Occurrence of Selected Pharmaceutical and Non-Pharmaceutical Compounds and Stable Hydrogen and Oxygen Isotope Ratios in a Riverbank Filtration Study, Platte River, Nebraska, 2001 to 2003, Volume 1

By J.R. Vogel, I.M. Verstraeten, T.B. Coplen, E.T. Furlong, M.T. Meyer, and L.B. Barber

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Conversion Factors and Datums

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
micrometer (µm)	0.00003937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Volume	
liter (L)	33.82	ounce, fluid (fl. oz)
milliliter (mL)	0.03382	ounce, fluid (fl. oz)
microliter (µL)	0.00003382	ounce, fluid (fl. oz)
liter (L)	2.113	pint (pt)
liter (L)	1.057	quart (qt)
liter (L)	0.2642	gallon (gal)
	Flow rate	
meter per second (m/s)	3.281	foot per second (ft/s)
centimeter per second (cm/s)	0.03281	foot per second (ft/s)
meter per day (m/d)	3.281	foot per day (ft/d))
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)
million liters per day (ML/d)	264.2	million gallons per day (MG/d)
cubic meter per second (m^3/s)	22.83	million gallons per day (MG/d)
	Mass	
nanogram (ng)	3.527×10^{-11}	ounce, avoirdupois (oz)
microgram (µg)	0.00000003527	ounce, avoirdupois (oz)
milligram (mg)	0.00003527	ounce, avoirdupois (oz)
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound, avoirdupois (lb)

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

$$°F=(1.8\times°C)+32$$

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

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

Altitude, as used in this report, refers to distance above the vertical datum. Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

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

Water year is the 12-month period, October 1 through September 30, and is designated by the calendar year in which it ends. Thus, the water year ending September 30, 2003, is called the “2003 water year.”

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Abstract

Although studied extensively in recent years in Europe, the occurrence of endocrine disrupters and other organic wastewater compounds in the environment in the United States is not well documented. To better understand the efficiency of riverbank filtration with respect to endocrine disrupting compounds and to evaluate the use of riverbank filtration as an effective means of drinking-water treatment, a study was conducted during 2001-2003 by the U.S. Geological Survey, in cooperation with the U.S. Environmental Protection Agency and the City of Lincoln, at an established riverbank-filtration well field with horizontal collector wells and vertical wells. This study provides information that will be useful for (1) increased understanding of the processes and factors important in controlling the transport of endocrine disrupters, such as pesticides and pharmaceuticals during riverbank filtration, (2) better understanding of the physical and chemical processes that affect riverbank-filtration efficiency, and (3) managing the water resources of the eastern Platte River Basin. This report presents analytical methods and data collected during the study. Data are presented as generalized statistics and in figures showing temporal variations.

Sites from which water-quality samples were collected for this study included wastewater sites (a cattle feedlot lagoon, a hog confinement lagoon, and wastewater-treatment plant effluent), surface-water sites (Platte River, Salt Creek, and Loup Power Canal), ground-water sites (one collector well and three vertical wells), and drinking-water sites (raw and finished). Field water-quality properties were measured in samples from these sites.

Pharmaceutical compounds were detected often in the wastewater-treatment plant effluent. Surface and ground water showed low-level concentrations of pharmaceuticals. Finished drinking-water samples did not contain detectable concentrations of pharmaceuticals except for low levels of cotinine and caffeine. Antibiotics were found in some of the wastewater samples and twice in Salt Creek. Antibiotics were not detected in any samples from the Platte River or the well field.

Surface-water samples were analyzed for total organic carbon and ground-water samples were analyzed for dissolved organic carbon. Samples from all sites were analyzed for major ions. Herbicides commonly detected in surface, ground, and drinking water included acetachlor, alachlor, atrazine, and metolachlor as well as degradates of these compounds. Most of the samples from wastewater sites were found to contain predominantly acetamide degradates. High concentrations of several organic wastewater indicator compounds were detected at the wastewater sites and in Salt Creek. Several organic wastewater indicator compounds were detected multiple times in samples from the Platte River. Bromoform, a by-product of disinfection in the treatment plant, was found in samples from the finished drinking water.

Stable hydrogen isotope ratios show a range in seasonal variation of -73.6 per mill to -38.1 per mill relative to Vienna Standard Mean Ocean Water (VSMOW) reference water and -69.2 per mill to -46.5 per mill for surface water and ground water, respectively. Oxygen isotope ratios for surface-water samples varied between -9.86 per mill and -5.05 per mill. Stable oxygen isotope ratios of ground waters varied between -9.62 per mill and -5.81 per mill.

Introduction

The growing need for high-quality drinking water has led to an increasing interest in the use of bank filtration as an inexpensive means of water-supply pretreatment. In Europe, bank filtration has been an important pretreatment for drinking water for more than a century. Bank filtration has a positive effect on the quality of drinking water (Kühn, 1999; Verstraeten, Thurman, and others, 2002; Verstraeten and others, 2003; Zuehlke and others, 2004). In the United States, drinking water for public supplies originates mainly from surface water. About 37 percent of our public-supply water is from aquifers (Solley and others, 1998). Increased use of water from alluvial aquifers along riverbanks is expected, given the rise in demand for drinking water (Solley and others, 1998), the ease of obtaining water from alluvial aquifers, the positive effects of riverbank filtration on the quality of surface water, and the potential promulgation of more stringent drinking-water regulations in the United States.

Drinking-water systems using riverbank filtration may be classified as surface water, ground water under the direct influence of surface water, or ground water. In the United States, the number of utilities receiving riverbank-filtered water for drinking water is increasing. For example, most cities in Nebraska historically have developed along the Platte River or its tributaries; as the population increases, the dependence on this river increases. In the United States, utilities have used riverbank-filtered water in States such as Iowa, Kansas, Kentucky, Nebraska, New Jersey, New York, Ohio, Texas, and Wyoming. Given the proximity of many wells to streams, additional riverbank filtration sites probably exist along most major and some smaller rivers in the United States.

Generally, given the right set of physical and chemical conditions and adequate distance and traveltime in the subsurface, riverbank-filtered water may require little additional treatment to produce high-quality drinking water (Bouwer, 1999). Interest in the effectiveness of riverbank filtration as pretreatment for drinking water in the United States has increased because of (1) recent developments in the construction of large capacity collector wells near the banks of large rivers, (2) improved understanding of the interaction of surface- and ground-water systems (Winter and others, 1998), (3) new and improved analytical techniques (Harvey and Wagner, 2000), (4) source-water protection awareness, and (5) increased understanding of the transport and fate of anthropogenic chemicals in hydrologic systems.

Endocrine disrupting chemicals have been strictly defined as compounds in which the primary effect of the chemicals is on the endocrine system. These may include effects on the level of receptor-mediated hormone action, hormone synthesis, or clearance (Pickering and Sumpter, 2003). Rivers and streams may contain endocrine disrupting compounds, including pharmaceuticals and pesticides (Heberer and Stan, 1998; Heberer and others, 1998, 2001; Heberer and Dünnbier, 1999; Ternes, 1998; Daughton and Ternes, 1999; Kolpin and others, 2002; Verstraeten and others, 1999, 2003; Verstraeten and Heberer, 2002; Verstraeten, Heberer, and Scheytt, 2002; and Verstraeten, Thurman, and others, 2002). Riverbank filtration induces ground-water recharge from surface water by enhancing seepage losses from a stream. Filtration in riverbeds improves the raw surface-water quality by diminishing the concentrations of endocrine disrupters by the mechanisms of: (1) filtration (2) dilution with ground water; (3) adsorption; and (or) (4) providing opportunities for degradation of biodegradable compounds. Several issues regarding riverbank filtration need to be studied including hydrogeologic properties affecting vulnerability of wells to contamination and the physical and chemical properties governing fate and transport of contaminants in the subsurface. Riverbank filtration is considered to be a natural treatment technology of increased interest to water utilities with respect to the removal of microorganisms and removal of potential endocrine disrupters. Little knowledge has been gathered on the temporal and spatial distributions of endocrine disrupters, such as pharmaceuticals, in surface water, ground water, and drinking water and their removal during ground-water recharge including riverbank filtration (Heberer and others, 2001; Verstraeten, Thurman, and others, 2002). Effects of ozonation and chlorination on selected herbicides and degradates have been studied at the selected study site during spring-runoff events by Verstraeten and others (1999) and Verstraeten, Thurman, and others (2002). A preliminary evaluation of pharmaceuticals at bank-filtration sites has been done in Nebraska, USA, and in Germany (Heberer and others, 2001).

To understand the efficiency of riverbank filtration with respect to organic compounds including endocrine disrupting compounds, more information is needed concerning the fate of contaminants as they move through the riverbed sediments into an aquifer and on to collector wells. A study was conducted during 2001-2003 at a riverbank filtration site on the Platte River in eastern Nebraska (fig. 1) by the U.S. Geological Survey (USGS), in cooperation with the U.S. Environmental Protection Agency (USEPA) and the City of Lincoln, to evaluate the use of riverbank filtration as an effective means of drinking-water treatment. During the study, water quality samples were collected monthly or quarterly from three wastewater sites, two surface-water sites, four ground-water sites, and two drinking-water sites. The samples were analyzed for selected pharmaceutical and non-pharmaceutical compounds and for stable hydrogen and oxygen isotope ratios. Additional stable hydrogen and oxygen isotope ratios from wells in the area of the well field also are included in the data tables of this report. One sample was also collected in April 2003 from the Loup Power Canal, which discharges into the Platte River upstream of the riverbank-filtration site. The objectives of the study were to provide information useful for (1) increased understanding of the processes and factors important in controlling the transport of endocrine disrupters such as pesticides and pharmaceuticals during riverbank filtration, (2) better understanding of the physical and chemical processes and factors that affect riverbank-filtration efficiency, and (3) managing the water resources of the eastern Platte River Basin.

The purpose of this report is to describe the sampling and analytical methods used during the study and to present data obtained during the study from 2001 through 2003. Data are presented as generalized statistics and in figures showing temporal variations.

Environmental Setting

The Platte River and its tributaries receive municipal waste from most cities along its course, except the City of Omaha, which releases its wastewater into the Missouri River above its confluence with the Platte River. Along the Platte River and its tributaries, an estimated 200 sewage treatment

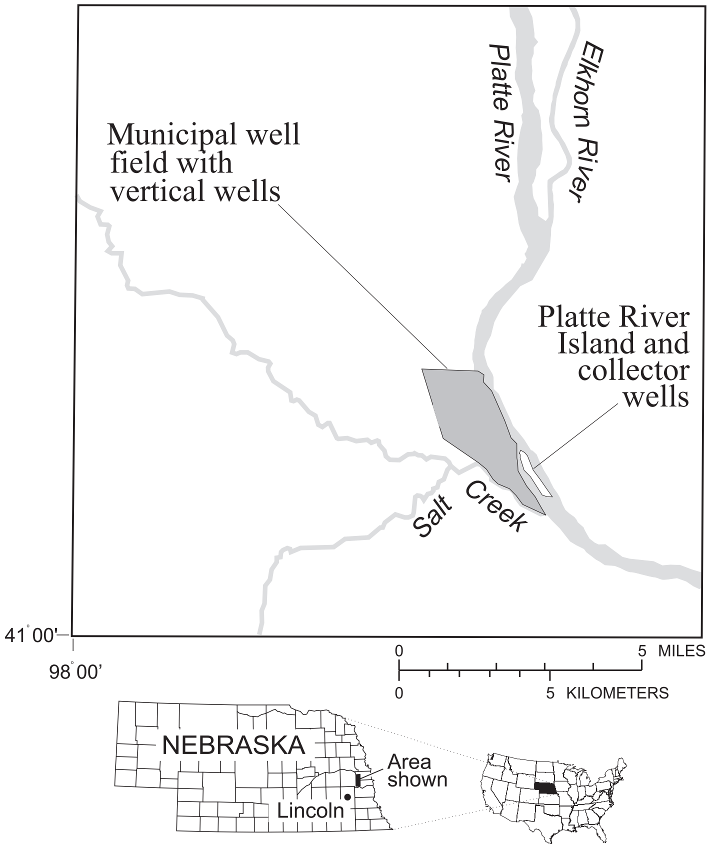

Figure 1. Location of the riverbank-filtration study at a municipal well field along the Platte River in eastern Nebraska.

plants (STPs) release treated or untreated wastewater into the rivers with flows varying from about 0.4 ML/d (million liters per day) to about 200 ML/d (Ronald Ash, Nebraska Department of Environmental Quality, oral commun., 2001). In addition, more than an estimated 7,000 animal feeding operations (AFOs) exist in Nebraska, of which less than 1,000 are confined animal feeding operations (CAFOs). A CAFO is defined by the State of Nebraska as having at least 1,000 animal units (Dennis Heitmann, Nebraska Department of Environmental Quality, oral commun., 2001). The AFOs vary in size from more than 1 unit to almost 100,000 units of cattle and pigs. During runoff events or chronic wet periods (several rainfalls within 1 month leaving the soils saturated and standing water in collection pits high), unregulated and regulated discharges occur from these AFOs into nearby streams. Nebraska was ranked third on January 1, 2004, in inventory of cattle and calves in the United States with 6.25 M (million) head, or about 6.6 percent of the national inventory (Nebraska Agricultural Statistics, 2004). Moreover, Nebraska was ranked seventh in the United States on December 1, 2003, in inventory of hogs and pigs with about 2.9 M head, or 4.8 percent of the national production (Nebraska Agricultural Statistics, 2004).

The alluvial sediments deposited by the Platte River, consisting mainly of sand and gravel and some silt and clay, increasingly have been developed for drinking-water supplies by cities along the Platte River. At the same time, river and ground-water quality are being influenced by releases of wastewater and runoff from fields along the river. The municipal water supply from the well field along the river generally is affected by the quality of water from the local streams and the main channel (Verstraeten and others, 1999). The well field consists of 2 horizontal and 36 vertical wells completed in the alluvial sediments, generally at depths of less than 40 m (meters). Water obtained from the well field is used for a population of more than 230,000 people, which is growing at a rapid rate, that will require development of additional large capacity wells at the well field in the near future.

Methods

Prior to this study, the well field (fig. 1) had existing instrumentation (such as pressure transducers) and available hydrologic background information and estimations of traveltimes and tracer velocities (Davis, 1992). This section describes water-quality sampling sites and methods, and laboratory analytical methods.

Sampling Methods

Sites were selected on the basis of ground-water travel times, distances from the Platte River to wells, tracer velocities (including effect of pumping rates), hydraulic conductivities, and physicochemical characteristics. In the selection of sampling sites and evaluation of the data, consideration was given to watershed characteristics such as point sources of anthropogenic contamination (for example, wastewater treatment plants, lagoons, feedlots, and other industries) that are upstream from the well field.

Water samples were collected from 16 sites (table 1). Water-quality samples were collected from 11 sites, and supplemental samples for stable isotope analysis were collected from the other 5 sites. Representative samples of surface water and ground water, and grab samples of raw water and finished water were collected at the well field to evaluate changes in concentrations and loading over time. Raw water is influent to the drinking-water treatment plant that uses water from the site as source water. In general, the raw water is comprised of approximately 50 percent vertical-well water and 50 percent horizontal-well water. This ratio varies throughout the year based upon management of the well field. Finished water is the effluent of the drinking-water treatment plant after treatment by rapid sand filtration, ozonation, and chloramines. Water samples also were collected from the well-field sites during a spring-runoff event and a summer-runoff event. Grab samples from wastewater-treatment plant effluent, grab samples from the bank of two lagoons of CAFOs, and representative samples from Salt Creek near the well field also were collected during a spring and summer runoff event and during summer, fall, and spring baseflow conditions. One representative sample set was collected during spring baseflow from the Loup River Canal right before it empties into the Platte River upstream from the well-field site. Finally, a few water samples also were collected from a public-supply ground-water well 11 km upgradient (northeast) from the well field for comparison (Memphis).

Representative samples were collected and cross contamination of samples was prevented by using approved USGS sampling protocols (U.S. Geological Survey, 1997-2004). Water samples were analyzed in the field for pH, temperature, specific conductance, dissolved oxygen (DO) and turbidity using USGS standard methods for collecting field measurements (U.S. Geological Survey, 1997-2004). All sampling equipment was cleaned and sterilized using standard USGS methods for the constituent of concern (U.S. Geological Survey, 1997-2004).

Table 1. Sites at which samples were collected for analysis.

[well field, located at municipal well field in this study; outside-well field, not located near municipal well field in this study; SW, surface water; GW, ground water; WW, wastewater; DW, drinking water]

Station name	Site type	Station number
Water-quality sampling sites		
Platte River near Ashland (well field)	SW	06801000
Salt Creek near Ashland (well field)	SW	06805000
Loup Power Canal (outside well field)	SW	412411097165601
W90-1H (well field)	GW	410322096191701
W54-10 (well field)	GW	410315096193501
W49-9 (well field)	GW	410349096202101
Memphis, G040474 Ithaca (outside well field)	GW	410547096254801
Raw water (well field)	DW	410315096190101
Finished water (well field)	DW	410315096190102
Cattle feedlot lagoon (outside well field)	WW	410322096190103
Hog confinement lagoon (outside well field)	WW	410322096190104
Wastewater-treatment plant effluent (outside well field)	WW	06803496
Supplemental isotope sampling sites		
W66-4 (well field)	GW	410341096201101
W90-2H (well field)	GW	410703096205301
Memphis 2 (outside well field)	GW	410547096254802
Ithaca (non-well field)	GW	410945096322401
Ranney #2 (well field)	GW	410254096185501

Analytical Methods

Pharmaceutical compounds (pharmaceuticals and antibiotics), non-pharmaceutical compounds (total or dissolved organic carbon (TOC or DOC), selected pesticides (parent herbicides, acetamide degradates, and organophosphate insecticides), major ions, and organic wastewater indicator compounds), and stable hydrogen and oxygen isotope ratios were determined by analytical laboratory methods. TOC and DOC analysis was completed at the USGS National Water Quality Laboratory (NWQL) using USGS approved methods. The NWQL is certified by the National Environmental Laboratory Accreditation Program, which is the only program that accredits environmental laboratories on a national basis for drinking-water analyses. Other laboratory analyses described in this report were completed at various other USGS research laboratories. The USGS National Water Information System (NWIS) database permanently stores water-quality information collected by the USGS. However, some analytical data are not entered into the NWIS database, such as values for constituents that were obtained using non-approved methods (screening or research methods). These data are entered into a project water-quality database that is archived by the USGS Nebraska Water Science Center office.

Pharmaceutical Compounds

Pharmaceutical compounds analyzed for this study include pharmaceuticals and antibiotics. Pharmaceuticals were analyzed at the NWQL using a custom method designed to determine concentrations of 27 over-the-counter and prescription pharmaceuticals and their metabolites in filtered natural-water samples (table 2). Pharmaceuticals were extracted by using disposable polypropylene syringe cartridges that contain 0.5 gram (g) of a polymeric sorbent. One liter of sample was pumped through the solid-phase extraction (SPE) cartridge at a flow rate of 15 milliliters per minute (mL/min). After extraction, the adsorbed compounds were eluted from the SPE cartridge by using two sequential elutions of 6 mL methanol and 6 mL methanol that was acidified with trifluoroacetic acid. The two fractions were reduced under nitrogen to near dryness and then combined in a final volume of 1,000 microliters (μL). Analytes were chromatographically separated by high-performance liquid chromatography (HPLC) by using a reverse-phase octadecylsilane HPLC column and gradient elution, which was coupled to an electrospray ionization interface and quadrupole mass spectrometer for detection, identification, and quantitation. The extract was analyzed by using positive electrospray ionization. This method was in development for the duration of this study, with some compounds dropped from the method during the course of the study. The analytical results from this custom method are archived in the project database.

SPE was used to provide sample concentrates for analysis of 26 antibiotics (table 3) by HPLC in the USGS laboratory in Ocala, Florida. Two types of cartridges, connected in series, were used and designed to process 16 samples simultaneously (11 environmental samples, 1 duplicate sample, 2 blank samples, and 2 standards). Two manifolds were used, one for conditioning cartridges and eluting extracts, and the other for sampling. The analytical results from this custom method are archived in the project database.

Non-Pharmaceutical Compounds

Non-pharmaceutical compounds analyzed for this study include TOC, DOC, major ions, pesticides, and organic wastewater compounds. TOC and DOC were analyzed at the NWQL using the methods of Wershaw and others (1987), and Brenton and Arnett (1993), respectively. Major ions including calcium, magnesium, sodium, potassium, sulfate, chloride, fluoride, bromide, silica, manganese, and iron were analyzed at the NWQL using the methods of Fishman and Friedman (1989). Analytical results of TOC, DOC, and major ions are stored in the NWIS database.

Pesticides analyzed for in this study include parent herbicide compounds, acetamide degradates, and organophosphate insecticides (table 4). Samples were analyzed for parent herbicides by the Organic Geochemistry Research Laboratory (OGRL) in Lawrence, Kansas, using gas chromatography/mass spectrometry methods (Zimmerman and Thurman, 1999). Acetamide degradates (herbicide metabolites) were analyzed using liquid chromatography methods as described in Zimmerman and others (2000) and Lee and others (2001). Insecticides also were analyzed at the OGRL using gas chromatography. Analytical results for parent herbicides, acetamide degradates, and organophosphate insecticides are stored in the NWIS database.

Organic wastewater compound concentrations were determined using the analysis methods of Zaugg and others (2002) at the NWQL. This method analyzed for 63 compounds typically found in domestic and industrial wastewater samples (table 5). Filtered samples received at the NWQL were immediately preserved with 60 g of sodium chloride. Compounds were isolated on 0.5-g polystyrene divinylbenzene adsorbent at a flow rate of 40 mL/min by using SPE cartridges. SPE cartridges were dried thoroughly by using nitrogen, and adsorbed compounds were eluted with dichloromethane-ethyl ether (ratio of 4 to 1), which also was used to rinse sample bottles. Elution solvent was reduced under nitrogen to a final volume of 0.4 mL, and compounds were determined by capillary-column gas chromatography/mass spectrometry. Recoveries in reagent-water samples ranged from 30 to 125 percent, and laboratory reporting levels (LRL) ranged from 0.2 to 5 mg/L.

