey, Lawrence, Kansas).

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By Heather C. Ross Schmidt

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**U.S. Department of the Interior
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Conversion Factors and Datum

Multiply	By	To obtain
Length		
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Area		
acre	4,047	square meter (m ²)
square mile (mi ²)	2.590	square kilometer (km ²)
Flow rate		
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second (m ³ /s)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
Weight		
milligram per day (mg/d)	0.0000353	ounce per day (oz/d)
ton (short)	0.9072	megagram (Mg)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32.$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) / 1.8.$$

Vertical coordinate information is referenced to the *North American Vertical Datum of 1988 (NAVD 88)*.

Horizontal coordinate information is referenced to the *North American Datum of 1983 (NAD 83)*.

Altitude, as used in this report, refers to distance above the vertical datum.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (μS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (μg/L).

Water-Quality Abbreviations

<i>E. coli</i>	<i>Escherichia coli</i>
col/100 mL	colonies per 100 milliliters of water
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter at 25 degrees Celsius
meq/L	milliequivalents per liter
mg/L	milligrams per liter
mV	millivolts
NTU	nephelometric turbidity units

Acronyms

ANC	acid neutralizing capacity
CaCO ₃	calcium carbonate
COD	chemical oxygen demand
DWA	Drinking-Water Advisory
ELISA	enzyme-linked immunosorbent assay
GC/MS	gas chromatography/mass spectrometry
HCO ₃	bicarbonate
KDHE	Kansas Department of Health and Environment
MCL	Maximum Contaminant Level
NWQL	National Water-Quality Laboratory
OGRL	Organic Geochemistry Research Laboratory
PVC	polyvinyl chloride
SDWR	Secondary Drinking-Water Regulation
SSC	suspended-sediment concentration
TSS	total suspended solids
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	volatile organic compound
YSI	Yellow Springs Instruments

Quality of Water on the Prairie Band Potawatomi Reservation, Northeastern Kansas, May 2001 Through August 2003

By Heather C. Ross Schmidt

Abstract

Water-quality samples were collected from 20 surface-water sites and 11 ground-water sites on the Prairie Band Potawatomi Reservation in northeastern Kansas in an effort to describe existing water-quality conditions on the reservation and to compare water-quality conditions to results from previous reports published as part of a multiyear cooperative study with the Prairie Band Potawatomi Nation. Water is a valuable resource to the Prairie Band Potawatomi Nation as tribal members use the streams draining the reservation, Soldier, Little Soldier, and South Cedar Creeks, to fulfill subsistence hunting and fishing needs and as the tribe develops an economic base on the reservation. Samples were collected once at 20 surface-water monitoring sites during June 2001, and quarterly samples were collected at 5 of the 20 monitoring sites from May 2001 through August 2003. Ground-water-quality samples were collected once from seven wells and twice from four wells during April through May 2003 and in August 2003.

Surface-water-quality samples collected from May through August 2001 were analyzed for physical properties, nutrients, pesticides, fecal indicator bacteria, and total suspended solids. In November 2001, an additional analysis for dissolved solids, major ions, trace elements, and suspended-sediment concentration was added for surface-water samples. Ground-water samples were analyzed for physical properties, dissolved solids, major ions, nutrients, trace elements, pesticides, and fecal indicator bacteria. Chemical oxygen demand and volatile organic compounds were analyzed in a sample from one monitoring well located near a construction and demolition landfill on the reservation.

Previous reports published as a part of this ongoing study identified total phosphorus, triazine herbicides, and fecal coliform bacteria as exceeding their respective water-quality criteria in surface water on the reservation. Previous ground-water assessments identified occasional sample concentrations of dissolved solids, sodium, sulfate, boron, iron, and manganese as exceeding their respective water-quality criteria.

Forty percent of the 65 surface-water samples analyzed for total phosphorus exceeded the aquatic-life goal of 0.1 mg/L (milligrams per liter) established by the U.S. Environmental

Protection Agency (USEPA). Concentrations of dissolved solids and sodium occasionally exceeded USEPA Secondary Drinking-Water Regulations and Drinking-Water Advisory Levels, respectively. One of the 20 samples analyzed for atrazine concentrations exceeded the Maximum Contaminant Level (MCL) of 3.0 $\mu\text{g/L}$ (micrograms per liter) as an annual average established for drinking water by USEPA. A triazine herbicide screen was used on 63 surface-water samples, and triazine compounds were frequently detected. Triazine herbicides and their degradates are listed on the USEPA Contaminant Candidate List.

Nitrite plus nitrate concentrations in two ground-water samples from one monitoring well exceeded the MCL of 10 mg/L established by USEPA for drinking water. Arsenic concentrations in two samples from one monitoring well also exceeded the proposed MCL of 10 $\mu\text{g/L}$ established by the USEPA for drinking water. Concentrations of dissolved solids and sulfate in some ground-water samples exceeded their respective Secondary Drinking-Water Regulations, and concentrations exceeded the taste threshold of the USEPA's Drinking-Water Advisory Level for sodium. Consequently, in the event that ground water on the reservation is to be used as a drinking-water source, additional treatment may be necessary to remove excess dissolved solids, sulfate, and sodium.

Introduction

Water quality is very important to the Prairie Band Potawatomi Nation. Three of the four creeks draining the reservation in northeastern Kansas, Soldier (locally referred to as Big Soldier Creek), Little Soldier, and South Cedar Creeks, provide for the fishing and hunting needs of tribal members (fig. 1). Therefore, the quality of the surface water needs to be maintained at a level that poses no danger to human health and protects the wildlife resources on the reservation. Ground water is used as a domestic water supply throughout the reservation. The potential of developing a stable ground-water supply also is important as the tribe develops an economic base on the reservation; therefore, establishing a baseline for ground-water

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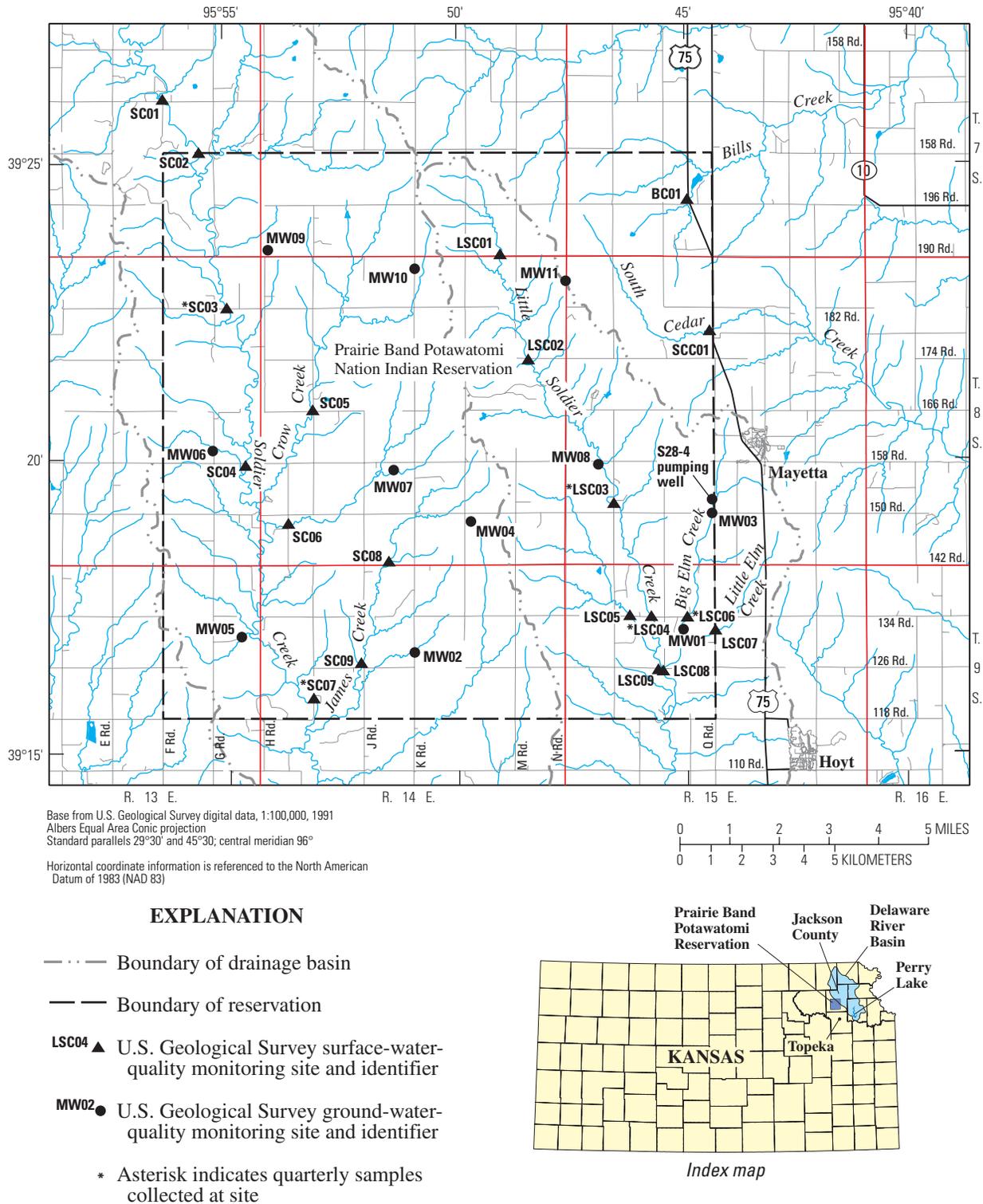


Figure 1. Location of water-quality monitoring sites on and near the Prairie Band Potawatomi Reservation, northeastern Kansas.

quality on the reservation will help identify any potential treatment concerns for this potential water source (Trombley, 2001).

Nonpoint sources such as runoff from agricultural lands and seepage from septic systems or sewage lagoons servicing a rural population are considered the primary sources of potential water-quality problems on the reservation (Trombley, 2001). Three wastewater facilities are operated by the tribe on the reservation and are potential sources of point-source wastewater discharge (Latane Donelin, Prairie Band Potawatomi Nation, Department of Planning and Environmental Protection, oral commun., 2004).

Under the Federal Water Pollution Control Act Amendments of 1972, which later were amended in 1977 and became known as the Clean Water Act, an Indian tribe is sovereign for the purposes of delegating the authority to regulate water within reservation boundaries. Therefore, establishing water-quality baseline concentrations as well as continued water-quality monitoring will aid the tribe with establishing water-quality criteria for the Prairie Band Potawatomi Reservation. To address their needs, the Prairie Band Potawatomi Nation, in cooperation with the U.S. Geological Survey (USGS), began a water-quality monitoring program in 1996 to begin steps toward establishing water-quality standards for the reservation. The monitoring program began as a surface-water assessment focused on nutrients, pesticides, bacteria, and total suspended solids and now includes major ions, dissolved solids, trace elements, and suspended-sediment analysis of surface-water samples as well as the addition of a ground-water-quality monitoring component using dedicated ground-water monitoring wells. The ground-water-quality monitoring includes analysis of major ions, dissolved solids, nutrients, trace elements, pesticides, and fecal indicator bacteria, as well as chemical oxygen demand (COD) and volatile organic compounds (VOCs) for one monitoring well.

Purpose and Scope

The purpose of this report is to describe surface- and ground-water quality on the Prairie Band Potawatomi Reservation from May 2001 through August 2003 and to compare results from this study period to results in previous water-quality reports published as a part of this ongoing study. Surface-water samples were collected approximately every 3 months from May 2001 through August 2003, and ground-water samples were collected twice (April–May 2003 and August 2003) to describe the distribution of inorganic and organic constituents and bacteria in the water on the reservation.

This report is the third in a series of reports resulting from the ongoing cooperative study with the Prairie Band Potawatomi Nation. Previous reports describe surface-water quality on the reservation from June 1996 through November 1998 (Trombley, 1999) and surface- and ground-water quality on the reservation from February 1999 through February 2001 (Trombley, 2001).

Principal Results from Previous Studies

Total phosphorus, triazine herbicides, and fecal coliform bacteria concentrations in surface water were identified as exceeding water-quality criteria established by USEPA and the Kansas Department of Health and Environment (KDHE) during the June 1996 through November 1998 reporting period (Trombley, 1999). The same constituents in surface water exceeded water-quality criteria established by USEPA and KDHE during the reporting period February 1999 through February 2001 (Trombley, 2001). Dissolved solids, sodium, sulfate, boron, iron, and manganese concentrations in some samples exceeded their respective water-quality criteria established by USEPA for drinking water as part of the February 1999 through February 2001 ground-water assessment and were related to large mineral concentrations resulting from dissolution of the surrounding sedimentary rocks (Trombley, 2001).

Description of Study Area

The Prairie Band Potawatomi Reservation is located approximately 20 mi north of the city of Topeka in northeastern Kansas and encompasses approximately 121 mi² in Jackson County (fig. 1). Primary land uses in the two major drainage basins (Soldier and Little Soldier Creek Basins) are cropland (26–27 percent) and pastureland (64–69 percent), with cropland mostly along the streams and pastureland in upland areas (table 1, fig. 2).

Physically, the Prairie Band Potawatomi Reservation is located within the Kansas Drift Plains section of the Central Lowland Province of the Interior Plains (Fenneman, 1938; Fenneman and Johnson, 1946; Schoewe, 1949). The topography of the Kansas Drift Plains reflects a gently undulating, glacial-drift-dominated, erosional surface. The broad, smooth, well-rounded, interstream areas are remnants of the uneroded original basal till deposited by the last retreating glacial ice sheet.

Table 1. Drainage area and land-use percentages in Soldier and Little Soldier Creek Basins within the Prairie Band Potawatomi Reservation, northeastern Kansas.

[Land-use data from Kansas Geological Survey, Data Access and Support Center (DASC), digital land-use data, 1993]

	Soldier Creek Basin	Little Soldier Creek Basin
Drainage area (acres)	43,720	23,090
Land-use classes	Land use (percent)	
Cropland	25.6	27.0
Pastureland	68.5	63.7
Woodland	5.7	8.9
Water	.15	.33
Other	.05	.07

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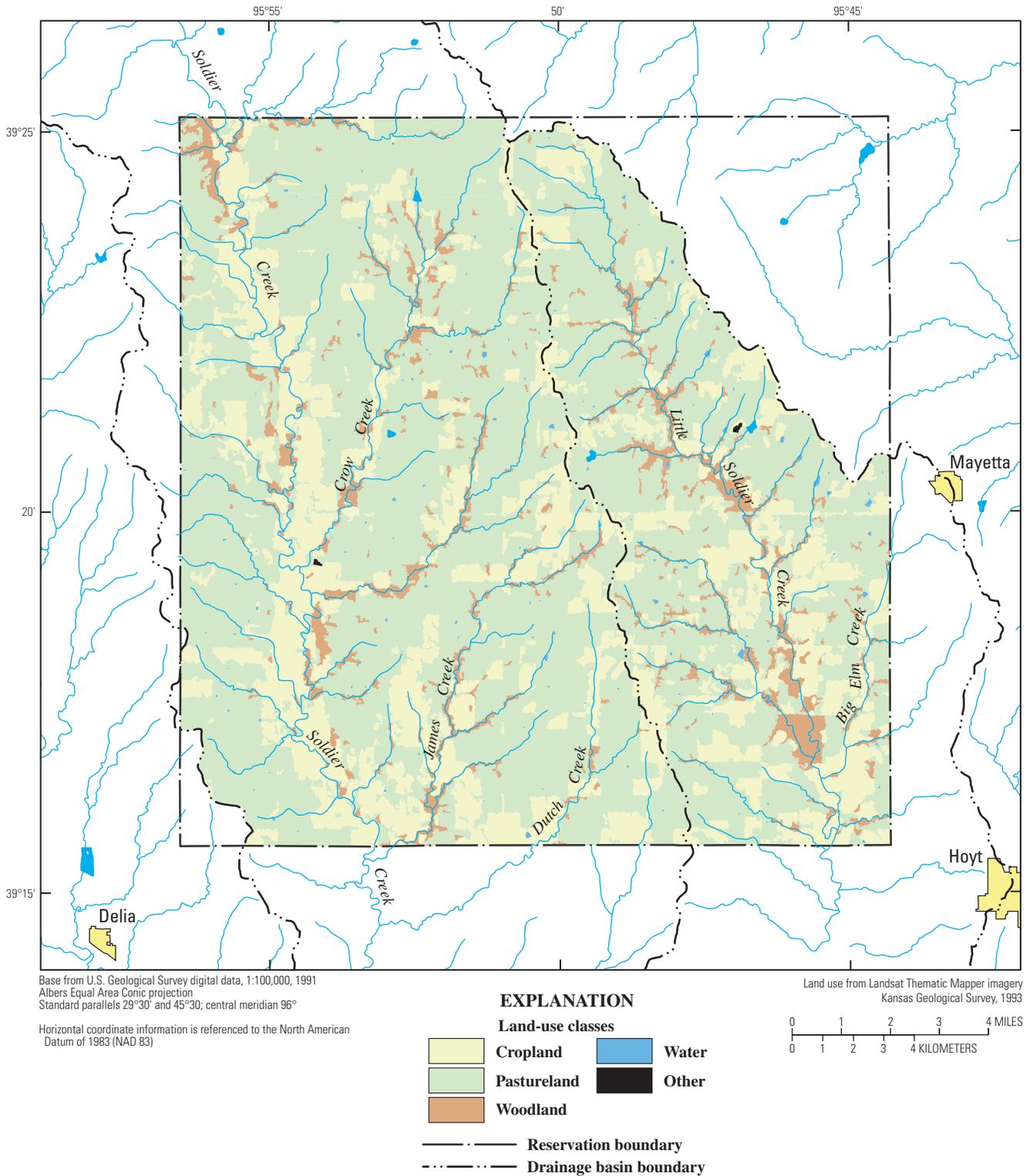


Figure 2. Land use in the Soldier and Little Soldier Creek Basins within the Prairie Band Potawatomi Reservation, 1993 (Kansas Geological Survey, 1993).

Glacial deposits of boulder till, sand and gravel, silt, and clay lie beneath the erosional surface. A preglacial bedrock valley, buried by glacial deposits, lies along the course of Soldier Creek within the reservation (Dreeszen and Burchett, 1971).

Geologically, the Prairie Band Potawatomi Reservation lies within the stable interior of the North American Continent. Since Precambrian time (about 600 million years ago), most of this part of the continent has undergone gentle upwarp and downwarp of the Earth's crust over large areas. Structurally, this part of the continent is characterized by broad basins and arches, with subtle folding of sedimentary rocks and few major fault zones (Jorgensen and others, 1993). Uppermost bedrock

within the reservation consists mostly of limestone and shale of Permian and Pennsylvanian age (about 245 to 320 million years ago) (Walters, 1953). Unconsolidated glacial and stream (alluvial) deposits overlie the erosional surface of sedimentary rocks (fig. 3). The composition of these unconsolidated deposits varies vertically and horizontally and ranges from fine-grained sediment consisting of till, silt, and clay to coarse-grained sediment consisting of sand, gravel, pebbles, cobbles, and boulders (Trombley and others, 1996). The unconsolidated glacial and alluvial deposits are the primary source of ground water on the reservation. Well yields from these deposits are variable and generally less than 300 gal/min (Trombley and others, 1996).

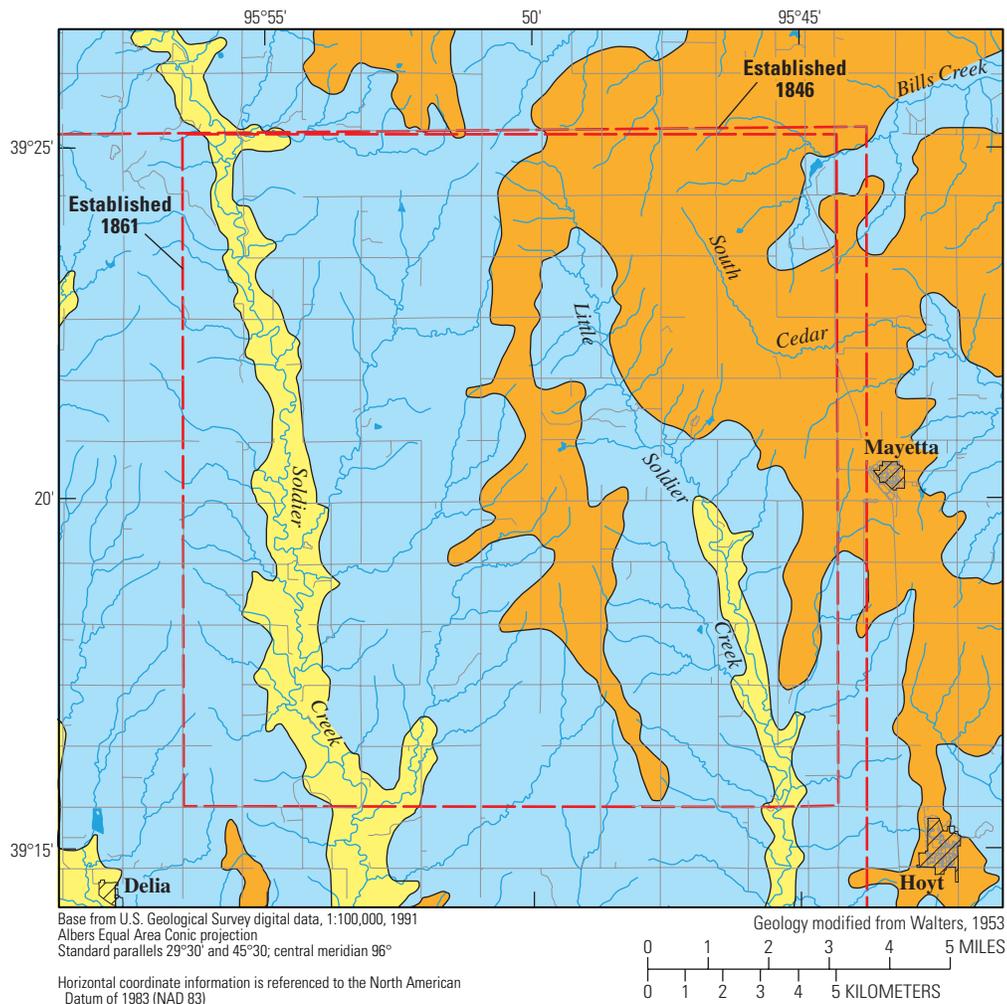


Figure 3. Generalized geology underlying the Prairie Band Potawatomi Reservation (modified from Walters, 1953).

Methods of Sample Collection and Analysis

Sample Collection

Surface Water

A network of 20 surface-water monitoring sites (referred to herein as “synoptic sites”) was established on or near the reservation to evaluate the spatial and temporal variability of surface-water quality on the reservation (fig. 1, table 2). Eighteen of the 20 sites were located within the two major drainage basins on the reservation, Soldier Creek and Little Soldier Creek. Surface-water-quality monitoring sites were selected to represent areal distribution across the reservation, surface water flowing into and out of the reservation, as well as surface water downstream from potential sources of contamination. Two sites were located on streams that flow into the Delaware River Basin located to the east of the reservation. All 20 sites were sampled once during this study period and had been sampled annually since 1996 as a part of previous studies (results from these previous studies are published in Trombley, 1999, 2001). The last of six synoptic sample collections conducted as a part of the ongoing study occurred in June 2001, and the data are published in this report.

Since November 1996, a subset of 5 of the 20 synoptic sites was sampled approximately quarterly (referred to herein after as “quarterly sites”). Two sites are located on Soldier Creek (sites SC03 and SC07), two are located on Little Soldier Creek (sites LSC03 and LSC04), and one is located on Big Elm Creek (LSC06) (fig. 1) downstream from a sewage treatment lagoon in operation on the reservation (Latane Donelin, Prairie Band Potawatomi Nation, Department of Planning and Environmental Protection, oral commun., 2004) and approximately 1 mi upstream from Big Elm Creek’s confluence with Little Soldier Creek.

Surface-water-quality samples were collected in June 2001 at the 20 synoptic sites (fig. 1, table 2), after seasonal herbicide application on fields in the area. A total of 45 samples were collected from May 2001 through August 2003 from the five quarterly sites. The quarterly samples were collected during the months of February, May, August, and November. From May through August 2001, all surface-water samples were analyzed for physical properties, nutrients, pesticides, bacteria, and total suspended solids. Beginning in November 2001, quarterly surface-water samples were analyzed for physical properties, dissolved solids, major ions, nutrients, trace elements, pesticides, bacteria, total suspended solids, and suspended sediment (table 3).

Surface-water-quality sampling techniques are described in Wilde and others (1999). Streamflow was measured at each monitoring site along with each surface-water-quality sample. Streamflow measurement techniques are described in Buchanan and Somers (1976).

Ground Water

Ground-water sampling from dedicated monitoring wells was added to the scope of the continuing study in November 2001. A total of 11 ground-water monitoring wells within the reservation were sampled from April 26 through May 1, 2003, and August 12–14, 2003. The first round of ground-water-quality sampling (April–May 2003) included nine wells, and the second round (August 2003) included six wells. Four of the six wells sampled in August 2003 also were sampled in the first round in addition to two wells that were installed after the first round of sampling (monitoring wells MW01 and MW03). The ground-water samples were collected from recently (2003) installed wells that are dedicated for water-quality-monitoring purposes only; ground-water samples were collected from domestic and pumping wells in a previous ground-water assessment on the reservation (Trombley, 2001). Monitoring wells were located to provide a spatial assessment of the ground-water quality across the reservation. The monitoring wells were installed by private contractor through the Prairie Band Potawatomi Nation, consist of 2-in. polyvinyl chloride (PVC) pipe, and are completed at various depths (table 2). Wells were completed in the local water-bearing formation (Gregory Wold, Prairie Band Potawatomi Nation, Department of Planning and Environmental Protection, oral commun., 2004). Water in these wells is derived from alluvial and glacial deposits as well as Permian- and Pennsylvanian-age carbonate deposits (Walters, 1953).

Ground-water-quality samples were analyzed for physical properties, dissolved solids, major ions, nutrients, trace elements, pesticides, and bacteria. Additional analyses for chemical oxygen demand (COD) and volatile organic compounds (VOCs) were completed on the May 2003 sample from monitoring well MW04. Ground-water-quality samples were collected and processed in a mobile water-quality laboratory following ground-water-sampling protocols described in detail in Gibs and Wilde (1999). Each well was purged of at least three well volumes before samples were collected. Well purging was necessary to assure that the water samples were representative of aquifer conditions. During the purging period, physical properties of the water (specific conductance, pH, water temperature, dissolved oxygen, oxidation-reduction potential, and turbidity) were observed and recorded every 5 minutes. Water-quality samples were collected after the three-volume purge was complete and physical properties stabilized (Gibs and Wilde, 1999).

After onsite processing, all water-quality samples were chilled to a temperature of 4 °C during transport to the USGS laboratory in Lawrence, Kansas. Samples then were shipped to either the USGS National Water-Quality Laboratory (NWQL) in Denver, Colorado; the Organic Geochemistry Research Laboratory (OGRL) in Lawrence, Kansas; or the USGS Sediment Laboratory in Iowa City, Iowa, according to the desired analysis.