Table 2. Pharmaceuticals, common names, and general use.

[--, none]

Compound	Common name	Use
1,7-dimethylxanthine	--	caffeine metabolite
Acetaminophen	Tylenol	over-the-counter analgesic
Azithromycin	Zithromax	antibiotic
Caffeine	No-Doz	stimulant
Carbamazapine	Tegretol	management of epilepsy, bipolar disorder
Cimetidine	Tagamet	acid reducer; prescription and over-the-counter
Clarithromycin	Biaxin	antibiotic
Codeine	Robitussin AC	opiod narcotic; cough suppressant
Cotinine	--	nicotine metabolite
Dehydronifedipine	--	antianginal
Digoxigenin	Lanoxicaps; Lanoxin	cardiac stimulant/regulator, digoxin metabolite
Diltiazem	Cardizem CD	antianginal, antiarrhythmic, and antihypertensive
Diphenhydramine	Benadryl	antihistamine
Erythromycin	E-mycin, Ery-tab, Benzamycin	antibiotic
Fluoxetine	Prozac	antidepressant
Furosemide	Lasix	diuretic
Gemfibrozil	Lopid	antihyperlipidemic
Ibuprofen	Advil	over-the-counter analgesic
Metformin	Glucophage	antidiabetic
Miconazole	Micatin, Monistant	antifungal agent
Paroxetine metabolite	Paxil	antidepressant
Ranitidine	Zantac	acid reducer; prescription and over-the-counter
Salbutamol	Albuterol Aerosol	bronchiodilator for asthma
Sulfamethoxazole	component of Bactrim	antibiotic
Thiabendazole	Mintezol	treats worm infections
Trimethoprim	component of Bactrim	antibiotic
Warfarin	Coumadin Tabs	anticoagulant

Table 3. Antibiotics analyzed for in water-quality samples and their uses.

[Samples were analyzed using solid-phase extraction, liquid chromatography/mass spectrometry analysis]

Analytes	Use
	Tetracyclines
Chlortetracycline	a yellow crystalline antibiotic (trade name Aureomycin) used to treat certain bacterial and rickettsial diseases
Demeclocycline	Antibiotic (trade name declomycin) used to treat bacterial infections
Doxycycline	an antibiotic derived from tetracycline (trade name Vibramycin) that is effective against many infections
Oxytetracycline	a yellow crystalline antibiotic (trademark Terramycin) obtained from a soil actinomycete; used to treat various bacterial and rickettsial infections
Tetracycline	an antibiotic (trade name Achromycin) derived from microorganisms of the genus Streptomyces and used broadly to treat infections
	Fluoroquinolones
Ciprofloxacin	an oral antibiotic (trade name Cipro) used against serious bacterial infections of the skin or respiratory tract or urinary tract or bones or joints
Enrofloxacin	used in either dogs or cats to combat different types of infections, especially those involving Pseudomonas.
Norfloxacin	used to treat certain infections caused by bacteria, such as gonorrhea, prostate, and urinary tract infections.
Sarafloxacin	given to humans and poultry for the treatment and/or control of bacterial disease
	Sulfonamides
Sulfachloropyradizine	a competitive antagonist of para-aminobenzoic acid (PABA), a precursor of folic acid, in protozoa and bacteria
Sulfadimethoxine	a broad-spectrum systemic antibacterial often used with trimethoprim
Sulfamethizole	anti-bacterial agent used for infections in the urinary tract
Sulfathiazole	a sulfa drug once widely used in the treatment of gonorrhea, bacterial pneumonia, and other bacterial infections. It has been replaced by less toxic sulfonamides.
Sulfamethoxazole	an antiprotazoal (trade name Gantanol) used to treat infections (especially infections of the urinary tract)
Sulfamerazine	a readily absorbed antibacterial substance usually used in combination with other sulfonamides; formerly used for treatment of food fish
Sulfamethazine	used as an antibacterial in a variety of infections in the United States, usually used in combination with other sulfonamides
	Macrolides
Erythromycin-H_2O	metabolite of erythromycin; an antibiotic (trade name Erythrocin or E-Mycin or Ethril or Ilosone or Pediamycin) obtained from the actinomycete Streptomyces erythreus; effective against many Gram-positive bacteria and some Gram-negative ones
Tylosin	used as a broad spectrum antibiotic for injectable or oral use in treatment of infection in livestock.
Roxitrhomycin	semisynthetic derivative of erythromycin. It is concentrated by human phagocytes and is bioactive intracellularly. While the drug is active against a wide spectrum of pathogens, it is particularly effective in the treatment of respiratory and genital tract infections
Virginiamycin	used to treat infections with Gram-positive organisms and as a growth promoter in cattle, swine, and poultry
Lincomycin	Antibiotic (trade name Lincocin) obtained from a Streptomyces bacterium and used in the treatment of certain penicillin-resistant infections
	Others
Carbadox	Carbadox is an antimicrobial product that was approved in the 1970s to prevent and treat dysentery in swine and to maintain weight gain during periods of stress, such as weaning. It has been shown to cause cancer in laboratory animals, but when fed to swine, is metabolized or transformed over a relatively short period of time. Carbadox remains in use in the United States, but is banned in other countries (Australia and many in Europe).
Trimethoprim	an antibacterial diaminopyrimidine derivate that synergises with sulfonamides in the inhibition of bacterial replication
Spectinomycin	used to treat gonorrhea
Ivermectin	broad-spectrum anti-parasite medication (trade name Ivomec) used for most common intestinal worms (except tapeworms), most mites, and some lice
Roxarsone	an arsenic derivative that has anticoccidial action and promotes growth in animals

Table 4. Herbicide parent compounds, acetimide degradates, and organophosphate insecticides analyzed for in water-quality samples.

[Method: GC/MS, gas chromatography/mass spectrometry; LC, liquid chromatography; GC, gas chromatography. Analysis code: GCS, corn and soybean herbicides; LCAA, acetamide degradation product; GCOP, organophosphates (OP) (insecticides). *, metabolite; L, liter; µg/L, micrograms per liter; --, not a metabolite; method detection limit was 0.05 micrograms per liter; MDL, method detection limit]

Herbicide	Parent, if metabolite	Analysis method
Herbicide parent compounds (GCS)		
Acetachlor	--	GC/MS
Alachlor	--	GC/MS
Ametryn	--	GC/MS
Atrazine	--	GC/MS
Deethylatrazine*	Atrazine	GC/MS
Deisopropylatrazine*	Atrazine	GC/MS
Cyanazine	--	GC/MS
Cyanazine amide*	Cyanazine	GC/MS
Dimethenamid	--	GC/MS
Flufenacet	--	GC/MS
Metolachlor	--	GC/MS
Metribuzin	--	GC/MS
Pendimethalin	--	GC/MS
Prometon	--	GC/MS
Prometryn	--	GC/MS
Propachlor	--	GC/MS
Propazine	--	GC/MS
Simazine	--	GC/MS
Terbutryn	--	GC/MS
Acetamide degradates (LCAA)		
Acetochlor ESA (ethane sulfonic acid)	Acetochlor	LC
Acetachlor OXA (oxanilic acide)	Acetochlor	LC
Acetachlor SAA (sulfynil acetic acid)	Acetochlor	LC
Alachlor ESA	Alachlor	LC
Alachlor SSA	Alachlor	LC
Dimethenamid ESA	Dimethenamid	LC
Dimethenamid OXA	Dimethenamid	LC
Flufenacet ESA	Flufenacet	LC
Flufenacet OXA	Flufenacet	LC
Metolachlor ESA	Metolachlor	LC
Metolachlor OXA	Metolachlor	LC
Propachlor ESA	Propachlor	LC
Propachlor OXA	Propachlor	LC

Table 4. Herbicide parent compounds, acetimide degradates, and organophosphate insecticides analyzed for in water-quality samples.—Continued

Herbicide	Parent, if metabolite	Analysis method
Organophosphate insecticides (GCOP) (MDL: 1 L water: 0.005 mg/L)		
Aldrin	--	GC
Aspon	--	GC
Azinphos-ethyl	--	GC
Azinphos-methyl	--	GC
Bolstar	--	GC
Carbophenothion	--	GC
Chlorfenvinphos	--	GC
Chlorpyriphos	--	GC
Coumaphos	--	GC
Diazinon	--	GC
Dichlorofenthion	--	GC
Dichlorvos	--	GC
Dicrotophos	--	GC
Dimethoate	--	GC
Dioxathion	--	GC
Disulfoton	--	GC
EPN	--	GC
Ethion	--	GC
Ethoprop	--	GC
Famphur	--	GC
Fenitrothion	--	GC
Fensulfothion	--	GC
Fenthion	--	GC
Fonophos	--	GC
Leptophos	--	GC
Malathion	--	GC

Table 5. Organic wastewater compounds analyzed for in water-quality samples, endocrine-disrupting potential, registry numbers, and common uses, applications, or occurrences.

[EDP, Endocrine Disrupting Potential; K, known, S, suspected, --, none known; CAS, Chemical Abstract Service; %, percent; >, greater than; PAH, polycyclic aromatic hydrocarbon; F, fungicide; H, herbicide; I, insecticide; GUP, general use pesticide; FR, flame retardant; WW, wastewater; Manuf, manufacturing; UV, ultraviolet]

Compound name	EDP	CAS registry number	Common use, application, or occurrence
1,4-Dichloro-benzene	S	106-46-7	moth repellant, fumigant, deodorant
1-Methylnaphthalene	--	90-12-0	nearly equal concentrations (2-5%) in gasoline/diesel/crude
2,6-Dimethylnaphthalene	--	58-14-2	indicator of diesel, kerosene, (not much in gasoline)
2-Methylnaphthalene	--	91-57-6	nearly equal concentrations (2-5%) in gasoline/diesel/crude
3-beta-Coprostanol	--	360-68-9	usually a carnivore fecal indicator
3-Methyl-1(H)-indole (skatol)	--	83-34-1	fragrance: odor in feces and coal tar
3-tert-Butyl-4-hydroxy anisole (BHA)	K	25013-16-5	antioxidant, preservative
4-Cumylphenol	K	599-64-4	nonionic detergent metabolite
4-n-Octylphenol	K	1806-26-4	nonionic detergent metabolite
4-tert-Octylphenol	K	140-66-9	nonionic detergent metabolite
5-Methyl-1H-benzotriazole	--	136-85-6	antioxidant in antifreeze, deicers
Acetophenone	--	98-86-2	fragrance: soap, detergent, tobacco; flavor: beverages
Acetyl hexamethyl tetrahydronaphthalene (AHTN)	--	21145-77-7	fragrance: musk, widespread usage, persistent in ground-water
Anthracene	--	120-12-7	wood preservative, in tar/diesel/crude (not gasoline)
Anthraquinone	--	84-65-1	manufacture of dye/textiles; seed treatment, bird repellant
Benzo(a)pyrene	K	50-32-8	regulated PAH, used in cancer research
Benzophenone	S	119-61-9	fixative for perfumes and soaps
beta-Sitosterol	--	83-46-5	generally a plant sterol
beta-Stigmastanol	--	19466-47-8	generally a plant sterol
Bisphenol A	K	80-05-7	manufacture of polycarbonate resins; antioxidant, FR
Bromacil	--	314-40-9	H (GUP); >80% non-crop grass/brush control
Bromoform	--	75-25-2	by-product of WW ozonation, military uses/explosives
Caffeine	--	58-08-2	medical: diuretic; highly mobile/biodegradable
Camphor	--	76-22-2	flavor, odorant, in ointments
Carbaryl	K	63-25-2	I, crop and garden uses, low environmental persistence
Carbazole	--	86-74-8	manufacture of dyes, explosives, and lubricants, I
Chlorpyrifos	K	2921-88-2	domestic pest/termite control; highly restricted (2000)
Cholesterol	--	57-88-5	often a fecal indicator, also a plant sterol
Cotinine	--	486-56-6	primary nicotine metabolite
Diazinon	K	333-41-5	I, > 40% nonagricultural uses, ants, flies
Dichlorvos	S	62-73-7	I, pet collars, flies; breakdown of naled and trichlofon
d-Limonene	--	5989-27-5	F, antimicrobial, antiviral; fragrance in aerosols
Fluoranthene	--	206-44-0	common in coal tar/asphalt (not gasoline /diesel)
Hexahydrohexamethyl Cyclopentabenzopyran (HHCB)	--	1222-05-5	fragrance: musk; widespread usage, persistent in ground water
Indole	--	120-72-9	pesticide inert, fragrance: coffee
Isoborneol	--	124-76-5	fragrance: perfumery, disinfectants
Isophorone	--	78-59-1	solvent for lacquers, plastics, oils, silicon, resins
Isopropylbenzene (cumene)	--	98-82-8	manufacture of phenol/acetone; component of fuels/paint thinner

Table 5. Organic wastewater compounds analyzed for in water-quality samples, endocrine-disrupting potential, registry numbers, and common uses, applications, or occurrences.—Continued

Compound name	EDP	CAS registry number	Common use, application, or occurrence
Isoquinoline	--	119-65-3	flavors and fragrances
Menthol	--	89-78-1	cigarettes, cough drops, liniment, mouthwash
Metalaxyl	--	57837-19-1	H, F (GUP), soil pathogens, mildew, blight, golf turf
Methyl salicylate	--	119-36-8	liniment, food, beverage, UV-absorbing lotions
Metolachlor	--	51218-45-2	H (GUP), indicator of agricultural drainage
N,N'-diethyl-methyl-toluamide (DEET)	--	134-62-3	I, urban uses, mosquito control
Naphthalene	--	91-20-3	fumigant, moth repellent, about 10% of gasoline
Nonylphenol, diethoxy- (total)	K	26027-38-3	nonionic detergent metabolite
Octylphenol, diethoxy-	K	26636-32-8	nonionic detergent metabolite
Octylphenol, monoethoxy-	K	26636-32-8	nonionic detergent metabolite
para-Cresol	S	106-44-5	wood preservative
para-Nonylphenol (total)	K	84852-15-3	nonionic detergent metabolite
Pentachlorophenol	S	87-86-5	H, F, wood preservative, termite control
Phenanthrene	--	85-01-8	manufacture of explosives; in tar/diesel/crude (not gasoline)
Phenol	--	108-95-2	disinfectant, manufacture of several products, leachate
Prometon	--	1610-18-0	H, only non-crop areas, applied prior to blacktop
Pyrene	--	129-00-0	common in coal tar/asphalt (not gasoline /diesel)
Tetrachloroethylene	--	127-18-4	solvent, degreaser; veterinary: anthelminic
tri(2-Chloroethyl) phosphate	S	115-96-8	plasticizer and flame retardant
tri(Dichlorisopropyl) phosphate	S	13674-87-8	flame retardant
Tributylphosphate	--	126-73-8	antifoaming agent and flame retardant
Triclosan	S	3380-34-5	disinfectant, antimicrobial (concern: induced resistance)
Triethyl citrate (ethyl citrate)	--	77-93-0	cosmetics, pharmaceuticals, widely used
Triphenyl phosphate	--	115-86-6	plasticizer, resins, waxes, finishes, roofing paper, FR
tris(2-Butoxyethyl) phosphate	--	78-51-3	flame retardant

Stable Hydrogen and Oxygen Isotope Ratios

Variations in stable isotope abundance ratios typically are small. Stable isotope ratios commonly are determined as relative difference in the ratio of the less abundant isotope (usually heavy) to the more abundant isotope (usually light) of the sample with respect to the reference. This difference is designated $\delta({}^{i}\mathrm{E})$ notation (pronounced delta) and it is defined according to the relation in equation 1:

$$\delta\left({}^{i}\mathrm{E}\right) = \left[\frac{n_{\mathrm{X}}\left({}^{i}\mathrm{E}\right)/n_{\mathrm{X}}\left({}^{j}\mathrm{E}\right)}{n_{\mathrm{ref}}\left({}^{i}\mathrm{E}\right)/n_{\mathrm{ref}}\left({}^{j}\mathrm{E}\right)}-1\right] \quad (1)$$

where $\delta({}^{i}\mathrm{E})$ refers to the delta value of isotope number *i* of element E of sample X relative to the reference (ref), and $n_X({}^{i}\mathrm{E})/n_X({}^{j}\mathrm{E})$ and $n_{ref}({}^{i}\mathrm{E})/n_{ref}({}^{j}\mathrm{E})$ are the ratios of the isotope amounts in unknown X and a reference (ref). A positive $\delta({}^{i}\mathrm{E})$ value indicates that the unknown is more enriched in the heavy isotope than the reference. A negative $\delta({}^{i}\mathrm{E})$ value indicates that the unknown is depleted in the heavy isotope relative to the reference. The $\delta({}^{i}\mathrm{E})$ is commonly shortened to $\delta({}^{i}\mathrm{E})$ and has been reported in parts per hundred (% or percent), parts per thousand (‰ or per mill), and parts per ten thousand. Herein, $\delta({}^{i}\mathrm{E})$ values are given in per mill; thus, the expression can be written

$$\delta\left({}^{i}\mathrm{E}\right) = \left[\frac{n_{\mathrm{X}}\left({}^{i}\mathrm{E}\right)/n_{\mathrm{X}}\left({}^{j}\mathrm{E}\right)}{n_{\mathrm{ref}}\left({}^{i}\mathrm{E}\right)/n_{\mathrm{ref}}\left({}^{j}\mathrm{E}\right)}-1\right]\cdot 1000\ ‰ \quad (2)$$

because a per mill is 1/1000, and 1000 · 1/1000 = 1.

The stable hydrogen isotope ratio is:

$$\delta\,{}^{2}\mathrm{H} = \left[\frac{n_{\mathrm{X}}\left({}^{2}\mathrm{H}\right)/n_{\mathrm{X}}\left({}^{1}\mathrm{H}\right)}{n_{\mathrm{VSMOW}}\left({}^{2}\mathrm{H}\right)/n_{\mathrm{VSMOW}}\left({}^{1}\mathrm{H}\right)}-1\right]\cdot 1000\ ‰ \quad (3)$$

where the isotope ratio is expressed relative to Vienna Standard Mean Ocean Water (VSMOW) reference water and is normalized such that •^{2}H of Standard Light Antarctic Precipitation (SLAP) reference water is -428 ‰ (Coplen, 1996). Hydrogen isotope ratios were determined by hydrogen-water equilibration and analysis by isotope ratio mass spectrometry (Coplen and others, 1991). About 25 percent of analyses each day were reference samples and samples are analyzed in replicate. The 2-sigma uncertainty of hydrogen isotopic results is 2 per mill. This means that if a sample was resubmitted for analysis at a later date, there was a 95-percent probability that the hydrogen isotopic result reported will be within 2 per mill of that originally reported.

The oxygen isotope ratio is:

$$\delta\,{}^{18}\mathrm{O} = \left[\frac{n_{\mathrm{X}}\left({}^{18}\mathrm{O}\right)/n_{\mathrm{X}}\left({}^{16}\mathrm{O}\right)}{n_{\mathrm{VSMOW}}\left({}^{18}\mathrm{HO}\right)/n_{\mathrm{VSMOW}}\left({}^{16}\mathrm{O}\right)}-1\right]\cdot 1000\ ‰ \quad (4)$$

where the isotope ratio is expressed relative to VSMOW reference water and is normalized such that •^{18}O of SLAP reference water is -55.5 ‰ (Coplen, 1996). Oxygen isotope ratios are determined by the carbon dioxide-water equilibration method of Epstein and Mayeda (1953). About 20 percent of analyses each day were isotopic reference waters and about 35 percent of samples were analyzed in replicate. The 2-sigma uncertainty of oxygen isotopic results is 0.2 per mill. This means that if a sample is resubmitted for analysis at a later date, there is a 95-percent probability that the isotopic result reported will be within 0.2 per mill of that originally reported.

Quality Assurance/Quality Control

Various quality-assurance (QA) samples were collected for this study. Duplicate samples consist of splits from the same sample aliquot that are collected in such a manner that the samples are assumed to be essentially identical in composition. Three duplicate samples were collected in August 2002 during low-flow conditions: a surface-water sample from the Platte River, a collector-well water sample, and a finished water sample. These samples were analyzed for pharmaceuticals, antibiotics, pesticides, organic wastewater compounds, and stable isotopes. Equipment blanks, which are samples of ultrapure deionized water that have been processed with the same sample collection equipment used to collect the environmental samples, also were submitted from the same sites and analyzed for major ions. Additional quality-assurance and quality-control (QC) measures inherent to the laboratory methods and consistent with each laboratory QA plan also were taken. In addition, a three-tiered approach of QC divided into method performance (instrument and method), data review and blind sample programs, and performance evaluation studies is applied at the NWQL (Pirkey and Glodt, 1998). The results of the QA/QC samples are presented in the tables and discussed in the text in the following sections of the report.

Streamflow and Well Field Pumpage

Streamflow during the period of study of riverbank filtration at the established well field was compared to the natural variability in the hydrologic system through use of long-term streamflow information. Historical median streamflow data used for comparisons are available at *http://nwis.waterdata.usgs.gov/ne/nwis/sw* for the Platte River near Ashland (station 0681000) for water years 1929 to 2003 and for Salt Creek near Greenwood (station 0680355) for water years 1952 to 2003. The Salt Creek near Greenwood gage is located approximately 12 km upstream from the sampling point; there are no tributaries between the gage and sampling point. Daily mean streamflow during the study period was compared to the historic median daily streamflow in the Platte River (fig. 2) and Salt Creek (fig. 3). Flow conditions were tracked for several days around each sample date at these two sites (figs. 4 and 5).

Monthly pumpage from vertical wells W49-9 and W54-10 is shown in table 6. In addition, pumping was variable during the study period in the horizontal collector wells W90-1H and W90-2H relative to total flow into the east treatment plant and total well field pumpage (fig. 6).

Table 6. Monthly pumpage from vertical wells W49-9 and W54-10 during the riverbank filtation study.

[MG, millions of gallons]

Month and year	Pumpage, in MG	
	W49-9	W54-10
November 2001	16.045	27.975
December 2001	27.744	88.905
January 2002	18.269	52.898
February 2002	33.699	77.728
March 2002	28.458	62.897
April 2002	30.429	35.922
May 2002	29.934	100.629
June 2002	40.661	108.557
July 2002	25.908	91.532
August 2002	28.870	109.238
September 2002	25.480	91.304
October 2002	23.087	97.632
November 2002	38.464	68.811
December 2002	49.136	79.062
January 2003	3.936	51.475
February 2003	0	101.201
March 2003	0	88.578
April 2003	27.280	46.493
May 2003	22.993	20.326
June 2003	16.048	45.518
July 2003	31.866	68.918
Minimum	**0**	**20.326**
Mean	**24.681**	**72.171**
Median	**27.280**	**77.728**
Maximum	**49.136**	**109.238**

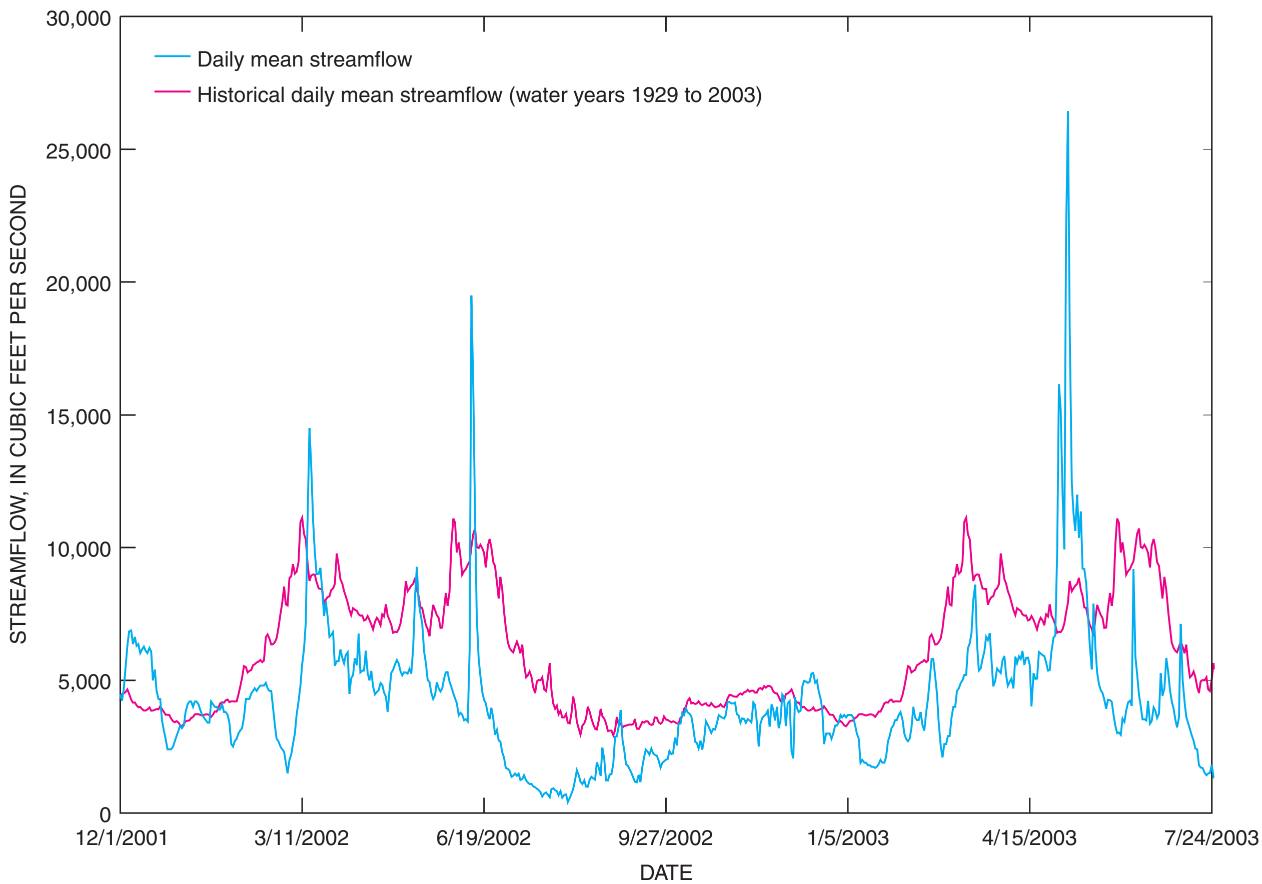

Figure 2. Comparison of average daily streamflow and historical mean daily streamflow at the Platte River near Ashland gage.

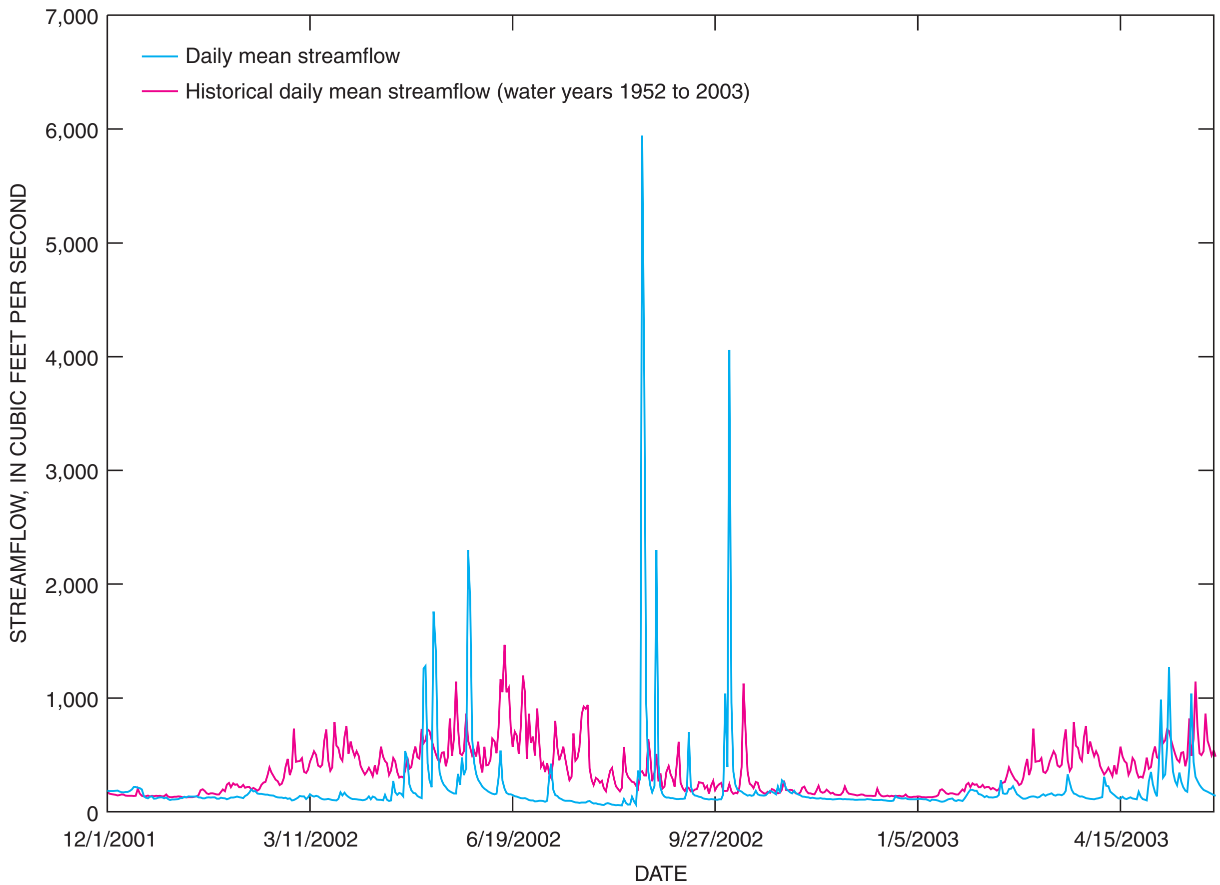

Figure 3. Comparison of average daily streamflow and historical mean daily streamflow at the Salt Creek near Greenwood gage.

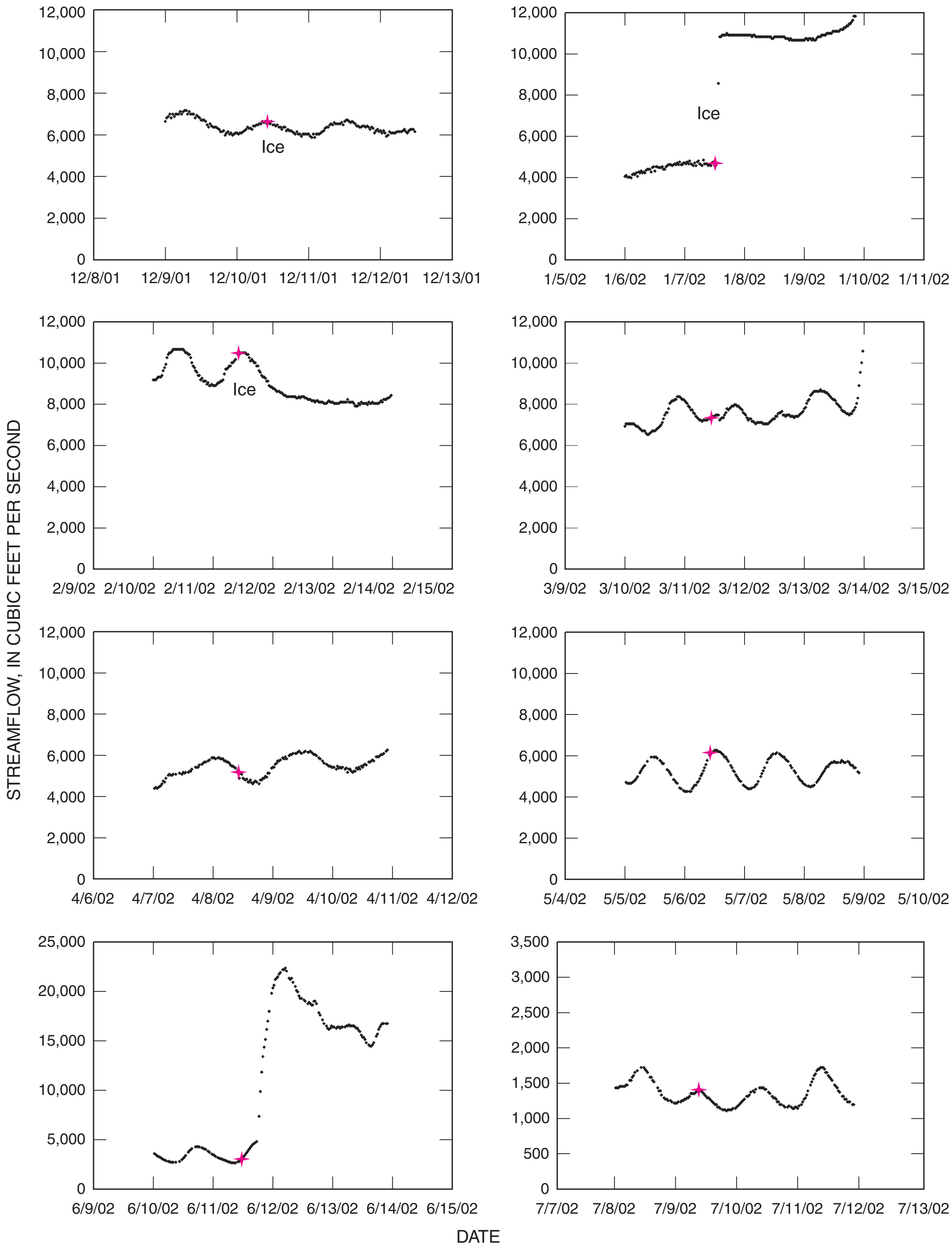

Figure 4. Flow conditions during sampling in the Platte River near Ashland between December 2001 and May 2003. Sample collection times are represented by stars.

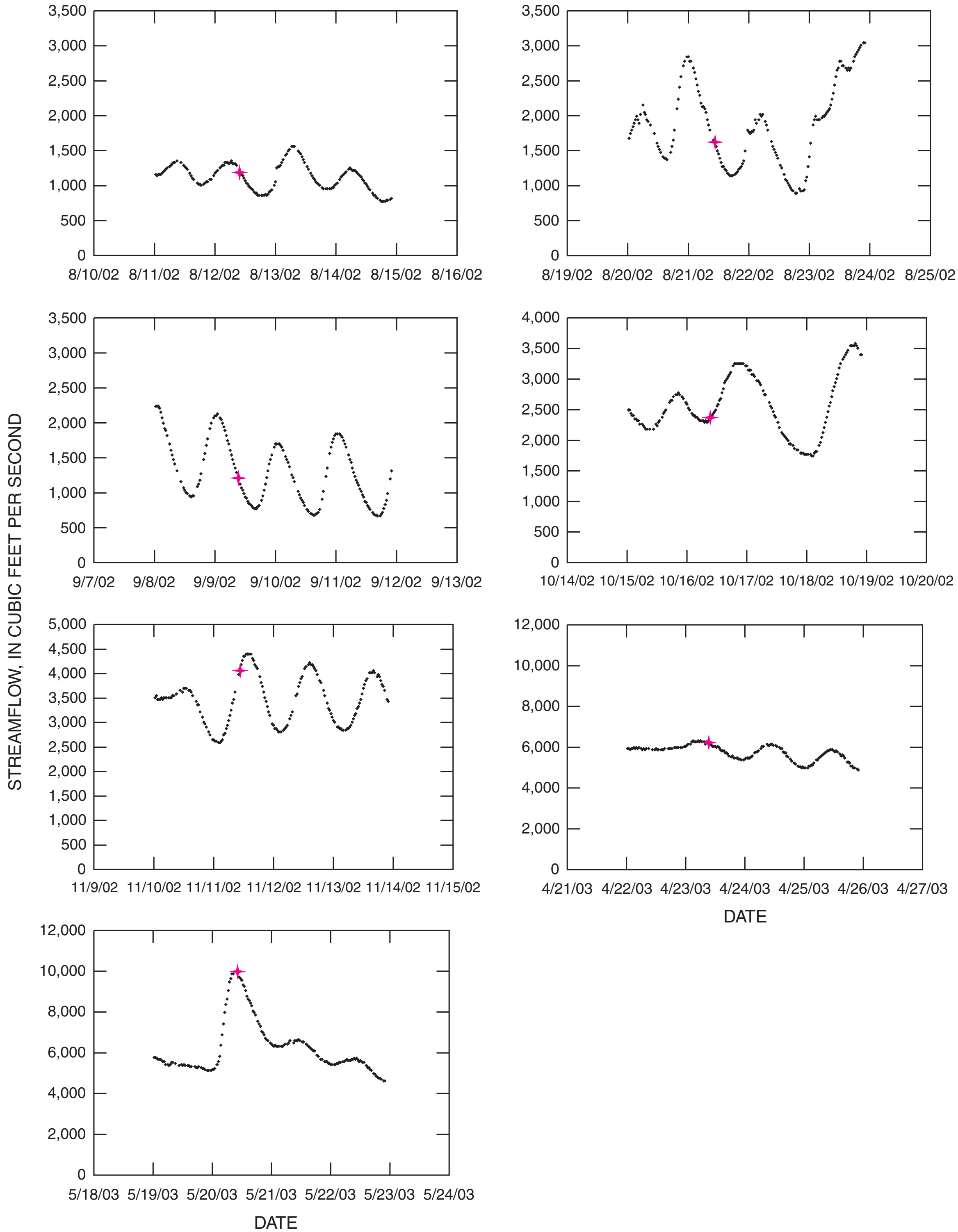

Figure 4. Flow conditions during sampling in the Platte River near Ashland between December 2001 and May 2003. Sample collection times are represented by stars.—Continued

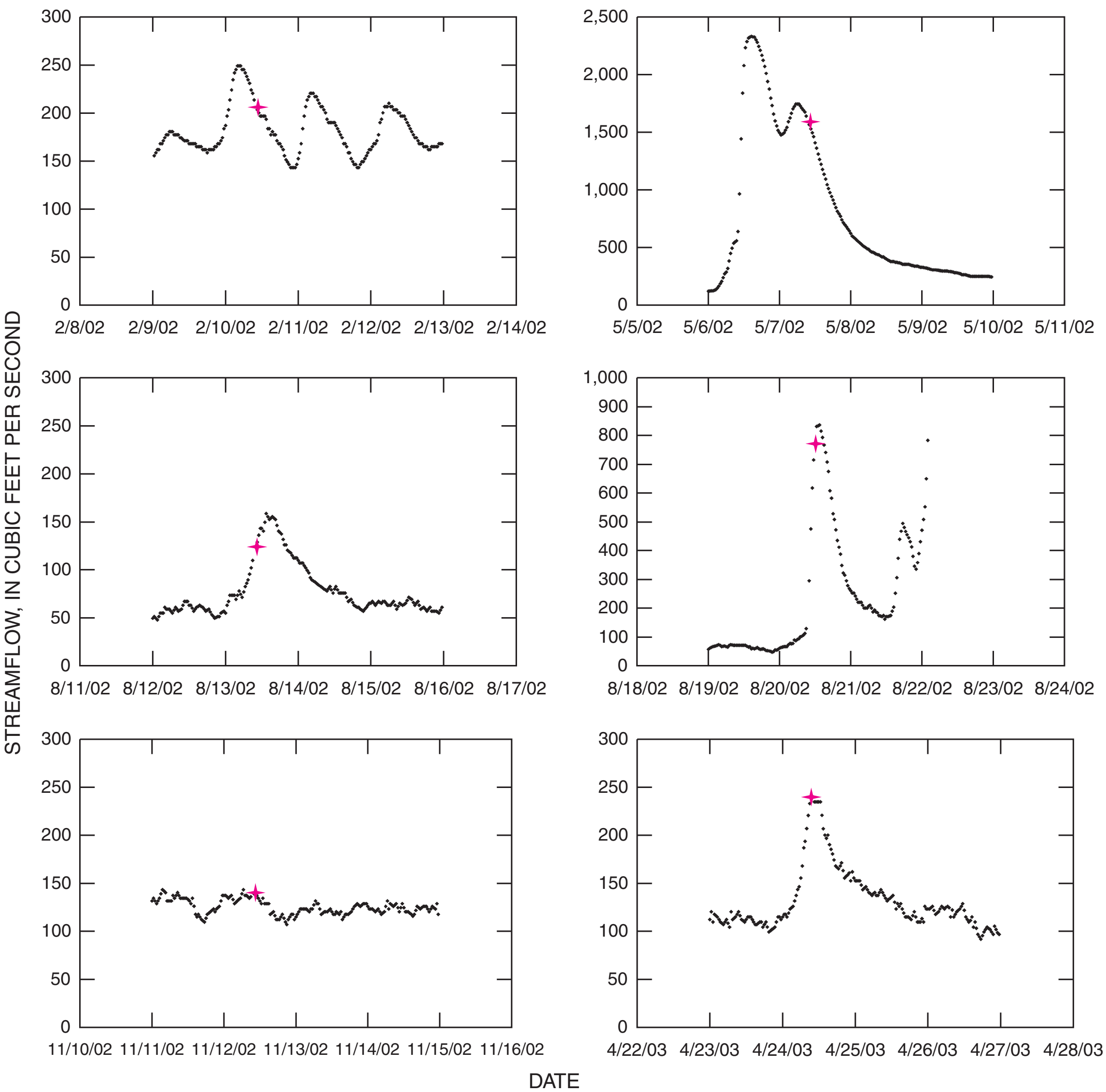

Figure 5. Flow conditions during sampling at Salt Creek near Greenwood, February 2002 to April 2003. Sample collection times are represented by stars.