Table 2. Surface- and ground-water-quality monitoring sites on the Prairie Band Potawatomi Reservation, northeastern Kansas.

[--, not determined; *, asterisk indicates quarterly samples collected at site]

Stream basin	Map identifier (fig. 1)	U.S. Geological Survey site identification number	Local number (township, range, and section) ¹	Site name	Approximate well depth (feet)	Approximate depth of screened interval (feet)
Surface-water monitoring sites						
Bills Creek Basin	BC01	392425095445100	7S 15E 28CDD	Bills Creek, U.S. Highway 75 near Holton	--	--
Little Soldier Creek Basin	LSC01	392328095490300	7S 14E 35DCDC	Little Soldier Creek, 190 Road near Mayetta	--	--
	LSC02	392143095482700	8S 14E 12CCDD	Little Soldier Creek, 174 Road near Mayetta	--	--
	*LSC03	391915095463100	8S 15E 29CCBC	Little Soldier Creek, O Road near Mayetta	--	--
	*LSC04	391720095454200	9S 15E 08ABAA	Little Soldier Creek, 134 Road near Mayetta	--	--
	LSC05	391721095460900	9S 15E 05CDDC	Little Soldier Creek tributary, 134 Road near Hoyt	--	--
	*LSC06	391720095445400	9S 15E 04CDDD	Big Elm Creek, 134 Road near Hoyt	--	--
	LSC07	391704095441700	9S 15E 10CBDB	Little Elm Creek, Q Road near Hoyt	--	--
	LSC08	391629095452400	9S 15E 09CCCC	Big Elm Creek, P Road near Hoyt	--	--
	LSC09	391628095452800	9S 15E 17AAAA	Little Soldier Creek, 126 Road near Hoyt	--	--
Soldier Creek Basin	SC01	392603095563000	7S 13E 23BBBB	Soldier Creek, 214 Road near Circleville	--	--
	SC02	392512095552800	7S 13E 23DDDD	Soldier Creek tributary, G Road near Circleville	--	--
	*SC03	06889180	8S 13E 12BABB	Soldier Creek near Saint Clere	--	--
	SC04	391956095544000	8S 13E 25ABAB	Soldier Creek, 158 Road near Saint Clere	--	--
	SC05	392049095531300	8S 14E 18DDDD	Crow Creek, 166 Road near Saint Clere	--	--
	SC06	391852095534500	8S 14E 31BADD	South Branch Soldier Creek, H.5 Road near Saint Clere	--	--
	*SC07	391557095531100	9S 14E 17CBBC	Soldier Creek, I Road near Delia	--	--
	SC08	391813095513200	8S 14E 33CDDD	James Creek, 142 Road near Delia	--	--
	SC09	391630095520800	9S 14E 08DDDD	James Creek, 126 Road near Delia	--	--
South Cedar Creek Basin	SCC01	392212095441800	8S 15E 09ADDA	South Cedar Creek, U.S. Highway 75 near Mayetta	--	--

Table 2. Surface- and ground-water-quality monitoring sites on the Prairie Band Potawatomi Reservation, northeastern Kansas.—Continued

[--, not determined; *, asterisk indicates quarterly samples collected at site]

Stream basin	Map identifier (fig. 1)	U.S. Geological Survey site identification number	Local number (township, range, and section) ¹	Site name	Approximate well depth (feet)	Approximate depth of screened interval (feet)
Ground-water monitoring sites						
Little Soldier Creek Basin	MW01	391707095445901	9S 15E 09BAD01	Monitoring well #1	33.5	--
Soldier Creek Basin	MW02	391644095505601	9S 14E 10CBCC01	Monitoring well #2	26.0	9–25
Little Soldier Creek Basin	MW03	391907095441901	8S 15E 28DDDD01	Monitoring well #3	96.5	--
Soldier Creek Basin	MW04	391850095483801	8S 14E 36BCBD01	Monitoring well #4	40.0	10–30
Do.	MW05	391700095544601	9S 13E 12ACCA01	Monitoring well #5	22.8	10–20
Do.	MW06	392010095552301	8S 13E 24CBCC01	Monitoring well #6	40.1	20–40
Do.	MW07	391948095512201	8S 14E 28ABCA01	Monitoring well #7	28.6	16–26
Little Soldier Creek Basin	MW08	391955095465301	8S 15E 30ABAB01	Monitoring well #8	37.2	15–35
Soldier Creek Basin	MW09	392325095542101	8S 13E 01AAAB01	Monitoring well #9	73.7	20–70
Do.	MW10	392315095505801	8S 14E 04AADD01	Monitoring well #10	41.1	10–40
Little Soldier Creek Basin	MW11	392310095473501	8S 14E 01ADAD01	Monitoring well #11	63.0	15–60

¹Local numbers are assigned according to a modification of the Bureau of Land Management's system of land subdivision. In this system, the first set of digits in the number refers to the township north (N) or south (S) of the Kansas-Nebraska State line; the second set refers to the range east (E) or west (W) of the sixth principal meridian; and the third set refers to the section in which the site is located. The terminal letters refer to the 160-acre, 40-acre, 10-acre, and 2.5-acre tracts within the section. The letters A, B, C, D are assigned in a counterclockwise direction beginning in the northeast quadrant. For example, the local number 7S 14E 35DCDC indicates a site located in the southwest quarter of the southeast quarter of the southwest quarter of the southeast quarter of sec. 35, T.7 S., R.14 E.

Table 3. Constituents analyzed as part of the water-quality assessment on the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.

[Unless otherwise noted, constituents were analyzed in both surface- and ground-water samples]

Physical properties	
Specific conductance	Hardness
pH	Oxidation-reduction potential ¹
Water temperature	Acid neutralizing capacity as CaCO ₃ , field, total ²
Turbidity	Acid neutralizing capacity as CaCO ₃ , laboratory, total
Oxygen, dissolved	Alkalinity as CaCO ₃ , dissolved ¹
Dissolved solids	
Major ions	
Calcium, dissolved	Carbonate as CaCO ₃ , total, onsite
Magnesium, dissolved	Sulfate, dissolved
Sodium, dissolved	Chloride, dissolved
Potassium, dissolved	Fluoride, dissolved
Bicarbonate as HCO ₃ , dissolved	Silica, dissolved
Nutrients	
Nitrogen, nitrite, dissolved	Phosphorus, dissolved
Nitrogen, nitrite plus nitrate, dissolved	Phosphorus, total
Nitrogen, ammonia, dissolved	Phosphorus, orthophosphate, dissolved
Nitrogen, ammonia plus organic nitrogen, dissolved	
Trace elements	
Arsenic, dissolved	Iron, dissolved
Boron, dissolved	Selenium, dissolved
Triazine pesticides or metabolites	
Triazine screen (ELISA), dissolved ²	Dimethenamid, dissolved
2-Chloro-4-isopropylamino-6-amino-s-triazine, dissolved	Flufenacet, dissolved
2-Chloro-6-ethylamino-4-amino-s-triazine, dissolved	2-Hydroxy-4-isopropylamino-6-amino-s-triazine, dissolved ²
Acetochlor, dissolved	2-Hydroxy-6-ethylamino-4-amino-s-triazine, dissolved ²
Alachlor, dissolved	Metolachlor, dissolved
Ametryn, dissolved	Metribuzin, dissolved
Atrazine, dissolved	Pendimethalin, dissolved
Chlorodiamino-s-triazine, dissolved ²	Prometon, dissolved
Cyanazine, dissolved	Prometryn, dissolved
Cyanazine amide, dissolved	Propachlor, dissolved
Deethylcyanazine, dissolved ²	Propazine, dissolved
Deethylcyanazine acid, dissolved ²	Simazine, dissolved
Deethylcyanazine amide, dissolved ²	Terbutryn, dissolved

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Table 3. Constituents analyzed as part of the water-quality assessment on the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

[Unless otherwise noted, constituents were analyzed in both surface- and ground-water samples]

Other pesticides	
alpha-HCH, dissolved ²	Lindane, dissolved ²
Azinphos-methyl, dissolved ²	Linuron, dissolved ²
Benfluralin, dissolved ²	Malathion, dissolved ²
Bromacil, dissolved ²	Methyl parathion, dissolved ²
Butylate, dissolved ²	Molinate, dissolved ²
Carbaryl, dissolved ²	Napropamide, dissolved ²
Carbofuran, dissolved ²	p,p'-DDE, dissolved ²
Chloropyrifos, dissolved ²	Parathion, dissolved ²
cis-Permethrin, dissolved ²	Pebulate, dissolved ²
DCPA, dissolved ²	Phorate, dissolved ²
Demethylfluometuron, dissolved ²	Pronamide, dissolved ²
Diazinon, dissolved ²	Propanil, dissolved ²
Dieldrin, dissolved ²	Propargite, dissolved ²
Disulfoton, dissolved ²	Tebuthiuron, dissolved ²
2,6-Diethylaniline, dissolved ²	Terbacil, dissolved ²
Diuron, dissolved ²	Terbufos, dissolved ²
EPTC, dissolved ²	Thiobencarb, dissolved ²
Ethoprop, dissolved ²	Triallate, dissolved ²
Fluometuron, dissolved ²	Trifluralin, dissolved ²
Fonofos, dissolved ²	
Chemical oxygen demand ¹	
Volatile organic compounds ¹	
Acetone, total	2-Ethyltoluene, total
Acrylonitrile, total	Hexachlorobutadiene, total
Benzene, total	Hexachloroethane, total
Bromobenzene, total	Iodomethane, total
Bromochloromethane, total	Isobutyl methyl ketone, total
Bromodichloromethane, total	Isopropylbenzene, total
Bromoethene, total	4-Isopropyltoluene, total
n-Butylbenzene, total	Methacrylonitrile, total
sec-Butylbenzene, total	Methyl acrylate, total
tert-Butylbenzene, total	Methyl methacrylate, total
n-Butyl methyl ketone, total	Methyl tert-butyl ether, total
tert-Butyl ethyl ether, totalcis	Naphtalene, total
Carbon disulfide, total	n-Propylbenzene, total
Chlorobenzene, total	Tetrachloroethane, total
Chloroethane, total	1,1,1,2-Tetrachloroethane, total
Chloromethane, total	1,1,2,2-Tetrachloroethane, total

Table 3. Constituents analyzed as part of the water-quality assessment on the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

[Unless otherwise noted, constituents were analyzed in both surface- and ground-water samples]

Volatile organic compounds—Continued	
3-Chloropropene, total	Tetrachloromethane, total
2-Chlorotoluene, total	Tetrahydrofuran, total
4-Chlorotoluene, total	1,2,3,4-Trimethylbenzene, total
Dibromochloromethane, total	1,2,4-Trichlorobenzene, total
Dibromomethane, total	1,1,1-Trichloroethane, total
1,2-Dibromo-3-chloropropane, total	1,1,2-Trichloroethane, total
1,3-Dichloropropane, total	Trichloroethene, total
2,2-Dichloropropane, total	Trichlorofluoromethane, total
cis-1,3-Dichloropropene, total	Trichloromethane, total
trans-1,3-Dichloropropene, total	1,2,3-Trichloropropane, total
Diethyl ether, total	1,2,4-Trimethylbenzene, total
Diisopropyl ether, total	1,3,5-Trimethylbenzene, total
Ethyl methacrylate, total	Vinyl chloride, total
Ethyl methyl ketone, total	m-Xylene plus p-xylene, total
Ethylbenzene, total	o-Xylene, total
Fecal indicator bacteria	
Fecal coliform bacteria	Fecal streptococcus bacteria
<i>Escherichia coli</i> bacteria	Enterococci bacteria
Sediment	
Total suspended solids ²	Suspended-sediment concentration ²

¹Sampled in ground water only.

²Sampled in surface water only.

Sample Analysis

Water-quality samples were analyzed at the NWQL for physical properties, major ions, nutrients, trace element concentrations, pesticides, COD, and VOC using methods described in Fishman and Friedman (1989), Zaugg and others (1995), Connor and others (1998), and Jones and Garbarino (1999). Pesticides, including herbicides and insecticides, were analyzed at the OGRL using two different methods. Enzyme-linked immunosorbent assay (ELISA) was used for all surface-water samples to screen for triazine herbicides using procedures described in Thurman and others (1990). Selected surface-water and all ground-water samples were analyzed using gas chromatography/mass spectrometry (GC/MS) for concentrations of specific triazine herbicides using methods described in Kish and others (2000). The suspended-sediment concentrations in surface-water samples were determined at the USGS Sediment Laboratory in Iowa City, Iowa, using methods described in Guy (1977).

Fecal coliform, *Escherichia coli* (*E. coli*), fecal streptococcus, and enterococci bacteria in water samples were processed onsite by USGS or tribal personnel. Bacteria samples were returned to the USGS laboratory in Lawrence, Kansas, to complete incubation and subsequent determination of bacteria colonies in each water sample. All bacteria were processed within 6 hours of collection using membrane-filtration methods presented in Myers and Wilde (2003). Fecal coliform bacteria were cultured using the mFC method (American Public Health Association and others, 1992), fecal streptococci bacteria were cultured using the KF membrane filtration method (Myers and Wilde, 2003), and enterococci bacteria were cultured using USEPA method 1600 (U.S. Environmental Protection Agency, 2000a). Determination of *E. coli* bacteria was accomplished using two different agar types throughout the study. From May 15, 2001, through May 22, 2002, the mTec agar (American Public Health Association and others, 1992) was used to determine *E. coli* densities. This agar often had other bacterial growth on the plate that interfered with the growth of the *E. coli* bacteria colonies thus creating difficulties with obtaining ideal

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counts of the *E. coli* colonies. To remedy this problem, the USGS laboratory in Lawrence, Kansas, began use of a modified mTec agar (U.S. Environmental Protection Agency, 2002a) for determining *E. coli* after May 22, 2002.

Slightly different minimum reporting and detection levels are possible as a result of the same constituent being analyzed at different laboratories. Concentrations are reported as less than the minimum reporting level specific to the given laboratory for samples in which the constituent was either not detected or could not be identified. Constituents that were detected at concentrations less than the minimum reporting level and that could be identified are reported as estimated. Estimated concentrations are noted with a remark code of "E" preceding the value in the data tables and should be used with the knowledge that there are increased uncertainties associated with these data (Childress and others, 1999). The remark code "E" also is used in the reporting of bacterial data where calculations to determine concentrations were based on nonideal counts of colonies. Ideal counts are ranges of colony counts that are defined for the individual bacteria types. The maximum limit of the range is established because overcrowding of the colonies inhibits the full growth of individual colonies causing atypical growth and increased errors in counting colonies. The lower limit of the ideal range is set as a number below which statistical validity becomes questionable (Britton and Greeson, 1989).

Quality Assurance and Quality Control

Field blank and replicate samples are the two types of quality-control samples collected and analyzed to identify and document variability in the collection and processing of water-quality data as a part of this study. Water-quality samples are collected and processed in the field; therefore, field blank samples were collected throughout the study. Field blank samples are collected by passing blank water through the same sampling equipment as the actual samples and processing the blank sample in the same manner as an actual sample would be processed. The inorganic blank water used in this process is free of impurities and is provided by the USGS Ocala (Florida) Field Services Unit where the blank water is quality assured for use in testing of equipment and environmental conditions. The purpose of field blank samples is to determine the concentrations of target analytes that could be present in the environment in which the samples are collected and processed (Wilde and others, 1999). A field blank sample also will provide information regarding the cleanliness of the sample equipment and if equipment decontamination procedures are effective as well as the effects from laboratory handling.

Replicate samples were collected to identify the variability in sample collection and analysis. A replicate sample is a set of samples collected close in time and space and in a manner so that the samples are thought to be representative of the ambient water composition at the time of the collection. Replicate samples also provide information on the variability introduced from collection, processing, shipping, and laboratory handling and analysis of the sample (Wilde and others, 1999). Quality-

control data are on file with the USGS office in Lawrence, Kansas, and are available upon request.

Six field blank samples were collected between May 2001 through August 2003. Results from the field blank samples showed one detection of calcium of 0.02 mg/L (reporting level 0.01 mg/L) in May 2002. The detected concentration of calcium is very small, especially when considering that the range of calcium concentrations in samples collected as a part of the study was 48 to 200 mg/L of calcium; therefore, the detection of calcium in the field blank sample was not considered to have affected the integrity of the sample data. A subsequent field blank analysis in February 2003 did not have any detections of analytes above their respective reporting levels.

Twenty-two replicate samples were collected from May 2001 through August 2003. Replicate samples were compared with their respective original sample as the relative percentage difference between the two samples. Relative percentage differences were calculated as the difference between the replicate and original sample concentrations divided by the average of the two values, multiplied by 100. Relative percentage differences ranged from 0 to 57 percent depending on the analyte. The largest relative percentage differences occurred in two replicate samples of suspended-sediment concentrations that had relative percentage differences greater than 50 percent. However, the majority of relative percentage differences between analytes were less than 10 percent.

Water Quality on the Prairie Band Potawatomi Reservation

Physical Properties

Physical properties of water include specific conductance, pH, water temperature, turbidity, dissolved oxygen, hardness, oxidation-reduction potential, and acid neutralizing capacity or alkalinity (table 3). Physical properties were measured onsite with a multiparameter water-quality monitor that measured specific conductance, pH, water temperature, turbidity, and dissolved oxygen in surface water. Specific conductance, pH, and turbidity also were measured in samples at NWQL. The acid neutralizing capacity of the surface water and the alkalinity of ground-water samples were determined onsite through titration, and the acid neutralizing capacity for each sample also was determined at the laboratory.

It is important to consider the physical properties of a water sample because these properties are unique in a number of respects and sometimes are affected by other properties. For example, dissolved major ions (calcium, sodium, chloride, and sulfate) have a tendency to increase specific conductance values (Hem, 1992). The physical properties that have current (2004) Kansas Department of Health and Environment (KDHE) water-quality criteria are pH and dissolved oxygen. A drinking-water standard has been established by USEPA for laboratory

turbidity as well as onsite turbidity criteria that are based on the ecoregion of the collection site.

Specific conductance is a measure of the capacity of a sample of water to transmit an electrical current, which is associated with the concentration of ionized substances in the water. Therefore, the specific conductance becomes greater as the amount of ionized substances in the water increases (Hem, 1992). The reporting units for specific conductance in this report are microsiemens per centimeter at 25 °C ($\mu\text{S}/\text{cm}$).

Specific conductance measurements made onsite in surface water ranged from 306 to 1,180 $\mu\text{S}/\text{cm}$, with a median concentration of 646 $\mu\text{S}/\text{cm}$ (table 4). Generally, specific conductance measurements in surface water decreased as flow in the stream increased; however, the majority of samples collected during the reporting period were collected under relatively low-flow conditions, and it was difficult to establish a relation between specific conductance and streamflow for this set of samples. The largest specific conductance measurement, 1,180 $\mu\text{S}/\text{cm}$, was made on February 19, 2003, at Big Elm Creek, 134 Road near Hoyt (site LSC06), when streamflow was 0.18 ft^3/s , and the smallest specific conductance of 306 $\mu\text{S}/\text{cm}$ recorded during the reporting period was on August 28, 2002, for the Little Soldier Creek, 134 Road near Mayetta (site LSC04), when streamflow was 0.01 ft^3/s .

Specific conductance measurements made onsite in ground water ranged from 467 to 2,430 $\mu\text{S}/\text{cm}$ (table 5). The median onsite specific conductance measurement in ground water was 743 $\mu\text{S}/\text{cm}$. The largest specific conductance was detected in water from monitoring well MW03, which also had the largest dissolved-solids concentration compared with water from other wells. Monitoring well MW03 is the deepest well sampled during the study period (table 2), and it is located next to a pumping well (S28-4, fig. 1) that was sampled during the previous study period (results reported in Trombley, 2001) where water sampled on September 22 and 25, 2000, had onsite specific conductance values of 2,650 and 2,560 $\mu\text{S}/\text{cm}$, respectively (Trombley, 2001, table 7).

The pH of a water sample is a measure of the activity of the hydrogen ion and indicates the degree of acidity or alkalinity of a solution. A pH of less than 7.0 standard units is considered acidic and greater than 7.0 standard units is considered alkaline. Generally, the pH of natural stream water ranges from 6.0 to 8.5 standard units (Hem, 1992). Extremes of pH in water can cause stress on aquatic organisms in addition to having effects on stream- or ground-water chemistry because the pH of water can increase the erosional ability of water. The Kansas surface-water-quality standard established by KDHE (2001) is a range from 6.5 to 8.5 standard units and is established for support of aquatic life in the streams. Most ground water found in the United States has a pH ranging from about 6.0 to about 8.5 standard units (Hem, 1992).

Onsite pH measurements in streams on the reservation ranged from 6.9 to 8.5 standard units and were within the Kansas aquatic-life criteria (table 4). The median pH concentration in surface water was 7.9 standard units. Onsite pH measurements of ground-water samples from the Prairie Band

Potawatomi Reservation ranged from 6.8 to 7.5 standard units, with a median concentration of 7.1 standard units (table 5) and were within the expected range for ground water.

The density, solubility of constituents, pH, specific conductance, the rate of chemical reactions and biological activity in water are all temperature dependent. Water temperature in surface water on the reservation ranged from 0.2 to 28.7 °C, with a median concentration of 22 °C and varied seasonally (table 4). Water temperature in ground water ranged from 11.3 to 18.1 °C, with a median concentration of 14 °C (table 5). The highest ground-water temperature was recorded in well MW11 on August 12, 2003. An open, hand-dug well, with a depth of about 10.5 ft below land surface, is located within a few feet of well MW11, and the warmer air temperatures that heat the water in the open well may account for the higher water temperatures in well MW11. Water temperatures in both water samples collected from well MW11 were higher than samples collected from other wells.

Turbidity is a water-quality term that refers to the cloudy appearance of water and is caused by particles or "suspended matter." Turbidity is measured by quantifying the amount of light scattered by particles in the water. Although turbid water generally is not harmful, it can be a sign of more serious problems because turbidity particles may absorb or be associated with other harmful contaminants. However, some suspended matter that causes turbidity in water is known to be harmful and includes asbestos, lead, bacteria, viruses, and protozoan cysts such as *Giardia* and *Cryptosporidium*. Turbidity also can interfere with the disinfection of drinking water. Turbidity measurements have been used to estimate bacteria densities using site-specific regression equations developed for selected sites in Kansas where real-time turbidity data are available (Rasmussen and Ziegler, 2003).

The water-quality criteria for turbidity established by USEPA (2004a) state that at no time can turbidity in finished drinking water exceed 5 nephelometric turbidity units (NTU), and systems that filter must ensure that turbidity in finished drinking water does not exceed 1 NTU in at least 95 percent of daily turbidity samples. USEPA also has established water-quality criteria for onsite turbidity in streams and rivers according to ecoregions. An ecoregion is defined as an area of similar climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables (U.S. Environmental Protection Agency, 2001). The Prairie Band Potawatomi Reservation is located at the convergence of three of USEPA's defined Level III ecoregions; these are ecoregions IV, VI, and IX (U.S. Environmental Protection Agency, 2000b, 2000c, 2001). Each ecoregion is assigned a unique turbidity criterion, the largest turbidity criterion on the reservation is established for ecoregion IV and is 6.4 NTU (U.S. Environmental Protection Agency, 2001).

Onsite turbidity is reported in two separate columns in table 4 because the differences in the measurement techniques that are encountered with the continuing advancement of technologies used to measure turbidity. The two turbidity sensors used during the study described in this report were the YSI 6026

Table 4. Streamflow measurements and results of analysis of physical properties in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.