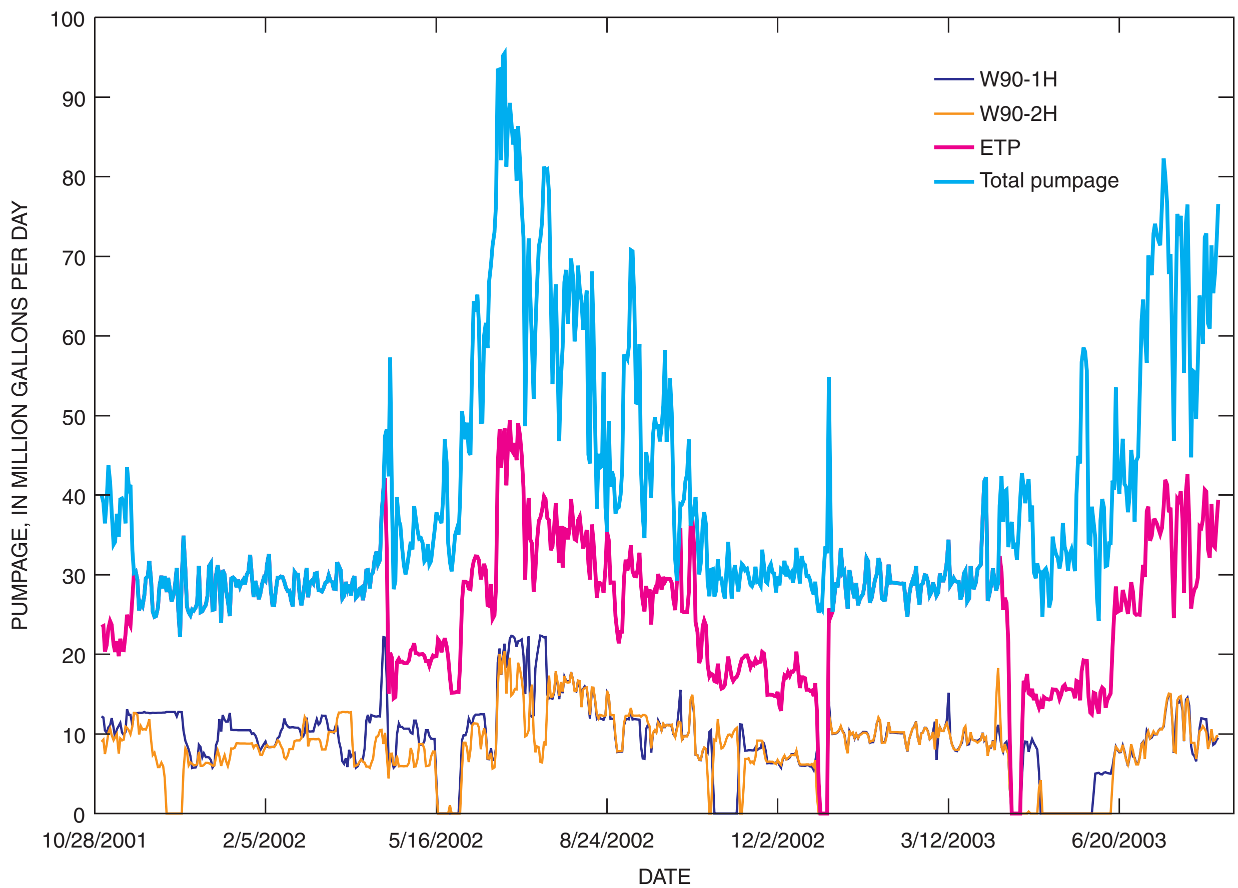

Figure 6. Comparison of pumpage in collector wells W90-1H and W90-2H, total flow through City of Lincoln east treatment plant (ETP), and total pumpage from the well field during the period of the study.

Field Water-Quality Properties

Field water-quality properties were measured at selected sites (table 7 and fig. 7). In the cattle and hog lagoon samples, specific conductance and turbidity varied throughout the year. These two properties were more consistent in the samples from the wastewater-treatment plant effluent. In general, specific conductivity and turbidity were higher in the lagoon samples than in the wastewater-treatment plant effluent samples. Water temperatures at all three sites closely reflected the air temperatures at the time of sampling. The pH values at all sites were fairly consistent, with the lower values measured in samples from the wastewater-treatment plant effluent. One large pH value of 9.10 was measured in the cattle lagoon sample collected on August 15, 2002. Dissolved oxygen was consistently higher in the wastewater-treatment plant effluent samples than in the lagoon samples, a result of the respective treatment processes used.

Among the two surface-water sites, specific conductance was consistently much greater in Salt Creek than in the Platte River. Similar to the wastewater measurements, water temperature reflected the air temperature at time of measurement. The Platte River consistently had higher pH values than Salt Creek. Both surface-water sites had similar trends in dissolved oxygen, with higher values in the winter and lower values in the summer. Turbidity ranges between the two sites also generally were similar, with samples collected during runoff events showing much higher turbidity measurements at both sites.

Relative to the other two wells sampled at the well field site, all field properties were the most consistent in samples from well W49-9, which is the farthest from the Platte River and has the least amount of surface-water influence. Samples from well W54-10 consistently showed lower specific-conductance values than samples from the other two wells. Samples from wells W90-1H and W54-10 showed similar pH values, with samples from W49-9 being consistently lower. Water temperature and dissolved oxygen in samples from wells W90-1H and W54-10 reflected the surface water influence from the Platte River on these properties. Turbidities in all of the ground-water samples were very low (less than 0.25 nephelometric turbidity units (NTU)).

The raw water samples were a composite from all the ground-water wells in operation at the site at the time of sampling and the field measurements reflect this. For specific conductance, raw and finished water were similar in 2002. Two samples collected in 2003 showed higher specific conductance in the finished water than in the raw water. Water temperature was fairly consistent and did not reach the extremes of outside temperature, as would be expected for these inside treatment-plant locations. In general, the pH of the water appears to have decreased slightly, dissolved oxygen increased, and turbidity stayed about the same during the treatment process.

Pharmaceutical Compounds

Results for pharmaceutical compounds (pharmaceuticals and antibiotics) are presented in this section of the report. Results of QA/QC samples that were analyzed for pharmaceutical compounds also are presented.

Pharmaceuticals

Concentrations of 27 pharmaceutical compounds were determined in samples from all water quality sites (table 8; table 9 on CD-ROM at back of the report). Two duplicate samples also were collected and analyzed in August 2002 for pharmaceuticals – one from the Platte River and one of finished water. In the Platte River duplicate analysis, the largest detected difference between the two samples for pharmaceuticals was for caffeine with a difference of 0.015 microgram per liter (µg/L) (19 percent). None of the pharmaceuticals analyzed were detected in the finished water or the finished water duplicate. A set blank, set spike, 0.10 continuing calibration verification (ccv), 0.20 ccv, and/or 0.40 ccv also were analyzed during each analysis run (table 10 on CD-ROM at back of the report). Caffeine and cotinine were analyzed with both the pharmaceuticals (table 2) and the organic wastewater compounds method (table 5). Detection and concentration differences for caffeine and cotinine between the two analytical methods could reflect differences in sample processing, transport, or analysis.

Measured concentrations less than the laboratory reporting level (LRL) are denoted on the data tables with an "E" (estimated). Measured concentrations for compounds where the LRL was not determined are also denoted with an "E". Results are denoted with a "G" when the measured concentration is greater than the highest calibration level for the method. Measured concentrations for samples that had to be diluted to analyze are denoted with a "D" and the data is considered estimated. Results are denoted with a "B" when the measured concentration is less than 10 times the concentration detected in the laboratory blank for that compound. Finally, detections of caffeine, caffeine degradates, and cotinine (nicotine degradate) may be a result of contamination because the analytical method is very sensitive and the use of products containing these compounds prior to or during sampling, sample processing, or analysis could result in detectable concentrations.

Many more pharmaceuticals were found in the wastewater-treatment plant effluent samples than in samples from the two lagoons (table 8). Compounds from the pharmaceutical schedule detected in the cattle feedlot lagoon samples were acetaminophen, caffeine, carbamazapine, and diphenhydramine. In the hog confinement lagoon the pharmaceutical compounds detected at least once included acetaminophen, caffeine, carbamazapine, cotinine, and sulfamethoxazole. Pharmaceuticals detected in at least one sample of the wastewater-treatment plant effluent were 1,7-dimethylxanthine, acetaminophen, caffeine, carbamazapine, cimetidine, codeine, cotinine, dehydronifedipine, diltiazem, diphenhydramine, erythromycin, fluoxetine, ibuprofen, ranitidine, salbutamol, sulfamethoxazole, thiabendazole, and trimethoprim.

Numerous pharmaceuticals were detected in low levels in surface-water samples. Compounds from the pharmaceutical schedule that were detected in multiple samples from the Platte River included acetaminophen, caffeine, carbamazapine, cotinine, and sulfamethoxazole. Additionally, 1,7-dimethylxanthine, azithromycin, dehydronifedipine, and diphenhydramine were detected in single samples from the Platte River. In Salt Creek, pharmaceuticals detected multiple times included 1,7-dimethylxanthine, acetaminophen, caffeine, carbamazapine, cimetidine, codeine, cotinine, salbutamol, sulfamethoxazole, and trimethoprim. Pharmaceuticals detected in single samples from Salt Creek were dehydronifedipine, diltiazem, erythromycin, fluoxetine, and metformin.

Pharmaceuticals were detected at low levels in all three ground-water wells sampled for water-quality analysis. Compounds that were detected multiple times in samples from a single ground-water site included acetaminophen, caffeine, carbamazapine, codeine, cotinine, diltiazem, diphenhydramine, sulfamethoxazole, and thiabendazole. Pharmaceuticals detected once in samples from a single ground-water site included azithromycin, cimetidine, dehydronifedipine, diltiazem, erythromycin, furosemide, salbutamol, and trimethoprim.

Low levels of pharmaceuticals were found in the raw water samples. Compounds detected in the raw water samples included acetaminophen, caffeine, carbamazapine, cotinine, and sulfamethoxazole. Except for caffeine and cotinine detected in very low levels in a single sample each, no pharmaceuticals were found in the finished water samples.

Antibiotics

Samples from all water-quality sampling sites were analyzed for 26 antibiotics (table 11; table 12 on CD-ROM at back of the report). Duplicate samples were collected once from the Platte River and once from the finished water and were analyzed for antibiotics (table 12). The environmental samples and duplicate samples on that sampling date had no detections of antibiotics.

For the wastewater sites, similar compounds were found in samples from the two lagoons. However, the concentrations in samples from the hog confinement lagoon generally were higher than in samples from the cattle feedlot lagoon. Antibiotics detected in samples from the cattle feedlot lagoon included chlortetracycline, oxytetracycline, and sulfadimethoxine. Chlortetracycline, lincomycin, oxytetracycline, sulfadimethoxine, sulfamethazine, tetracycline, and tylosin were detected in samples from the hog confinement lagoon. The antibiotics detected in samples from the wastewater-treatment plant effluent were ciprofloxacin, erythromycin, sulfadimethoxine, sulfamethoxazole, tetracycline, and trimethoprim.

In single samples from Salt Creek during the study, doxycycline, erythromycin and trimethoprim were detected in low levels. Antibiotics from this schedule were not detected in any of the samples from the Platte River, ground-water wells, raw water, or finished water with the exception of sulfamethoxazole, which was detected but not quantified in one sample from a ground-water well.

Table 7. Field properties measured for all samples collected.

[mS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; NTU, nephelometric turbidity units; nm, no measurement]

Station number	Station name	Date	Time	Specific conductance (µS/cm)	Temperature Air (°C)	Temperature Water (°C)	pH	Dissolved oxygen (mg/L)	Turbidity (NTU)
410322096190103	Cattle feedlot lagoon	2/14/02	9:00	3,690	4.5	2.5	7.47	nm	505
		5/9/02	9:00	4,070	10.0	15.5	7.76	0.45	460
		8/15/02	9:00	907	23.5	21.0	9.10	nm	48.5
		8/23/02	9:00	1,520	22.0	23.0	7.95	.72	1,706
		5/22/03	9:00	3,470	nm	12.0	7.92	.27	387
410322096190104	Hog confinement lagoon	2/14/02	14:00	4,110	5.0	7.0	7.32	nm	198
		5/9/02	13:30	4,610	17.5	18.0	7.83	1.31	149
		8/15/02	12:30	2,330	23.5	23.0	8.10	nm	8.59
		8/23/02	16:00	1,858	22.0	28.0	7.96	2.12	7.23
		5/22/03	14:30	3,840	18.0	23.5	8.16	.26	315
06803496	Wastewater-treatment plant effluent	2/13/02	9:00	1,365	6.0	11.0	7.45	6.44	5.45
		5/8/02	8:30	1,463	15.5	19.0	7.39	4.18	nm
		8/14/02	9:00	1,320	18.0	22.0	7.20	4.10	11.7
		8/22/02	9:00	1,039	nm	24.0	7.27	3.58	11.7
		5/21/03	10:30	1,332	15.0	16.5	7.03	3.64	21
06801000	Platte River near Ashland	12/10/01	10:00	536	10.0	3.0	7.84	10.74	62.4
		1/7/02	12:00	613	nm	1.1	6.95	10.69	12.5
		2/11/02	10:00	504	2.0	0.5	7.92	10.80	17.9
		3/11/02	10:00	554	4.0	2.5	8.01	10.16	17.7
		4/8/02	11:00	495	10.5	10.5	8.51	8.71	32.8
		5/6/02	10:30	492	21.0	15.5	8.91	7.92	61.8
		6/11/02	10:30	453	29.5	20.5	8.88	6.64	66.7
		7/9/02	10:00	445	31.0	23.0	9.04	6.93	48.1
		8/12/02	11:30	462	26.0	27.0	8.91	5.90	46.8
		8/21/02	11:00	336	nm	20.0	8.89	6.90	56.3
		9/9/02	9:30	398	23.0	21.0	8.49	6.32	45.7
		10/16/02	9:30	466	8.0	12.0	8.50	9.20	22.8
		11/11/02	10:30	450	2.0	5.0	8.16	9.95	46.3
		4/23/03	10:00	453	12.0	16.3	8.43	8.42	56.4
		5/20/03	10:30	498	26.0	15.0	8.56	9.75	502
06805000	Salt Creek near Ashland	2/12/02	10:00	3010	2.0	2.0	6.80	9.76	13.6
		5/7/02	10:00	878	14.5	15.5	7.71	5.02	1,490
		8/13/02	10:00	5180	16.5	21.5	8.16	4.79	12.6
		8/20/02	10:00	4330	nm	24.0	7.96	6.04	73.2
		11/12/02	10:00	4070	4.5	6.0	7.90	8.62	11.0
		4/24/03	9:30	3590	12.0	13.3	7.75	5.57	17.8

Table 7. Field properties measured for all samples collected.—Continued

Station number	Station name	Date	Time	Specific conductance (µS/cm)	Temperature Air (ºC)	Temperature Water (ºC)	pH	Dissolved oxygen (mg/L)	Turbidity (NTU)
410547096254801	G-040474 - Memphis	12/17/01	7:30	385	nm	11.5	7.03	5.65	0.36
		1/14/02	7:30	389	1.0	9.0	6.72	5.68	.08
		2/19/02	7:30	409	3.5	11.5	6.71	6.30	.16
		3/18/02	7:30	408	4.0	11.5	6.54	6.48	.13
		4/15/02	7:30	400	16.0	12.0	6.40	6.03	.15
		6/17/02	1:05	404	18.5	13.0	6.80	6.46	.15
		8/19/02	7:30	405	26.5	12.0	6.75	7.58	.10
		9/16/02	7:30	404	12.0	12.0	6.50	7.10	.09
412411097165601	Loup Power Canal	4/22/03	10:30	295	19.0	14.5	8.21	8.66	32.4
410322096191701	W90-1H	12/17/01	9:30	504	nm	10.0	7.90	4.81	.15
		1/14/02	9:20	568	1.5	7.5	7.86	6.13	.03
		2/20/02	9:00	516	3.5	3.5	7.52	9.85	.09
		3/18/02	9:30	548	8.0	3.5	8.02	1.82	.08
		4/15/02	9:30	543	16.0	8.0	7.98	5.49	.14
		5/13/02	9:00	502	15.0	11.5	7.96	1.96	.10
		6/17/02	9:30	516	18.5	16.0	7.91	.54	.09
		7/16/02	9:40	476	30.0	22.0	7.94	.45	.09
		8/19/02	10:00	468	26.5	23.0	7.90	.14	.09
		8/28/02	8:30	446	24.0	22.0	7.85	.16	.10
		9/16/02	10:20	432	21.0	22.5	7.80	.20	.09
		10/23/02	9:30	448	nm	17.0	7.90	1.40	.11
		11/18/02	9:00	448	nm	17.0	7.90	1.36	.11
		4/30/03	9:00	491	12.0	8.5	7.78	3.02	.18
		5/27/03	10:30	494	nm	11.2	7.78	1.88	.23
410315096193501	W54-10	12/17/01	10:30	471	nm	17.0	7.87	1.32	.12
		1/14/02	10:20	489	2.0	14.5	7.92	3.08	.04
		2/20/02	11:00	502	3.5	12.0	7.81	4.64	.36
		3/18/02	10:30	524	10.0	10.0	7.94	3.72	.10
		4/15/02	10:50	535	18.0	8.5	7.92	5.25	.18
		5/13/02	10:30	472	16.0	8.5	7.78	3.64	.09
		6/17/02	10:50	460	18.5	16.0	8.00	.68	.11
		7/16/02	11:30	451	33.0	22.5	7.95	.15	.09
		8/19/02	12:00	456	26.5	22.5	7.82	.25	.09
		8/28/02	11:00	449	28.0	23.0	7.78	.21	.22
		9/16/02	11:00	385	18.0	23.5	7.80	.20	.12
		10/23/02	10:40	367	nm	22.5	7.90	1.40	.17
		11/18/02	11:00	398	nm	17.0	7.68	4.32	.12
		4/30/03	11:30	428	13.0	5.0	8.02	4.68	.22
		5/27/03	11:30	452	nm	9.0	8.02	1.43	.18

Table 7. Field properties measured for all samples collected.—Continued

Station number	Station name	Date	Time	Specific conductance (µS/cm)	Temperature Air (ºC)	Temperature Water (ºC)	pH	Dissolved oxygen (mg/L)	Turbidity (NTU)
410349096202101	W49-9	12/17/01	11:20	576	nm	13.5	7.21	0.66	0.22
		1/14/02	11:10	575	3.0	14.5	7.19	.75	.14
		2/20/02	12:30	568	3.5	15.0	7.15	.90	.09
		3/18/02	11:20	583	11.0	14.5	7.16	1.32	.12
		4/15/02	11:50	662	20.0	13.5	7.18	.73	.15
		5/13/02	12:00	550	18.0	14.0	7.24	1.42	.11
		6/17/02	11:50	570	18.5	14.0	7.29	1.72	.09
		7/16/02	13:00	477	36.0	20.0	7.82	2.52	.07
		8/19/02	13:30	544	26.5	14.0	7.32	1.00	.08
		8/28/02	12:30	544	24.0	14.0	7.28	.89	.09
		9/16/02	11:30	533	22.0	14.0	7.30	.80	.17
		10/23/02	12:00	536	nm	13.5	7.35	.89	.23
		11/18/02	12:30	548	nm	14.0	7.26	.80	.21
		4/30/03	12:30	556	14.0	13.0	7.34	1.68	.24
		5/27/03	13:00	548	nm	12.5	7.34	2.84	.24
410315096190101	Raw water	12/17/01	12:15	505	nm	15.5	7.80	3.28	.10
		1/14/02	12:10	545	3.0	15.5	7.61	4.07	.18
		2/19/02	10:30	526	3.5	14.5	7.60	5.90	.16
		3/18/02	12:20	550	12.0	14.5	7.64	5.02	.08
		4/15/02	12:40	435	22.0	18.0	7.72	6.04	.10
		5/13/02	14:00	496	20.0	20.0	7.87	4.11	.06
		6/17/02	13:00	510	18.5	16.0	7.81	2.42	.06
		7/16/02	13:00	477	36.0	20.0	7.82	2.52	.07
		8/19/02	15:00	463	26.5	25.0	7.96	2.12	.07
		8/28/02	13:30	439	24.0	26.0	8.01	2.40	.08
		9/16/02	12:30	427	23.0	24.5	7.78	1.12	.07
		10/23/02	13:00	441	nm	18.0	7.80	2.80	.10
		11/18/02	13:00	441	nm	20.5	7.80	2.80	.10
		4/30/03	13:30	471	14.0	12.5	7.86	4.91	.13
		5/27/03	15:00	483	nm	17.0	8.04	3.88	.18

Table 7. Field properties measured for all samples collected.—Continued

Station number	Station name	Date	Time	Specific conductance (µS/cm)	Temperature Air (ºC)	Temperature Water (ºC)	pH	Dissolved oxygen (mg/L)	Turbidity (NTU)
410315096190102	Finished water	12/17/01	12:30	507	nm	13.5	7.67	5.25	0.06
		1/14/02	12:30	545	3.0	13.0	7.63	6.63	.08
		2/19/02	9:30	526	3.5	14.5	7.58	5.91	.16
		3/18/02	12:40	554	12.0	11.0	7.73	8.35	.07
		4/15/02	13:10	542	22.0	16.0	7.67	7.05	.05
		5/13/02	15:00	502	20.0	17.0	7.70	6.28	.04
		6/17/02	13:30	542	18.5	16.0	7.78	nm	.05
		7/16/02	13:30	524	36.0	22.0	7.76	6.00	.08
		8/19/02	16:00	481	26.5	25.0	7.76	4.64	.09
		8/28/02	15:00	445	24.0	23.5	7.62	4.80	.08
		9/16/02	13:00	509	23.0	21.5	7.56	5.44	.09
		10/23/02	13:30	462	nm	18.0	7.80	5.40	.12
		11/18/02	14:30	448	nm	19.0	7.50	2.20	.08
		4/30/03	14:00	560	14.0	16.5	7.70	6.06	.15
		5/27/03	14:00	520	nm	19.0	7.75	7.49	.22
6801000	Platte River near Ashland blank	8/12/02	11:15	462	26.0	27.0	8.91	5.90	46.8
	Platte River near Ashland duplicate	8/12/02	11:40	462	26.0	27.0	8.91	5.90	46.8
410315096190102	Finished water blank	8/19/02	16:05	481	26.5	25.0	7.76	4.64	.09
	Finished water duplicate	8/19/02	16:10	481	26.5	25.0	7.76	4.64	.09

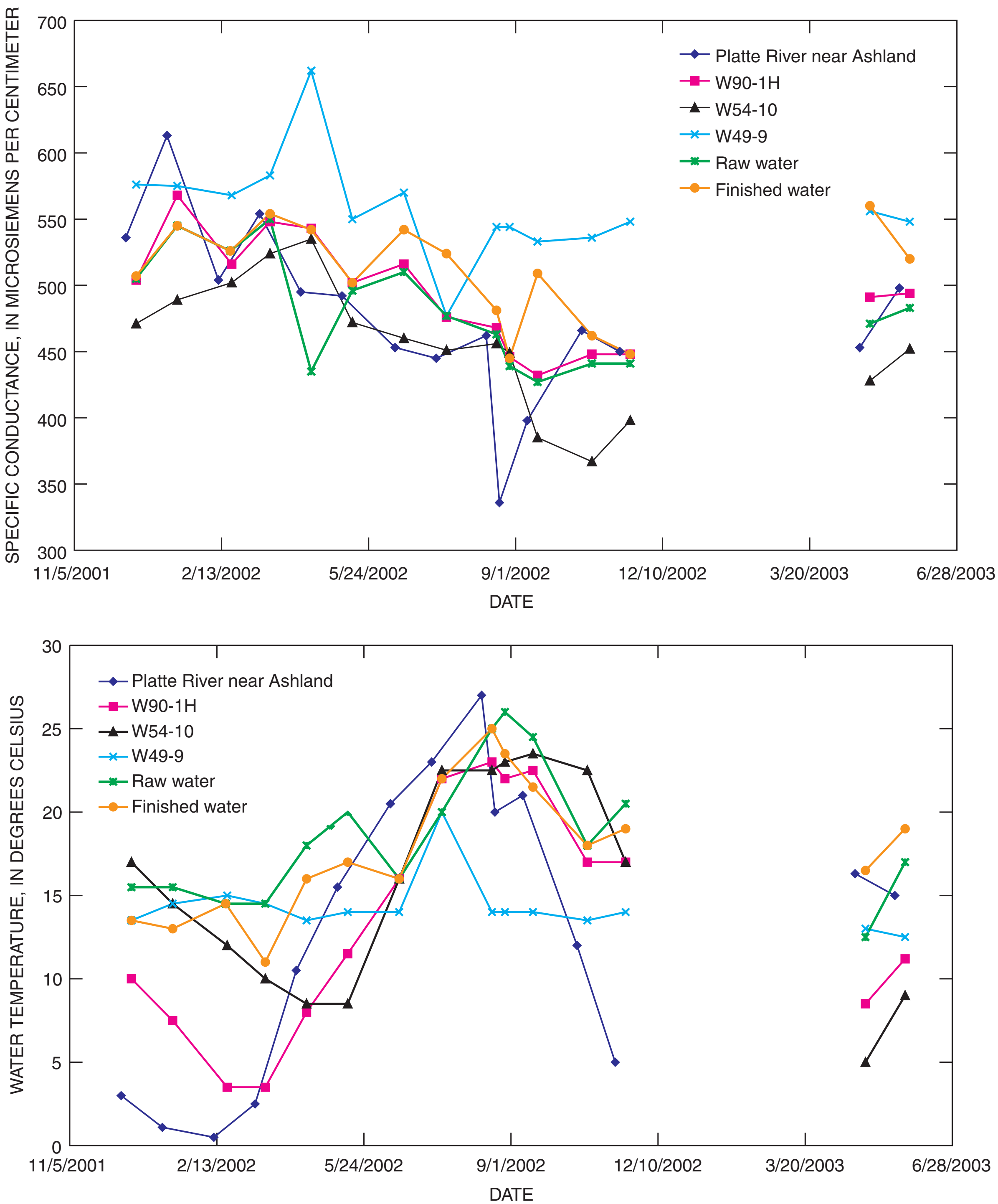

Figure 7. Field properties at selected sites.