[ft³/s, cubic feet per second; μS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; YSI, Yellow Springs Instruments Incorporated, Yellow Springs, Ohio; Hach 2100 AN, HACH Company, Loveland, Colorado; NTU, nephelometric turbidity units; mg/L, milligrams per liter; mg/L as CaCO₃, milligrams per liter as calcium carbonate; --, not determined; E, estimated]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Streamflow (ft ³ /s)	Specific conductance, onsite (μS/cm)	Specific conductance, laboratory (μS/cm)	pH, onsite (standard units)	pH, laboratory (standard units)	Air temperature (°C)	Water temperature (°C)	Turbidity, onsite, YSI 6026 (NTU)	Turbidity, onsite, YSI 6136 (NTU)	Turbidity, laboratory, Hach2100 AN (NTU)	Dissolved oxygen (mg/L)	Total calculated hardness (mg/L as CaCO ₃)	Acid neutralizing capacity, total, onsite (mg/L as CaCO ₃)	Acid neutralizing capacity, total, laboratory (mg/L as CaCO ₃)
Water-quality criteria																
			--	--	--	¹ 6.5–8.5	--	--	--	--	--	² 5	15	--	--	--
Bills Creek Basin																
BC01	Bills Creek, U.S Highway 75 near Holton	06/12/01	0.06	609	--	7.5	--	27.8	22.4	98	--	--	6.2	--	--	--
Little Soldier Creek Basin																
LSC01	Little Soldier Creek, 190 Road near Mayetta	06/12/01	.10	542	--	8.1	--	32.4	25.6	140	--	--	7.7	--	--	--
LSC02	Little Soldier Creek, 174 Road near Mayetta	06/12/01	.50	625	--	8.0	--	30.2	24.5	26	--	--	8.3	--	--	--
LSC03	Little Soldier Creek, O Road near Mayetta	05/15/01	.70	636	--	7.9	--	21.0	21.4	--	--	--	6.5	--	--	--
		06/12/01	1.6	574	--	8.1	--	23.1	25.5	76	--	37	--	--	--	--
		11/13/01	.83	704	723	8.0	8.1	16.0	12.1	1.4	--	1.3	8.2	370	--	380
		02/12/02	1.0	623	624	8.1	8.1	--	2.6	4.6	--	6.8	14	310	--	290
		05/22/02	2.6	658	663	8.0	8.3	--	16.1	--	8.2	3.4	14	350	300	300
		08/28/02	.01	355	331	7.8	7.9	22.0	23.8	--	50	28	6.8	170	160	160
		11/13/02	.40	332	332	7.7	7.8	14.0	6.8	--	15	21	7.7	250	260	E260
		02/19/03	.59	575	575	7.7	8.0	2.5	.6	--	--	15	9.3	290	--	E260
05/14/03	1.6	640	640	7.6	8.1	26.0	20.1	--	8.1	4.6	8.2	320	310	240		
LSC04	Little Soldier Creek, 134 Road near Mayetta	05/15/01	.93	629	--	7.8	--	23.5	20.7	--	--	--	6.0	--	--	--
		06/12/01	2.1	570	--	7.7	--	25.0	23.4	48	--	31	7.2	--	--	--
		11/13/01	1.1	696	714	8.1	8.1	16.0	12.9	1.9	--	1.7	12	360	--	380
		02/12/02	1.5	640	638	8.1	8.1	4.0	.9	16	--	3.2	15	310	--	290
		05/22/02	3.7	675	681	8.0	8.2	--	16.0	--	11	7.1	11	320	300	320

Table 4. Streamflow measurements and results of analysis of physical properties in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

[ft³/s, cubic feet per second; μS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; YSI, Yellow Springs Instruments Incorporated, Yellow Springs, Ohio; Hach 2100 AN, HACH Company, Loveland, Colorado; NTU, nephelometric turbidity units; mg/L, milligrams per liter; mg/L as CaCO₃, milligrams per liter as calcium carbonate; --, not determined; E, estimated]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Streamflow (ft ³ /s)	Specific conductance, onsite (μS/cm)	Specific conductance, laboratory (μS/cm)	pH, onsite (standard units)	pH, laboratory (standard units)	Air temperature (°C)	Water temperature (°C)	Turbidity, onsite, YSI 6026 (NTU)	Turbidity, onsite, YSI 6136 (NTU)	Turbidity, laboratory, Hach2100 AN (NTU)	Dissolved oxygen (mg/L)	Total calculated hardness (mg/L as CaCO ₃)	Acid neutralizing capacity, total, onsite (mg/L as CaCO ₃)	Acid neutralizing capacity, total, laboratory (mg/L as CaCO ₃)
Little Soldier Creek Basin—Continued																
LSC04	Little Soldier Creek, 134 Road near Mayetta—Continued	08/28/02	0.01	306	325	7.5	8.0	--	22.5	--	33	20	7.6	160	150	160
		11/13/02	.17	484	457	7.6	8.0	1.0	2.9	--	5.0	8.6	9.7	230	230	E230
		02/19/03	.86	565	542	7.8	8.0	.2	.9	--	1.1	2.5	15	280	--	E220
		05/14/03	1.8	622	588	7.6	8.1	18.5	17.8	--	5.0	7.8	7.5	310	290	240
LSC05	Little Soldier Creek tributary, 134 Road near Hoyt	06/12/01	.56	553	--	7.7	--	27.0	23.4	24	--	--	7.5	--	--	--
LSC06	Big Elm Creek, 134 Road near Hoyt	05/15/01	.38	870	--	7.8	--	19.2	--	--	--	--	7.6	--	--	--
		06/12/01	.54	789	--	7.5	--	25.0	22.0	--	--	7.8	7.4	--	--	--
		08/21/01	.01	875	--	7.6	--	23.8	21.9	.6	--	3.3	7.0	--	--	--
		11/13/01	.39	1,010	1,030	7.9	8.0	14.0	11.8	1.5	--	1.9	8.5	340	--	310
		02/12/02	.36	1,091	1,060	7.9	8.1	4.0	1.2	4.3	--	4.7	15	330	--	250
		05/22/02	1.0	793	798	7.9	8.3	--	14.7	--	2.4	1.7	12	330	360	270
		08/28/02	.20	964	906	7.2	7.9	19.4	22.3	--	2.3	2.2	6.1	280	320	240
		11/13/02	.06	1,080	1,020	7.1	8.0	-1.0	3.0	--	1.0	2.4	9.4	300	350	E240
		02/19/03	.18	1,180	1,140	7.2	7.9	-1.5	.2	--	2.7	8.9	15	300	--	E240
		05/14/03	.14	865	865	6.9	8.1	--	16.3	--	3.1	3.1	7.6	310	260	250
LSC07	Little Elm Creek, Q Road near Hoyt	06/12/01	.21	584	--	7.8	--	28.0	24.1	22	--	--	7.5	--	--	--
LSC08	Big Elm Creek, P Road near Hoyt	06/12/01	.98	646	--	7.8	--	31.5	28.7	1.7	--	--	6.9	--	--	--
LSC09	Little Soldier Creek, 126 Road near Hoyt	06/12/01	3.6	598	--	8.0	--	30.0	27.5	68	--	--	7.7	--	--	--

Table 4. Streamflow measurements and results of analysis of physical properties in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

[ft³/s, cubic feet per second; μS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; YSI, Yellow Springs Instruments Incorporated, Yellow Springs, Ohio; Hach 2100 AN, HACH Company, Loveland, Colorado; NTU, nephelometric turbidity units; mg/L, milligrams per liter; mg/L as CaCO₃, milligrams per liter as calcium carbonate; --, not determined; E, estimated]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Streamflow (ft ³ /s)	Specific conductance, onsite (μS/cm)	Specific conductance, laboratory (μS/cm)	pH, onsite (standard units)	pH, laboratory (standard units)	Air temperature (°C)	Water temperature (°C)	Turbidity, onsite, YSI 6026 (NTU)	Turbidity, onsite, YSI 6136 (NTU)	Turbidity, laboratory, Hach2100 AN (NTU)	Dissolved oxygen (mg/L)	Total calculated hardness (mg/L as CaCO ₃)	Acid neutralizing capacity, total, onsite (mg/L as CaCO ₃)	Acid neutralizing capacity, total, laboratory (mg/L as CaCO ₃)
Soldier Creek Basin																
SC01	Soldier Creek, 214 Road near Circleville	06/13/01	12	637	--	7.8	--	28.0	24.1	22	--	--	7.5	--	--	--
SC02	Soldier Creek tributary, G Road near Circleville	06/13/01	1.4	749	--	7.8	--	31.5	28.7	1.7	--	--	6.9	--	--	--
SC03	Soldier Creek near Saint Clere	05/15/01	14	679	--	8.0	--	31.0	23.4	--	--	--	8.2	--	--	--
		06/13/01	21	635	--	7.9	--	23.5	23.8	59	--	29	7.8	--	--	--
		08/21/01	3.2	618	--	8.0	--	27.0	24.0	23	--	12	7.5	--	--	--
		11/13/01	12	752	770	8.5	8.1	16.0	11.6	10	--	5.4	10	380	--	330
		02/12/02	9.1	735	731	8.0	8.2	10.0	5.0	12	--	7.3	14	360	--	260
		05/22/02	28	670	659	8.2	8.1	--	19.1	--	20	11	14	350	270	270
		08/28/02	1.6	662	607	7.7	8.1	25.0	24.6	--	4.5	20	9.8	320	200	210
		11/13/02	3.3	746	719	7.9	8.0	13.0	5.3	--	3.4	6.8	12	380	280	E230
		02/19/03	3.9	771	745	8.0	8.0	5.5	4.1	--	2.5	3.5	12	390	--	E140
		05/14/03	11	608	596	7.6	8.1	24.0	19.6	--	16	36	8.3	310	260	250
SC04	Soldier Creek, 158 Road near Saint Clere	08/20/03	.03	669	626	7.9	7.9	30.5	26.1	--	18	32	7.2	310	--	230
		06/13/01	23.2	633	--	8.1	--	31.0	26.8	65	--	--	8.7	--	--	--
SC05	Crow Creek, 166 Road near Saint Clere	06/13/01	.91	617	--	7.9	--	33.0	24.7	28	--	--	7.3	--	--	--
SC06	South Branch Soldier Creek, H.5 Road near Saint Clere	06/13/01	.33	727	--	8.0	--	32.5	24.1	23	--	--	7.0	--	--	--

Table 4. Streamflow measurements and results of analysis of physical properties in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

[ft³/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; YSI, Yellow Springs Instruments Incorporated, Yellow Springs, Ohio; Hach 2100 AN, HACH Company, Loveland, Colorado; NTU, nephelometric turbidity units; mg/L, milligrams per liter; mg/L as CaCO₃, milligrams per liter as calcium carbonate; --, not determined; E, estimated]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Streamflow (ft ³ /s)	Specific conductance, onsite (µS/cm)	Specific conductance, laboratory (µS/cm)	pH, onsite (standard units)	pH, laboratory (standard units)	Air temperature (°C)	Water temperature (°C)	Turbidity, onsite, YSI 6026 (NTU)	Turbidity, onsite, YSI 6136 (NTU)	Turbidity, laboratory, Hach2100 AN (NTU)	Dissolved oxygen (mg/L)	Total calculated hardness (mg/L as CaCO ₃)	Acid neutralizing capacity, total, onsite (mg/L as CaCO ₃)	Acid neutralizing capacity, total, laboratory (mg/L as CaCO ₃)
Soldier Creek Basin—Continued																
SC07	Soldier Creek, I Road near Delia	05/15/01	20	646	--	8.1	--	32.0	26.1	--	--	--	7.7	--	--	--
		06/13/01	30	631	--	8.2	--	32.0	25.9	87	--	38	7.0	--	--	--
		08/21/01	3.2	576	--	8.3	--	30.0	26.7	29	--	16	9.3	--	--	--
		11/13/01	17	726	700	8.3	8.1	17.0	11.4	7.5	--	3.7	--	370	--	310
		02/12/02	16	704	690	8.3	8.1	8.0	4.0	21	--	12	17	340	--	260
		05/22/02	32	689	684	8.2	8.2	--	18.4	--	40	27	12	360	310	280
		08/28/02	4.2	564	513	8.0	8.2	--	27.7	--	60	33	9.1	260	210	220
		11/13/02	6.8	686	659	8.0	8.1	13.0	7.4	--	5.9	9.7	11	350	300	E290
		02/19/03	8.5	657	636	8.2	8.0	8.5	3.3	--	3.2	5.1	9.8	300	--	E160
		05/14/03	20	608	573	7.7	8.2	25.0	22.3	--	56	25	8.9	300	250	240
		08/20/03	.08	669	599	7.5	8.0	28.5	24.7	--	27	32	5.2	250		210
SC08	James Creek, 142 Road near Delia	06/13/01	.05	662	--	7.8	--	32.0	22.8	--	--	--	6.1	--	--	--
SC09	James Creek, 126 Road near Delia	06/13/01	.37	614	--	7.9	--	--	22.6	19	--	--	6.9	--	--	--
South Cedar Creek Basin																
SCC01	South Cedar Creek, U.S. Highway 75 near Mayetta	06/12/01	.62	610	--	8.0	--	27.0	22.7	36	--	--	8.0	--	--	--

¹Water-quality criteria established for aquatic life by the Kansas Department of Health and Environment (2001).

²Water-quality criteria established for drinking water by the U.S. Environmental Protection Agency (2004a).

Table 5. Results of analysis of physical properties in ground-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, April through August 2003.

[$\mu\text{S/cm}$, microsiemens per centimeter at 25 degrees Celsius; $^{\circ}\text{C}$, degrees Celsius; NTU, nephelometric turbidity units; mg/L, milligrams per liter; mg/L as CaCO_3 , milligrams per liter as calcium carbonate; mV, millivolts; --, not determined; E, estimated]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Specific conductance, onsite ($\mu\text{S/cm}$)	Specific conductance, laboratory ($\mu\text{S/cm}$)	pH, onsite (standard units)	pH, laboratory (standard units)	Air temperature ($^{\circ}\text{C}$)	Water temperature ($^{\circ}\text{C}$)	Turbidity, onsite, Lamotte 2020 turbidity meter (NTU)	Dissolved oxygen (mg/L)	Total calculated hardness (mg/L as CaCO_3)	Oxidation-reduction (redox) potential (mV)	Acid neutralizing capacity, total, laboratory (mg/L as CaCO_3)	Alkalinity, water, filtered, incremental titration, onsite, (mg/L as CaCO_3)
			Water-quality criteria											
			--	--	--	¹ 6.5–8.5	--	--	² 5	15	--	--	--	--
			Ground-water quality											
MW01	Monitoring well #1	08/13/03	686	675	7.1	7.3	29.0	13.8	0.20	0.14	320	110	280	290
MW02	Monitoring well #2	04/30/03	467	455	6.8	7.2	28.0	11.3	.34	1.9	240	520	230	220
		08/14/03	492	468	6.9	7.2	--	14.4	4.3	2.9	230	220	190	240
MW03	Monitoring well #3	08/13/03	2,430	2,440	6.9	7.0	--	14.4	.32	.14	800	100	370	400
MW04	Monitoring well #4	05/2/03	851	665	7.3	7.4	22.0	14.0	36	3.0	280	50	330	300
		08/14/03	735	643	7.5	7.5	--	14.0	14	E8.5	250	151	370	310
MW05	Monitoring well #5	04/29/03	743	736	7.2	7.5	23.9	12.3	84	2.6	360	375	350	260
MW06	Monitoring well #6	04/30/03	770	740	6.9	7.1	--	14.2	.30	1.2	380	180	380	380
		08/13/03	775	754	6.9	7.0	28.5	14.3	.15	.21	400	90	390	400
MW07	Monitoring well #7	04/29/03	576	557	7.1	7.4	26.0	13.7	2.5	.34	310	431	310	260
MW08	Monitoring well #8	04/30/03	875	857	6.9	7.1	--	13.5	.64	.37	440	320	400	330
MW09	Monitoring well #9	05/1/03	517	484	7.4	7.8	--	12.9	2.6	9.9	270	570	270	270
MW10	Monitoring well #10	05/2/03	621	603	7.1	7.5	22.0	14.6	5.2	5.4	330	240	300	290
MW11	Monitoring well #11	05/2/03	836	797	7.1	7.4	22.0	16.0	18	1.3	400	380	400	350
		08/12/03	813	826	7.0	7.1	--	18.1	100	1.0	410	240	420	350

¹Water-quality criteria established for aquatic life by the Kansas Department of Health and Environment (2001).

²Water-quality criteria established for drinking water by the U.S. Environmental Protection Agency (2004a).

and the YSI 6136 turbidity sensors (Yellow Springs Instruments Incorporated, Yellow Springs, Ohio). The two sensors have different ranges and ability to measure turbidity; therefore, the measurements obtained by the different sensors cannot be compared directly. The instrument used to measure turbidity can have a substantial effect on the measured turbidity level (Ziegler, 2003).

The YSI 6026 sensor was used for surface-water onsite turbidity measurements from June 2001 through February 2002, and the YSI 6136 sensor was used to measure onsite turbidity for the remainder of the study. Surface-water onsite turbidity measured by the YSI 6026 sensor ranged from 0.6 to 140 NTU (table 4), with a median concentration of 22 NTU. The largest turbidity was measured at site LSC01 on June 12, 2001. This turbidity value (140 NTU) corresponds to the second largest total suspended-solids concentration (58 mg/L, table 18, results presented in the "Sediment" section). Surface-water onsite turbidity measured by the YSI 6136 sensor ranged from 1.0 to 60 NTU (table 4), with a median concentration of 7 NTU. Turbidity samples measured at the laboratory using a HACH 2100AN turbidity meter in differential mode (HACH Company, Loveland, Colorado) ranged from 1.3 to 38 NTU (table 4), with a median concentration of 7.8 NTU. The largest concentration of laboratory turbidity occurred in a sample from site SC07 collected on June 13, 2001, and corresponded to the largest concentration of total suspended solids detected during this study (table 18, results presented in the "Sediment" section). Turbidity concentrations in nearly all surface-water samples often exceeded both the water-quality criterion for ecoregion IV and the criterion of 5 NTU established for drinking water by USEPA (2004a).

Turbidity measurements in ground water were made using a LaMotte 2020 turbidity meter (LaMotte Company, Chestertown, Maryland). Turbidity concentrations in ground-water samples ranged from 0.15 to 100 NTU in (table 5). The largest turbidity concentration was measured in a sample from well MW11 collected on August 12, 2003. The larger turbidity values occurred in water from wells that had slow recovery rates during pumping and were difficult to sample with the submersible pump. Monitoring wells MW04, MW05, and MW09 were sampled using a Teflon bailer because recovery rates could not maintain ground-water levels necessary for sampling water with the submersible pump. Water sampled from wells MW04 and MW05 recorded the second and third largest turbidity values. Monitoring well MW11 was not bailed, but it was very difficult to maintain flow without substantial drawdown in the well. This difficulty in maintaining consistent flow conditions probably contributed to the large turbidity values in water from this well. The median concentration of turbidity was 2 NTU in the remainder of the wells (table 5).

The concentration of dissolved oxygen in surface water is related to atmospheric reaeration, photosynthetic activity of aquatic plants, temperature, and salinity of the water (Radtke and others, 1998). Dissolved oxygen contributes to chemical reactions in water and in the survival of aquatic organisms.

KDHE (2001) has established an aquatic-life support standard of not less than 5.0 mg/L dissolved oxygen.

Dissolved oxygen concentrations in ground water are one indicator of the oxidation-reduction (redox) environment of the ground water in the vicinity of the monitoring well. Oxygen is supplied to ground water through recharge and by movement of air through the unsaturated zone above the water table. As the oxygen moves through the system it reacts with oxidizable material. Measurable amounts of dissolved oxygen in ground water may persist for long distances if little reactive material is available along the flow path (Hem, 1992).

The range of onsite dissolved oxygen measurements in surface water collected during the reporting period was 5.2 to 17 mg/L (table 4) and is within the standard. The median dissolved oxygen concentration for surface water was 8.2 mg/L. Dissolved oxygen concentrations in ground water ranged from 0.14 to 9.9 mg/L, and the median concentration was 1.3 mg/L. The largest dissolved oxygen concentrations in ground water were detected in monitoring wells MW04 and MW09 (table 5).

The oxidation-reduction (redox) potential (Eh) is a numerical index of the intensity of oxidizing or reducing conditions within a system (Hem, 1992). Eh was measured as a part of the ground-water-quality sampling to determine the redox conditions of the ground-water environment in the vicinity of the well. The redox potential of a system is important because the amount of oxygen in an environmental system is one of the factors affecting the chemical precipitation and dissolution of rocks and minerals. Some water-quality constituents such as arsenic, iron, and selenium are sensitive to the redox environment, and any change to the redox potential in an environment potentially could cause these constituents to dissolve into solution from surrounding aquifer material or to precipitate out of solution into the aquifer. Both situations eventually could affect the permeability of the aquifer material in addition to releasing potentially harmful constituents such as arsenic. Positive potentials indicate that the system is relatively oxidizing, and negative potentials indicate that it is relatively reducing (Hem, 1992).

The Eh measurements in samples from the monitoring wells ranged from 50 to 570 mV, with a median value of 240 mV (table 5). The smallest redox potential was measured in a sample from monitoring well MW04 collected on May 2, 2003, and the largest potential was measured in a sample from monitoring well MW09 collected on May 1, 2003.

Hardness is a characteristic of water that causes an increase in soap consumption in water used for cleaning. The presence of calcium as well as magnesium (discussed in the section on "Major Ions") contributes to the "hardness" of water. Hard water is typical in regions largely dominated by carbonate rocks at the land surface and causes increased expense in water treatment as well as sometimes requiring further treatment by consumers in the form of water softeners. The hardness of water is computed by multiplying the sum of milliequivalents per liter (meq/L) of calcium and magnesium by 50. The resulting hardness value is expressed as "hardness as CaCO₃" (Hem, 1992). Milligrams-per-liter values may be converted to milliequiva-

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lents per liter by multiplying the milligrams per liter by the reciprocals of the combining weights of the appropriate ions (Hem, 1992). Water with total calculated hardness concentrations of 0 to 60 is considered “soft,” from 61 to 120 mg/L is considered “moderately hard,” from 121 to 180 mg/L is considered “hard,” and greater than 180 mg/L, “very hard” (Hem, 1992).

Total calculated hardness in surface-water samples ranged from 160 to 390 mg/L as CaCO_3 (table 4), with a median concentration of 310 mg/L, and total calculated hardness in ground-water samples ranged from 230 to 800 mg/L as CaCO_3 (table 5) with a median concentration of 330 mg/L.

The acid neutralizing capacity (ANC) or alkalinity of a solution is defined as the capacity of solutes it contains to react with and neutralize acid (Hem, 1992). The properties of alkalinity evaluate the potential of the solution for some kinds of water-rock interaction or interaction with other material the water may contact (Hem, 1992). ANC is determined by titration of an unfiltered sample, whereas alkalinity is determined by titration of a filtered water sample.

The range of laboratory measurements of the ANC of surface-water samples collected as a part of this study was an estimated 140 to 380 mg/L as CaCO_3 , with a median concentration of 260 mg/L as CaCO_3 (table 4). The range of laboratory ANC measurements in ground-water samples collected as a part of this study was 190 to 420 mg/L as CaCO_3 , with a median concentration of 350 mg/L as CaCO_3 (table 5).

Dissolved Solids

Dissolved solids in natural water consist primarily of the cations calcium, magnesium, sodium, and potassium and the anions bicarbonate, sulfate, and chloride. Dissolved solids in surface water are a result of natural dissolution of rocks and minerals or of discharges from municipal or industrial sources (Hem, 1992). Dissolved-solids concentrations are used widely as an evaluation of water quality. Freshwater has dissolved-solids concentrations less than 1,000 mg/L, whereas slightly saline water ranges from 1,000 to 3,000 mg/L (Hem, 1992). According to USEPA (1986), excess dissolved solids are objectionable in drinking water because of possible physiological effects, unpalatable mineral tastes, and higher costs because of corrosion or the necessity for additional treatment. Consequently, USEPA established a Secondary Drinking-Water Regulation (SDWR) for dissolved solids of 500 mg/L.

Dissolved-solids concentrations in surface-water samples collected for this study ranged from 204 to 671 mg/L, with the largest concentration occurring in a sample from site LSC06 (table 6, fig. 4A). The median concentration for dissolved solids in surface water was 389 mg/L. Six of seven samples from site LSC06 exceeded the SDWR of 500 mg/L for dissolved solids and corresponds to large concentrations of major ions in water samples from site LSC06 (table 6, major ion results discussed in following “Major Ions” section). Site LSC06 is located downstream from a discharging sewage-treatment lagoon, and larger concentrations of dissolved ions and dissolved solids generally are found downstream of treated sewage

effluent when compared to upstream concentrations. Six of 37 surface-water samples (16 percent) exceeded the 500-mg/L SDWR.

The range of dissolved-solids concentrations in ground-water samples was 280 to 1,840 mg/L. The largest concentration was in a sample from well MW03, which was approximately four times larger than the median concentration of 442 mg/L from all the ground-water samples (table 7, fig. 4B), and also corresponds to large concentrations of major ions in the water sample from this monitoring well (table 7, discussion of results in following “Major Ions” section). Twenty percent of the ground-water samples had dissolved-solids concentrations equal to or greater than the SDWR of 500 mg/L (fig. 4B). Dissolved solids were identified as exceeding the SDWR by Trombley (2001) and continue to exceed the SDWR in the current ground-water assessment in three of the monitoring wells. Treatment to remove the dissolved solids may be needed in the event water resources on the reservation are used as a source for public drinking-water supply.

Major Ions

Major ions in natural water typically are a result of the dissolution of rocks and minerals but also can occur in discharge from municipal or industrial sources (Hem, 1992). Excessively large concentrations of major ions are objectionable in drinking water because of possible physiological effects, unpleasant taste, and greater costs due to corrosion or the need for additional treatment (U.S. Environmental Protection Agency, 1986). The major ions analyzed for this study included calcium, magnesium, sodium, potassium, bicarbonate, carbonate, sulfate, chloride, fluoride, and silica. Secondary Drinking-Water Regulations have been established by USEPA (2004a) for sulfate (250 mg/L) and chloride (250 mg/L) concentrations in finished drinking water, and a Drinking-Water Advisory has been established by USEPA (2004a) for sodium concentrations (20 mg/L) in finished drinking water. Results of analyses for major ions in surface- and ground-water samples are reported in tables 6 and 7, respectively.

Calcium is a major constituent of carbonate rocks such as limestone and dolomite, and it dissolves readily in water; therefore, the calcium concentration in water from areas with carbonate rocks and associated deposits tends to be larger than in other areas (Hem, 1992). Carbonate rocks predominate the surface and near-surface geology in Kansas including the Prairie Band Potawatomi Reservation (fig. 3). Large concentrations of calcium are objectionable in domestic water supplies because they contribute to the hardness of the water and tend to cause encrustations on cooking utensils, pipes, and in water heaters.

Calcium concentrations in surface-water samples ranged from 48 to 120 mg/L, with a median concentration of 90 mg/L (table 6). Calcium concentrations in ground-water samples ranged from 67 to 200 mg/L (table 7). The median calcium concentration in ground-water samples was 96 mg/L and is typical of ground water from a carbonate setting.

Table 6. Results of analysis of dissolved solids and major ions in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.

[Water-quality criteria established by the U.S. Environmental Protection Agency (1986, 2003, 2004a); mg/L, milligrams per liter; mg/L as HCO₃, milligrams per liter as bicarbonate; mg/L as CaCO₃, milligrams per liter as calcium carbonate; SDWR, Secondary Drinking-Water Regulation; DWA, Drinking-Water Advisory; --, not determined]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Dissolved solids (mg/L)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Bicarbonate, total, onsite (mg/L as HCO ₃)	Carbonate, total, onsite (mg/L as CaCO ₃)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L)
			Water-quality criteria										
			500 (SDWR)	--	--	20 (DWA)	--	--	--	250 (SDWR)	250 (SDWR)	2.0 (SDWR)	--
			Little Soldier Creek Basin										
LSC03	Little Soldier Creek, O Road near Mayetta	05/15/01	--	--	--	--	--	--	--	--	--	--	--
		06/12/01	--	--	--	--	--	--	--	--	--	--	--
		11/13/01	360	110	26	18	3.6	--	--	49	8.6	0.3	15
		02/12/02	382	87	22	16	2.0	--	--	51	8.3	.3	9.7
		05/22/02	373	100	24	16	3.0	380	0	47	6.4	.2	8.8
		08/28/02	206	48	11	8.1	1.1	190	0	18	4.1	.3	9.3
		11/13/02	327	71	17	11	3.2	220	0	32	4.5	.3	13
		02/19/03	340	81	21	14	2.3	--	--	41	5.4	.2	8.1
		05/14/03	373	90	24	17	3.3	380	0	41	6.9	.3	7.2
		LSC04	Little Soldier Creek, 134 Road near Mayetta	05/15/01	--	--	--	--	--	--	--	--	--
06/12/01	--			--	--	--	--	--	--	--	--	--	--
11/13/01	366			100	24	18	4.0	--	--	45	9.5	.3	13
02/12/02	388			87	22	17	2.2	--	--	56	12	.3	10
05/22/02	397			94	21	15	2.9	310	0	49	9.3	.3	11
08/28/02	204			49	10	7.8	3.9	180	0	17	3.8	.3	9.7
11/13/02	302			68	16	11	4.6	280	0	28	5.1	.3	12
02/19/03	294			78	20	15	2.7	--	--	36	7.3	.2	8.0
05/14/03	363			88	23	17	3.5	350	0	41	7.3	.3	6.4
LSC06	Big Elm Creek, 134 Road near Hoyt			05/15/01	--	--	--	--	--	--	--	--	--
		06/12/01	--	--	--	--	--	--	--	--	--	--	--
		08/21/01	--	--	--	--	--	--	--	--	--	--	--
		11/13/01	630	100	21	84	5.4	--	--	88	120	.4	18

Table 6. Results of analysis of dissolved solids and major ions in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

[Water-quality criteria established by the U.S. Environmental Protection Agency (1986, 2003, 2004a); mg/L, milligrams per liter; mg/L as HCO₃, milligrams per liter as bicarbonate; mg/L as CaCO₃, milligrams per liter as calcium carbonate; SDWR, Secondary Drinking-Water Regulation; DWA, Drinking-Water Advisory; --, not determined]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Dissolved solids (mg/L)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Bicarbonate, total, onsite (mg/L as HCO ₃)	Carbonate, total, onsite (mg/L as CaCO ₃)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L)
Little Soldier Creek Basin—Continued													
LSC06	Big Elm Creek, 134 Road near Hoyt—Continued	02/12/02	656	98	21	92	4.4	--	--	98	140	0.4	13
		05/22/02	488	98	20	46	3.8	440	0	86	50	.3	12
		08/28/02	556	86	17	76	4.6	280	0	70	120	.4	19
		11/13/02	636	89	19	99	6.3	300	0	88	140	.4	16
		02/19/03	671	89	19	110	7.6	--	--	99	170	.4	11
		05/14/03	521	92	20	73	6.4	320	0	86	88	.4	7.4
Soldier Creek Basin													
SC03	Soldier Creek near Saint Clere	05/15/01	--	--	--	--	--	--	--	--	--	--	--
		06/13/01	--	--	--	--	--	--	--	--	--	--	--
		08/21/01	--	--	--	--	--	--	--	--	--	--	--
		11/13/01	398	110	25	20	2.9	--	--	100	16	.3	7.2
		02/12/02	456	100	24	21	2.0	--	--	110	15	.2	12
		05/22/02	389	100	22	16	2.9	320	0	81	11	.3	9.8
		08/28/02	424	93	22	16	3.0	350	0	110	14	.3	11
		11/13/02	491	110	25	20	2.6	340	0	120	14	.3	11
		02/19/03	495	120	25	21	2.2	--	--	150	17	.2	6.3
		05/14/03	362	89	20	17	3.5	320	0	69	11	.3	8.0
SC07	Soldier Creek, I Road near Delia	08/20/03	413	81	24	27	3.3	--	--	85	29	.4	16
		05/15/01	--	--	--	--	--	--	--	--	--	--	--
		06/13/01	--	--	--	--	--	--	--	--	--	--	--
		08/21/01	--	--	--	--	--	--	--	--	--	--	--
		11/13/01	372	100	26	23	2.6	--	--	84	20	.25	5.9
		02/12/02	410	97	23	21	1.9	--	--	90	17	.3	10

Table 6. Results of analysis of dissolved solids and major ions in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

[Water-quality criteria established by the U.S. Environmental Protection Agency (1986, 2003, 2004a); mg/L, milligrams per liter; mg/L as HCO₃, milligrams per liter as bicarbonate; mg/L as CaCO₃, milligrams per liter as calcium carbonate; SDWR, Secondary Drinking-Water Regulation; DWA, Drinking-Water Advisory; --, not determined]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Dissolved solids (mg/L)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Bicarbonate, total, onsite (mg/L as HCO ₃)	Carbonate, total, onsite (mg/L as CaCO ₃)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L)
Soldier Creek Basin—Continued													
SC07	Soldier Creek, I Road near Delia—Continued	05/22/02	403	110	23	18	2.9	380	0	66	13	0.36	12
		08/28/02	340	74	18	16	3.7	250	0	62	15	.36	12
		11/13/02	399	100	25	18	2.8	370	0	60	11	.33	9.4
		02/19/03	422	86	21	18	1.8	--	--	93	16	.26	5.2
		05/14/03	317	85	21	19	3.2	310	0	49	11	.27	7.0
		08/20/03	297	64	23	37	3.8	--	--	50	43	.38	6.9

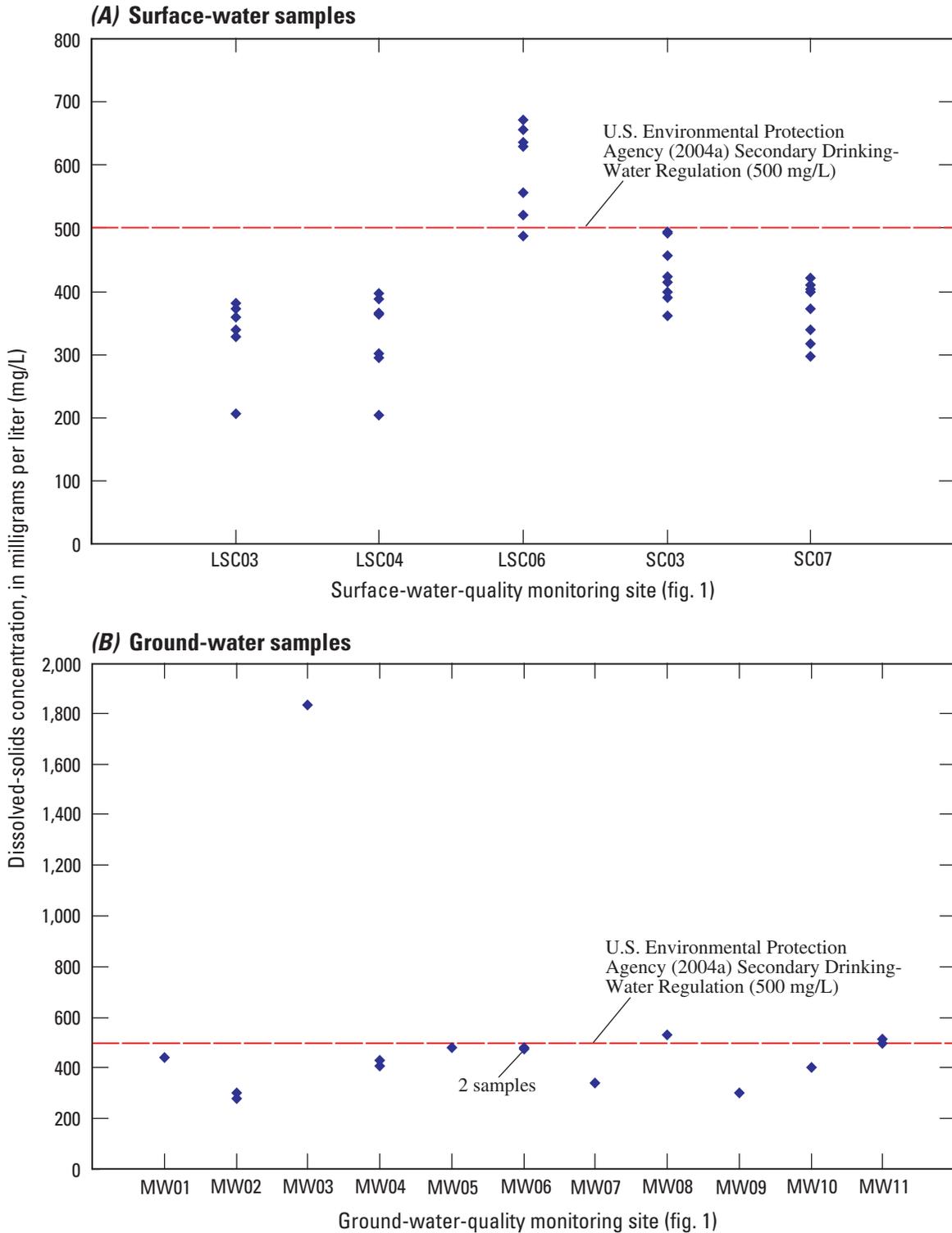


Figure 4. Concentrations of dissolved solids in (A) surface-water-quality samples and (B) ground-water-quality samples, May 2001 through August 2003. Secondary Drinking-Water Regulation from U.S. Environmental Protection Agency (2004a).

Table 7. Results of analysis of dissolved solids and major ions in ground-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, April through August 2003.

[Water-quality criteria established by the U.S. Environmental Protection Agency (2004a). mg/L, milligrams per liter; mg/L as HCO₃, milligrams per liter as bicarbonate; mg/L as CaCO₃, milligrams per liter as calcium carbonate; SDWR, Secondary Drinking-Water Regulation; DWA, Drinking-Water Advisory; --, not determined]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Dissolved solids, dissolved (mg/L)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Bicarbonate, total, onsite (mg/L as HCO ₃)	Carbonate, total, onsite (mg/L as CaCO ₃)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L)
Water-quality criteria													
			500 (SDWR)	--	--	20 (DWA)	--	--	--	250 (SDWR)	250 (SDWR)	2.0 (SDWR)	--
Ground-water quality													
MW01	Monitoring well #1	08/13/03	442	96	19	30	1.4	350	0	86	12	0.2	28
MW02	Monitoring well #2	04/30/03	280	73	14	14	.56	270	0	27	1.5	.4	17
		08/14/03	299	69	13	14	.62	300	0	27	3.6	.4	18
MW03	Monitoring well #3	08/13/03	1,840	200	74	190	7.0	490	0	700	220	.3	37
MW04	Monitoring well #4	05/02/03	429	76	21	53	1.2	370	0	45	11	.4	22
		08/14/03	410	67	20	54	1.0	380	0	38	11	.5	23
MW05	Monitoring well #5	04/29/03	483	100	24	26	4.5	320	0	82	5.9	.3	14
MW06	Monitoring well #6	04/30/03	472	100	31	17	1.1	460	0	51	3.6	.4	17
		08/13/03	481	110	32	18	.94	490	0	51	5.6	.4	18
MW07	Monitoring well #7	04/29/03	340	82	25	8.8	.93	320	0	15	2.0	.4	12
MW08	Monitoring well #8	04/30/03	531	130	30	32	1.0	400	0	46	29	.3	17
MW09	Monitoring well #9	05/01/03	300	84	14	2.2	.58	330	0	9.6	1.1	.4	9.3
MW10	Monitoring well #10	05/02/03	403	96	21	16	.81	350	0	53	1.9	.3	15
MW11	Monitoring well #11	05/02/03	497	100	36	22	2.5	420	0	26	14	.8	30
		08/12/03	516	100	37	24	2.2	430	0	36	16	.8	32

Magnesium is a common alkaline-earth metal and is essential for plant and animal nutrition (Hem, 1992). The principal sources for magnesium on the reservation are carbonate rocks. Magnesium also contributes to the total hardness of water and may cause encrustation and increase soap or detergent consumption in water used for cleaning.

Magnesium concentrations in the surface-water samples collected for this study ranged from 10 to 26 mg/L, with a median concentration of 22 mg/L (table 6). Concentrations in ground-water samples ranged from 13 to 74 mg/L, with a median concentration of 24 mg/L (table 7).

Sodium is the most abundant member of the alkali-metal group of elements and, once dissolved, tends to remain in solution. Natural sources of sodium include the weathering of plagioclase feldspar and the dissolution of sodium salts from sedimentary rocks (Hem, 1992). Human-related sources include road salt, seepage from septic systems, and a by-product of water treatment (it is discharged by water softeners and reverse-osmosis units) (U.S. Environmental Protection Agency, 2003). Sodium in drinking water may impart a salty taste and may be harmful to persons suffering from heart, kidney, and circulatory diseases and women with toxemias of pregnancy (U.S. Environmental Protection Agency, 2003). Therefore, USEPA has established a Drinking-Water Advisory (DWA) of 20 mg/L in finished drinking water for people who are on restricted sodium diets (500 milligrams per day) and a taste threshold of 30 to 60 mg/L in finished drinking water (U.S. Environmental Protection Agency, 2004a).

Sodium concentrations in surface-water samples ranged from 7.8 to 110 mg/L, with a median concentration of 18 mg/L (table 6). The largest sodium concentrations were detected in samples from site LSC06. Six of seven samples at this site exceeded the maximum taste threshold of 60 mg/L. Sodium concentrations at the other quarterly sites were generally about 20 mg/L or less (fig. 5A).

Sodium concentrations in ground water ranged from 2.2 to 190 mg/L (table 7). The largest concentration was detected in a water sample from well MW03 (fig. 5B) and was approximately nine times larger than the median concentration of 22 mg/L of sodium concentrations from all samples collected from ground-water monitoring wells.

Potassium is an essential element for both plants and animals. Maintenance of optimal soil fertility depends on a supply of available potassium. Potassium is present in plant material and is lost from agricultural soil by crop harvesting and by leaching and runoff acting on organic residues (Hem, 1992).

Concentrations of potassium in surface-water samples collected for this study ranged from 1.1 to 7.6 mg/L, with a median concentration of 3.2 mg/L (table 6). The largest concentration of 7.6 mg/L occurred in a water sample from site LSC06, and potassium concentrations from this site were generally larger than from other surface-water sites.

Potassium concentrations in ground-water samples ranged from 0.56 to 7.0 mg/L, with a median concentration of

1.0 mg/L. The largest concentration in ground water was detected in water from monitoring well MW03 (table 7).

In most surface streams, bicarbonate concentrations are much less than 200 mg/L, but larger concentrations in ground water are not uncommon (Hem, 1992). The primary source for bicarbonate on the Prairie Band Potawatomi Reservation is the dissolution of carbonate rocks and deposits.

Bicarbonate concentrations in surface-water samples ranged from 180 to 440 mg/L (table 6). The largest concentration of bicarbonate occurred in water sampled from site LSC06 on May 22, 2002. The median bicarbonate concentration in surface-water samples was 320 mg/L.

Bicarbonate concentrations in ground-water samples ranged from 270 to 490 mg/L, with a median concentration of 370 mg/L (table 7). The largest bicarbonate concentration in ground water was detected in samples from wells MW03 and MW06.

Natural sources of sulfate in water include the weathering of sulfur-bearing minerals, such as pyrite and gypsum, volcanic discharges to the atmosphere, and biologic and biochemical processes (Hem, 1992). Human-related sources include industrial discharges to both streams and the atmosphere and the combustion of fossil fuels, such as coal and gasoline. USEPA (2004a) established a SDWR of 250 mg/L in drinking water to avoid laxative effects that can result from excessive sulfate concentrations in drinking water.

Sulfate concentrations in surface-water samples ranged from 17 to 150 mg/L, with a median concentration of 66 mg/L. Sulfate concentrations were less than the SDWR of 250 mg/L (table 6, fig. 6A).

The range of sulfate concentrations in ground-water samples was 9.6 to 700 mg/L, with a median concentration of 45 mg/L (table 7, fig. 6B). The largest sulfate concentration was detected in water from well MW03 and was approximately 15 times the median concentration from all ground-water samples and almost three times the SDWR. The large sulfate concentration in water from this well corresponds to large specific conductance values and large concentrations of other dissolved ions in the water from the well. Treatment to remove excess dissolved ion concentrations would be required in the event this water should become a drinking-water source for the tribe.

Chloride is present in all natural water but is generally found in small concentrations in surface water (Hem, 1992). The probable natural source of chloride on the reservation is dissolution of halite from sedimentary rocks. The discharge of human, agricultural, animal, or industrial wastes also may add substantial quantities of chloride to surface and ground water. Chloride can impart a salty taste to drinking water and may accelerate the corrosion of metals used in water-supply systems. On the basis of taste, USEPA (2004a) established a SDWR of 250 mg/L in finished drinking water. KDHE (2001) has established an aquatic-life criterion of 352 mg/L for chronic exposure to chloride.

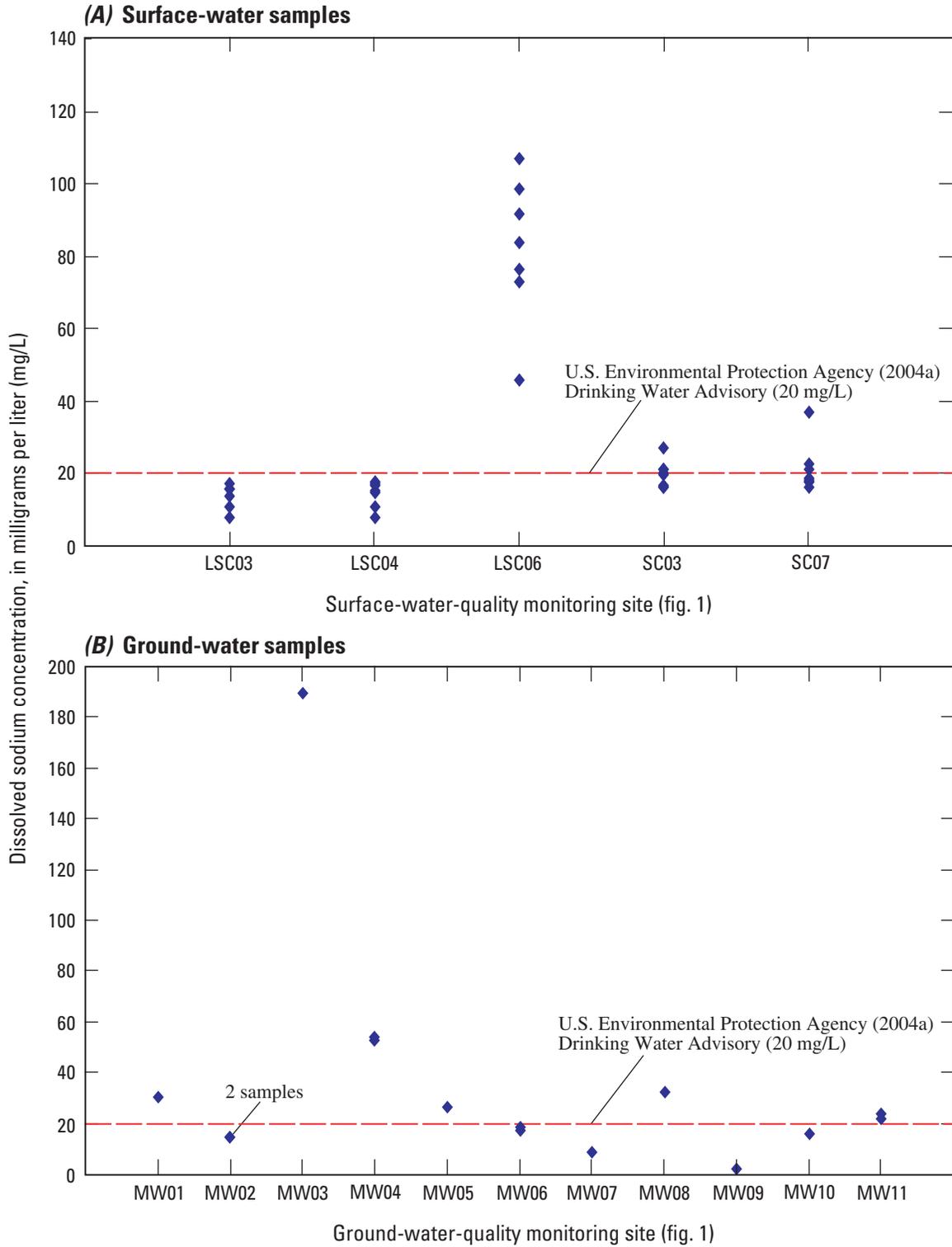


Figure 5. Concentrations of dissolved sodium in (A) surface-water-quality samples and (B) ground-water-quality samples, May 2001 through August 2003. Drinking-Water Advisory from U.S. Environmental Protection Agency (2004a).

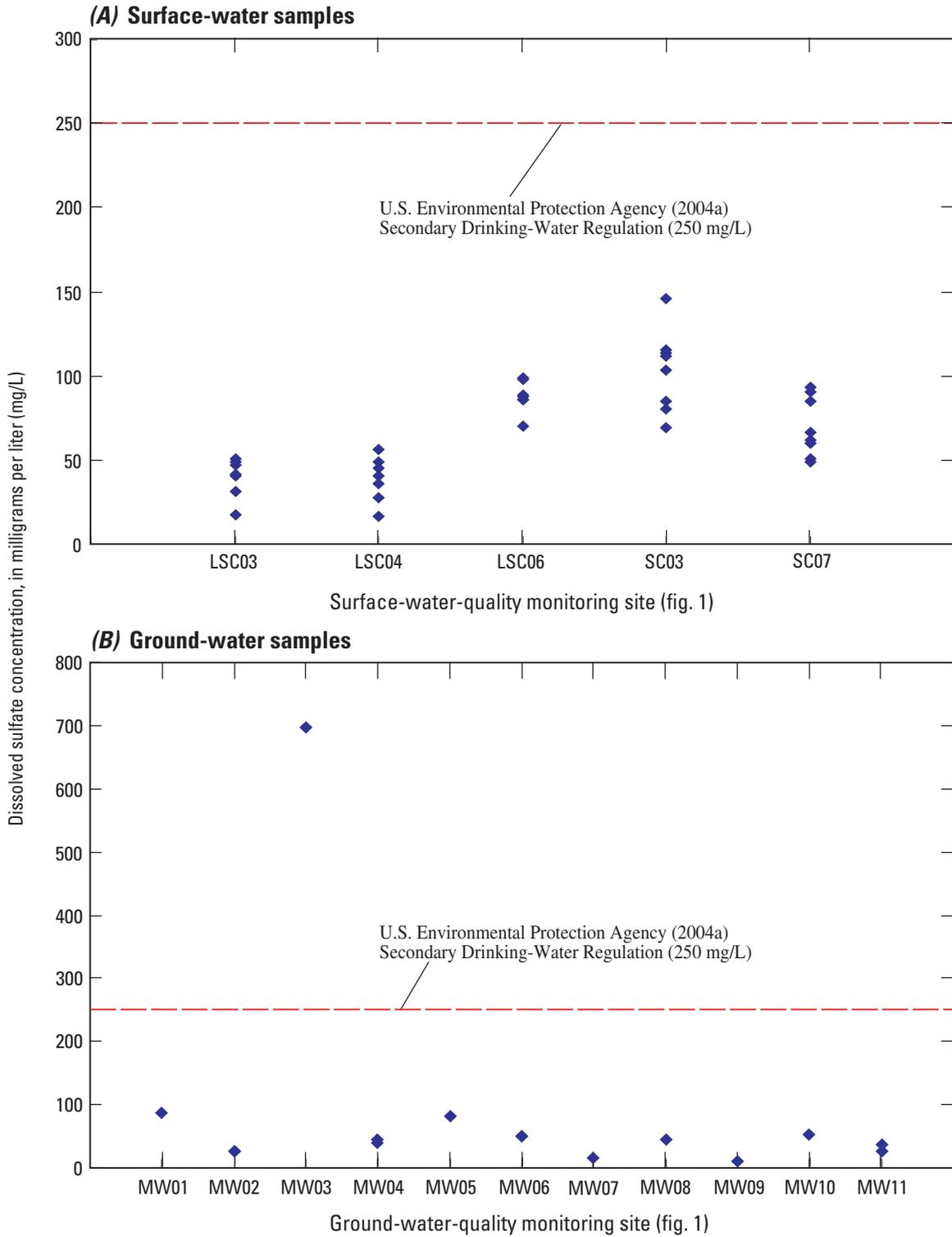


Figure 6. Concentrations of dissolved sulfate in (A) surface-water-quality samples and (B) ground-water-quality samples, May 2001 through August 2003. Secondary Drinking-Water Regulation from U.S. Environmental Protection Agency (2004a).

Chloride concentrations in surface-water samples collected during this study ranged from 3.8 to 170 mg/L and were substantially less than the SDWR (table 6, fig. 7A). The median concentration of chloride in the surface-water samples was 13 mg/L. The largest chloride concentrations occurred in surface-water samples from site LSC06, but these concentrations were less than the SDWR. Relatively large chloride concentrations at this site probably are attributable to its location downstream from a discharging sewage-treatment lagoon.

Chloride concentrations in ground-water samples ranged from 1.1 to 220 mg/L, with a median concentration of 5.9 mg/L (table 7). The largest chloride concentration, detected in water from well MW03, was slightly less than the SDWR (fig. 7B).

Nutrients

Nitrogen and phosphorus are essential for the growth and reproduction of plants (Hem, 1992). Rooted aquatic plants and algae, for example, require dissolved forms of nitrogen and phosphorus as nutrients. Compounds of nitrogen, such as nitrite, nitrate, and ammonia, are the basic building blocks for protein synthesis, and phosphorus serves as an energy source in cellular chemical reactions. However, large inputs of nitrogen and phosphorus compounds to waterbodies can cause excessive algal growth (Hem, 1992). This may result in taste-and-odor problems in drinking water, reduce the aesthetic and recreational value of water, and stress aquatic organisms due to decreased dissolved oxygen concentrations after the algal blooms die. Therefore, it is desirable to prevent or mitigate the introduction of excessive nutrient concentrations into surface water used as public supply or where sensitive aquatic organisms may be present (Trombley, 1999, 2001).

Major sources of nutrients in and around the reservation include agricultural activities such as the application of fertilizers to enhance crop production and the pasturing and confined feeding of livestock. Common fertilizers used include, among others, anhydrous ammonia, ammonium nitrate, urea, and mono- and diammonium phosphates. The amount of fertilizer sold in Kansas has increased substantially during the last four decades. In 1950, about 180,000 tons of fertilizer were sold in Kansas, whereas by 2003 sales increased to more than 1,100,000 tons during a 6-month period (January through June 2003) (Kansas Department of Agriculture, 2004). It is likely that this statewide increasing trend in fertilizer use also occurred on and near the reservation. Additionally, farm livestock such as cattle and buffalo can produce considerable amounts of nitrogenous waste (urine and manure) that can concentrate in areas where large numbers of animals are pastured or confined. Decomposition of large amounts of fertilizers and manure can release nutrients to surface runoff or to shallow ground water with the potential for discharge to nearby streams (Trombley, 1999, 2001).

Another potential source of nutrients on the reservation is bacterial decomposition of plant and animal protein and seepage from septic systems or sewage lagoons. Nutrients,

particularly nitrate and ammonia, also may be components of precipitation (Christensen and Pope, 1997); however, because of dominant agricultural land use in the area, precipitation is probably a relatively minor contributor of nutrients to surface water and ground water on the reservation.

Nitrate is formed by complete oxidation of ammonium ions by microorganisms found in soil, water, sewage, and the digestive tract (U.S. Environmental Protection Agency, 1986). In most oxygenated surface water, nitrate is by far the dominant ion due to rapid oxidation of nitrite. Nitrate nitrogen is the form of nitrogen most easily used by most rooted green plants and algae. Nitrate nitrogen generally occurs in uncontaminated surface water, with a worldwide mean concentration of 0.30 mg/L (Reid and Wood, 1976). Larger nitrate nitrogen concentrations may stimulate growth of rooted plants or accelerate algal production to an extent that may result in taste-or-odor problems in finished drinking water. Because most aquatic organisms can tolerate nitrite plus nitrate concentrations far in excess of what normally might be found even in contaminated surface water, no water-quality criteria have been established for protection of aquatic life. However, a MCL in drinking water of 10 mg/L nitrate as nitrogen was established by USEPA (2004a) because of possible toxic effects to infants.

Nitrite plus nitrate concentrations ranged from an estimated 0.03 to 0.93 mg/L in the surface-water samples collected from the reservation (table 8, fig. 8A) and were substantially less than the MCL of 10 mg/L. The median surface-water concentration was 0.1 mg/L.