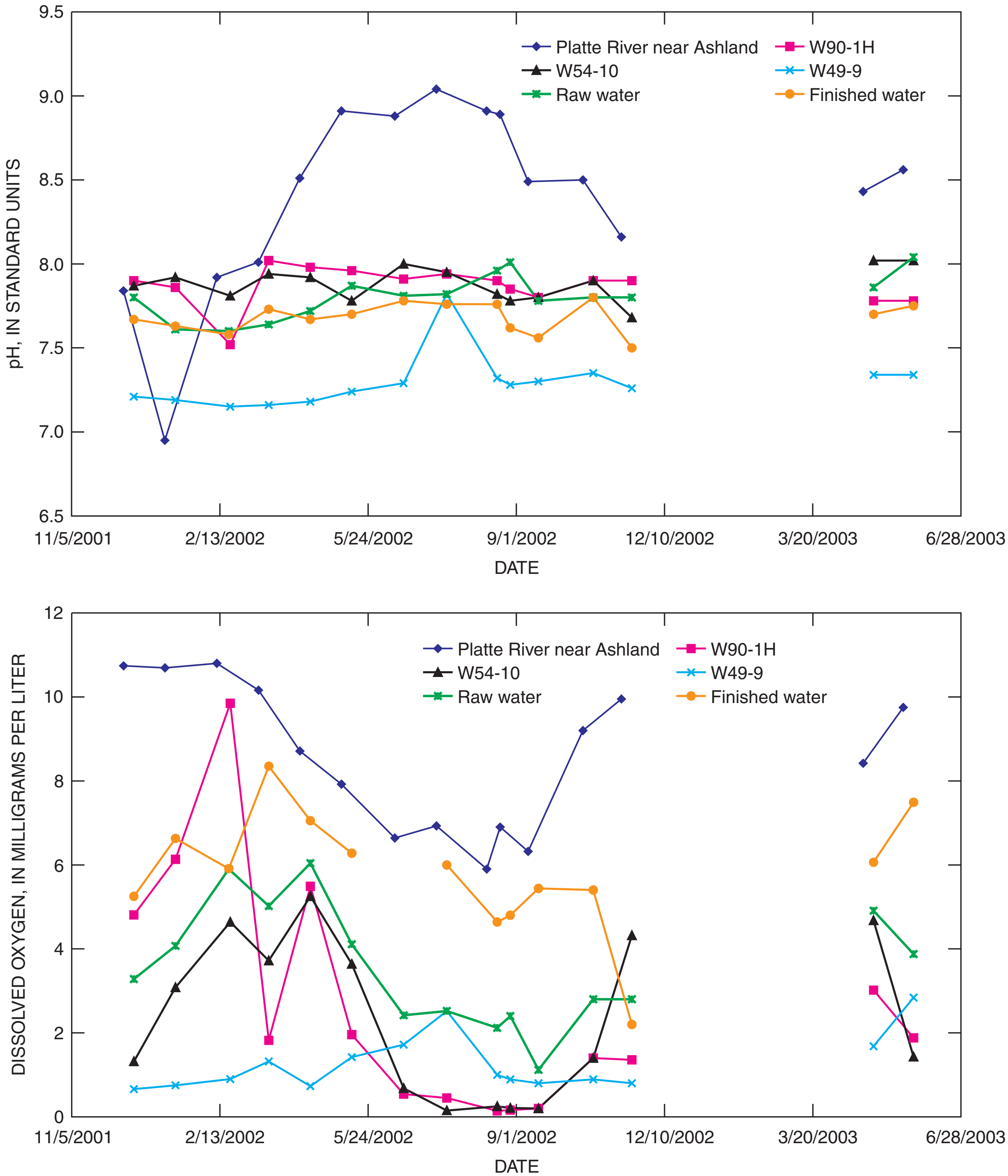

Figure 7. Field properties at selected sites.—Continued

Table 8. Summary statistics of pharmaceuticals in samples collected during riverbank filtration study, Platte River, Nebraska.

[All concentrations in micrograms per liter; summary statistics based upon detected concentrations (excluding samples where concentration was less than 10 times the laboratory blank detection as denoted by "B" in table 9); LRL, laboratory reporting level, shown for samples collected in 2001-2002, and for samples collected in 2003; nd, not determined; n, number of samples ; det, number of detections; max, maximum; med, median; $\bar{x}$, mean; s^2, standard deviation; na, not applicable; E, estimated; G, greater than highest calibration level]

Constituent	LRL (2001-2002, 2003)	410322096190103 Cattle feedlot lagoon						410322096190104 Hog confinement lagoon						06803496 Wastewater-treatment plant effluent					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Wastewater samples																			
1,7-Dimethyl-xanthine	nd, 0.144	5	0	na	na	na	na	5	0	na	na	na	na	5	5	G7.26	G4.57	G3.82	G2.90
Acetamino-phen	.017, .036	5	3	0.45	0.24	0.30	0.13	5	2	0.05	0.05	0.05	na	5	5	G4.93	1.51	G1.93	G1.78
Azithromycin	nd, .004	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Caffeine	.028, .016	5	1	.20	.20	.20	na	5	1	.02	.02	.02	na	5	5	G6.43	G4.29	G3.60	G2.50
Carbamaza-pine	nd, .011	5	1	E.09	E.09	E.09	na	5	1	E.04	E.04	E.04	na	5	5	E0.17	E0.11	E0.10	E0.04
Cimetidine	.013, .012	5	0	na	na	na	na	5	0	na	na	na	na	5	1	.70	.70	.70	na
Clarithromy-cin	nd, nd	2	0	na	na	na	na	2	0	na	na	na	na	2	0	na	na	na	na
Codeine	nd, .015	5	0	na	na	na	na	5	0	na	na	na	na	5	5	E.47	E.16	E.22	E.16
Cotinine	.046, .014	5	0	na	na	na	na	5	5	E.07	E.04	E.04	E0.02	5	5	.92	.59	.56	.35
Dehydronife-dipine	.019, .015	5	0	na	na	na	na	5	0	na	na	na	na	5	4	E.009	E.006	E.006	E.002
Digoxigenin	.015, nd	2	0	na	na	na	na	2	0	na	na	na	na	2	0	na	na	na	na
Diltiazem	.024, .016	5	0	na	na	na	na	5	0	na	na	na	na	5	3	E.06	E.02	E.03	E.03
Diphenhy-dramine	nd, .015	5	1	.06	.06	.06	na	5	0	na	na	na	na	5	4	E.12	E.04	E.05	E.05
Erythromycin	nd, .009	5	0	na	na	na	na	5	0	na	na	na	na	5	1	E.65	E.65	E.65	na
Fluoxetine	.036, .014	5	0	na	na	na	na	5	0	na	na	na	na	5	2	E.07	E.04	E.04	E.04
Furosemide	nd, nd	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Gemfibrozil	.028, .013	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Ibuprofen	.036, .042	5	0	na	na	na	na	5	0	na	na	na	na	5	1	.19	.19	.19	na

Table 8. Summary statistics of pharmaceuticals in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

Constituent	LRL (2001-2002, 2003)	410322096190103 Cattle feedlot lagoon						410322096190104 Hog confinement lagoon						06803496 Wastewater-treatment plant effluent					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Wastewater samples—Continued																			
Metformin	0.007, nd	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Miconazole	nd, .018	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Paroxetine metabolite	.036, nd	2	0	na	na	na	na	2	0	na	na	na	na	2	0	na	na	na	na
Ranitidine	.020, .013	5	0	na	na	na	na	5	0	na	na	na	na	5	1	0.46	0.46	0.46	na
Salbutamol	.058, .023	5	0	na	na	na	na	5	0	na	na	na	na	5	2	.09	E.06	E.06	E0.04
Sulfamethox-azole	.046, .064	5	0	na	na	na	na	5	2	0.22	0.22	0.22	0.00	5	4	.32	.17	.19	.09
Thiabenda-zole	nd, .011	5	0	na	na	na	na	5	0	na	na	na	na	5	1	E.16	E.16	E.16	na
Trimethoprim	.028, .013	5	0	na	na	na	na	5	0	na	na	na	na	5	5	E.26	E.06	E.12	E.11
Warfarin	.012, .012	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na

Constituent	LRL (2001-2002, 2003)	06801000 Platte River near Ashland						06805000 Salt Creek near Ashland					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Surface-water samples													
1,7-Dimethyl-xanthine	nd, .144	15	1	E0.02	E0.02	E0.02	na	5	4	.96	E.60	E.58	E.36
Acetamino-phen	.017, .036	14	5	E.010	E.004	E.005	E0.003	5	5	.21	.07	.09	.08
Azithromycin	nd, .004	15	1	E.003	E.003	E.003	na	5	0	na	na	na	na
Caffeine	.028, .016	13	6	E.015	E.007	E.007	E.004	5	5	.88	.49	.51	.34
Carbamaza-pine	nd, .011	15	8	E.016	E.004	E.005	E.005	4	4	E.035	E.023	E.021	E.012
Cimetidine	.013, .012	15	0	na	na	na	na	5	3	.05	.02	.03	.02

Table 8. Summary statistics of pharmaceuticals in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

Constituent	LRL (2001-2002, 2003)	06801000 Platte River near Ashland						06805000 Salt Creek near Ashland					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Surface-water samples—Continued													
Clarithromycin	nd, nd	9	0	na	na	na	na	2	0	na	na	na	na
Codeine	nd, 0.015	15	0	na	na	na	na	5	4	E0.04	E0.02	E0.02	E0.01
Cotinine	.046, .014	15	12	E0.008	E0.003	E0.004	E0.002	5	5	E.14	E.11	E.09	E.05
Dehydronifedipine	.019, .015	15	1	E.001	E.001	E.001	na	5	1	E.005	E.005	E.005	na
Digoxigenin	.015, nd	9	0	na	na	na	na	2	0	na	na	na	na
Diltiazem	.024, .016	15	0	na	na	na	na	5	1	E.01	E.01	E.01	na
Diphenhydramine	nd, .015	15	1	0.01	0.01	0.01	na	5	0	na	na	na	na
Erythromycin	nd, .009	15	0	na	na	na	na	5	1	E.09	E.09	E.09	na
Fluoxetine	.036, .014	15	0	na	na	na	na	5	1	E.007	E.007	E.007	na
Furosemide	nd, nd	15	0	na	na	na	na	5	0	na	na	na	na
Gemfibrozil	.028, .013	15	0	na	na	na	na	5	0	na	na	na	na
Ibuprofen	.036, .042	15	0	na	na	na	na	5	0	na	na	na	na
Metformin	.007, nd	15	0	na	na	na	na	5	1	E.024	E.024	E.024	na
Miconazole	nd, .018	15	0	na	na	na	na	5	0	na	na	na	na
Paroxetine metabolite	.036, nd	9	0	na	na	na	na	2	0	na	na	na	na
Ranitidine	.020, .013	15	0	na	na	na	na	5	0	na	na	na	na
Salbutamol	.058, .023	15	0	na	na	na	na	5	4	E.012	E.006	E.007	E0.003
Sulfamethoxazole	.046, .064	15	3	.007	.003	.004	.003	5	3	E.05	E.04	E.04	E.02
Thiabendazole	nd, .011	15	0	na	na	na	na	5	0	na	na	na	na

Table 8. Summary statistics of pharmaceuticals in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

Constituent	LRL (2001-2002, 2003)	06801000 Platte River near Ashland						06805000 Salt Creek near Ashland					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Surface-water samples—Continued													
Trimethoprim	0.028, .013	15	0	na	na	na	na	4	3	E0.035	E0.025	E0.022	E0.014
Warfarin	.012, .012	15	0	na	na	na	na	5	0	na	na	na	na

Constituent	LRL (2001-2002, 2003)	410322096191701 Well W90-1H						410349096202101 Well W49-9						410315096193501 Well W54-10					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Ground-water samples																			
1,7-Dimethylxanthine	nd, .144	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Acetaminophen	.017, .036	7	4	E0.055	E0.006	E0.017	E0.026	7	1	E.002	E.002	E.002	na	7	4	0.055	E0.005	E0.017	E0.025
Azithromycin	nd, .004	7	0	na	na	na	na	7	1	E.011	E.011	E.011	na	7	0	na	na	na	na
Caffeine	.028, .016	6	2	E.012	E.010	E.010	E.003	6	3	E.005	E.004	E.004	E.002	6	5	.057	E.016	E.020	E.023
Carbamazapine	nd, .011	7	6	E.004	E.003	E.003	E.001	5	4	E.002	E.002	E.002	E.001	6	5	E.003	E.003	E.003	E.000
Cimetidine	.013, .012	7	0	na	na	na	na	7	0	na	na	na	na	7	1	E.003	E.003	E.003	na
Clarithromycin	nd, nd	2	0	na	na	na	na	2	0	na	na	na	na	2	0	na	na	na	na
Codeine	nd, .015	7	0	na	na	na	na	7	1	E.001	E.001	E.001	na	7	2	E.007	E.004	E.004	E.004
Cotinine	.046, .014	6	5	E.004	E.003	E.003	E.001	6	1	E.001	E.001	E.001	na	6	1	E.002	E.002	E.002	na
Dehydronifedipine	.019, .015	7	1	E.004	E.004	E.004	na	5	0	na	na	na	na	6	1	E.002	E.002	E.002	na
Digoxigenin	.015, nd	2	0	na	na	na	na	2	0	na	na	na	na	2	0	na	na	na	na
Diltiazem	.024, .016	7	1	E.007	E.007	E.007	na	7	2	E.003	E.002	E.002	E.001	7	1	E.003	E.003	E.003	na
Diphenhydramine	nd, .015	7	3	E.03	E.003	E.01	E.02	6	2	E.011	E.008	E.008	E.004	6	2	E.002	E.002	E.002	E.001

Table 8. Summary statistics of pharmaceuticals in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

Constituent	LRL (2001-2002, 2003)	410322096191701 Well W90-1						410349096202101 Well W49-9						410315096193501 Well W54-10					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Ground-water samples—Continued																			
Erythromycin	nd, 0.009	7	1	E0.004	E0.004	E0.004	na	7	0	na	na	na	na	7	0	na	na	na	na
Fluoxetine	.036, .014	6	0	na	na	na	na	6	0	na	na	na	na	6	0	na	na	na	na
Furosemide	nd, nd	7	1	E.010	E.010	E.010	na	7	0	na	na	na	na	7	0	na	na	na	na
Gemfibrozil	.028, .013	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Ibuprofen	.036, .042	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Metformin	.007, nd	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Miconazole	nd, 0.018	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Paroxetine metabolite	.036, nd	2	0	na	na	na	na	2	0	na	na	na	na	2	0	na	na	na	na
Ranitidine	.020, .013	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Salbutamol	.058, .023	7	0	na	na	na	na	7	0	na	na	na	na	7	1	E0.002	E0.002	E0.002	na
Sulfamethox-azole	.046, .064	7	5	E.018	E.007	E.008	E0.006	7	4	E0.016	E0.002	E0.005	E0.007	7	5	E.017	E.005	E.007	E0.005
Thiabenda-zole	nd, .011	7	1	E.006	E.006	E.006	na	7	2	E.006	E.003	E.003	E.003	7	1	E.006	E.006	E.006	na
Trimethoprim	.028, .013	7	0	na	na	na	na	7	1	E.004	E.004	E.004	na	6	1	E.002	E.002	E.002	na
Warfarin	.012, .012	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na

Table 8. Summary statistics of pharmaceuticals in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

Constituent	LRL (2001-2002, 2003)	410315096190101 Raw water						410315096190102 Finished water					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Drinking-water samples													
1,7-Dimethyl-xanthine	nd, .0144	7	0	na	na	na	na	5	0	na	na	na	na
Acetamino-phen	0.017, .036	7	2	E0.017	E0.011	E0.011	E0.009	5	0	na	na	na	na
Azithromycin	nd, .004	7	0	na	na	na	na	5	0	na	na	na	na
Caffeine	.028, .016	6	1	.034	.034	.034	na	5	1	E0.007	E0.007	E0.007	na
Carbamaza-pine	nd, .011	6	5	E.004	E.003	E.003	E.001	5	0	na	na	na	na
Cimetidine	.013, .012	7	0	na	na	na	na	5	0	na	na	na	na
Clarithromy-cin	nd, nd	2	0	na	na	na	na	2	0	na	na	na	na
Codeine	nd, .015	7	0	na	na	na	na	5	0	na	na	na	na
Cotinine	.046, .014	7	3	E.002	E.002	E.001	E.001	5	1	E.002	E.002	E.002	na
Dehydronife-dipine	.019, .015	5	0	na	na	na	na	5	0	na	na	na	na
Digoxigenin	.015, nd	2	0	na	na	na	na	2	0	na	na	na	na
Diltiazem	.024, .016	7	0	na	na	na	na	5	0	na	na	na	na
Diphenhy-dramine	nd, .015	6	0	na	na	na	na	5	0	na	na	na	na
Erythromycin	nd, .009	7	0	na	na	na	na	5	0	na	na	na	na
Fluoxetine	.036, .014	7	0	na	na	na	na	5	0	na	na	na	na
Furosemide	nd, nd	7	0	na	na	na	na	5	0	na	na	na	na
Gemfibrozil	.028, .013	7	0	na	na	na	na	5	0	na	na	na	na
Ibuprofen	.036, .042	7	0	na	na	na	na	5	0	na	na	na	na
Metformin	.007, nd	7	0	na	na	na	na	5	0	na	na	na	na

Table 8. Summary statistics of pharmaceuticals in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

Constituent	LRL (2001-2002, 2003)	410315096190101 Raw water						410315096190102 Finished water					
		n	det	max	med	$\overline{x}$	s^2	n	det	max	med	$\overline{x}$	s^2
Drinking-water samples—Continued													
Miconazole	nd, 0.018	7	0	na	na	na	na	5	0	na	na	na	na
Paroxetine metabolite	.036, nd	2	0	na	na	na	na	2	0	na	na	na	na
Ranitidine	.020, .013	7	0	na	na	na	na	5	0	na	na	na	na
Salbutamol	.058, .023	7	0	na	na	na	na	5	0	na	na	na	na
Sulfamethoxazole	.046, .064	7	6	E0.027	E0.006	E0.008	E0.010	5	0	na	na	na	na
Thiabendazole	nd, .011	7	0	na	na	na	na	5	0	na	na	na	na
Trimethoprim	.028, .013	7	0	na	na	na	na	5	0	na	na	na	na
Warfarin	.012, .012	7	0	na	na	na	na	5	0	na	na	na	na

Table 11. Summary statistics of antibiotics in samples collected during riverbank filtration study, Platte River, Nebraska.

[Summary statistics are based on detected concentrations; All concentrations in micrograms per liter; LRL, laboratory reporting level; n, number of samples ; det, number of detections; max, maximum; med, median; $\bar{x}$, mean; s^2 , standard deviation; na, not applicable; E, estimated quantity below laboratory reporting level but above method detection limit; M, presence verified but not quantified]

		410322096190103 Cattle feedlot lagoon						410322096190104 Hog confinement lagoon						06803496 Wastewater-treatment plant effluent					
Constituent	**LRL**	**n**	**det**	**max**	**med**	$\bar{x}$	s^2	**n**	**det**	**max**	**med**	$\bar{x}$	s^2	**n**	**det**	**max**	**med**	$\bar{x}$	s^2
Wastewater samples																			
Carbadox	0.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Chlortetracycline	.02	5	2	4.60	2.49	2.49	2.98	5	4	25.0	4.20	8.75	10.9	5	0	na	na	na	na
Ciprofloxacin	.01	5	0	na	na	na	na	5	0	na	na	na	na	5	1	0.14	0.14	0.14	na
Demeclocycline	.02	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Doxycycline	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Enrofloxacin	.01	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Erythromycin-H_2O	.02	5	0	na	na	na	na	5	0	na	na	na	na	5	1	.15	.15	.15	na
Lincomycin	.01	5	0	na	na	na	na	5	3	0.32	0.14	0.20	0.11	5	0	na	na	na	na
Methotrexate	.02	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Minocycline	.02	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Norfloxaxin	.01	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Oxytetracycline	.05	5	1	1.20	1.20	1.20	na	5	1	.44	.44	.44	na	5	0	na	na	na	na
Roxarsone	.50	1	0	na	na	na	na	1	0	na	na	na	na	1	0	na	na	na	na
Roxithromycin	.01	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Sarafloxacin	.01	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Sulfadimethoxine	.01	5	1	0.04	0.04	0.04	na	5	3	.59	.50	.52	.06	5	1	.05	.05	.05	na
Sulfamerazine	.02	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Sulfamethazine	.01	5	0	na	na	na	na	5	1	.33	.33	.33	na	5	0	na	na	na	na
Sulfamethizole	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Sulfamethoxazole	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	1	E.04	E.04	E.04	na
Sulfathiazole	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Sulfachlorpyradazine	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Tetracycline	.02	5	0	na	na	na	na	5	1	.24	.24	.24	na	5	1	.13	.13	.13	na
Trimethoprim	.01	5	0	na	na	na	na	5	0	na	na	na	na	5	3	.10	.03	.05	0.05
Tylosin	.02	5	0	na	na	na	na	5	3	.21	.05	.10	.10	5	0	na	na	na	na
Virginiamycin	.10	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na

Table 11. Summary statistics of antibiotics in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

		406801000 Platte River near Ashland						06805000 Salt Creek near Ashland					
Constituent	**LRL**	**n**	**det**	**max**	**med**	$\bar{x}$	s^2	**n**	**det**	**max**	**med**	$\bar{x}$	s^2
Surface-water samples													
Carbadox	0.05	14	0	na	na	na	na	6	0	na	na	na	na
Chlortetracycline	.02	14	0	na	na	na	na	6	0	na	na	na	na
Ciprofloxacin	.01	14	0	na	na	na	na	6	0	na	na	na	na
Demeclocycline	.02	14	0	na	na	na	na	6	0	na	na	na	na
Doxycycline	.05	14	0	na	na	na	na	6	1	E0.02	E0.02	E0.02	na
Enrofloxacin	.01	14	0	na	na	na	na	6	0	na	na	na	na
Erythromycin-H_2O	.02	14	0	na	na	na	na	6	1	.11	.11	.11	na
Lincomycin	.01	14	0	na	na	na	na	6	0	na	na	na	na
Methotrexate	.02	14	0	na	na	na	na	6	0	na	na	na	na
Minocycline	.02	14	0	na	na	na	na	6	0	na	na	na	na
Norfloxaxin	.01	14	0	na	na	na	na	6	0	na	na	na	na
Oxytetracycline	.05	14	0	na	na	na	na	6	0	na	na	na	na
Roxarsone	.50	2	0	na	na	na	na	1	0	na	na	na	na
Roxithromycin	.01	14	0	na	na	na	na	6	0	na	na	na	na
Sarafloxacin	.01	14	0	na	na	na	na	6	0	na	na	na	na
Sulfadimethoxine	.01	14	0	na	na	na	na	6	0	na	na	na	na
Sulfamerazine	.02	14	0	na	na	na	na	6	0	na	na	na	na
Sulfamethazine	.01	14	0	na	na	na	na	6	0	na	na	na	na
Sulfamethizole	.05	14	0	na	na	na	na	6	0	na	na	na	na
Sulfamethoxazole	.05	14	0	na	na	na	na	6	0	na	na	na	na
Sulfathiazole	.05	14	0	na	na	na	na	6	0	na	na	na	na
Sulfqchlorpyradazine	.05	14	0	na	na	na	na	6	0	na	na	na	na
Tetracycline	.02	14	0	na	na	na	na	6	0	na	na	na	na
Trimethoprim	.01	14	0	na	na	na	na	6	1	.02	.02	.02	na
Tylosin	.02	14	0	na	na	na	na	6	0	na	na	na	na
Virginiamycin	.10	14	0	na	na	na	na	6	0	na	na	na	na

Table 11. Summary statistics of antibiotics in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

		410322096191701 Well W90-1						410349096202101 Well W49-9						410315096193501 Well W54-10					
Constituent	LRL	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Ground-water samples																			
Carbadox	0.05	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Chlortetracycline	.02	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Ciprofloxacin	.01	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Demeclocycline	.02	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Doxycycline	.05	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Enrofloxacin	.01	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Erythromycin-H_2O	.02	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Lincomycin	.01	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Methotrexate	.02	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Minocycline	.02	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Norfloxaxin	.01	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Oxytetracycline	.05	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Roxarsone	.50	1	0	na	na	na	na	1	0	na	na	na	na	1	0	na	na	na	na
Roxithromycin	.01	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Sarafloxacin	.01	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Sulfadimethoxine	.01	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Sulfamerazine	.02	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Sulfamethazine	.01	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Sulfamethizole	.05	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Sulfamethoxazole	.05	7	0	na	na	na	na	6	0	na	na	na	na	7	1	M	M	M	M
Sulfathiazole	.05	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Sulfqchlorpyrada-zine	.05	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Tetracycline	.02	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Trimethoprim	.01	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Tylosin	.02	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na
Virginiamycin	.10	7	0	na	na	na	na	6	0	na	na	na	na	7	0	na	na	na	na

Table 11. Summary statistics of antibiotics in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

		410315096190101 Raw water						410315096190102 Finished water					
Constituent	**LRL**	**n**	**det**	**max**	**med**	$\overline{x}$	s^2	**n**	**det**	**max**	**med**	$\overline{x}$	s^2
Drinking-water samples													
Carbadox	0.05	7	0	na	na	na	na	5	0	na	na	na	na
Chlortetracycline	.02	7	0	na	na	na	na	5	0	na	na	na	na
Ciprofloxacin	.01	7	0	na	na	na	na	5	0	na	na	na	na
Demeclocycline	.02	7	0	na	na	na	na	5	0	na	na	na	na
Doxycycline	.05	7	0	na	na	na	na	5	0	na	na	na	na
Enrofloxacin	.01	7	0	na	na	na	na	5	0	na	na	na	na
Erythromycin-H_2O	.02	7	0	na	na	na	na	5	0	na	na	na	na
Lincomycin	.01	7	0	na	na	na	na	5	0	na	na	na	na
Methotrexate	.02	7	0	na	na	na	na	5	0	na	na	na	na
Minocycline	.02	7	0	na	na	na	na	5	0	na	na	na	na
Norfloxaxin	.01	7	0	na	na	na	na	5	0	na	na	na	na
Oxytetracycline	.05	7	0	na	na	na	na	5	0	na	na	na	na
Roxarsone	.50	1	0	na	na	na	na	1	0	na	na	na	na
Roxithromycin	.01	7	0	na	na	na	na	5	0	na	na	na	na
Sarafloxacin	.01	7	0	na	na	na	na	5	0	na	na	na	na
Sulfadimethoxine	.01	7	0	na	na	na	na	5	0	na	na	na	na
Sulfamerazine	.02	7	0	na	na	na	na	5	0	na	na	na	na
Sulfamethazine	.01	7	0	na	na	na	na	5	0	na	na	na	na
Sulfamethizole	.05	7	0	na	na	na	na	5	0	na	na	na	na
Sulfamethoxazole	.05	7	0	na	na	na	na	5	0	na	na	na	na
Sulfathiazole	.05	7	0	na	na	na	na	5	0	na	na	na	na
Sulfqchlorpyradazine	.05	7	0	na	na	na	na	5	0	na	na	na	na
Tetracycline	.02	7	0	na	na	na	na	5	0	na	na	na	na
Trimethoprim	.01	7	0	na	na	na	na	5	0	na	na	na	na
Tylosin	.02	7	0	na	na	na	na	5	0	na	na	na	na
Virginiamycin	.10	7	0	na	na	na	na	5	0	na	na	na	na

Non-Pharmaceutical Compounds

Results for non-pharmaceutical compounds are presented in this section of the report. Non-pharmaceutical compounds presented here include TOC and DOC, major ions, pesticides, and organic wastewater compounds.

Total and Dissolved Organic Carbon

Total and dissolved organic carbon samples were collected at all water-quality sites (table 13 on CD-ROM at back of report) and concentrations are shown in figure 8 for well-field sites. QA/QC samples included one duplicate sample from the Platte River for TOC and one duplicate sample from the finished water analyzed for DOC. Duplicate sample results agreed within 6 percent for TOC and within 4 percent for DOC. In addition, blind samples were analyzed by the NWQL as part of the Organic Blind Sample Project to assess operational performance of the total and dissolved organic methods (table 14) (U.S. Geological Survey, 2004a).

TOC was measured at all three wastewater sites. Generally, TOC values were higher in samples from the cattle feedlot lagoon than in samples from the hog confinement lagoon. The TOC concentrations in samples from the wastewater-treatment plant effluent were consistently much lower than in samples from the two lagoons.

In the Platte River, TOC concentrations increased during the summer months (fig. 8). The sample collected during a runoff event on May 20, 2003, provides an indication of the ratio of DOC and TOC in the surface water, at least during a runoff event. TOC concentrations in Salt Creek were fairly consistent during the sampling times with the exception of the runoff event on May 7, 2002, where the concentration was elevated.

Samples from all three ground-water sites monitored during this study showed somewhat similar concentrations of DOC. DOC concentrations in samples from W49-9 were consistently slightly less than concentrations in samples from the other two wells.

DOC concentrations in the raw water were similar to those in the ground-water samples. In general, drinking-water treatment appears to slightly reduce the DOC concentration from raw water to finished water.

Table 14. Summary of percent recovery of total and dissolved organic carbon blind samples analyzed as part of the Organic Blind Sample Project by the National Water Quality Laboratory from February 23, 1999 to September 25, 2003. (Data from U.S. Geological Survey, 2004a)

[mg/L, milligrams per liter]

Range	Number of samples	Median (percent)	Mean (percent)	Standard deviation (percent)
Total organic carbon blind samples				
0.600–1.000 mg/L	47	118	122	26.0
1.000–15.00 mg/L	47	101	104	9.7
15.00–20.00 mg/L	22	98.2	102	15.4
Dissolved organic carbon blind samples				
0.600–1.000 mg/L	10	113	119	16.8
1.000–15.00 mg/L	11	99.8	100	5.5
15.00–20.00 mg/L	4	110	114	20.1

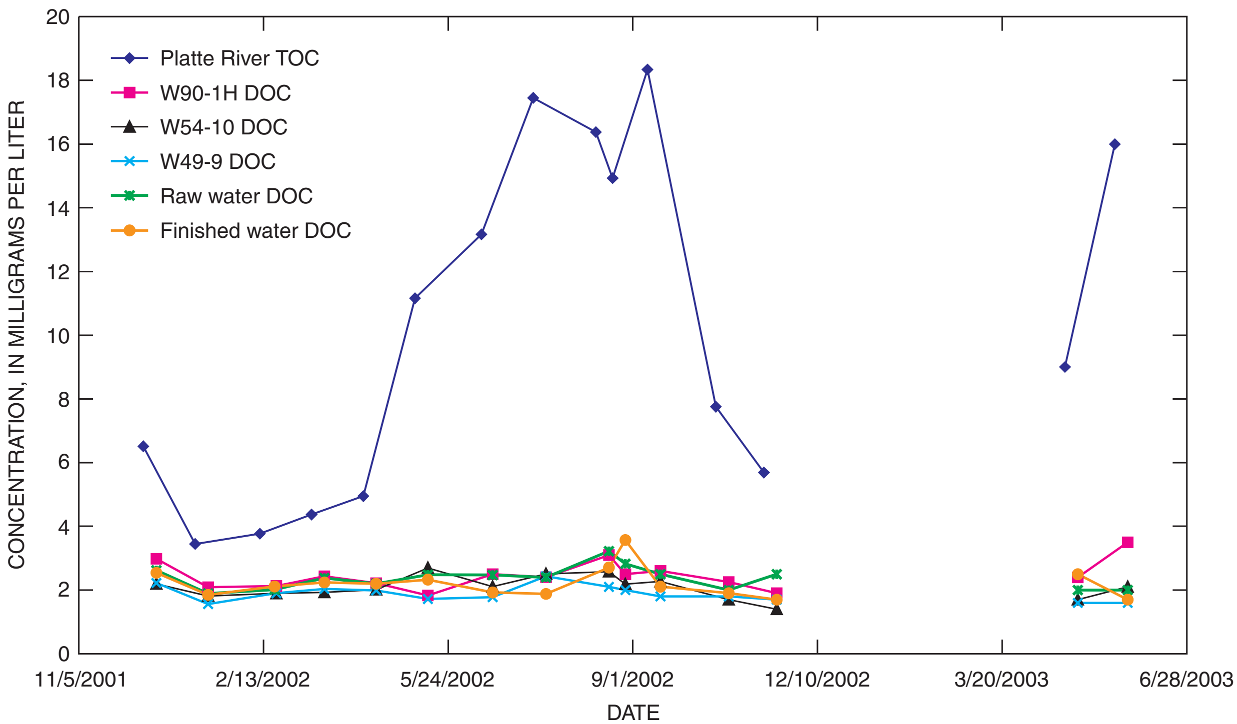

Figure 8. Total organic carbon (TOC) in surface-water samples and dissolved organic carbon (DOC) in the ground-water and drinking-water samples at the well field.

Major Ions

Concentration data for 11 major ions were measured at the water-quality sites (table 15; table 16, on CD-ROM at back of report). One duplicate sample collected from the Platte River was analyzed for major ions. The duplicate sample results agreed within 2.5 percent for all constituents except bromide and iron. Bromide concentrations were within 0.02 mg/L, but contained low concentrations, which caused larger percentage differences between the duplicate and environmental samples. The iron concentration in the environmental sample on that date was less than the detection limit and could not be compared to the concentration in the duplicate sample. Equipment blank samples were collected once at the Platte River site and once at the finished water site (table 16). The equipment blank samples had low concentrations for all major ions except iron, for which concentrations were similar to those found in the Platte River samples. In addition, the NWQL completed inter-laboratory performance ratings to assess operational performance of the major ions schedule. The analysis of these samples was rated on the following scale: 4=excellent, 3=good, 2=satisfactory, 1=marginal, and 0=unsatisfactory. The major ions scheduled rated 3.3 in Fall 2003 (U.S. Geological Survey, 2004b).

In general, major-ion concentrations were more variable in samples from the lagoon sites than in samples from the wastewater-treatment plant effluent. Of the wastewater sites, samples from the cattle feedlot lagoon had higher concentrations of calcium, magnesium, sodium, and manganese. Samples from both the cattle and hog lagoons had equally high concentrations of potassium, chloride, and bromide. Samples from the wastewater-treatment plant effluent had higher concentrations of sulfate, fluoride, and iron than the lagoon samples. Samples from the hog confinement lagoon showed the highest concentrations of silica.

All major ion concentrations were higher in Salt Creek than in the Platte River except for potassium, which was similar at the two sites. Iron was not detected in the Platte River samples and was detected in only one sample from Salt Creek.

Of samples from the three ground-water wells analyzed for this study for major ions, well W90-1H showed the highest mean concentrations of magnesium, well W54-10 samples had the highest mean concentrations of potassium and silica, and well W49-9 samples had the highest mean concentrations of calcium, sodium, sulfate, chloride, fluoride, bromide, and manganese. In general, samples from W90-1H and W54-10 (wells closest to the river) had concentrations of major ions similar to the Platte River.

Pesticides

Concentration data for 53 pesticides (herbicide parent compounds, acetamide degradates, and organophosphate insecticides) were measured in samples from all water-quality sites (table 17; tables 18-20 on CD-ROM at back of report). Two QA/QC samples were collected and analyzed for pesticides. A duplicate sample was collected during one sampling round from both the Platte River and the finished water. For herbicide parent compounds, the largest difference between the environmental sample and duplicate concentrations for the Platte River duplicate results was 0.03 µg/L (9 percent) for atrazine. For acetamide degradates, the largest difference for the Platte River duplicate results was 0.02 µg/L (12 percent) for metolachlor OXA. Insecticides were not detected in either the environmental or duplicate sample from the Platte River on that date. The largest difference between environmental and duplicate sample concentrations in the finished water for compounds on the herbicide schedule was 0.03 µg/L (8 percent) for atrazine. For acetamide degradates, the largest difference in the finished water on that date was 0.083 µg/L (92 percent) for alachlor ESA. Insecticides were not detected in either the environmental or duplicate sample from the finished water on that date.

Laboratory duplicates for 10 of the samples collected during the study were analyzed for herbicide parent compounds and acetamide degradates (tables 18 and 19, respectively). The laboratory duplicates essentially analyzed two portions of the same sample twice using the same instrument and method. For the herbicide parent compounds, the largest difference in concentrations between the environmental sample and the laboratory duplicate was 0.08 µg/L (9 percent) for atrazine in the Platte River on June 11, 2002. The largest difference in concentrations between the environmental sample and the laboratory duplicate for acetamide degradates was 0.35 µg/L (23 percent) for alachlor ESA in the wastewater-treatment plant effluents on May 8, 2002.

In samples from the wastewater sampling sites, most of the pesticide detections were degradates of acetochlor, alachlor, and metolachlor, plus atrazine and atrazine degradates. Pesticide concentrations in samples from the lagoon sites are likely representative of agricultural practices at the site. These samples were not analyzed for insecticides.

Similar pesticides were detected in samples from both the Platte River and Salt Creek during this study. In general, concentrations were higher in Salt Creek than in the Platte River. Herbicides regularly detected included acetochlor and its degradates, alachlor and its degradates, atrazine and its degradates, and metolachlor and its degradates. To a lesser extent, low concentrations of herbicides such as ametryn, dimethenamide, flufenacet, prometon, propachlor, propazine, and simazine were also detected in Salt Creek and/or the Platte River. A runoff event in Salt Creek in May 2002 resulted in a total pesticide concentration of more than 50 µg/L. Insecticides were not detected in either the Platte River or Salt Creek at the two sampling sites.

In samples from the ground-water wells at the well field site, the herbicides regularly detected included acetochlor degradates, alachlor degradates, atrazine and its degradates, and metolachlor and its degradates. Parent compounds of these compounds were most often detected in samples from well W90-1H, which is the site closest to and directly below the surface water. Degradates were detected in samples from all three wells, with concentrations generally lower in samples from well W49-9 than from the other two wells. Insecticides were not detected in the three ground-water wells at the site.

Similar to the ground-water samples, herbicides regularly detected in drinking-water samples included acetochlor degradates, alachlor degradates, atrazine and its degradates, and metolachlor and its degradates. Concentrations of parent compounds generally decreased during the treatment process, whereas concentrations of many degradates stayed about the same or increased slightly. Insecticides were not detected in drinking-water samples.

Organic Wastewater Compounds

Concentrations of 63 organic wastewater indicator compounds were measured at all water-quality sites (table 21; table 23 on CD-ROM at back of report). Two duplicate QA/QC samples were collected and analyzed for the organic wastewater indicator compounds. The largest detected difference between the environmental sample and the duplicate sample for the Platte River was for N,N'-diethyl-methyl-toluamide (DEET) with a difference of 0.013 µg/L (46 percent). The only detected organic wastewater indicator compound in the environmental and duplicate samples of finished water was bromoform. The difference for bromoform between the two samples collected on this date was 1.2 mg/L (14 percent).

The USGS NWQL ran 132 set spikes for the compounds analyzed on this schedule in 2003. Mean recovery was less than 60 percent on 12 of the 64 compounds analyzed in the method (S.D. Zaugg, U.S. Geological Survey, written commun., 2004) and these are denoted with an "E" (estimated) on the data tables for this schedule (tables 21 and 22) . Concentrations of bromoform also are estimated because any residual free bromine in the sample can react with DOC to form bromoform (U.S. Geological Survey, 2004c). Samples where a compound was detected and verified, but not quantified, are denoted with an "M" on tables 21 and 22.

At the two lagoon sites, organic wastewater indicator compounds that were detected in multiple samples included 3-beta-coprostanol, 3-methyl-1(H)-indole (skatol), beta-sitosterol, caffeine, camphor, cholesterol, diethoxy-nonylphenol, indole, DEET, methyl silicate, para-cresol, para-nonylphenol, pentachlorophenol, phenol, beta-stigmastanol, tri(2-chloroethyl) phosphate, tributylphosphate, triphenyl phosphate, and tris(2-butoxyethyl) phosphate. Some of the organic wastewater indicator compounds that were detected multiple times in the wastewater-treatment plant effluent included 1,4-dichlorobenzene, 1-methylnaphthalene, 2-methylnaphthalene, 3-beta-coprostanol, 3-methyl-1(H)-indole (skatol), 3-tert-butyl-4-hydroxy anisole (BHA), 4-tert-octylphenol, 5-methyl-1H-benzotriazole, acetophenone, acetyl hexamethyl tetrahydronaphthalene (AHTN), benzophenone, beta-sitosterol, bisphenol A, bromacil, bromoform, caffeine, camphor, chlorpyrifos, cholesterol, cotinine, diazanon, d-limonene, hexahydrohexamethylcyclopenta-benzopyran, indole, isopropylbenzene (cumene), menthol, metolachlor, DEET, diethoxy-nonylphenol (total), monethoxyoctylphenol, diethoxy-2-octylphenol, para-cresol, para-nonylphenol (total), pentachlorophenol, phenol, tri(2-chloroethyl) phosphate, tri(dichlorisopropyl) phosphate, tributylphosphate, triclosan, triethyl citrate (ethyl citrate), triphenyl phosphate, and tris(2-butoxyethyl) phosphate.