Nitrite plus nitrate concentrations in ground-water samples ranged from an estimated 0.05 to 14 mg/L (table 9), with a median concentration of 0.47 mg/L. The largest concentration was in water from well MW11; the well was sampled in both rounds of ground-water sampling and had similar values both times (fig. 8B). The nitrite plus nitrate concentrations in water from well MW11 exceeded the USEPA MCL. The well is located adjacent to an open hand-dug well that could provide a conduit for contaminants into the ground water in that localized area. Primary land use near the well is pastureland and cropland, and agricultural activities in the area could contribute to elevated nitrite plus nitrate concentrations in this well.

Ammonia toxicity is dependent on the pH and temperature of the water; as the pH and temperature increase, the chronic exposure criterion for ammonia decreases (U.S. Environmental Protection Agency, 1999). Acute toxicity of ammonia in fish causes increased respiration, oxygen uptake, and heart rate; reduction in hatching success and growth and morphologic development; and injuries to gills, liver, and kidneys. At larger concentrations, fish may experience convulsions, coma, and death. Small ammonia concentrations can cause reduction in hatching success, reduction in growth rate or morphological development, and pathologic changes in tissues of the gills, livers, and kidneys (U.S. Environmental Protection Agency, 1986). The pH in surface water on the reservation ranged from 6.9 to 8.5 standard units, and the water temperature ranged from 0.2 to 28.7 °C (table 3). For these pH and water temperature conditions, the range of the chronic ammonia criteria for

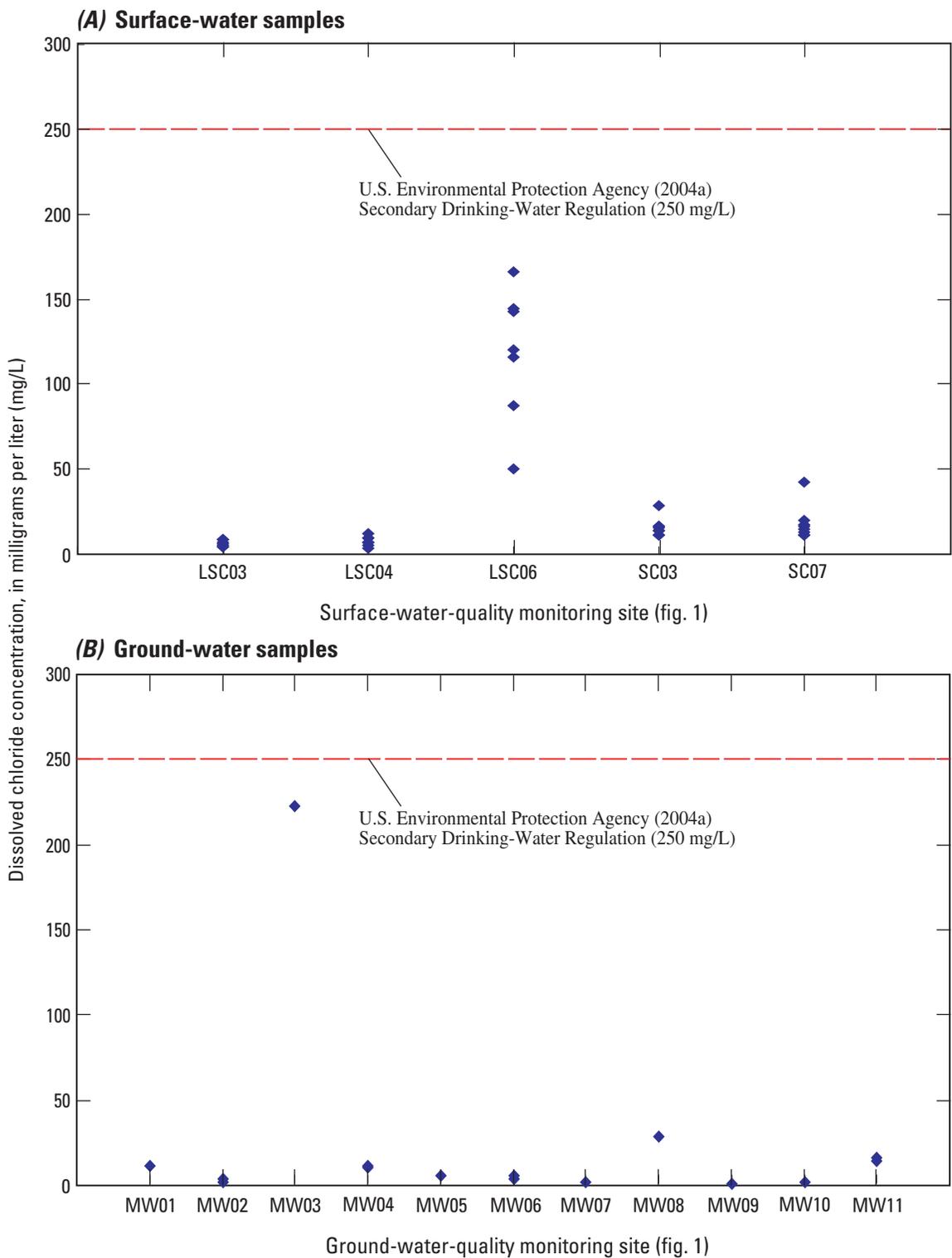


Figure 7. Concentrations of dissolved chloride in (A) surface-water-quality samples and (B) ground-water-quality samples, May 2001 through August 2003. Secondary Drinking-Water Regulation from U.S. Environmental Protection Agency (2004a).

Table 8. Results of analysis of nutrients in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.

[Water-quality criteria established by the U.S. Environmental Protection Agency (1986, 2004a). mg/L as N, milligrams per liter as nitrogen; mg/L as P, milligrams per liter as phosphorus; MCL, Maximum Contaminant Level; --, not determined; <, less than; E, estimated]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Nitrite, dissolved (mg/L as N)	Nitrite plus nitrate, dissolved (mg/L as N)	Ammonia, dissolved (mg/L as N)	Ammonia plus organic nitrogen, dissolved (mg/L as N)	Ammonia plus organic nitrogen, total (mg/L as N)	Phosphorus, dissolved (mg/L)	Phosphorus, total (mg/L)	Ortho-phosphate, dissolved (mg/L as P)
Water-quality criteria			--	10 mg/L (MCL)	--	--	--	--	0.10 mg/L (aquatic-life goal)	--
Bills Creek Basin										
BC01	Bills Creek, U.S Highway 75 near Holton	06/12/01	0.02	0.12	0.07	--	0.58	--	0.11	0.03
Little Soldier Creek Basin										
LSC01	Little Soldier Creek, 190 Road near Mayetta	06/12/01	<.01	<.05	<.04	--	1.0	--	.14	<.02
LSC02	Little Soldier Creek, 174 Road near Mayetta	06/12/01	<.01	.06	<.04	--	.43	--	.07	.02
LSC03	Little Soldier Creek, O Road near Mayetta	05/15/01	.01	.10	.08	--	.43	--	E.04	.03
		06/12/01	.02	.30	E.04	--	.79	--	.12	.04
		11/13/01	<.01	<.05	<.04	0.21	.83	0.08	.09	.07
		02/12/02	<.01	E.03	<.04	.16	.21	<.06	E.03	E.02
		05/22/02	<.01	<.05	<.04	.19	.21	<.06	E.04	E.02
		08/28/02	<.01	.11	<.04	.44	.64	E.05	.11	.03
		11/13/02	<.01	<.06	<.04	.28	.44	.13	.18	.13
		02/19/03	<.01	<.05	<.04	.20	.20	<.06	E.03	E.01
		05/14/03	<.01	<.06	<.04	.23	.32	<.04	E.04	E.01
		LSC04	Little Soldier Creek, 134 Road near Mayetta	05/15/01	.01	.10	.06	--	.37	--
06/12/01	.02			.41	.07	--	.56	--	.08	.07
11/13/01	<.01			E.03	<.04	.26	.26	.07	.07	.05
02/12/02	<.01			E.04	<.04	.16	.22	<.06	E.04	<.02
05/22/02	<.01			.08	<.04	.21	.26	E.03	E.04	.03

Table 8. Results of analysis of nutrients in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

[Water-quality criteria established by the U.S. Environmental Protection Agency (1986, 2004a). mg/L as N, milligrams per liter as nitrogen; mg/L as P, milligrams per liter as phosphorus; MCL, Maximum Contaminant Level; --, not determined; <, less than; E, estimated]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Nitrite, dissolved (mg/L as N)	Nitrite plus nitrate, dissolved (mg/L as N)	Ammonia, dissolved (mg/L as N)	Ammonia plus organic nitrogen, dissolved (mg/L as N)	Ammonia plus organic nitrogen, total (mg/L as N)	Phosphorus, dissolved (mg/L)	Phosphorus, total (mg/L)	Ortho-phosphate, dissolved (mg/L as P)
Little Soldier Creek Basin—Continued										
LSC04	Little Soldier Creek, 134 Road near Mayetta—Continued	08/28/02	0.02		0.05	<0.1	0.49	E0.05	0.08	0.05
		11/13/02	<.01	<0.06	<.04	.29	.39	.10	.14	.10
		02/19/03	<.01	<.05	<.04	.16	.24	<.06	E.04	E.01
		05/14/03	<.01	<.06	<.04	.23	.33	E.02	.04	.02
LSC05	Little Soldier Creek tributary, 134 Road near Hoyt	06/12/01	.01	.93	<.04	--	.30	--	.06	.03
LSC06	Big Elm Creek, 134 Road near Hoyt	05/15/01	.01	.24	E.04	--	.34	--	.38	.35
		06/12/01	.01	.33	.05	--	.41	--	.43	.37
		08/21/01	<.01	E.04	<.04	--	.21	--	.17	.13
		11/13/01	<.01	E.04	<.04	.41	.51	.38	.41	.36
		02/12/02	E.01	E.58	E.09	.53	1.1	.31	.41	E.30
		05/22/02	<.01	.07	<.04	.23	.34	.19	.22	.18
		08/28/02	<.01	.12	.04	.26	.26	.16	.17	.16
		11/13/02	<.01	<.06	<.04	.19	.45	.20	.48	.19
		02/19/03	.02	.74	2.4	3.2	4.3	.87	1.2	.92
		05/14/03	<.01	<.06	<.04	.34	.38	.31	.32	.29
LSC07	Little Elm Creek, Q Road near Hoyt	06/12/01	.04	.38	.07	--	1.0	--	E.05	.02
LSC08	Big Elm Creek, P Road near Hoyt	06/12/01	.01	.85	<.04	--	.77	--	.22	.19
LSC09	Little Soldier Creek, 126 Road near Hoyt	06/12/01	.01	.50	E.03	--	.47	--	.15	.09
Soldier Creek Basin										
SC01	Soldier Creek, 214 Road near Circleville	06/13/01	.02	.80	<.04	--	.54	--	.08	E.02
SC02	Soldier Creek tributary, G Road near Circleville	06/13/01	.01	.30	E.02	--	.27	--	E.05	.03

Table 8. Results of analysis of nutrients in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

[Water-quality criteria established by the U.S. Environmental Protection Agency (1986, 2004a). mg/L as N, milligrams per liter as nitrogen; mg/L as P, milligrams per liter as phosphorus; MCL, Maximum Contaminant Level; --, not determined; <, less than; E, estimated]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Nitrite, dissolved (mg/L as N)	Nitrite plus nitrate, dissolved (mg/L as N)	Ammonia, dissolved (mg/L as N)	Ammonia plus organic nitrogen, dissolved (mg/L as N)	Ammonia plus organic nitrogen, total (mg/L as N)	Phosphorus, dissolved (mg/L)	Phosphorus, total (mg/L)	Ortho-phosphate, dissolved (mg/L as P)
Soldier Creek Basin—Continued										
SC03	Soldier Creek near Saint Clere	05/15/01	0.01	0.13	<0.04	--	0.42	--	0.08	0.02
		06/13/01	.01	.72	<.04	--	.50	--	.10	.04
		08/21/01	<.01	.07	<.04	--	.34	--	E.05	E.02
		11/13/01	<.01	.18	<.04	0.22	.31	E0.03	E.05	E.01
		02/12/02	<.01	E.41	E.03	.18	.24	<.06	E.04	E.01
		05/22/02	<.01	.11	<.04	.19	.36	<.06	E.06	E.01
		08/28/02	<.01	<.05	<.04	.16	.51	<.06	.08	E.02
		11/13/02	E.01	<.06	<.04	.15	.31	<.04	.06	E.02
		02/19/03	<.01	<.05	<.04	.12	.30	<.06	E.06	<.02
		05/14/03	.02	.49	<.04	.36	.61	E.03	.10	.03
		08/20/03	<.01	<.06	<.04	.31	.84	.05	.16	.04
SC04	Soldier Creek, 158 Road near Saint Clere	06/13/01	.01	.68	<.04	--	.52	--	.14	.06
SC05	Crow Creek, 166 Road near Saint Clere	06/13/01	.01	.12	<.04	--	.28	--	.07	.04
SC06	South Branch Soldier Creek, H.5 Road near Saint Clere	06/13/01	.03	.18	.04	--	.45	--	.12	.09
SC07	Soldier Creek, I Road near Delia	05/15/01	.01	.06	<.04	--	.53	--	.10	.02
		06/13/01	.01	.87	<.04	--	.49	--	.17	.08
		08/21/01	<.01	E.04	<.04	--	.38	--	.07	.04
		11/13/01	<.01	E.04	<.04	.19	.29	<.06	E.04	<.02
		02/12/02	<.01	<.05	<.04	.20	.24	E.03	E.05	<.02
		05/22/02	<.01	.36	<.04	.19	.39	E.06	.10	.05
		08/28/02	<.01	<.05	<.04	.27	.59	E.04	.11	.03
		11/13/02	<.01	<.06	<.04	.21	.30	.05	.08	.06
		02/19/03	<.01	<.05	<.04	.16	.25	<.06	E.05	<.02

Table 8. Results of analysis of nutrients in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

[Water-quality criteria established by the U.S. Environmental Protection Agency (1986, 2004a). mg/L as N, milligrams per liter as nitrogen; mg/L as P, milligrams per liter as phosphorus; MCL, Maximum Contaminant Level; --, not determined; <, less than; E, estimated]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Nitrite, dissolved (mg/L as N)	Nitrite plus nitrate, dissolved (mg/L as N)	Ammonia, dissolved (mg/L as N)	Ammonia plus organic nitrogen, dissolved (mg/L as N)	Ammonia plus organic nitrogen, total (mg/L as N)	Phosphorus, dissolved (mg/L)	Phosphorus, total (mg/L)	Ortho-phosphate, dissolved (mg/L as P)
Soldier Creek Basin—Continued										
SC07	Soldier Creek, I Road near Delia—Continued	05/14/03	0.01	0.33	<0.04	0.31	0.52	0.04	0.11	0.04
		08/20/03	<.01	.19	<.04	.59	.86	.07	.13	.03
SC08	James Creek, 142 Road near Delia	06/13/01	<.01	.14	<.04	--	.39	--	E.05	E.02
SC09	James Creek, 126 Road near Delia	06/13/01	<.01	.09	<.04	--	.31	--	E.05	.05
South Cedar Creek Basin										
SCC01	South Cedar Creek, U.S. Highway 75 near Mayetta	06/12/01	.015	.47	.05	--	.47	--	.13	.09

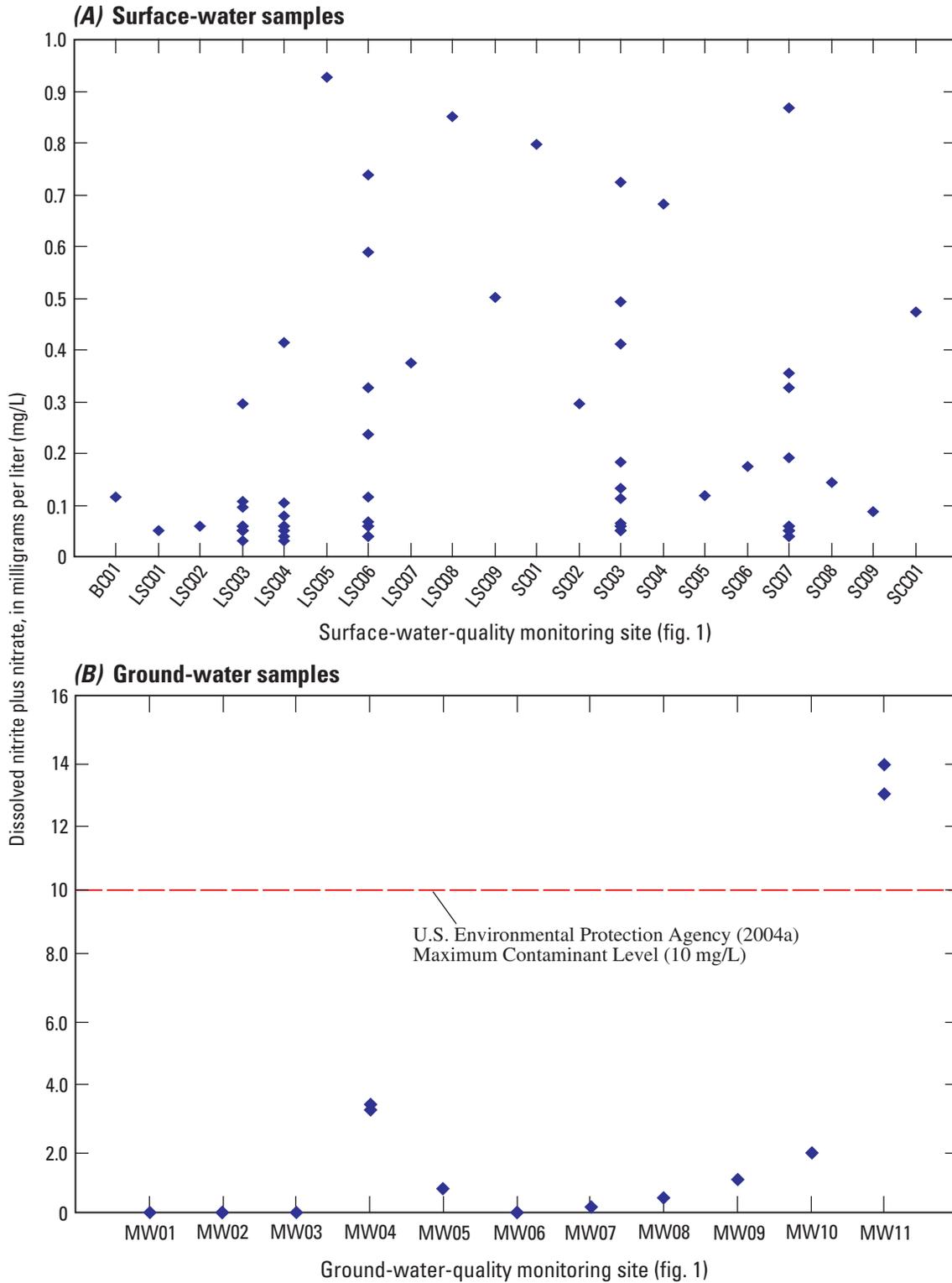


Figure 8. Concentrations of dissolved nitrite plus nitrate in (A) surface-water-quality samples and (B) ground-water-quality samples, May 2001 through August 2003. Maximum Contaminant Level from U.S. Environmental Protection Agency (2004a).

Table 9. Results of analysis of nutrients in ground-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, April through August 2003.

[Water-quality criterion established by the U.S. Environmental Agency (1986). mg/L as N, milligrams per liter as nitrogen; mg/L as P, milligrams per liter as phosphorus; MCL, Maximum Contaminant Level; --, not determined; <, less than; E, estimated]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Nitrite, dissolved (mg/L as N)	Nitrite plus nitrate, dissolved (mg/L as N)	Ammonia, dissolved (mg/L as N)	Ammonia plus organic nitrogen, dissolved (mg/L as N)	Ammonia plus organic nitrogen, total (mg/L as N)	Phosphorus, dissolved (mg/L)	Phosphorus, total (mg/L)	Orthophosphate, dissolved (mg/L as P)
Water-quality criterion										
			--	10 mg/L (MCL)	--	--	--	--	--	--
Ground-water quality										
MW01	Monitoring well #1	08/13/03	<0.008	<0.06	0.08	E0.10	0.16	0.06	0.08	0.05
MW02	Monitoring well #2	04/30/03	<.008	<.06	<.04	E.07	.11	.04	E.02	.03
		08/14/03	<.008	<.06	<.04	E.05	.11	E.03	.05	<.18
MW03	Monitoring well #3	08/13/03	<.008	<.06	1.3	1.4	1.8	.11	.15	.04
MW04	Monitoring well #4	05/2/03	<.008	3.3	<.04	.11	.63	E.03	.29	.02
		08/14/03	<.008	3.2	<.04	.11	.55	E.03	.38	<.18
MW05	Monitoring well #5	04/29/03	<.008	.71	.10	.26	1.2	E.03	.76	.03
MW06	Monitoring well #6	04/30/03	<.008	E.05	.16	.21	.26	.13	.15	.10
		08/13/03	<.008	<.06	.20	.22	.29	.16	.20	.12
MW07	Monitoring well #7	04/29/03	<.008	.19	<.04	<.10	<.10	<.03	.05	.02
MW08	Monitoring well #8	04/30/03	<.008	.47	.23	.30	.36	.09	.28	.03
MW09	Monitoring well #9	05/1/03	<.008	1.0	<.04	.10	.14	<.03	E.03	<.02
MW10	Monitoring well #10	05/2/03	<.008	2.0	<.04	<.10	.14	<.03	.04	E.01
MW11	Monitoring well #11	05/2/03	.04	13	.13	.23	.54	.10	.33	.11
		08/12/03	.02	14	<.04	.11	.59	.09	.50	.09

streams that have fish early-life stages present is 0.4 to 6.12 mg/L (U.S. Environmental Protection Agency, 1999). The most likely source for ammonia on the reservation probably is related to agricultural land use or wastewater.

Ammonia concentrations in the surface-water samples ranged from an estimated 0.02 to 2.4 mg/L, with a median concentration of less than 0.04 mg/L (table 8). The largest concentration of 2.4 mg/L occurred on February 19, 2003, in a water sample from site LSC06, which is located downstream from a discharging sewage-treatment lagoon. The chronic exposure criterion for this sample (pH of 7.2 and temperature of 0.2 °C) is 5.39 mg/L. This ammonia concentration was substantially larger than other concentrations from that site as well as all the other surface-water sites.

Ammonia concentrations in ground-water samples ranged from less than 0.04 to 1.3 mg/L, with a median concentration of less than 0.04 mg/L (table 9), none of which exceeded the USEPA (1999) water-quality criterion, which is not directly applicable to ground water as it is a chronic exposure criterion; however, in cases where ground water provides the base flow to the streams on the reservation, this criterion could apply.

Total phosphorus includes all forms of phosphorus (Hem, 1992). Excessive concentrations of phosphorus in water may contribute to eutrophication of water bodies. Eutrophication (nutrient enrichment) is characterized by excessive nutrient concentrations, decreasing dissolved oxygen concentrations, and dense growths of algae (Reid and Wood, 1976). Domestic, municipal, and industrial sewage effluents are substantial sources of phosphorus in surface water because phosphorus is essential in metabolism and always present in human and animal metabolic waste (Hem, 1992).

USEPA (1986) established a goal for total phosphorus concentration of 0.10 mg/L to limit cultural eutrophication of flowing water. Larger concentrations also may interfere with coagulation in water-treatment plants. To prevent excessive algal growth in impounded water, concentrations of total phosphates (as phosphorus) should not exceed 0.05 mg/L in any stream at the point where it enters a lake or reservoir (U.S. Environmental Protection Agency, 1986). USEPA also has recommended water-quality criteria for total phosphorus that are based on the aggregate nutrient ecoregions. The total phosphorus criterion for ecoregion IV is 0.02 mg/L; for ecoregion VI, it is 0.08 mg/L; and for ecoregion IX, it is 0.04 mg/L (U.S. Environmental Protection Agency, 2000a, 2000b, 2001). Ecoregions are defined in the previous section on "Physical Properties." Potential sources for large concentrations of phosphorus in streams on the Prairie Band Potawatomi Reservation include human or animal waste and fertilizers applied to agricultural lands. Total phosphorus was identified as exceeding water-quality criteria on the reservation in the two previous reports published as a part of this cooperative study (Trombley, 1999, 2001).

The concentrations of total phosphorus in surface-water samples ranged from an estimated 0.03 to 1.2 mg/L, with a median concentration of 0.12 mg/L (table 8). All 10 samples from site LSC06 exceeded the water-quality goal of 0.10 mg/L,

and the largest concentration of 1.2 mg/L occurred on February 19, 2003, in a sample from site LSC06 (fig. 9). Other nutrient concentrations also were large in the February 19, 2003, sample from site LSC06. Overall, 40 percent of the 65 surface-water samples that were analyzed for total phosphorus exceeded the aquatic-life goal of 0.10 mg/L (U.S. Environmental Protection Agency, 1986).

Total phosphorus concentrations in ground-water samples ranged from an estimated 0.02 to 0.76 mg/L, with a median concentration of 0.15 mg/L (table 9). The aquatic-life goal does not apply to ground water.

Trace Elements

A trace element is an element that is not essential in a mineral (generally less than 1 percent) but is found in small quantities in its structure or adsorbed on its surfaces (Bates and Jackson, 1980). Trace elements generally are found in the environment at relatively small concentrations (less than 1.0 mg/L), but some of them are vital for human and plant health. However, the concentrations of trace elements in surface and ground water can be increased as a result of human activities such as mining and industrial activities. Water samples for this study were analyzed for the trace elements arsenic, boron, iron, and selenium, and all have water-quality criteria.

Arsenic is a trace element that occurs naturally in the environment, but the presence of arsenic in water also can be a result of mining activity or application of pesticides. Arsenic also can occur in water as a result of an arsenic-bearing formation dissolving naturally over time (Haack and Rachol, 2000). Large concentrations of arsenic have shown to be detrimental to human health (Hem, 1992). In 2001, USEPA revised the drinking-water MCL for arsenic from 50 to 10 µg/L (effective in 2006) (U.S. Environmental Protection Agency, 2004a).

Arsenic concentrations in the surface-water samples collected for this study ranged from an estimated 1 to 7 µg/L (table 10) and were less than the MCL for arsenic. The median concentration in surface-water samples was less than 2 µg/L.

Ground-water concentrations ranged from an estimated 1 to 26 µg/L (table 11), with a median concentration of less than 2 µg/L. The two ground-water samples from well MW06 had arsenic concentrations of 19 and 26 µg/L (table 11), which were about twice the MCL for arsenic (fig. 10). Arsenic also was detected in water from wells MW03, MW08, and MW11, but the concentrations were substantially less than the MCL.

Boron is a minor constituent in ground water and usually is found in evaporate deposits as sodium or calcium borate salt (Hem, 1992). Boron is an essential element for the growth of plants, but there is no evidence that it is required by animals (Pais and Jones, 1997). USEPA (2004a) established a lifetime DWA of 600 µg/L (concentration in drinking water that is not expected to cause any adverse effects for a lifetime of exposure).