In the samples collected from the two surface-water sites, 19 organic wastewater indicator compounds were detected in samples from the Platte River compared to 43 compounds detected in Salt Creek samples. Detectable concentrations of 3-beta-coprostanol, AHTN, benzophenone, caffeine, cholesterol, isophorone, metolachlor, DEET, phenol, tri(2-chloroethyl) phosphate, tri(dichloroisopropyl) phosphate, tributylphosphate, triphenyl phosphate, and tris(2-butoxyethyl) phosphate were measured in multiple samples from the Platte River at Ashland. Compounds detected in multiple samples from Salt Creek at Ashland were 3-beta-coprostanol, 4-tert-octylphenol, acetophenone, AHTN, anthraquinone, benzophenone, bisphenol A, bromacil, caffeine, cholesterol, cotinine, diazinon, hexahydrohexamethylcyclopentabenzopyran, isophorone, metolachlor, DEET, diethoxy-nonylphenol (total), monethoxy-octylphenol, para-cresol, para-nonylphenol (total), pentachlorophenol, phenanthrene, phenol, beta-stigmastanol, tri(2-chloroethyl)-phosphate, tri(dechloroisopropyl) phosphate, tributylphosphate, triclosan, triethyl citrate, triphenyl phosphate, and tris(2-butoxyethyl) phosphate.

Organic wastewater indicator compounds detected in samples from well W90-1H were 5-methyl-1H-benzotriazole, benzophenone, metolachlor, DEET, para-nonylphenol (total), and phenol. Samples from well W49-9 had detections of metolachlor, DEET, para-nonylphenol (total), phenol, prometon, tetrachloroethylene, tri(2-chloroethyl) phosphate, and triclosan. Organic wastewater indicator compounds detected in samples from well W54-10 were metolachlor, DEET, para-nonylphenol (total), phenol, prometon, and tetrachloroethylene.

Organic wastewater indicator compounds detected in the raw water were benzophenone, caffeine, isophorone, metolachlor, DEET, para-nonlyphenol, phenol, tri(2-chloroethyl) phosphate, tributylphosphate, and triphenyl phosphate. The organic wastewater indicator compounds detected in the finished water samples were bromoform, metolachlor, and DEET. Bromoform was detected in all finished water samples. The presence of this compound is a result of the drinking water treatment process. Bromoform concentrations are estimated values and may be high because residual free bromine in the sample can react with DOC to form bromoform during analysis.

Table 15. Summary statistics of major ions in samples collected during riverbank filtration study, Platte River, Nebraska.

[All concentrations in milligrams per liter; summary statistics are based on detected concentrations; LRL, laboratory reporting level; n, number of samples ; det, number of detections; max, maximum; med, median; $\bar{x}$, mean; s^2, standard deviation; na, not applicable]

Wastewater samples	LRL	410322096190103 Cattle feedlot lagoon						410322096190104 Hog confinement lagoon						06803496 Wastewater-treatment plant effluent					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Calcium	0.01	3	3	172	122	119	54	3	3	83.5	78.0	57.4	40.5	3	3	65.9	60.7	59.1	7.7
Magnesium	.008	3	3	65.0	55.5	46.3	24.7	3	3	22.6	20.8	21.2	1.2	3	3	18.2	15.0	15.6	2.3
Sodium	.1	3	3	291	244	207	108	3	3	152	135	139	11	3	3	171	168	164	10
Potassium	.1	3	3	537	482	352	275	3	3	350	325	316	39	3	3	24.2	23.1	22.8	1.5
Sulfate	.1	3	3	113	12.9	43.1	60	3	3	39.8	39.5	29.8	17.1	3	3	111	88.5	95.4	14
Chloride	.3	3	3	375	316	240	185	3	3	272	239	242	28	3	3	210	191	187	24
Fluoride	.1	3	3	0.30	0.25	0.24	0.07	3	3	0.20	0.11	0.14	0.05	3	3	1.13	1.10	1.07	0.07
Bromide	.03	3	3	1.13	.56	.57	.56	3	3	.51	.46	.37	.20	3	3	0.13	0.06	0.08	.04
Silica	.1	3	3	34.3	32.5	31.4	3.6	3	3	47.0	41.2	40.6	6.7	3	3	34.9	33.4	33.7	1.1
Manganese	1.6	3	3	324	172	171	154	3	3	93.3	42.4	48.0	42.8	3	3	133	102	102	32
Iron	30	3	3	259	101	126	122	3	3	165	98.0	106	55	3	3	520	301	329	179

Table 15. Summary statistics of major ions in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

Surface-water samples	LRL	06801000 Platte River near Ashland						06805000 Salt Creek near Ashland					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Calcium	0.01	7	7	58.3	52.2	50.6	8.0	6	6	80.7	73.0	68.5	17.1
Magnesium	.008	7	7	12.5	12.2	10.6	3.4	6	6	24.0	22.5	20.3	5.7
Sodium	.1	7	7	30.6	25.4	24.7	4.3	6	6	968	686	619	288
Potassium	.1	7	7	12.4	8.68	9.07	1.76	6	6	14.0	12.3	11.7	2.2
Sulfate	.1	7	7	73.6	53.2	51.3	14.1	6	6	253	202	180	68.2
Chloride	.3	7	7	14.7	11.2	11.7	2.0	6	6	1,366	946	870	412
Fluoride	.1	7	7	0.49	0.37	0.37	0.07	6	6	0.73	0.62	0.60	0.11
Bromide	.03	7	7	.03	.03	.03	.01	6	6	.16	.14	.12	.05
Silica	.1	7	7	39.0	28.5	29.3	31.5	6	6	22.0	18.5	17.8	3.7
Manganese	1.6	7	7	4.14	1.70	2.35	1.2	6	6	327	261	233	91
Iron	30	7	0	na	na	na	na	6	1	10.4	10.4	10.4	na

Ground-water samples	LRL	410322096191701 Well W90-1H						410349096202101 Well W49-9						410315096193501 Well W54-10					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Calcium	0.01	5	5	62.2	53.7	51.8	7.6	2	2	54.9	54.8	54.8	0.12	5	5	51.8	46.4	46.2	3.5
Magnesium	.008	5	5	15.0	13.0	13.4	1.1	2	2	10.8	10.8	10.8	.01	5	5	14.2	12.3	12.5	1.1
Sodium	.1	5	5	29.4	25.9	26.7	1.8	2	2	37.2	36.5	36.5	.99	5	5	33.1	27.5	29.4	3.2
Potassium	.1	5	5	10.0	9.37	8.91	1.11	2	2	8.24	8.09	8.09	.21	5	5	10.2	8.80	9.00	1.14
Sulfate	.1	5	5	68.1	54.3	58.0	9.3	2	2	92.9	92.0	92.0	1.23	5	5	77.3	56.4	61.4	13.6
Chloride	.3	5	5	14.5	13.4	13.1	1.2	2	2	15.8	15.6	15.6	.24	5	5	14.4	13.6	13.5	1.0
Fluoride	.1	5	5	0.40	0.40	0.38	0.03	2	2	0.5	0.47	0.47	.04	5	5	0.44	0.38	0.39	0.04
Bromide	.03	5	4	.10	.03	.05	.04	2	2	.07	.07	.07	.00	5	5	.05	.03	.03	.01
Silica	.1	5	5	31.1	30.9	29.9	1.5	2	2	26.0	25.6	25.6	.65	5	5	43.8	35.1	34.4	6.3
Manganese	1.6	5	5	26.5	8.46	14.2	9.1	2	2	31.2	30.5	30.5	.97	5	5	3.75	3.34	3.07	0.87
Iron	30	5	0	na	na	na	na	2	0	na	na	na	na	5	0	na	na	na	na

Table 17. Summary statistics of pesticides in samples collected during riverbank filtration study, Platte River, Nebraska.

[All concentrations in micrograms per liter; summary statistics are based on detected concentrations; MDL, method detection limit; n, number of samples; det, number of detections; max, maximum; med, median; $\bar{x}$, mean; s^2, standard deviation; na, not applicable]

Constituent	MDL	410322096190103 Cattle feedlot lagoon						410322096190104 Hog confinement lagoon						06803496 Wastewater-treatment plant effluent					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Wastewater samples																			
Acetochlor	0.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Acetochlor ESA	.05	5	1	0.05	0.05	0.05	na	5	2	0.17	0.12	0.12	0.08	5	4	1.33	0.99	0.96	0.39
Acetochlor OXA	.05	5	2	.16	.11	.11	0.07	5	3	.08	.06	.06	.02	5	3	0.08	.07	.07	.02
Acetochlor SAA	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Alachlor	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Alachlor ESA	.05	5	3	.45	.20	.24	.19	5	4	.57	.43	.44	.10	5	4	1.87	1.23	1.30	.45
Alachlor OXA	.05	5	1	.06	.06	.06	na	5	0	na	na	na	na	5	0	na	na	na	na
Alachlor SAA	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Aldrin	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na
alpha-HCH	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na
Ametryn	.05	5	1	.08	.08	.08	na	5	0	na	na	na	na	5	1	.08	.08	.08	na
Atrazine	.05	5	4	.50	.30	.30	.18	5	4	1.12	.18	.39	.49	5	5	.33	.28	.24	.11
beta-HCH	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na
cis-Chlordane	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na
Cyanazine	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Cyanazine amide	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Deethylatrazine	.05	5	1	.67	.67	.67	na	5	1	.06	.06	.06	na	5	2	.07	.07	.07	.01
Deisopropylatrazine	.05	5	1	.20	.20	.20	na	5	0	na	na	na	na	5	0	na	na	na	na
delta-HCH	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na
Dieldrin	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na
Dimethenamid	.05	5	1	.66	.66	.66	na	5	0	na	na	na	na	5	0	na	na	na	na
Dimethenamid ESA	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Dimethenamid OXA	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Endosulfan I	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na
Endosulfan II	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na
Endosulfan sulfate	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na
Endrin	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na

Table 17. Summary statistics of major ions in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

Constituent	MDL	410322096190103 Cattle feedlot Lagoon						410322096190104 Hog confinement lagoon						06803496 Wastewater-treatment plant effluent					
		n	det	max	med	$\overline{x}$	s^2	n	det	max	med	$\overline{x}$	s^2	n	det	max	med	$\overline{x}$	s^2
Wastewater samples—Continued																			
Endrin aldehyde	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na
Endrin ketone	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na
Flufenacet	0.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Flufenacet ESA	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Flufenacet OXA	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
gamma-HCH/lindane	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na
Heptachlor	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na
Heptachlor epoxide	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na
Methoxychlor	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na
Metolachlor	.05	5	1	0.05	0.05	0.05	na	5	0	na	na	na	na	5	1	0.06	0.06	0.06	na
Metolachlor ESA	.05	5	5	.71	.48	.42	0.22	5	4	0.21	0.18	0.18	0.03	5	5	.14	.08	.10	0.03
Metolachlor OXA	.05	5	2	.50	.32	.32	.25	5	0	na	na	na	na	5	4	.11	.08	.09	.02
Metribuzin	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
p,p'-DDD	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na
p,p'-DDE	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na
p,p'-DDT	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na
Pendimethalin	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Prometon	.05	5	1	.12	.12	.12	na	5	0	na	na	na	na	5	2	.06	.06	.06	.0
Prometryn	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Propachlor	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Propachlor EOXA	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Propachlor ESA	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Propazine	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Simazine	.05	5	0	na	na	na	na	5	1	.05	.05	.05	na	5	0	na	na	na	na
Terbutryn	.05	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
trans-Chlordane	5	0	0	na	na	na	na	0	0	na	na	na	na	0	0	na	na	na	na

Table 17. Summary statistics of major ions in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

Constituent	MDL	06801000 Platte River near Ashland						06805000 Salt Creek near Ashland					
		n	det	max	med	$\overline{x}$	s^2	n	det	max	med	$\overline{x}$	s^2
Surface-water samples													
Acetochlor	0.05	15	3	0.54	0.07	0.22	0.27	6	1	8.69	8.69	8.69	na
Acetochlor ESA	.05	15	4	.12	.06	.07	.03	6	6	.80	0.17	0.26	0.27
Acetochlor OXA	.05	15	7	.21	.12	.13	.07	6	4	1.54	.08	.44	.73
Acetochlor SAA	.05	15	1	.11	.11	.11	na	6	0	na	na	na	na
Alachlor	.05	15	0	na	na	na	na	6	1	0.48	.48	.48	na
Alachlor ESA	.05	15	14	.23	.11	.12	.04	6	6	.25	.18	.17	.07
Alachlor OXA	.05	15	1	.02	.02	.02	na	6	1	.06	.06	.06	na
Alachlor SAA	.05	15	0	na	na	na	na	6	1	.05	.05	.05	na
Aldrin	5	6	0	na	na	na	na	4	0	na	na	na	na
alpha-HCH	5	9	0	na	na	na	na	5	0	na	na	na	na
Ametryn	.05	15	0	na	na	na	na	6	1	.05	.05	.05	na
Atrazine	.05	15	12	2.49	.14	.42	.70	6	6	35.0	.16	5.98	14.2
beta-HCH	5	9	0	na	na	na	na	5	0	na	na	na	na
cis-Chlordane	5	9	0	na	na	na	na	5	0	na	na	na	na
Cyanazine	.05	15	0	na	na	na	na	6	0	na	na	na	na
Cyanazine amide	.05	15	0	na	na	na	na	6	0	na	na	na	na
Deethylatrazine	.05	15	5	.15	.13	.12	.03	6	4	1.84	.13	.54	.87
Deisopropylatrazine	.05	15	3	.07	.06	.06	.01	6	2	.89	.49	.49	.57
delta-HCH	5	9	0	na	na	na	na	5	0	na	na	na	na
Dieldrin	5	9	0	na	na	na	na	5	0	na	na	na	na
Dimethenamide	.05	15	1	.07	.07	.07	na	6	1	.95	.95	.95	na
Dimethenamide ESA	.05	15	0	na	na	na	na	6	0	na	na	na	na
Dimethenamide OXA	.05	15	0	na	na	na	na	6	1	.08	.08	0.08	na
Endosulfan I	5	9	0	na	na	na	na	5	0	na	na	na	na
Endosulfan II	5	9	0	na	na	na	na	5	0	na	na	na	na
Endosulfan sulfate	5	9	0	na	na	na	na	5	0	na	na	na	na
Endrin	5	9	0	na	na	na	na	5	0	na	na	na	na
Endrin aldehyde	5	9	0	na	na	na	na	5	0	na	na	na	na
Endrin ketone	5	9	0	na	na	na	na	5	0	na	na	na	na

Table 17. Summary statistics of major ions in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

		06801000 Platte River near Ashland						06805000 Salt Creek near Ashland					
Constituent	**MDL**	**n**	**det**	**max**	**med**	$\overline{x}$	s^2	**n**	**det**	**max**	**med**	$\overline{x}$	s^2
Surface-water samples—Continued													
Flufenacet	0.05	15	0	na	na	na	na	6	1	0.56	0.56	0.56	na
Flufenacet ESA	.05	15	0	na	na	na	na	6	0	na	na	na	na
Flufenacet OXA	.05	15	0	na	na	na	na	6	0	na	na	na	na
gamma-HCH/lindane	5	9	0	na	na	na	na	5	0	na	na	na	na
Heptachlor	5	9	0	na	na	na	na	5	0	na	na	na	na
Heptachlor epoxide	5	9	0	na	na	na	na	5	0	na	na	na	na
Methoxychlor	5	9	0	na	na	na	na	5	0	na	na	na	na
Metolachlor	.05	15	6	0.87	0.08	0.23	0.32	6	1	8.33	8.33	8.33	na
Metolachlor ESA	.05	15	15	.27	.16	.16	.05	6	6	.54	.11	.17	0.18
Metolachlor OXA	.05	15	14	.19	.07	.09	.04	6	4	.54	.09	.19	.23
Metribuzin	.05	15	0	na	na	na	na	6	1	1.09	1.09	1.09	na
p,p'-DDD	5	9	0	na	na	na	na	5	0	na	na	na	na
p,p'-DDE	5	9	0	na	na	na	na	5	0	na	na	na	na
p,p'-DDT	5	9	0	na	na	na	na	5	0	na	na	na	na
Pendimethalin	.05	15	0	na	na	na	na	6	0	na	na	na	na
Prometon	.05	15	0	na	na	na	na	6	1	.06	.06	.06	na
Prometryn	.05	15	0	na	na	na	na	6	0	na	na	na	na
Propachlor	.05	15	0	na	na	na	na	6	0	na	na	na	na
Propachlor EOXA	.05	15	0	na	na	na	na	6	1	.06	.06	.06	na
Propachlor ESA	.05	15	0	na	na	na	na	6	0	na	na	na	na
Propazine	.05	15	1	.05	.05	.05	na	6	1	.40	.40	.40	na
Simazine	.05	15	1	.11	.11	.11	na	6	0	na	na	na	na
Terbutryn	.05	15	0	na	na	na	na	6	0	na	na	na	na
trans-Chlordane	5	9	0	na	na	na	na	5	0	na	na	na	na

Table 17. Summary statistics of major ions in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

Constituent	MDL	410322096191701 Well W90-1H						410349096202101 Well W49-9						410315096193501 Well W54-10					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Ground-water samples																			
Acetochlor	0.05	7	1	0.89	0.89	0.89	na	7	0	na	na	na	na	7	1	0.05	0.05	0.05	na
Acetochlor ESA	.05	7	4	.21	.10	.12	0.06	7	3	0.11	0.07	0.08	0.03	7	3	.21	.09	.13	0.07
Acetochlor OXA	.05	7	6	.60	.12	.19	.21	7	4	.1	.06	.07	.02	7	3	.15	.11	.12	.03
Acetochlor SAA	.05	7	1	.62	.62	.62	na	7	0	na	na	na	na	7	1	.09	.09	.09	na
Alachlor	.05	7	1	.05	.05	.05	na	7	0	na	na	na	na	7	0	na	na	na	na
Alachlor ESA	.05	7	6	.15	.14	.13	.03	7	7	.2	.17	.15	.05	7	6	.13	.11	.10	.03
Alachlor OXA	.05	7	1	.08	.08	.08	na	7	1	.05	.05	.05	na	7	1	.05	.05	.05	na
Alachlor SAA	.05	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Aldrin	5	3	0	na	na	na	na	2	0	na	na	na	na	2	0	na	na	na	na
alpha-HCH	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na
Ametryn	.05	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Atrazine	.05	7	6	3.30	.38	.80	1.24	7	7	.21	.15	.16	.04	7	6	1.86	.41	.59	.70
beta-HCH	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na
cis-Chlordane	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na
Cyanazine	.05	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Cyanazine amide	.05	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Deethylatrazine	.05	7	3	.15	.15	.14	.02	7	6	.09	.06	.07	.02	7	3	.20	.18	.17	.03
Deisopropylatrazine	.05	7	3	.07	.06	.06	.01	7	0	na	na	na	na	7	2	.09	.09	.09	.01
delta-HCH	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na
Dieldrin	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na
Dimethenamide	.05	7	1	.16	.16	.16	na	7	0	na	na	na	na	7	0	na	na	na	na
Dimethenamide ESA	.05	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Dimethenamide OXA	.05	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Endosulfan I	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na
Endosulfan II	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na
Endosulfan sulfate	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na
Endrin	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na
Endrin aldehyde	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na
Endrin ketone	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na
Flufenacet	.05	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na

Table 17. Summary statistics of major ions in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

Constituent	MDL	410322096191701 Well W90-1H						410349096202101 Well W49-9						410315096193501 Well W54-10					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Ground-water samples—Continued																			
Flufenacet ESA	0.05	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Flufenacet OXA	.05	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
gamma-HCH/lindane	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na
Heptachlor	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na
Heptachlor epoxide	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na
Methoxychlor	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na
Metolachlor	.05	7	4	0.91	0.06	0.27	0.43	7	0	na	na	na	na	7	3	0.49	0.08	0.21	0.24
Metolachlor ESA	.05	7	7	.22	.21	.18	.05	7	7	0.19	0.16	0.15	0.03	7	7	.24	.14	.15	.07
Metolachlor OXA	.05	7	7	.18	.11	.11	.05	7	6	.13	.08	.08	.03	7	4	.16	.12	.12	.04
Metribuzin	.05	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
p,p'-DDD	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na
p,p'-DDE	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na
p,p'-DDT	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na
Pendimethalin	.05	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Prometon	.05	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Prometryn	.05	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Propachlor	.05	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Propachlor EOXA	.05	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Propachlor ESA	.05	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Propazine	.05	7	1	.05	.05	.05	na	7	0	na	na	na	na	7	0	na	na	na	na
Simazine	.05	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Terbutryn	.05	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
trans-Chlordane	5	6	0	na	na	na	na	4	0	na	na	na	na	4	0	na	na	na	na

Table 17. Summary statistics of major ions in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