Boron concentrations in surface-water samples collected for this study ranged from 40 to 120 µg/L, with a median

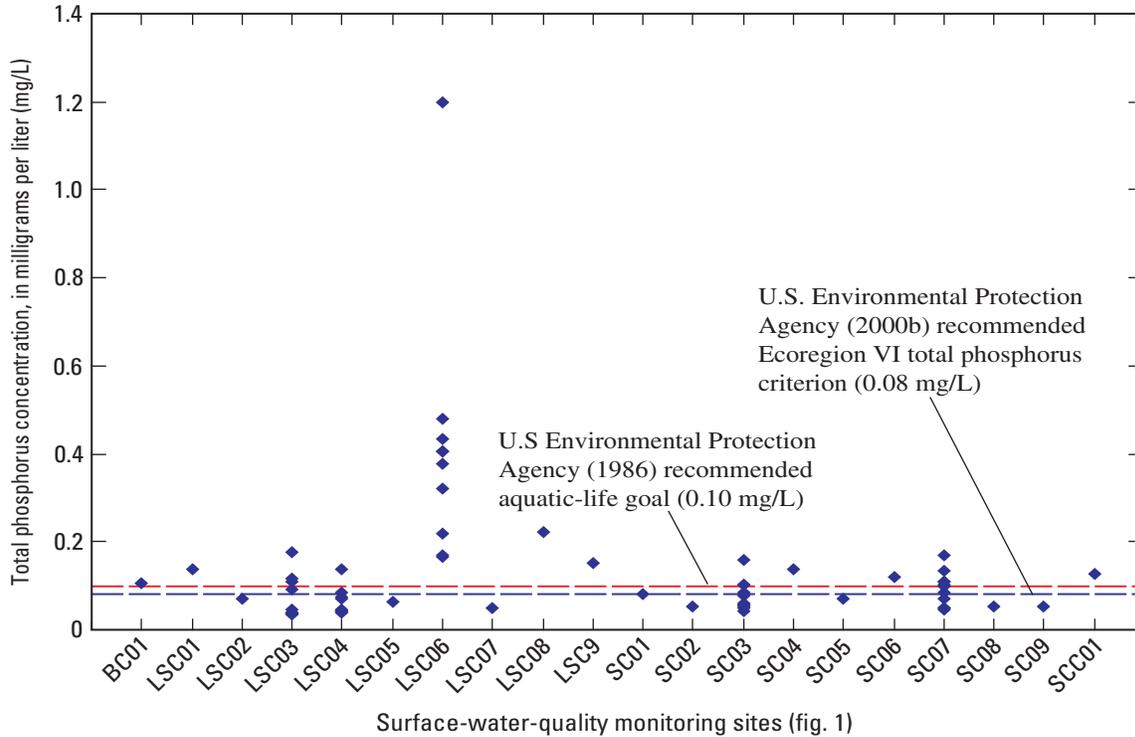


Figure 9. Concentrations of total phosphorus in surface-water-quality samples, May 2001 through August 2003. Recommended goal for aquatic life from U.S. Environmental Protection Agency (1986).

concentration of 60 µg/L (table 10). The largest detection of 120 µg/L occurred on August 20, 2003, in a water sample from site SC07.

Concentrations in ground-water samples ranged from 30 to 600 µg/L, with a median concentration of 80 µg/L (table 11). The largest concentration was in a sample from well MW03 on August 13, 2003, and corresponds to the large concentrations of calcium and sodium and other anions contributing to the large dissolved-solids concentration in water from that well.

Iron is an abundant element in the Earth's outer crust, but it typically occurs in small concentrations in water (Hem, 1992). Iron's chemical activity and its solubility in water depend strongly on the oxygen in the system as well as the pH of the water (Hem, 1992). Large amounts of iron are undesirable in water supplies because it forms a red oxyhydroxide precipitate that stains laundry and plumbing fixtures (Hem, 1992). USEPA (2004a) has established a SDWR of 300 µg/L for iron in treated drinking water.

Iron concentrations in surface-water samples ranged from an estimated 5 to 30 µg/L, with a median concentration of 6 µg/L (table 10). All concentrations in surface-water samples were substantially less than the USEPA SDWR.

Concentrations in ground-water samples ranged from an estimated 5 to 4,600 µg/L, with a median concentration of 30 µg/L (table 11, fig. 11). The largest iron concentration was detected in the August 13, 2003, sample from well MW06, which corresponds to the largest arsenic concentration. Iron concentrations in water from wells MW01, MW03, MW06 (two samples), and MW08 exceeded the USEPA SDWR of

300 µg/L. Iron concentrations in samples from the remainder of the wells were substantially less than the SDWR.

Selenium is a naturally occurring mineral element that is relatively rare, and geochemical factors tend to limit its aqueous mobility (Hem, 1992). Selenium was not detected at concentrations greater than the reporting limit in any surface- or ground-water sample (tables 10 and 11) but did have small estimated concentrations in several surface-water samples. The MCL for selenium is 50 µg/L (U.S. Environmental Protection Agency, 2004a).

Pesticides

The use of pesticides on the reservation is typical of pesticide use in all agricultural regions throughout Kansas. Atrazine, one of the triazine herbicides, has been used since the 1950s in the production of corn and grain sorghum in the area. Another potential source of atrazine may be its use in controlling weeds along railroad rights-of-way and along roads and highways. It is the most frequently detected herbicide in Kansas (Stamer and Zelt, 1994).

The triazine herbicides were analyzed in both surface- and ground-water samples. Triazine herbicides and their degradates are listed on the USEPA Contaminant Candidate List (U.S. Environmental Protection Agency, 2004b). The herbicides are applied pre- and post-emergence and are subject to runoff if applied before large rainfalls. Sixty-three surface-water samples collected during May 2001 through August 2003 were

Table 10. Results of analysis of trace elements in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.

[Water-quality criteria established by the U.S. Environmental Protection Agency (2004a). µg/L, micrograms per liter; MCL, Maximum Contaminant Level; DWA, Drinking-Water Advisory; SDWR, Secondary Drinking-Water Regulation; --, not determined; E, estimated; <, less than]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Arsenic, dissolved (µg/L)	Boron, dissolved (µg/L)	Iron, dissolved (µg/L)	Selenium, dissolved (µg/L)
			10 (MCL)	600 (DWA)	300 (SDWR)	50 (MCL)
Water-quality criteria						
Little Soldier Creek Basin						
LSC03	Little Soldier Creek, O Road near Mayetta	05/15/01	--	--	--	--
		06/12/01	--	--	--	--
		11/13/01	3	70	<10	<2
		02/12/02	<2	60	E9	<2
		05/22/02	<5	70	<10	<6
		08/28/02	E1	70	<10	<2
		11/13/02	<2	60	10	<3
		02/19/03	<2	50	<10	<2
		05/14/03	E2	70	E6	<3
LSC04	Little Soldier Creek, 134 Road near Mayetta	05/15/01	--	--	--	--
		06/12/01	--	--	--	--
		11/13/01	2	70	10	E1
		02/12/02	<2	50	<10	<2
		05/22/02	E1	70	<10	<2
		08/28/02	4	60	<10	E2
		11/13/02	<2	70	20	<3
		02/19/03	<2	50	E6	<2
		05/14/03	2	70	<10	E1
LSC06	Big Elm Creek, 134 Road near Hoyt	05/15/01	--	--	--	--
		06/12/01	--	--	--	--
		08/21/01	--	--	--	--
		11/13/01	3	60	11	<2
		02/12/02	E1	50	20	E1
		05/22/02	<5	60	20	<6
		08/28/02	2	80	<10	<2
		11/13/02	E1	70	30	<3
		02/19/03	<2	60	20	<4
05/14/03	3	70	E10	<3		

Table 10. Results of analysis of trace elements in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

[Water-quality criteria established by the U.S. Environmental Protection Agency (2004a). µg/L, micrograms per liter; MCL, Maximum Contaminant Level; DWA, Drinking-Water Advisory; SDWR, Secondary Drinking-Water Regulation; --, not determined; E, estimated; <, less than]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Arsenic, dissolved (µg/L)	Boron, dissolved (µg/L)	Iron, dissolved (µg/L)	Selenium, dissolved (µg/L)		
Soldier Creek Basin								
SC03	Soldier Creek near Saint Clere	05/15/01	--	--	--	--		
		06/13/01	--	--	--	--		
		08/21/01	--	--	--	--		
		11/13/01	2	60	10	E1		
		02/12/02	<2	60	10	<2		
		05/22/02	2	60	<10	E1		
		08/28/02	3	70	<10	<2		
		11/13/02	E1	70	10	<3		
		02/19/03	<2	50	10	<2		
		05/14/03	3	50	<10	<3		
		08/20/03	7	90	E5	<3		
		SC07	Soldier Creek, I Road near Delia	05/15/01	--	--	--	--
				06/13/01	--	--	--	--
08/21/01	--			--	--	--		
11/13/01	3			60	20	E2		
02/12/02	E2			50	E6	<2		
05/22/02	2			60	<10	E2		
08/28/02	3			60	<10	<2		
11/13/02	E2			70	E7	<3		
02/19/03	<2			40	E6	<2		
05/14/03	4			50	<10	E1		
08/20/03	5			120	<8	<3		

analyzed using the ELISA (enzyme-linked immunosorbent assay) triazine herbicide screen. The triazine herbicide screen ELISA is a reliable indicator of atrazine. Christensen and Ziegler (1998) found that at least 80 percent of the triazine herbicide concentration determined by ELISA is atrazine.

From June 1996 through August 2003, 227 surface-water samples from the reservation were analyzed for triazine herbicides by ELISA; 74 of these had atrazine concentrations confirmed by GC/MS (gas chromatography/mass spectrometry) analysis (see previous "Methods" section). Data from June 1996 through November 1998 are presented in Trombley (1999, table 5), and data from February 1999 through February 2001 are presented in Trombley (2001, table 11).

The relation between the triazine herbicide screen and atrazine is presented in figure 12; the correlation between results obtained from ELISA analysis and GC/MS analysis is apparent and has a correlation coefficient of 0.91. Therefore, results from the triazine screen can be compared to the drinking-water MCL of 3.0 µg/L as an annual average established by USEPA for atrazine.

Of 63 surface-water samples collected from May 2001 through August 2003 and analyzed for ELISA, 46 had concentrations of triazine herbicides ranging from 0.1 to 11 µg/L, with a median concentration of 0.40 µg/L (table 12). Triazine herbicides were detected in two surface-water samples using ELISA

Table 11. Results of analysis of trace elements in ground-water-quality samples from the Prairie Band Potawatomi Reservation, north-eastern Kansas, April through August 2003.

[Water-quality criteria established by the U.S. Environmental Protection Agency (2004a). µg/L, micrograms per liter; MCL, Maximum Contaminant Level; DWA, Drinking-Water Advisory; SDWR, Secondary Drinking-Water Regulation; --, not determined; E, estimated; <, less than]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Arsenic, dissolved (µg/L)	Boron, dissolved (µg/L)	Iron, dissolved (µg/L)	Selenium, dissolved (µg/L)
Water-quality criteria						
			10 (MCL)	600 (DWA)	300 (SDWR)	50 (MCL)
Ground-water quality						
MW01	Monitoring well #1	08/13/03	<2	80	1,100	<3
MW02	Monitoring well #2	04/30/03	<2	80	30	<3
		08/14/03	<2	100	30	<3
MW03	Monitoring well #3	08/13/03	E1	600	3,400	<3
MW04	Monitoring well #4	05/02/03	<2	60	<10	<3
		08/14/03	<2	80	E5	<3
MW05	Monitoring well #5	04/29/03	<2	80	<10	<3
MW06	Monitoring well #6	04/30/03	19	100	3,600	<3
		08/13/03	26	120	4,600	<3
MW07	Monitoring well #7	04/29/03	<2	80	30	<3
MW08	Monitoring well #8	04/30/03	4	90	1,000	<3
MW09	Monitoring well #9	05/01/03	<2	30	<10	<3
MW10	Monitoring well #10	05/02/03	<2	40	<10	<3
MW11	Monitoring well #11	05/02/03	E2	70	<10	<3
		08/12/03	E1	80	<8	<3

at concentrations greater than the MCL of 3.0 µg/L for atrazine (fig. 13). The samples were collected from the two sites on Soldier Creek on May 14, 2003.

Five surface-water samples collected from May 2001 through August 2001 were analyzed for specific triazine herbicides and other pesticides, and 22 surface-water samples collected from November 2001 through August 2003 were analyzed for specific triazine herbicides by GC/MS (table 12). Thirteen of the triazine herbicides and other pesticides analyzed were detected in surface-water samples. The results for detected pesticides are presented in table 12. Atrazine was detected in all samples analyzed by GC/MS, and concentrations ranged from 0.07 to 9.8 µg/L, with an median of 0.50 µg/L. There were multiple detections of atrazine metabolites, acetochlor, alachlor, metolachlor, and simazine in surface-water samples as well. Atrazine, atrazine metabolites, and simazine were detected in one ground-water sample from monitoring well MW02 in August 2003 (table 13); there were no detections of pesticides in water from this well when it was sampled in April 2003.

Chemical Oxygen Demand and Volatile Organic Compounds

The chemical oxygen demand of a water sample is a measure of the amount of oxygen needed to oxidize the reactive chemicals in a water system (Hem, 1992). If the chemical oxygen demand of a sample is high, as that water moves through a system, it will consume dissolved oxygen from the surrounding water to complete chemical reactions. Decreases in dissolved oxygen in a system can destroy aerobic organisms and cause changes in the redox environment of a system, which could release redox sensitive chemicals such as arsenic and iron into the water. Chemical oxygen demand also is used as a quantitative measure of organic pollution in a water sample (Hem, 1992). The chemical oxygen demand in the water sample from well MW04 was less than 10 mg/L (table 14). As this water moves through the ground-water system, it should not substantially alter the dissolved oxygen concentrations in the aquifer downgradient from the well.

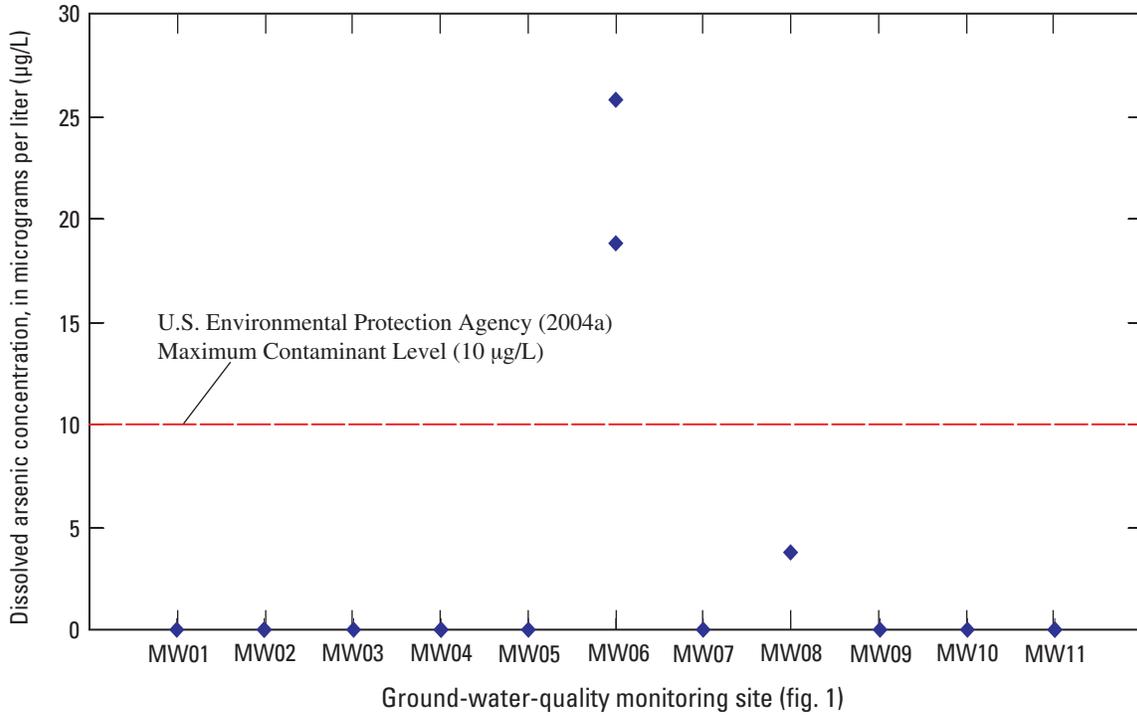


Figure 10. Concentrations of dissolved arsenic in ground-water-quality samples, April through August 2003. Maximum Contaminant Level from U.S. Environmental Protection Agency (2004a).

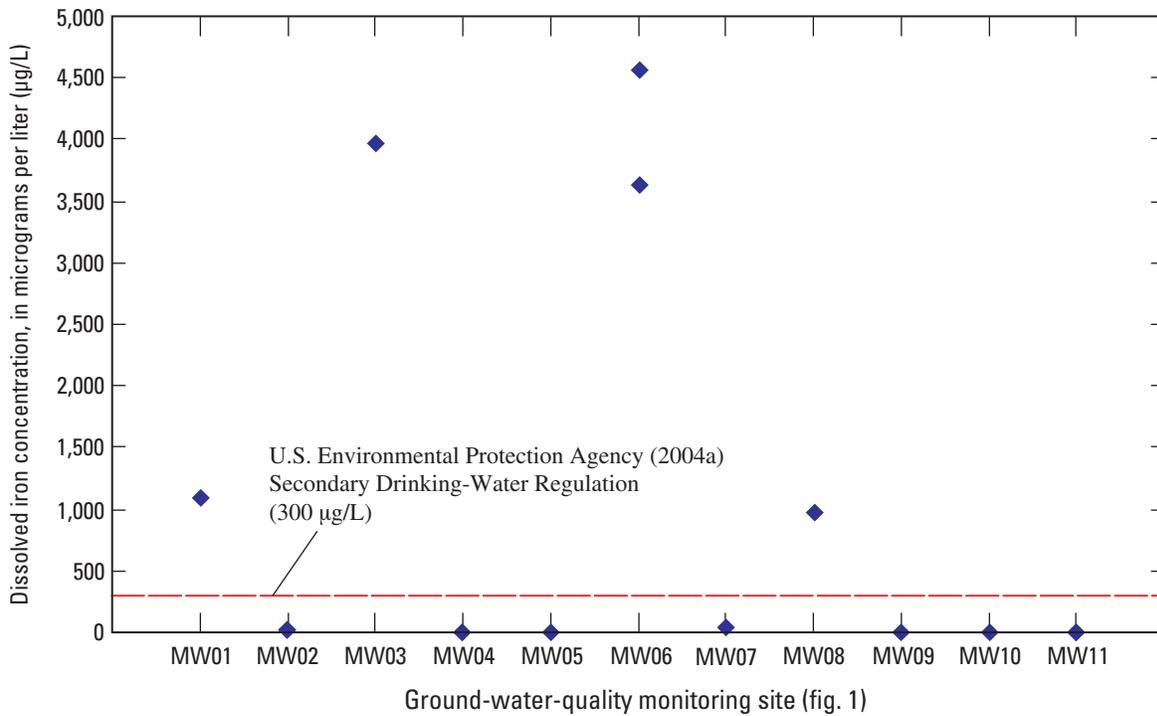


Figure 11. Concentrations of dissolved iron in ground-water-quality samples, April through August 2003. Secondary Drinking-Water Regulation from U.S. Environmental Protection Agency (2004a).

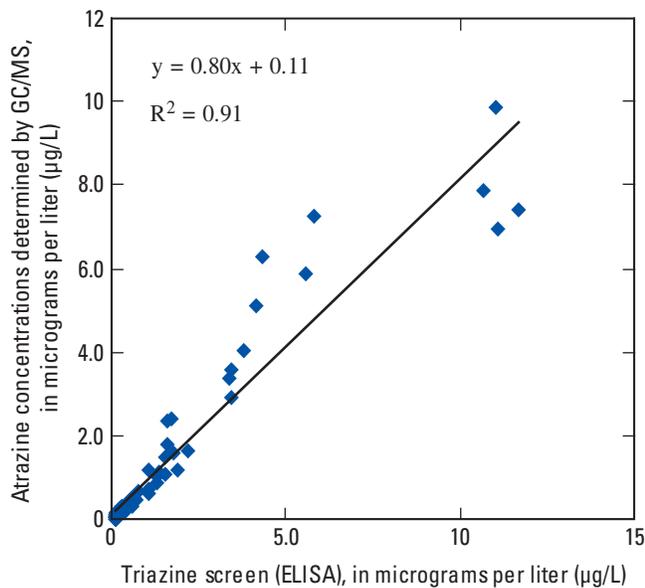


Figure 12. Relation between triazine herbicide concentrations determined by enzyme-linked immunosorbent assay (ELISA) and atrazine concentrations determined by gas chromatography/mass spectrometry (GC/MS) for samples collected from surface-water monitoring sites from June 1996 through August 2003.

Volatile organic compounds (VOCs) are compounds that have a high vapor pressure and low water solubility. Many VOCs are human-made chemicals that are used and produced in the manufacture of paints, pharmaceuticals, and refrigerants. VOCs typically are industrial solvents, fuel oxygenates, or by-products produced by chlorination in water treatment. VOCs often are components of petroleum fuels, hydraulic fluids, paint thinners, and dry cleaning agents (Daly and Lindsey, 1996).

The May 2, 2003, water sample from well MW04 was analyzed for the presence of VOCs because of the proximity of the well to a construction and demolition landfill. Of the 85 VOCs analyzed, three compounds were detected; these were carbon disulfide (0.15 µg/L), ethyl methyl ketone (estimated 0.96 µg/L), and tetrahydrofuran (11 µg/L) (table 14). There are no USEPA drinking-water criteria established for these compounds. Tetrahydrofuran is a solvent found in PVC cement (National Library of Medicine, 2004) and may be an artifact of the well construction. Similarly, carbon disulfide is associated with PVC but also can be found in grain fumigants (National Safety Council, 2004a). Methyl ethyl ketone is used as a solvent in pesticide formulations and can be used in varnishing and in cleaning fluids (National Safety Council, 2004b).

Bacteria

Fecal coliform, *Escherichia coli* (*E. coli*), fecal streptococcus, and enterococci bacteria are indigenous to the intestinal tract of warmblooded animals (Holt and others, 1993). The fecal coliform bacteria group can include any combination of

E. coli and species of the *Klebsiella*, *Enterbacter*, and *Citrobacter* genera (Gleeson and Gray, 1997). The presence of large concentrations of these organisms in surface water indicates fecal contamination and also may indicate the presence of disease-causing organisms. Potential sources of these bacteria on the reservation include sewage lagoons, runoff, and seepage from livestock areas, such as pastures and confined feedlots, and from wildlife populations.

USEPA (2002b) recommended criteria for *E. coli* and (or) enterococci bacteria in water designated for primary contact recreational use that are based on geometric-mean density and single-sample density (table 15). The ranges of the geometric-mean (table 15) criteria vary on the basis of the illness rate (8 to 14 illnesses per 1,000 swimmers). The geometric mean is calculated from at least five samples collected during separate 24-hour periods within a 30-day period. USEPA (2002b) also has established criteria on the basis of full-body contact and single-sample allowable density for water bodies defined as designated beach areas, moderately used, lightly used, and infrequently used (table 15). Primary contact use is defined as activities where the body is immersed into water to the extent that some inadvertent ingestion of the water is probable. These activities include boating, mussel harvesting, swimming, skin diving, water skiing, and wind surfing (Kansas Department of Health and Environment, 2001). USEPA currently (2004) has no recommended criteria for secondary contact (U.S. Environmental Protection Agency, 2002b). Secondary contact activities include wading, fishing, trapping, and hunting, where the ingestion of water is not probable (Kansas Department of Health and Environment, 2001). Tribal members primarily use the streams on the reservation for hunting and fishing; therefore, ingestion of water is not probable.

Fecal coliform bacteria densities range from less than 1 to 2,000 col/100 mL in surface-water samples from the reservation (table 16). The largest density of fecal coliform colonies was in a sample collected on June 12, 2001, from site LSC05 (fig. 1). The median density of fecal coliform bacteria for all the surface-water sites was 190 col/100 mL. Fecal coliform bacteria were detected twice in ground-water samples from monitoring wells MW02 and MW10 at estimated densities of 4 and 5 col/100 mL, respectively (table 17).

E. coli is the dominant bacteria of the fecal coliform group (Rasmussen and Ziegler, 2003). Rasmussen and Ziegler (2003) found that the ratio of *E. coli* to fecal coliform in the Soldier Creek Basin is 0.73, meaning that out of every 100 colonies of fecal coliform in a surface-water sample, 73 of the colonies are *E. coli* bacteria. This relation is important when comparing historic fecal coliform bacteria densities to the current (2004) USEPA bacteria water-quality criteria, which are based on *E. coli* densities.

The densities of *E. coli* colonies in surface-water samples ranged from less than 1 to 1,500 col/100 mL, and the median density in surface-water samples was 163 col/100 mL (table 16). Criteria that were based on an illness rate of 8 per 1,000 swimmers and the single-sample maximum allowable density were used for comparison purposes because the

Table 12. Results of analysis of pesticides in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.

[Water-quality criterion established by the U.S. Environmental Agency (2004a). ELISA, enzyme-linked immunosorbent assay; µg/L, micrograms per liter; --, not determined; <, less than; E, estimated; MCL, Maximum Contamiant Level]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Triazine screen, ELISA, dissolved (µg/L) as atrazine	2-Chloro-4-isopropyl-amino-6-triazine, dissolved (µg/L)	2-Chloro-6-ethylamino-4-amino-s-triazine, dissolved (µg/L)	Acetochlor, dissolved (µg/L)	Alachlor, dissolved (µg/L)	Atrazine, dissolved (µg/L)	Cyanazine, dissolved (µg/L)	Dimethenamid, dissolved (µg/L)
Water-quality criterion			--	--	--	--	--	3.0 (MCL)	--	--
Bills Creek Basin										
BC01	Bills Creek, U.S Highway 75 near Holton	06/12/01	<0.1	--	--	--	--	--	--	--
Little Soldier Creek Basin										
LSC01	Little Soldier Creek, 190 Road near Mayetta	06/12/01	1.5	--	--	--	--	--	--	--
LSC02	Little Soldier Creek, 174 Road near Mayetta	06/12/01	.9							
LSC03	Little Soldier Creek, O Road near Mayetta	05/15/01	.2	--	--	--	--	--	--	--
		06/12/01	1.2	--	--	--	--	--	--	--
		11/13/01	<.1	--	--	--	--	--	--	--
		02/12/02	<.1	--	--	--	--	--	--	--
		05/22/02	.5	0.06	<0.05	<0.05	<0.05	0.43	<0.05	<0.05
		08/28/02	1.4	.35	.24	<.05	.05	1.1	<.05	<.05
		11/13/02	.7	--	--	--	--	--	--	--
		02/19/03	.2	--	--	--	--	--	--	--
		05/14/03	.4	<.05	<.05	<.05	<.05	.26	<.05	<.05
LSC04	Little Soldier Creek, 134 Road near Mayetta	05/15/01	.2	--	--	--	--	--	--	--
		06/12/01	1.7	--	--	--	--	--	--	--
		11/13/01	<.1	--	--	--	--	--	--	--
		02/12/02	<.1	--	--	--	--	--	--	--
		05/22/02	.6	.07	<.05	<.05	<.05	.49	<.05	<.05

Table 12. Results of analysis of pesticides in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

[Water-quality criterion established by the U.S. Environmental Agency (2004a). ELISA, enzyme-linked immunosorbent assay; µg/L, micrograms per liter; --, not determined; <, less than; E, estimated; MCL, Maximum Contamiant Level]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Triazine screen, ELISA, dissolved (µg/L) as atrazine	2-Chloro-4-isopropyl-amino-6-amino-s-triazine, dissolved (µg/L)	2-Chloro-6-ethylamino-4-amino-s-triazine, dissolved (µg/L)	Acetochlor, dissolved (µg/L)	Alachlor, dissolved (µg/L)	Atrazine, dissolved (µg/L)	Cyanazine, dissolved (µg/L)	Dimethenamid, dissolved (µg/L)
Little Soldier Creek Basin—Continued										
LSC04	Little Soldier Creek, 134 Road near Mayetta—Continued	08/28/02	1.3	0.31	0.20	<0.05	0.05	0.86	<0.05	<0.05
		11/13/02	--	--	--	--	--	--	--	--
		02/19/03	--	--	--	--	--	--	--	--
		05/14/03	.6	<.05	<.05	<.05	<.05	.37	<.05	<.05
LSC05	Little Soldier Creek tributary, 134 Road near Hoyt	06/12/01	1.0	--	--	--	--	--	--	--
LSC06	Big Elm Creek, 134 Road near Hoyt	05/15/01	.1	--	--	--	--	--	--	--
		06/12/01	.2	--	--	--	--	--	--	--
		08/21/01	.2	--	--	--	--	--	--	--
		11/13/01	<.1	--	--	--	--	--	--	--
		02/12/02	<.1	--	--	--	--	--	--	--
		05/22/02	<.1	<.05	<.05	<.05	<.05	.10	<.05	<.05
		08/28/02	<.1	.07	<.05	<.05	<.05	.07	<.05	<.05
		11/13/02	.4	--	--	--	--	--	--	--
		02/19/03	.2	--	--	--	--	--	--	--
		05/14/03	.2	--	--	--	--	--	--	--
LSC07	Little Elm Creek, Q Road near Hoyt	06/12/01	<.1	--	--	--	--	--	--	--
LSC08	Big Elm Creek, P Road near Hoyt	06/12/01	.4	--	--	--	--	--	--	--
LSC09	Little Soldier Creek, 126 Road near Hoyt	06/12/01	1.6	E.14	--	.06	.13	1.8	<.02	--
Soldier Creek Basin										
SC01	Soldier Creek, 214 Road near Circleville	06/13/01	1.6	E.29	--	.09	.18	2.3	<.02	--
SC02	Soldier Creek tributary, G Road near Circleville	06/13/01	.2	--	--	--	--	--	--	--

Table 12. Results of analysis of pesticides in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

[Water-quality criterion established by the U.S. Environmental Agency (2004a). ELISA, enzyme-linked immunosorbent assay; µg/L, micrograms per liter; --, not determined; <, less than; E, estimated; MCL, Maximum Contaminant Level]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Triazine screen, ELISA, dissolved (µg/L) as atrazine	2-Chloro-4-isopropyl-amino-6-amino-s-triazine, dissolved (µg/L)	2-Chloro-6-ethylamino-4-amino-s-triazine, dissolved (µg/L)	Acetochlor, dissolved (µg/L)	Alachlor, dissolved (µg/L)	Atrazine, dissolved (µg/L)	Cyanazine, dissolved (µg/L)	Dimethenamid, dissolved (µg/L)
Soldier Creek Basin—Continued										
SC03	Soldier Creek near Saint Clere	05/15/01	1.6	--	--	--	--	--	--	--
		06/13/01	1.4	--	--	--	--	--	--	--
		08/21/01	.3	E0.06	--	<0.05	<0.05	0.21	<0.02	--
		11/13/01	<.1	--	--	--	--	--	--	--
		02/12/02	<.1	--	--	--	--	--	--	--
		05/22/02	1.8	.18	0.06	.05	.06	1.6	<.05	<.05
		08/28/02	.3	.07	<.05	<.05	<.05	.18	<.05	<.05
		11/13/02	.1	--	--	--	--	--	--	--
		02/19/03	<.1	--	--	--	--	--	--	--
		05/14/03	11	.53	.23	1.3	.75	9.8	.09	.16
08/20/03	.7	.21	.11	<.05	<.05	.51	<.05	<.05		
SC04	Soldier Creek, 158 Road near Saint Clere	06/13/01	1.5	--	--	--	--	--	--	--
SC05	Crow Creek, 166 Road near Saint Clere	06/13/01	1.0	--	--	--	--	--	--	--
SC06	South Branch Soldier Creek, H.5 Road near Saint Clere	06/13/01	1.3	--	--	--	--	--	--	--
SC07	Soldier Creek, I Road near Delia	05/15/01	1.5	--	--	--	--	--	--	--
		06/13/01	1.7	E.26	--	.08	.20	2.4	<.02	--
		08/21/01	.3	--	--	--	--	--	--	--
		11/13/01	<.1	--	--	--	--	--	--	--
		02/12/02	<.1	--	--	--	--	--	--	--
		05/22/02	1.6	.18	.06	.05	.06	1.5	<.05	<.05
08/28/02	.2	.08	<.05	<.05	<.05	.17	<.05	<.05		

Table 12. Results of analysis of pesticides in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

[Water-quality criterion established by the U.S. Environmental Agency (2004a). ELISA, enzyme-linked immunosorbent assay; µg/L, micrograms per liter; --, not determined; <, less than; E, estimated; MCL, Maximum Contamiant Level]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Triazine screen, ELISA, dissolved (µg/L) as atrazine	2-Chloro-4-isopropyl-amino-6-amino-s-triazine, dissolved (µg/L)	2-Chloro-6-ethylamino-4-amino-s-triazine, dissolved (µg/L)	Acetochlor, dissolved (µg/L)	Alachlor, dissolved (µg/L)	Atrazine, dissolved (µg/L)	Cyanazine, dissolved (µg/L)	Dimethenamid, dissolved (µg/L)
Soldier Creek Basin—Continued										
SC07	Soldier Creek, I Road near Delia	11/13/02	<0.1	--	--	--	--	--	--	--
		02/19/03	<.1	--	--	--	--	--	--	--
		05/14/03	11	--	--	--	--	--	--	--
		08/20/03	.7	0.22	--	--	0.46	<0.02	--	
SC08	James Creek, 142 Road near Delia	06/13/01	1.0	--	--	--	--	--	--	
SC09	James Creek, 126 Road near Delia	06/13/01	1.1	E.14	--	0.01	0.07	1.2	<.02	--
South Cedar Creek Basin										
SCC01	South Cedar Creek, U.S. Highway 75 near Mayetta	06/12/01	1.4	--	--	--	--	--	--	--

Table 12. Results of analysis of pesticides in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

Water-quality criterion established by the U.S. Environmental Agency (2004a). ELISA, enzyme-linked immunosorbent assay; µg/L, micrograms per liter; --, not determined; <, less than; E, estimated; MCL, Maximum Contamiant Level]

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Metolachlor, dissolved (µg/L)	Metribuzin, dissolved (µg/L)	Propazine, dissolved (µg/L)	Simazine, dissolved (µg/L)	2-Hydroxy-4-isopropyl-amino-6-ethylamino-s-triazine, dissolved (µg/L)	Chlorodi-amino-s-triazine, dissolved (µg/L)
		Water-quality criterion						
			--	--	--	--	--	--
		Bills Creek Basin						
BC01	Bills Creek, U.S Highway 75 near Holton	06/12/01	--	--	--	--	--	--
		Little Soldier Creek Basin						
LSC01	Little Soldier Creek, 190 Road near Mayetta	06/12/01			--	--	--	--
LSC02	Little Soldier Creek, 174 Road near Mayetta	06/12/01						
LSC03	Little Soldier Creek, O Road near Mayetta	05/15/01	--	--	--	--	--	--
		06/12/01	--	--	--	--	--	--
		11/13/01	--	--	--	--	--	--
		02/12/02	--	--	--	--	--	--
		05/22/02	<0.05	<0.05	<0.05	<0.05	--	--
		08/28/02	<.05	<.05	<.05	<.05	--	--
		11/13/02	--	--	--	--	--	--
		02/19/03	--	--	--	--	--	--
		05/14/03	<.05	<.05	<.05	<.05	--	--
LSC04	Little Soldier Creek, 134 Road near Mayetta	05/15/01	--	--	--	--	--	--
		06/12/01	--	--	--	--	--	--
		11/13/01	--	--	--	--	--	--
		02/12/02	--	--	--	--	--	--
		05/22/02	<.05	<.05	<.05	<.05		
		08/28/02	<.05	<.05	<.05	<.05		
		11/13/02	--	--	--	--	--	--
		02/19/03	--	--	<.05	<.05	--	--
		05/14/03	<.05	<.05	--	--	--	--

Table 12. Results of analysis of pesticides in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

Water-quality criterion established by the U.S. Environmental Agency (2004a). ELISA, enzyme-linked immunosorbent assay; µg/L, micrograms per liter; --, not determined; <, less than; E, estimated; MCL, Maximum Contamiant Level]

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Metolachlor, dissolved (µg/L)	Metribuzin, dissolved (µg/L)	Propazine, dissolved (µg/L)	Simazine, dissolved (µg/L)	2-Hydroxy-4-isopropyl-amino-6-ethylamino-s-triazine, dissolved (µg/L)	Chlorodi-amino-s-triazine, dissolved (µg/L)
Little Soldier Creek Basin—Continued								
LSC05	Little Soldier Creek tributary, 134 Road near Hoyt	06/12/01	--	--	--	--	--	--
LSC06	Big Elm Creek, 134 Road near Hoyt	05/15/01	--	--	--	--	--	--
		06/12/01	--	--	--	--	--	--
		08/21/01	--	--	--	--	--	--
		11/13/01	--	--	<0.05	<0.05	--	--
		02/12/02	--	--	<.05	<.05	--	--
		05/22/02	<0.05	<0.05	--	--	--	--
		08/28/02	<.05	<.05	--	--	--	--
		11/13/02	--	--	--	--	--	--
		02/19/03	--	--	--	--	--	--
		05/14/03	--	--	--	--	--	--
LSC07	Little Elm Creek, Q Road near Hoyt	06/12/01	--	--	--	--	--	--
LSC08	Big Elm Creek, P Road near Hoyt	06/12/01	--	--	--	--	--	--
LSC09	Little Soldier Creek, 126 Road near Hoyt	06/12/01	.12	<.01	--	<.01	--	--
Soldier Creek Basin								
SC01	Soldier Creek, 214 Road near Circleville	06/13/01	.58	<.01	--	.01	--	--
SC02	Soldier Creek tributary, G Road near Circleville	06/13/01	--	--	--	--	--	--
SC03	Soldier Creek near Saint Clere	05/15/01	--	--	--	--	--	--
		06/13/01	--	--	--	--	--	--
		08/21/01	.05	<.01	--	<.01	--	--
		11/13/01	--	--	--	--	--	--

Table 12. Results of analysis of pesticides in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

Water-quality criterion established by the U.S. Environmental Agency (2004a). ELISA, enzyme-linked immunosorbent assay; µg/L, micrograms per liter; --, not determined; <, less than; E, estimated; MCL, Maximum Contaminant Level]

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Metolachlor, dissolved (µg/L)	Metribuzin, dissolved (µg/L)	Propazine, dissolved (µg/L)	Simazine, dissolved (µg/L)	2-Hydroxy-4-isopropyl-amino-6-ethylamino-s-triazine, dissolved (µg/L)	Chlorodi-amino-s-triazine, dissolved (µg/L)
Soldier Creek Basin—Continued								
SC03	Soldier Creek near Saint Clere—Continued	02/12/02	--	--	--	--	--	--
		05/22/02	0.15	<0.05	<0.05	<0.05	--	--
		08/28/02	<.05	<.05	<.05	<.05	--	--
		11/13/02	--	--	--	--	--	--
		02/19/03	--	--	--	--	--	--
		05/14/03	1.1	<.05	.12	<.05	--	--
		08/20/03	<.05	<.05	<.05	.10	--	--
SC04	Soldier Creek, 158 Road near Saint Clere	06/13/01	--	--	--	--	--	
SC05	Crow Creek, 166 Road near Saint Clere	06/13/01	--	--	--	--	--	
SC06	South Branch Soldier Creek, H.5 Road near Saint Clere	06/13/01	--	--	--	--	--	
SC07	Soldier Creek, I Road near Delia	05/15/01	--	--	--	--	--	--
		06/13/01	.54	.01	--	.01	--	--
		08/21/01	--	--	--	--	--	--
		11/13/01	--	--	--	--	--	--
		02/12/02	--	--	--	--	--	--
		05/22/02	.16	<.05	<.05	<.05	--	--
		08/28/02	<.05	<.05	<.05	<.05	--	--
		11/13/02	--	--	--	--	--	--
		02/19/03	--	--	--	--	--	--
		05/14/03	--	--	--	--	--	--
		08/20/03	--	--	<.03	<.03	0.60	0.08

Table 12. Results of analysis of pesticides in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

Water-quality criterion established by the U.S. Environmental Agency (2004a). ELISA, enzyme-linked immunosorbent assay; µg/L, micrograms per liter; --, not determined; <, less than; E, estimated; MCL, Maximum Contamiant Level]

Map identifier (fig. 1)	Stream basin and site name	Date of sample collection (month/day/year)	Metolachlor, dissolved (µg/L)	Metribuzin, dissolved (µg/L)	Propazine, dissolved (µg/L)	Simazine, dissolved (µg/L)	2-Hydroxy-4-isopropyl-amino-6-ethylamino-s-triazine, dissolved (µg/L)	Chlorodi-amino-s-triazine, dissolved (µg/L)
Soldier Creek Basin—Continued								
SC08	James Creek, 142 Road near Delia	06/13/01	--	--	--	--	--	--
SC09	James Creek, 126 Road near Delia	06/13/01	0.10	<0.01	--	E0.01	--	--
South Cedar Creek Basin								
SCC01	South Cedar Creek, U.S. Highway 75 near Mayetta	06/12/01	--	--	--	--	--	--

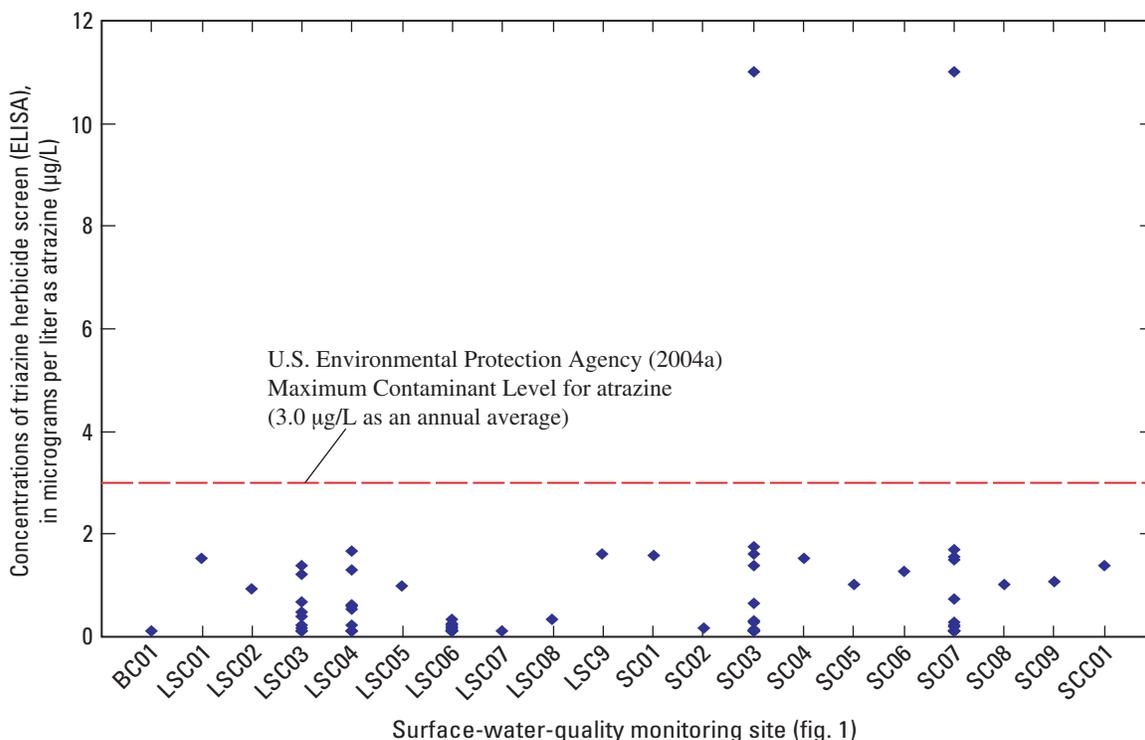


Figure 13. Concentrations of triazine herbicide screen (ELISA) in surface-water-quality samples, May 2001 through August 2003. Maximum Contaminant Level from U.S. Environmental Protection Agency (2004a).

collection schedule of samples did not allow for calculation of the geometric mean. Of 65 surface-water samples analyzed for *E. coli* bacteria, 12 samples exceeded the criterion for primary contact in moderately used water bodies (298 col/100 mL), 10 samples exceeded the primary contact criterion for lightly used water bodies (406 col/100 mL), and 6 samples exceeded the primary contact criterion for infrequently used water bodies (576 col/100 mL).

There was one detection of *E. coli* in ground-water samples. An estimated density of 5 col/100 mL was detected in a sample from well MW02 on April 30, 2003; the quantity was estimated because there was not an ideal count of the colonies present (table 17).

Fecal streptococci bacteria densities in surface-water samples ranged from less than 1 to an estimated 5,800 col/100 mL, with a median density of 330 col/100 mL (table 16). The largest density occurred in the November 13, 2002, sample from site LSC03. The only time fecal streptococci bacteria was not detected in surface-water samples from the Prairie Band Potawatomi Reservation was on November 13, 2001, at site LSC04.

Fecal streptococci bacteria were detected in seven ground-water samples. The largest estimated density of 230 col/100 mL was in water from monitoring well MW10 (table 17).

Enterococci bacteria are a subgroup of the fecal streptococci bacteria and are a valuable bacterial indicator for determining the extent of fecal contamination of recreational surface water. Studies at marine and freshwater bathing beaches indicated that swimming-associated gastroenteritis is related directly to the quality of the bathing water, and enterococci are

the most efficient bacterial indicator of water quality (American Public Health Association and others, 1992). USEPA has established water-quality criteria that are based on enterococci bacteria densities in recreational water (U.S. Environmental Protection Agency, 2002b).

Enterococci bacteria densities in surface-water samples from the reservation ranged from an estimated 40 to an estimated 8,100 col/100 mL, with a median density of 470 col/100 mL (table 16). The largest density was detected in a sample from site SC03 on August 20, 2003. Criteria that are based on an illness rate of 8 per 1,000 swimmers and the single-sample maximum allowable density were used for comparison purposes. Of 36 surface-water samples analyzed for enterococci bacteria, 33 samples exceeded the criterion for primary contact in moderately used water bodies (78 col/100 mL), 31 samples exceeded the primary contact criterion for lightly used water bodies (107 col/100 mL), and 28 samples exceeded the primary contact criterion for infrequently used water bodies (151 col/100 mL).

Enterococci bacteria were the most frequently detected bacteria in the ground-water samples (table 17). Enterococci were detected in 10 of 15 water samples, and densities ranged from less than 1 to an estimated 480 col/100 mL. The largest density of enterococci bacteria was in a water sample from monitoring well MW10 and corresponds to the largest density of fecal streptococci bacteria.

Figure 14 shows median densities of the different types of bacteria during the seasons as well median streamflow measured at the time of sample collection. Only quarterly samples

Table 13. Results of analysis of selected triazine herbicides and metabolites in ground-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, April through August 2003.

[Water-quality criterion established by the U.S. Environmental Agency (2004a). µg/L, micrograms per liter; --, not determined; MCL, Maximum Contaminant Level; <, less than]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	2-Chloro-4-isopropylamino-6-amino-s-triazine, dissolved (µg/L)	2-Chloro-6-ethylamino-4-amino-s-triazine, dissolved (µg/L)	Acetochlor, dissolved (µg/L)	Alachlor, dissolved (µg/L)	Ametryn, dissolved (µg/L)	Atrazine, dissolved (µg/L)	Cyanazine, dissolved (µg/L)	Cyanazine amide, dissolved (µg/L)
Water-quality criterion										
			--	--	--	--	--	3.0 (MCL)	--	--
Ground-water quality										
MW01	Monitoring well #1	08/13/03	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
MW02	Monitoring well #2	04/30/03	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
		08/14/03	.28	.15	<.05	<.05	<.05	.53	<.05	<.05
MW03	Monitoring well #3	08/13/03	.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
MW04	Monitoring well #4	05/02/03	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
		08/14/03	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
MW05	Monitoring well #5	04/29/03	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
MW06	Monitoring well #6	04/30/03	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
		08/13/03	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
MW07	Monitoring well #7	04/29/03	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
MW08	Monitoring well #8	04/30/03	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
MW09	Monitoring well #9	05/01/03	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
MW10	Monitoring well #10	05/02/03	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
MW11	Monitoring well #11	05/02/03	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
		08/12/03	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05

Table 14. Results of analysis of chemical oxygen demand and volatile organic compounds in a ground-water-quality sample from monitoring well MW04 on the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2, 2003.

[Location of monitoring well shown in figure 1. mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; E, estimated]

Constituent	Concentration
Chemical oxygen demand, total, mg/L	<10
1,1,1,2-Tetrachloroethane, total, µg/L	<.03
1,1,1-Trichloroethane, total, µg/L	<.032
1,1,2,2-Tetrachloroethane, total, µg/L	<.09
1,1,2-Trichloro-1,2,2-trifluoroethane, total, µg/L	<.06
1,1,2-Trichloroethane, total, µg/L	<.06
1,1-Dichloroethane, total, µg/L	<.035
1,1-Dichloroethene, total, µg/L	<.04
1,1-Dichloropropene, total, µg/L	<.05
1,2,3,4-Tetramethylbenzene, total, µg/L	<.23
1,2,3,5-Tetramethylbenzene, total, µg/L	<.2
1,2,3-Trichlorobenzene, total, µg/L	<.27
1,2,3-Trichloropropane, total, µg/L	<.16
1,2,3-Trimethylbenzene, total, µg/L	<.12
1,2,4-Trichlorobenzene, total, µg/L	<.12
1,2,4-Trimethylbenzene, total, µg/L	<.056
1,2-Dibromo-3-chloropropane, total, µg/L	<.5
1,2-Dibromoethane, total, µg/L	<.036
1,2-Dichlorobenzene, total, µg/L	<.031
1,2-Dichloroethane, total, µg/L	<.13
1,2-Dichloropropane, total, µg/L	<.029
1,3,5-Trimethylbenzene, total, µg/L	<.044
1,3-Dichlorobenzene, total, µg/L	<.03
1,3-Dichloropropane, total, µg/L	<.12
1,4-Dichlorobenzene, total, µg/L	<.05
2,2-Dichloropropane, total, µg/L	<.05
2-Chlorotoluene, total, µg/L	<.04
2-Ethyltoluene, total, µg/L	<.06
3-Chloropropene, total, µg/L	<.12
4-Chlorotoluene, total, µg/L	<.05
4-Isopropyltoluene, total, µg/L	<.12
Acetone, total, µg/L	<7
Acrylonitrile, total, µg/L	<1.2
Benzene, total, µg/L	<.035
Bromobenzene, total, µg/L	<.036

Table 14. Results of analysis of chemical oxygen demand and volatile organic compounds in a ground-water-quality sample from monitoring well MW04 on the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2, 2003.—Continued

[Location of monitoring well shown in figure 1. mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; E, estimated]

Constituent	Concentration
Bromochloromethane, total, µg/L	<0.12
Bromodichloromethane, total, µg/L	<.048
Bromoethene, total, µg/L	<.11
Bromomethane, total, µg/L	<.26
Carbon disulfide, total, µg/L	.15
Chlorobenzene, total, µg/L	<.028
Chloroethane, total, µg/L	<.12
Chloromethane, total, µg/L	<.17
cis-1,2-Dichloroethene, total, µg/L	<.038
cis-1,3-Dichloropropene, total, µg/L	<.09
Dibromochloromethane, total, µg/L	<.18
Dibromomethane, total, µg/L	<.05
Dichlorodifluoromethane, total, µg/L	<.18
Dichloromethane, total, µg/L	<.16
Diethyl ether, total, µg/L	<.17
Diisopropyl ether, total, µg/L	<.1
Ethyl methacrylate, total, µg/L	<.18
Ethyl methyl ketone, total, µg/L	E.96
Ethylbenzene, total, µg/L	<.03
Hexachlorobutadiene, total, µg/L	<.14
Hexachloroethane, total, µg/L	<.19
Iodomethane, total, µg/L	<.35
Isobutyl methyl ketone, total, µg/L	<.37
Isopropylbenzene, total, µg/L	<.06
Methacrylonitrile, total, µg/L	<.6
Methyl acrylate, total, µg/L	<2
Methyl methacrylate, total, µg/L	<.35
Methyl tert-pentyl ether, total, µg/L	<.08
m-Xylene plus p-xylene, total, µg/L	<.06
Naphthalene, total, µg/L	<.5
n-Butyl methyl ketone, total, µg/L	<.7
n-Butylbenzene, total, µg/L	<.19
n-Propylbenzene, total, µg/L	<.042
o-Xylene, total, µg/L	<.07
sec-Butylbenzene, total, µg/L	<.06

Table 14. Results of analysis of chemical oxygen demand and volatile organic compounds in a ground-water-quality sample from monitoring well MW04 on the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2, 2003.—Continued

[Location of monitoring well shown in figure 1. mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; E, estimated]

Constituent	Concentration
Styrene, total, µg/L	<0.042
tert-Butyl ethyl ether, total, µg/L	<.05
Methyl tert-butyl ether, total, µg/L	<.17
tert-Butylbenzene, total, µg/L	<.1
Tetrachloroethene, total, µg/L	<.027
Tetrachloromethane, total, µg/L	<.06
Tetrahydrofuran, total, µg/L	11
Toluene, total, µg/L	<.05
trans-1,2-Dichloroethene, total, µg/L	<.032
trans-1,3-Dichloropropene, total, µg/L	<.09
trans-1,4-Dichloro-2-butene, total, µg/L	<.7
Tribromomethane, total, µg/L	<.1
Trichloroethene, total, µg/L	<.038
Trichlorofluoromethane, total, µg/L	<.09
Trichloromethane, total, µg/L	<.024
Vinyl chloride, total, µg/L	<.11

Table 15. U.S. Environmental Protection Agency (2002b) recommended indicator bacteria criteria (modified from Rasmussen and Ziegler, 2003).[Criteria established by U.S. Environmental Protection Agency (2002b). All values are in colonies per 100 milliliters of water. *E. coli*, *Escherichia coli* bacteria]

Indicator bacteria type	Illness rate (per 1,000 swimmers)	Primary contact recreation ¹				
		Geometric mean ²	Single-sample maximum allowable density			
			Designated beach area	Moderately used full-body contact	Lightly used full- body contact	Infrequently used full-body contact
<i>E. coli</i>	8	126	235	298	406	576
	9	160	300	381	524	736
	10	206	383	487	669	941
	11	263	490	622	855	1,202
	12	336	626	795	1,092	1,536
	13	429	799	1,016	1,396	1,962
	14	548	1,021	1,298	1,783	2,507
Enterococci	8	33	62	78	107	151
	9	42	79	100	137	193
	10	54	100	128	175	246
	11	69	128	163	224	315
	12	88	164	208	286	402
	13	112	209	266	365	514
	14	144	267	340	467	656

¹Recreation during which the body is immersed in surface water to the extent that some inadvertent ingestion of water is probable.²Geometric mean of at least five samples collected during separate 24-hour periods within a 30-day period.

were used in this comparison with the May samples defined as “spring,” August samples defined as “summer,” November samples defined as “fall,” and February samples defined as “winter.” Median densities of all bacteria types were largest during the summer months and not necessarily larger during times of larger median streamflow.

Sediment

Fluvial sediment is defined as fragmentary material that originates mostly from weathering rocks and is transported by, suspended in, or deposited from water; it includes chemical and biological precipitates and decomposed organic material, such as humus (Federal Inter-Agency Sedimentation Project, 1963).

Fluvial sediment in surface-water samples collected for this study was measured by two different analytical methods—total suspended solids (TSS) and suspended-sediment concentration (SSC). TSS data were determined by measuring the dry weight of sediment from a known volume of a subsample of the original sample (Gray and others, 2000). SSC data were produced by measuring the dry weight of all the sediment from a known volume of a water-sediment mixture (Gray and others, 2000).

TSS were analyzed for in all surface-water samples collected during this study as well as in samples collected during the two previous periods of the ongoing cooperative study. TSS concentrations ranged from 7 to 66 mg/L, with a median concentration of 17 mg/L (table 18). The largest concentration occurred in a water sample collected on June 13, 2001, from site SC07 (table 18) and correlates to the second largest streamflow recorded during the study period (table 4). TSS were detected in 49 percent of all samples. SSC was analyzed in samples from the quarterly surface-water-quality monitoring sites that were collected from November 2001 through August 2003. SSC ranged from 1 to 93 mg/L, with a median concentration of 26 mg/L in all samples (table 18). The largest SSC was detected in a sample from site SC03 on August 28, 2002.

Concentrations of TSS and SSC were generally larger in the Soldier Creek Basin than in the Little Soldier Creek Basin (fig. 15). Median concentrations of TSS and SSC in water from monitoring sites on the main stem of Soldier Creek (sites SC03 and SC07, fig. 1) were larger than in water from monitoring sites on the main stem of Little Soldier Creek (sites LSC03 and LSC04, fig. 1) (fig. 15). The larger sediment concentrations may be attributed to Soldier Creek's larger drainage area as well as 4 percent more cropland in the basin that is in proximity to the main stream channel (fig. 2, table 1).

Table 16. Results of analysis of fecal indicator bacteria in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.

[Water-quality criteria listed in table 15. col/100 mL, colonies per 100 mL of water; --, not determined; E, estimated; <, less than]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Bacteria			
			Fecal coliform	<i>Escherichia coli</i>	Fecal streptococci	Enterococci
Bills Creek Basin						
BC01	Bills Creek, U.S Highway 75 near Holton	06/12/01	157	168	391	--
Little Soldier Creek Basin						
LSC01	Little Soldier Creek, 190 Road near Mayetta	06/12/01	430	450	110	--
LSC02	Little Soldier Creek, 174 Road near Mayetta	06/12/01	270	250	250	--
LSC03	Little Soldier Creek, O Road near Mayetta	05/15/01	520	350	294	--
		06/12/01	1,680	1,500	590	--
		11/13/01	90	93	E60	220
		02/12/02	E16	E10	110	E260
		05/22/02	113	133	520	E720
		08/28/02	410	370	750	580
		11/13/02	196	198	E5,800	E6,300
		02/19/03	E42	E13	610	460
		05/14/03	E218	40	450	530
		LSC04	Little Soldier Creek, 134 Road near Mayetta	05/15/01	168	189
06/12/01	667			610	838	--
11/13/01	E20			E13	<1	--
02/12/02	E18			E13	80	280
05/22/02	183			97	531	800
08/28/02	E235			200	E4,400	E2,700
11/13/02	70			67	107	130
02/19/03	E3			<3	E44	90
05/14/03	460			143	530	770
LSC05	Little Soldier Creek tributary, 134 Road near Hoyt			06/12/01	2,000	243
LSC06	Big Elm Creek, 134 Road near Hoyt	05/15/01	168	151	692	--
		06/12/01	590	550	105	--
		08/21/01	168	250	769	--
		11/13/01	E38	E30	120	220
		02/12/02	766	1,170	198	210
		05/22/02	438	220	348	480
		08/28/02	E854	815	E3,800	E4,500
		11/13/02	E50	E45	290	410
		02/19/03	E41	E44	450	630
		05/14/03	490	E260	312	E2,500

Table 16. Results of analysis of fecal indicator bacteria in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

[Water-quality criteria listed in table 15. col/100 mL, colonies per 100 mL of water; --, not determined; E, estimated; <, less than]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Bacteria			
			Fecal coliform	<i>Escherichia coli</i>	Fecal streptococci	Enterococci
Little Soldier Creek Basin—Continued						
LSC07	Little Elm Creek, Q Road near Hoyt	06/12/01	250	120	228	--
LSC08	Big Elm Creek, P Road near Hoyt	06/12/01	431	218	815	--
LSC09	Little Soldier Creek, 126 Road near Hoyt	06/12/01	900	792	2,550	--
Soldier Creek Basin						
SC01	Soldier Creek, 214 Road near Circleville	06/13/01	170	163	413	--
SC02	Soldier Creek tributary, G Road near Circleville	06/13/01	470	263	862	--
SC03	Soldier Creek near Saint Clere	05/15/01	180	192	110	--
		06/13/01	300	250	630	--
		08/21/01	66	E80	225	--
		11/13/01	E56	E23	E50	170
		02/12/02	E3	<1	E40	E40
		05/22/02	107	70	330	560
		08/28/02	733	510	530	1,370
		11/13/02	156	68	67	120
		02/19/03	<1	<3	E22	E40
		05/14/03	240	203	230	770
		08/20/03	198	123	692	E8,100
SC04	Soldier Creek, 158 Road near Saint Clere	06/13/01	195	240	310	--
SC05	Crow Creek, 166 Road near Saint Clere	06/13/01	E210	230	892	--
SC06	South Branch Soldier Creek, H.5 Road near Saint Clere	06/13/01	310	270	577	--
SC07	Soldier Creek, I Road near Delia	05/15/01	76	E20	131	--
		06/13/01	310	185	510	--
		08/21/01	E45	E33	150	--
		11/13/01	E26	E23	E46	90
		02/12/02	<1	<1	163	E3,300
		05/22/02	110	E20	430	610
		08/28/02	173	210	310	300
		11/13/02	E18	E10	E28	E60
		02/19/03	<3	<3	E7	120
		05/14/03	212	113	230	250

Table 16. Results of analysis of fecal indicator bacteria in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

[Water-quality criteria listed in table 15. col/100 mL, colonies per 100 mL of water; --, not determined; E, estimated; <, less than]

Map identifier (fig. 1)	Site name	Date of sample collection (month/ day/year)	Bacteria			
			Fecal coliform	<i>Escherichia coli</i>	Fecal streptococci	Enterococci
Soldier Creek Basin—Continued						
SC07	Soldier Creek, I Road near Delia—Continued	08/20/03	666	592	1,100	2,700
SC08	James Creek, 142 Road near Delia	06/13/01	280	250	106	--
SC09	James Creek, 126 Road near Delia	06/13/01	190	E160	1,900	--
South Cedar Creek Basin						
SCC01	South Cedar Creek, U.S. Highway 75 near Mayetta	06/12/01	500	523	870	--

Table 17. Results of analysis of fecal indicator bacteria in ground-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, April through August 2003.

[Water-quality criteria listed in table 15. col/100 mL, colonies per 100 mL of water; <, less than; E, estimated]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Bacteria			
			Fecal coliform	<i>Escherichia coli</i>	Fecal streptococci	Enterococci
MW01	Monitoring well #1	08/13/03	<1	<1	<1	<1
MW02	Monitoring well #2	04/30/03	E4	E5	44	E76
		08/14/03	<1	<1	E2	E4
MW03	Monitoring well #3	08/13/03	<1	<1	<1	E1
MW04	Monitoring well #4	05/02/03	<1	<1	<1	E5
		08/14/03	<1	<1	<1	<1
MW05	Monitoring well #5	04/29/03	<1	<1	<1	E91
MW06	Monitoring well #6	04/30/03	<1	<1	35	40
		08/13/03	<1	<1	<1	<1
MW07	Monitoring well #7	04/29/03	<1	<1	E2	E4
MW08	Monitoring well #8	04/30/03	<1	<1	<1	<1
MW09	Monitoring well #9	05/01/03	<1	<1	E2	E7
MW10	Monitoring well #10	05/02/03	E5	<1	E230	E480
MW11	Monitoring well #11	05/02/03	<1	<1	E4	<1
		08/12/03	<1	<1	<1	E16

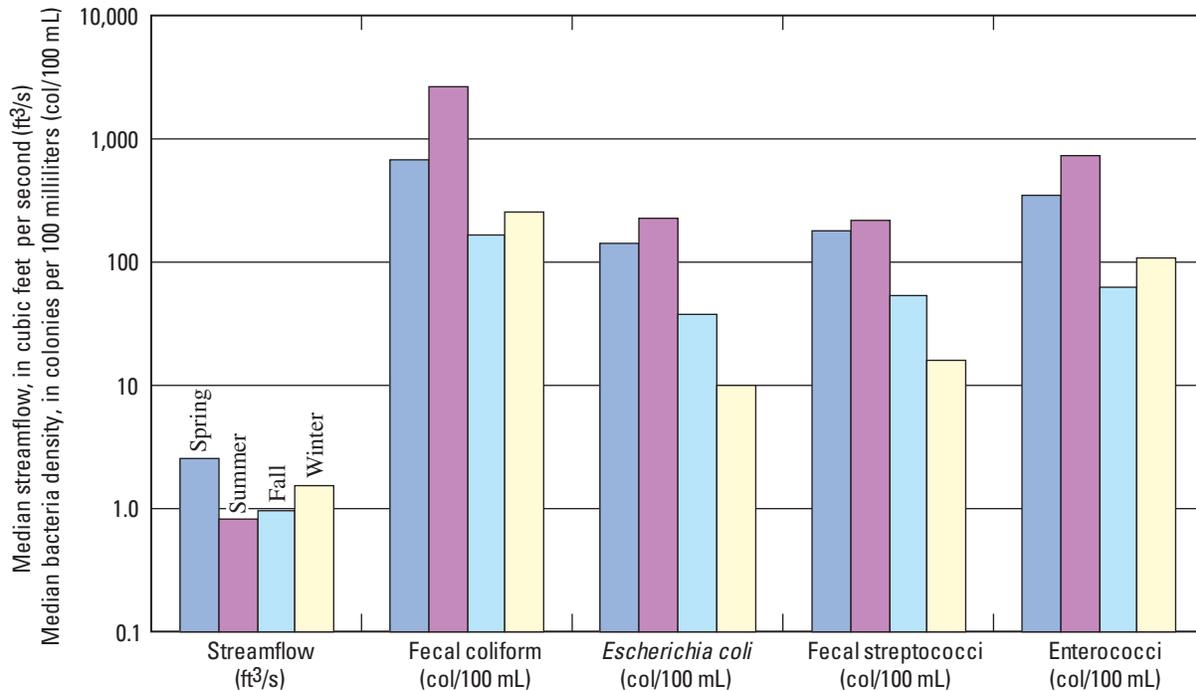


Figure 14. Seasonal distribution of median streamflow and median densities of all types of bacteria sampled during May 2001 through August 2003.

Comparison of Water-Quality Results to Previous Studies

This report describes surface- and ground-water quality on the Prairie Band Potawatomi Reservation from May 2001 through August 2003, and a comparison of results from this study period to results in previous water-quality reports published as a part of this ongoing study is presented in this section. Previous studies collected surface-water samples for analysis of physical properties, nutrients, pesticides, and fecal indicator bacteria (Trombley, 1999, 2001). These studies found total phosphorus, triazine herbicides, and fecal indicator bacteria as exceeding their respective water-quality criteria. Previous ground-water assessments collected ground-water samples from domestic supply wells and a pumping well installed for a pump test conducted as a part of exploration for development of the tribe’s water supply. These ground-water samples were analyzed for physical properties, major ions, dissolved solids, nutrients, trace elements, pesticides, and bacteria, and results identified dissolved solids, sodium, and sulfate as exceeding their respective water-quality criteria (Trombley, 2001).

The May 2001 through August 2003 study found that total phosphorus and triazine herbicide concentrations and fecal indicator bacteria densities continue to occasionally exceed their respective water-quality criteria at some surface-water monitoring sites on the reservation. Ranges of total phosphorus concentrations generally remained similar to the previous reporting periods with occasional samples exceeding the water-quality

criteria. However, total phosphorus concentrations did increase at site LSC06 from the June 1996 through November 1998 (figure 10, in Trombley, 1999) reporting period to the February 1999 through February 2001 reporting period (figure 9, in Trombley, 2001). The range in concentrations remained similar from the February 1999 through February 2001 reporting period to the May 2001 through August 2003 reporting period. The increase in total phosphorus could be attributed to installation of sewage treatment lagoons upstream from the monitoring site in 1998.

The median of triazine herbicide concentrations was similar during the May 2001 through August 2003 (current) reporting period to both the previous reporting periods—0.20 µg/L reported in Trombley (1999), 0.50 µg/L reported in Trombley (2001), and 0.40 µg/L during the current reporting period. However, there were fewer occurrences of surface-water samples exceeding the USEPA’s MCL of 3.0 µg/L for atrazine as an annual average during the current reporting period. Four surface-water samples collected during the first reporting period and nine surface-water samples collected during the second reporting period exceeded USEPA’s MCL for atrazine. Only two surface-water samples collected during the current reporting period exceeded the MCL.

The median concentration for fecal coliform bacteria decreased during the May 2001 through August 2003 reporting period when compared to results presented in Trombley (1999, 2001). The median concentration for the June 1996 through November 1998 reporting period was 570 col/100 mL, and the median concentration for the February 1999 through

Table 18. Results of analysis of sediment in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.

[mg/L, milligrams per liter; --, not determined; <, less than]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/ year)	Total suspended solids (mg/L)	Suspended- sediment concentration (mg/L)
Bills Creek Basin				
BC01	Bills Creek, U.S Highway 75 near Holton	06/12/01	24	--
Little Soldier Creek Basin				
LSC01	Little Soldier Creek, 190 Road near Mayetta	06/12/01	58	--
LSC02	Little Soldier Creek, 174 Road near Mayetta	06/12/01	20	--
LSC03	Little Soldier Creek, O Road near Mayetta	05/15/01	<10	--
		06/12/01	63	--
		11/13/01	<10	10
		02/12/02	<10	26
		05/22/02	<10	5
		08/28/02	17	32
		11/13/02	18	26
		02/19/03	17	84
		05/14/03	<10	18
		LSC04	Little Soldier Creek, 134 Road near Mayetta	05/15/01
06/12/01	33			--
11/13/01	<10			46
02/12/02	<10			32
05/22/02	<10			11
08/28/02	17			26
11/13/02	<10			5
02/19/03	<10			23
05/14/03	<10			13
LSC05	Little Soldier Creek tributary, 134 Road near Hoyt			06/12/01
LSC06	Big Elm Creek, 134 Road near Hoyt	05/15/01	<10	--
		06/12/01	<10	--
		08/21/01	<10	--
		11/13/01	<10	7
		02/12/02	<10	6
		05/22/02	<10	3
		08/28/02	<10	5
		11/13/02	<10	2
		02/19/03	18	16
		05/14/03	<10	2

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Table 18. Results of analysis of sediment in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

[mg/L, milligrams per liter; --, not determined; <, less than]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/ year)	Total suspended solids (mg/L)	Suspended- sediment concentration (mg/L)
Little Soldier Creek Basin—Continued				
LSC07	Little Elm Creek, Q Road near Hoyt	06/12/01	<10	--
LSC08	Big Elm Creek, P Road near Hoyt	06/12/01	<10	--
LSC09	Little Soldier Creek, 126 Road near Hoyt	06/12/01	44	--
Soldier Creek Basin				
SC01	Soldier Creek, 214 Road near Circleville	06/13/01	15	--
SC02	Soldier Creek tributary, G Road near Circleville	06/13/01	<10	--
SC03	Soldier Creek near Saint Clere	05/15/01	27	--
		06/13/01	39	--
		08/21/01	14	--
		11/13/01	10	37
		02/12/02	<10	59
		05/22/02	28	31
		08/28/02	13	93
		11/13/02	<10	29
		02/19/03	<10	1
		05/14/03	55	57
SC04	Soldier Creek, 158 Road near Saint Clere	08/20/03	20	23
		06/13/01	60	--
SC05	Crow Creek, 166 Road near Saint Clere	06/13/01	7	--
SC06	South Branch Soldier Creek, H.5 Road near Saint Clere	06/13/01	15	--
SC07	Soldier Creek, I Road near Delia	05/15/01	50	--
		06/13/01	66	--
		08/21/01	21	--
		11/13/01	10	13
		02/12/02	<10	37
		05/22/02	38	54
		08/28/02	<10	44
		11/13/02	<10	20
		02/19/03	<10	59
		05/14/03	33	39

Table 18. Results of analysis of sediment in surface-water-quality samples from the Prairie Band Potawatomi Reservation, northeastern Kansas, May 2001 through August 2003.—Continued

[mg/L, milligrams per liter; --, not determined; <, less than]

Map identifier (fig. 1)	Site name	Date of sample collection (month/day/year)	Total suspended solids (mg/L)	Suspended-sediment concentration (mg/L)
Soldier Creek Basin—Continued				
SC07	Soldier Creek, I Road near Delia—Continued	08/20/03	42	53
SC08	James Creek, 142 Road near Delia	06/13/01	18	--
SC09	James Creek, 126 Road near Delia	06/13/01	<10	--
South Cedar Creek Basin				
SCC01	South Cedar Creek, U.S. Highway 75 near Mayetta	06/12/01	<10	--

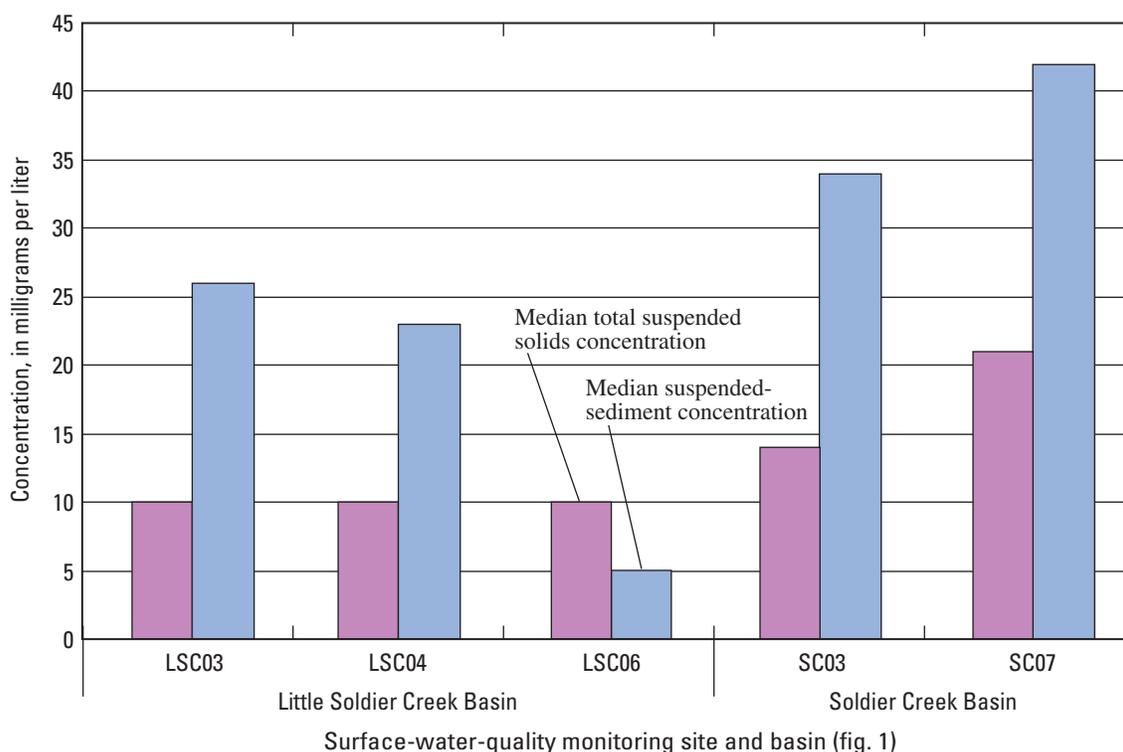


Figure 15. Median concentrations of total suspended solids and suspended sediment in surface-water-quality samples, May 2001 through August 2003.

February 2001 reporting period was 290 col/100 mL. The median concentration during the current reporting period was 190 col/100 mL.

Trombly (2001) found dissolved solids, sodium, sulfate, boron, iron, and manganese concentrations in some ground-water samples exceeding their respective water-quality criteria. The May 2001 through August 2003 study also found that dissolved solids, sodium, and sulfate were present in ground-water samples at concentrations greater than their respective water-quality criteria. It was not possible to infer trends in ground-water quality because the previous study consisted of ground-water samples collected from domestic wells and one pumping well. Ground-water sample results presented herein were collected from dedicated monitoring wells installed across the reservation.

Summary

Water quality is very important to the Prairie Band Potawatomi Nation both for the hunting and fishing needs of tribal members as well as a part of developing the economic base for the tribe. Under the Federal Clean Water Act of 1977, an Indian tribe is sovereign for the purposes of delegating the authority to regulate water within the reservation boundaries. To establish water-quality baseline concentrations with a goal of developing water-quality criteria to help manage the water resources on the reservation, the tribe, in cooperation with the U.S. Geological Survey (USGS), began a water-quality monitoring program in 1996.

A network of 20 surface-water monitoring sites was sampled in June 2001, and a subset of 5 of the 20 sites was sampled approximately quarterly from May 2001 through August 2003. All surface-water samples were analyzed for physical properties, nutrients, pesticides, fecal indicator bacteria, and total suspended solids. Dissolved solids, major ions, trace elements, and suspended-sediment concentration were added to the sample analysis in November 2001. Ground water was sampled twice during the study period from 11 dedicated ground-water monitoring wells completed on the reservation in August 2002 and in July 2003. Nine monitoring wells were sampled during April–May 2003, and six monitoring wells were sampled during August 2003. The second round of sampling included four wells that were sampled during the previous round as well as two new monitoring wells completed in July 2003. All ground-water samples were analyzed for physical properties, dissolved solids, major ions, nutrients, trace elements, pesticides, and fecal indicator bacteria. One ground-water monitoring well located near a construction and demolition landfill was sampled for chemical oxygen demand and volatile organic compounds in the first round of sampling.

Dissolved-solids concentrations exceeded the Secondary Drinking-Water Regulation of 500 mg/L established by the U.S. Environmental Agency (USEPA) in surface-water

samples from LSC06 located on Big Elm Creek downstream from a wastewater-treatment lagoon. In general, larger concentrations of dissolved solids can occur downstream from wastewater-treatment facilities when compared to upstream. Dissolved-solids concentrations in ground-water samples from well MW03 also exceeded the Secondary Drinking-Water Regulation.

Sodium concentrations exceeded the Drinking-Water Advisory of 20 mg/L established by USEPA in surface-water samples from site LSC06 and in ground-water samples from wells MW03, MW04, MW05, MW08, AND MW11. Sulfate concentrations in ground-water samples from well MW03 also exceeded the Secondary Drinking-Water Regulation of 250 mg/L established by USEPA.

Detections of nitrite plus nitrate in ground-water samples from well MW11 exceeded the USEPA Maximum Contaminant Level of 10 mg/L. Forty percent of the 65 surface-water samples analyzed for total phosphorus exceeded the water-quality goal of 0.1 mg/L established by USEPA. Two detections of arsenic in ground-water samples from well MW6 also exceeded the USEPA Maximum Contaminant Level of 10 µg/L.

Triazine herbicides, specifically atrazine, were detected frequently in surface-water samples, although the annual average of the collected samples did not exceed the USEPA Maximum Contaminant Level of 3.0 µg/L as an annual average. Triazine herbicide compounds were not detected frequently in samples collected from ground-water monitoring wells.

Three volatile organic compounds, carbon disulfide, ethyl methyl ketone, and tetrahydrofuran, were detected in water samples collected from well MW04. There are no USEPA drinking-water regulations for these compounds.

Fecal indicator bacteria (fecal coliform, *E. coli*, fecal streptococci, and enterococci) were detected in the majority of surface-water samples. Water-quality criteria have been established by USEPA for densities of *E. coli*. Densities of *E. coli* exceeded water-quality criteria in 12 samples. Total suspended solids and suspended-sediment concentrations were larger in surface-water samples from the Soldier Creek Basin when compared to samples from the Little Soldier Creek Basin.

Water quality on the Prairie Band Potawatomi Reservation generally meets water-quality criteria established by USEPA. Surface-water quality on the reservation is affected by agricultural runoff (triazine herbicides and fecal indicator bacteria), seepage from septic systems or sewage lagoons serving a rural population, and wastewater discharge from documented point sources (dissolved solids and sodium). Sources of total phosphorus in streams can be attributed to both agricultural activities and human and animal waste. Ground-water quality on the reservation probably is affected by agricultural practices with the detections of nitrite plus nitrate, and elevated dissolved-solids and arsenic concentrations in the water likely are affected by dissolution of sedimentary rocks. Concentrations of dissolved solids and sulfate in some ground-water samples exceeded their respective Secondary Drinking-Water Regulations, and concentrations exceeded the taste threshold of the

USEPA's Drinking-Water Advisory Level for sodium. Consequently, in the event that ground water on the reservation is to be used as a drinking-water source, additional treatment may be necessary to remove excess dissolved solids, sulfate, sodium, nitrite plus nitrate, and arsenic.

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