		410315096190101 Raw water						410315096190102 Finished water					
Constituent	**MDL**	**n**	**det**	**max**	**med**	$\bar{x}$	s^2	**n**	**det**	**max**	**med**	$\bar{x}$	s^2
Drinking-water samples													
Acetochlor	0.05	7	0	na	na	na	na	5	0	na	na	na	na
Acetochlor ESA	.05	7	4	0.09	0.08	0.08	0.01	5	5	0.16	0.07	0.09	0.04
Acetochlor OXA	.05	7	6	.19	.06	.09	.06	5	1	.05	.05	.05	na
Acetochlor SAA	.05	7	1	.05	.05	.05	na	5	0	na	na	na	na
Alachlor	.05	7	0	na	na	na	na	5	0	na	na	na	na
Alachlor ESA	.05	7	6	.15	.12	.11	0.03	5	3	.05	.05	.05	.00
Alachlor OXA	.05	7	0	na	na	na	na	5	1	.05	.05	.05	na
Alachlor SAA	.05	7	0	na	na	na	na	5	0	na	na	na	na
Aldrin	5	2	0	na	na	na	na	3	0	na	na	na	na
alpha-HCH	5	4	0	na	na	na	na	4	0	na	na	na	na
Ametryn	.05	7	0	na	na	na	na	5	0	na	na	na	na
Atrazine	.05	7	7	1.39	.26	.44	.47	5	5	.41	.23	.24	.13
beta-HCH	5	4	0	na	na	na	na	4	0	na	na	na	na
cis-Chlordane	5	4	0	na	na	na	na	4	0	na	na	na	na
Cyanazine	.05	7	0	na	na	na	na	5	0	na	na	na	na
Cyanazine amide	.05	7	0	na	na	na	na	5	0	na	na	na	na
Deethylatrazine	.05	7	2	.16	.14	.14	.03	5	4	.21	.13	.13	.08
Deisopropylatrazine	.05	7	1	.07	.07	.07	na	5	2	.10	.09	.09	.01
delta-HCH	5	4	0	na	na	na	na	4	0	na	na	na	na
Dieldrin	5	4	0	na	na	na	na	4	0	na	na	na	na
Dimethenamide	.05	7	0	na	na	na	na	5	0	na	na	na	na
Dimethenamide ESA	.05	7	0	na	na	na	na	5	0	na	na	na	na
Dimethenamide OXA	.05	7	0	na	na	na	na	5	0	na	na	na	na
Endosulfan I	5	4	0	na	na	na	na	4	0	na	na	na	na
Endosulfan II	5	4	0	na	na	na	na	4	0	na	na	na	na
Endosulfan sulfate	5	4	0	na	na	na	na	4	0	na	na	na	na
Endrin	5	4	0	na	na	na	na	4	0	na	na	na	na
Endrin aldehyde	5	4	0	na	na	na	na	4	0	na	na	na	na
Endrin ketone	5	4	0	na	na	na	na	4	0	na	na	na	na

Table 17. Summary statistics of major ions in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

Constituent	MDL	410315096190101 Raw water						410315096190102 Finished water					
		n	det	max	med	$\overline{x}$	s^2	n	det	max	med	$\overline{x}$	s^2
Drinking-water samples—Continued													
Flufenacet	0.05	7	0	na	na	na	na	5	0	na	na	na	na
Flufenacet ESA	.05	7	0	na	na	na	na	5	0	na	na	na	na
Flufenacet OXA	.05	7	0	na	na	na	na	5	0	na	na	na	na
gamma-HCH/lindane	5	4	0	na	na	na	na	4	0	na	na	na	na
Heptachlor	5	4	0	na	na	na	na	4	0	na	na	na	na
Heptachlor epoxide	5	4	0	na	na	na	na	4	0	na	na	na	na
Methoxychlor	5	4	0	na	na	na	na	4	0	na	na	na	na
Metolachlor	.05	7	3	0.41	0.09	0.19	0.19	5	0	na	na	na	na
Metolachlor ESA	.05	7	7	.21	.17	.17	.03	5	5	0.17	0.1	0.11	0.03
Metolachlor OXA	.05	7	7	.17	.08	.10	.04	5	4	.09	.08	.08	.01
Metribuzin	.05	7	0	na	na	na	na	5	0	na	na	na	na
p,p'-DDD	5	4	0	na	na	na	na	4	0	na	na	na	na
p,p'-DDE	5	4	0	na	na	na	na	4	0	na	na	na	na
p,p'-DDT	5	4	0	na	na	na	na	4	0	na	na	na	na
Pendimethalin	.05	7	0	na	na	na	na	5	0	na	na	na	na
Prometon	.05	7	0	na	na	na	na	5	0	na	na	na	na
Prometryn	.05	7	0	na	na	na	na	5	0	na	na	na	na
Propachlor	.05	7	0	na	na	na	na	5	0	na	na	na	na
Propachlor EOXA	.05	7	0	na	na	na	na	5	0	na	na	na	na
Propachlor ESA	.05	7	0	na	na	na	na	5	0	na	na	na	na
Propazine	.05	7	0	na	na	na	na	5	0	na	na	na	na
Simazine	.05	7	0	na	na	na	na	5	0	na	na	na	na
Terbutryn	.05	7	0	na	na	na	na	5	0	na	na	na	na
trans-Chlordane	5	4	0	na	na	na	na	4	0	na	na	na	na

Table 21. Summary statistics of organic wastewater indicator compounds in samples collected during riverbank filtration study, Platte River, Nebraska.

[All concentrations in micrograms per liter; Summary statistics are based on detected concentrations; LRL, laboratory reporting level; n, number of samples ; det, number of detections; max, maximum; med, median; $\bar{x}$, mean; s^2 , standard deviation; na, not applicable; E, statistics based on at least one estimated concentration; M, presence verified but not quantified in at least one sample]

		410322096190103 Cattle feedlot lagoon						410322096190104 Hog confinement lagoon						06803496 Wastewater-treatment plant effluent					
Constituent	LRL	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Wastewater samples																			
1,4-Dichlorobenzene	0.50	5	0	na	na	na	na	5	1	E0.20	E0.20	E0.20	na	5	3	E0.30	E0.27	E0.30	E0.06
1-Methylnaphthalene	.50	5	1	M	M	M	na	5	1	E.30	E.30	E.30	na	5	2	M	M	M	M
2,6-Dimethylnaphthalene	.50	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
2-Methylnaphthalene	.50	5	0	na	na	na	na	5	1	E.10	E.10	E.10	na	5	2	M	M	M	M
3-beta-Coprostanol	2.0	5	2	E0.83	E0.72	E0.72	E0.16	5	4	E1.90	E.99	E1.09	E0.59	5	4	M	M	M	M
3-Methyl-1(H)-indole (skatol)	1.0	5	4	160	27.4	53.8	73.7	5	4	230	43.5	79.3	103	5	3	M	M	M	M
3-tert-Butyl-4-hydroxy anisole (BHA)	5.0	5	0	na	na	na	na	5	0	na	na	na	na	5	3	M	M	M	M
4-Cumylphenol	1.0	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
4-n-Octylphenol	1.0	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
4-tert-Octylphenol	1.0	5	0	na	na	na	na	5	1	M	M	M	na	5	2	E.18	E.17	E.17	E.01
5-Methyl-1H-benzotriazole	2.0	5	0	na	na	na	na	5	1	2.00	2.00	2.00	na	5	5	4.60	2.20	2.52	1.20
Acetophenone	.50	5	1	E.49	E.49	E.49	na	5	2	.94	.88	.91	0.04	5	3	E.28	E.24	E.24	E.04
Acetyl hexamethyl tetrahydro-naphthalene (AHTN)	.50	5	1	.40	.40	.40	na	5	0	na	na	na	na	5	5	2.70	1.60	1.48	1.03
Anthracene	.50	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Anthraquinone	.50	5	0	na	na	na	na	5	0	na	na	na	na	5	1	.23	.23	.23	na
Benzo(a)pyrene	.50	5	0	na	na	na	na	5	1	M	M	M	na	5	0	na	na	na	na
Benzophenone	.50	5	1	E.17	E.17	E.17	na	5	1	E.04	E.04	E.04	na	5	5	.61	.34	.36	.15
beta-Sitosterol	2.0	5	2	3.60	2.40	2.40	1.70	5	3	3.60	1.70	2.10	1.35	5	3	1.20	.88	.97	.20
Bisphenol A	1.0	5	1	E.10	E.10	E.10	na	5	1	.3	.3	.3	na	5	2	.46	.43	.43	.04
Bromacil	.50	5	0	na	na	na	na	5	0	na	na	na	na	5	3	1.20	1.10	.81	.59
Bromoform	.50	5	0	na	na	na	na	5	0	na	na	na	na	4	4	M	M	M	M
Caffeine	.50	5	2	E.20	E.15	E.15	E.08	5	1	E.09	E.09	E.09	na	5	5	17.0	9.50	8.37	7.10
Camphor	.50	5	0	na	na	na	na	5	2	E.12	E.10	E.01	E.04	5	3	E.20	E.16	E.16	E.05
Carbaryl	1.0	5	1	M	M	M	na	5	0	na	na	na	na	5	1	E.23	E.23	E.23	na
Carbazole	.50	5	0	na	na	na	na	5	0	na	na	na	na	5	1	E.05	E.05	E.05	na
Chlorpyrifos	.50	5	0	na	na	na	na	5	1	2.00	2.00	2.00	na	5	2	E.04	E.04	E.04	E.01

Table 21. Summary statistics of organic wastewater indicator compounds in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

		410322096190103 Cattle feedlot lagoon						410322096190104 Hog confinement lagoon						06803496 Wastewater-treatment plant effluent					
Constituent	LRL	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Wastewater samples—Continued																			
Cholesterol	2.0	5	2	E1.00	E0.81	E0.81	E0.28	5	3	E1.60	E1.30	E1.15	E0.54	5	4	2.10	E1.50	E1.51	E0.50
Cotinine	1.0	5	0	na	na	na	na	5	0	na	na	na	na	5	2	E0.9	E0.6	E0.6	E.5
Diazinon	0.50	5	1	M	M	M	na	5	1	M	M	M	na	5	5	M	M	M	M
Dichlorvos	1.0	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
d-Limonene	.50	5	0	na	na	na	na	5	1	0.70	0.70	0.70	na	5	2	E.08	E.08	E.08	E.00
Fluoranthene	.50	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Hexahydrohexamethylcyclo-pentabenzopyran	.50	5	1	E0.07	E.07	E.07	na	5	0	na	na	na	na	5	3	.60	E.30	E.30	E.30
Indole	.50	5	3	2.50	2.10	1.63	1.17	5	2	3.10	1.85	1.85	1.77	5	2	.82	.53	.53	.42
Isoborneol	.50	5	0	na	na	na	na	5	0	na	na	na	na	5	1	E.12	E.12	E.12	na
Isophorone	.50	5	1	E.44	E.44	E.44	na	5	1	E.41	E.41	E.41	na	5	0	na	na	na	na
Isopropylbenzene (cumene)	.50	5	0	na	na	na	na	5	1	E.40	E.40	E.40	na	5	2	M	M	M	M
Isoquinoline	.50	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Menthol	.50	5	0	na	na	na	na	5	0	na	na	na	na	5	3	1.90	1.60	1.49	0.48
Metalaxyl	.50	5	0	na	na	na	na	5	0	na	na	na	na	5	0	na	na	na	na
Methyl salicylate	.50	5	0	na	na	na	na	5	3	M	M	M	M	5	1	E.07	E.07	E.07	na
Metolachlor	.50	5	0	na	na	na	na	5	0	na	na	na	na	5	4	M	M	M	M
N,N'-diethyl-methyl-toluamide (DEET)	.50	5	4	7.60	1.27	2.59	3.46	5	4	13.0	2.10	4.33	6.08	5	5	2.10	1.50	1.52	.53
Naphthalene	.50	5	0	na	na	na	na	5	1	.30	.30	.30	na	5	0	na	na	na	na
Nonylphenol, diethoxy- (total)	5.0	5	0	na	na	na	na	5	2	E5.00	E4.50	E4.50	E.71	5	5	E16.0	E9.90	E8.78	E6.60
Monethoxyoctylphenol	1.0	5	1	1.40	1.40	1.40	na	5	1	M	M	M	na	5	5	M	M	M	M
Octylphenol, diethoxy- 2	1.0	5	0	na	na	na	na	5	0	na	na	na	na	5	3	M	M	M	M
para-Cresol	1.0	5	4	2,500	445	851	1,141	5	5	M	M	M	M	5	5	M	M	M	M
para-Nonylphenol (total)	5.0	5	1	E3.1	E3.1	E3.1	na	5	3	E6.0	E3.1	E3.4	E2.4	5	5	E8.1	E5.5	E5.2	E2.4
Pentachlorophenol	2.0	5	4	M	M	M	M	5	1	M	M	M	na	5	5	M	M	M	M
Phenanthrene	.50	5	0	na	na	na	na	5	1	.03	.03	.03	na	5	0	na	na	na	na
Phenol	.50	5	5	E360	E120	E134	E147	5	3	1,800	180	700	953	5	5	E5.60	E3.40	E3.09	E2.49
Prometon	.50	5	0	na	na	na	na	5	0	na	na	na	na	5	1	E.09	E0.09	E.09	na

Table 21. Summary statistics of organic wastewater indicator compounds in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

Constituent	LRL	410322096190103 Cattle feedlot lagoon						410322096190104 Hog confinement lagoon						06803496 Wastewater-treatment plant effluent					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Wastewater samples—Continued																			
Pyrene	0.50	5	1	E0.04	E0.04	E0.04	na	5	0	na	na	na	na	5	0	na	na	na	na
Stigmastanol, beta-	2.0	5	2	E3.20	E2.30	E2.30	E1.27	5	3	E3.20	E1.80	E2.00	E1.11	5	1	E0.72	E0.72	E0.72	na
tri(2-Chloroethyl) phosphate	.50	5	1	.59	.59	.59	na	5	2	M	M	M	M	5	5	E.41	E.31	E.32	E0.05
Tetrachloroethylene	.50	5	0	na	na	na	na	5	1	E0.10	E0.10	E0.10	na	5	1	M	M	M	na
tri(Dichlorisopropyl phosphate	.50	5	1	E.34	E.34	E.34	na	5	0	na	na	na	na	5	5	E.41	E.32	E.27	E.13
Tributylphosphate	.50	4	2	E.72	E.42	E.42	E0.42	5	1	.76	.76	0.76	na	5	4	E.30	E.23	E.24	E.06
Triclosan	1.0	5	1	M	M	M	na	5	0	na	na	na	na	5	5	M	M	M	M
Triethyl citrate (ethyl citrate)	.50	5	1	E.26	E.26	E.26	na	5	0	na	na	na	na	5	5	E.53	E.45	E.43	E.10
Triphenyl phosphate	.50	5	3	M	M	M	M	5	1	M	M	M	na	5	3	E.22	E.18	E.18	E.05
tris(2-butoxyethyl) phosphate	.50	3	3	E1.60	E.29	E.68	E.80	4	1	E.25	E.25	E.25	na	5	5	E9.00	E2.70	E4.80	E3.43

Constituent	LRL	06801000 Platte River near Ashland						06805000 Salt Creek near Ashland					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Surface-water samples													
1,4-Dichlorobenzene	.50	15	0	na	na	na	na	6	0	na	na	na	na
1-Methylnaphthalene	.50	15	0	na	na	na	na	6	1	M	M	M	na
2,6-Dimethylnaphthalene	.50	15	0	na	na	na	na	6	0	na	na	na	na
2-Methylnaphthalene	.50	15	0	na	na	na	na	6	1	E.06	E.06	E.06	na
3-beta-Coprostanol	2.0	15	2	M	M	M	M	6	2	M	M	M	M
3-Methyl-1(H)-indole (skatol)	1.0	15	0	na	na	na	na	6	0	na	na	na	na
3-tert-Butyl-4-hydroxy anisole (BHA)	5.0	15	0	na	na	na	na	6	0	na	na	na	na
4-Cumylphenol	1.0	15	0	na	na	na	na	6	0	na	na	na	na
4-n-Octylphenol	1.0	15	0	na	na	na	na	6	0	na	na	na	na
4-tert-Octylphenol	1.0	15	0	na	na	na	na	6	2	E.07	E.06	E.06	E.02
5-Methyl-1H-benzotriazole	2.0	15	0	na	na	na	na	6	1	E.07	E.07	E.07	E.07
Acetophenone	.50	15	0	na	na	na	na	6	2	E.18	E.14	E.14	E.06

Table 21. Summary statistics of organic wastewater indicator compounds in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

		06801000 Platte River near Ashland						06805000 Salt Creek near Ashland					
Constituent	**LRL**	**n**	**det**	**max**	**med**	$\bar{x}$	s^2	**n**	**det**	**max**	**med**	$\bar{x}$	s^2
Surface-water samples—Continued													
Acetyl hexamethyl tetrahydro-naphthalene (AHTN)	0.50	15	2	M	M	M	M	6	6	M	M	M	M
Anthracene	.50	15	0	na	na	na	na	6	0	na	na	na	na
Anthraquinone	.50	15	0	na	na	na	na	6	2	M	M	M	M
Benzo(a)pyrene	.50	15	0	na	na	na	na	6	0	na	na	na	na
Benzophenone	.50	15	3	M	M	M	M	6	6	M	M	M	M
beta-Sitosterol	2.0	15	1	M	M	M	na	6	1	E1.0	E1.0	E1.0	na
Bisphenol A	1.0	15	0	na	na	na	na	6	2	M	M	M	M
Bromacil	.50	15	0	na	na	na	na	6	2	E2.20	E1.14	E1.14	E1.50
Bromoform	.50	15	0	na	na	na	na	6	1	0.01	0.01	0.01	na
Caffeine	.50	15	5	M	M	M	M	6	6	M	M	M	M
Camphor	.50	15	0	na	na	na	na	6	0	na	na	na	na
Carbaryl	1.0	15	0	na	na	na	na	6	0	na	na	na	na
Carbazole	.50	15	1	E0.02	E0.02	E0.02	na	6	0	na	na	na	na
Chlorpyrifos	.50	15	0	na	na	na	na	6	0	na	na	na	na
Cholesterol	2.0	15	2	M	M	M	M	6	3	M	M	M	M
Cotinine	1.0	15	1	M	M	M	na	6	4	M	M	M	M
Diazinon	.50	15	0	na	na	na	na	6	3	E.12	E.08	E.07	E0.05
Dichlorvos	1.0	15	0	na	na	na	na	6	0	na	na	na	na
d-Limonene	.50	15	0	na	na	na	na	6	0	na	na	na	na
Fluoranthene	.50	15	0	na	na	na	na	6	1	E.004	E.004	E.004	na
Hexahydrohexamethylcyclo-pentabenzopyran	.50	15	1	M	M	M	na	6	5	E.05	E.01	E.02	E.02
Indole	.50	15	0	na	na	na	na	6	1	E.03	E.03	E.03	na
Isoborneol	.50	15	0	na	na	na	na	6	0	na	na	na	na
Isophorone	.50	15	3	E1.20	E.36	E.58	E0.54	6	2	E.46	E.36	E.36	E.15
Isopropylbenzene (cumene)	.50	15	0	na	na	na	na	6	0	na	na	na	na
Isoquinoline	.50	15	0	na	na	na	na	6	0	na	na	na	na
Menthol	.50	15	0	na	na	na	na	6	1	E.10	E.10	E.10	na
Metalaxyl	.50	15	0	na	na	na	na	6	0	na	na	na	na
Methyl salicylate	.50	15	0	na	na	na	na	6	1	E.07	E.07	E.07	na

Table 21. Summary statistics of organic wastewater indicator compounds in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

		06801000 Platte River near Ashland						06805000 Salt Creek near Ashland					
Constituent	LRL	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Surface-water samples—Continued													
Metolachlor	0.50	15	13	M	M	M	M	6	5	M	M	M	M
N,N'-diethyl-methyl-toluamide (DEET)	.50	15	12	M	M	M	M	6	6	E0.54	E0.08	E0.19	E0.20
Naphthalene	.50	15	0	na	na	na	na	6	0	na	na	na	na
Nonylphenol, diethoxy- (total)	5.0	15	0	na	na	na	na	6	4	E4.00	E2.15	E2.31	E1.35
Monethoxyoctylphenol	1.0	15	0	na	na	na	na	6	2	E1.40	E.90	E.90	E.71
Octylphenol, diethoxy- 2	1.0	15	0	na	na	na	na	6	1	E.10	E.10	E.10	na
para-Cresol	1.0	15	1	E0.1	E0.1	E0.1	na	6	2	E1.30	E.67	E.67	E.89
para-Nonylphenol (total)	5.0	15	0	na	na	na	na	6	4	M	M	M	M
Pentachlorophenol	2.0	15	0	na	na	na	na	6	3	M	M	M	M
Phenanthrene	.50	15	0	na	na	na	na	6	2	M	M	M	M
Phenol	.50	15	10	M	M	M	M	6	5	E1.10	E.52	E.63	E.29
Prometon	.50	15	0	na	na	na	na	6	0	na	na	na	na
Pyrene	.50	15	0	na	na	na	na	6	1	M	M	M	na
Stigmastanol, beta-	2.0	15	0	na	na	na	na	6	2	M	M	M	M
Tetrachloroethylene	.50	15	0	na	na	na	na	6	1	E.24	E.24	E.24	na
tri(2-Chloroethyl) phosphate	.50	15	5	M	M	M	M	6	6	E.12	E.10	E.09	E.03
tri(Dichlorisopropyl) phosphate	.50	15	3	M	M	M	M	6	6	E.12	E.10	E.09	E.02
Tributylphosphate	.50	15	3	E.10	E.09	E.08	E0.03	6	5	E.11	E.08	E.09	E.02
Triclosan	1.0	15	0	na	na	na	na	6	5	M	M	M	M
Triethyl citrate (ethyl citrate)	.50	15	0	na	na	na	na	6	3	E.10	E.09	E.08	E.02
Triphenyl phosphate	.50	15	3	M	M	M	M	6	6	M	M	M	M
tris(2-butoxyethyl) phosphate	.50	15	5	M	M	M	M	6	6	E4.40	E1.04	E1.43	E1.50

Table 21. Summary statistics of organic wastewater indicator compounds in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

		410322096191701 Well W90-1H						410349096202101 Well W49-9						410315096193501 Well W54-10					
Constituent	LRL	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Ground-water samples																			
1,4-Dichlorobenzene	0.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
1-Methylnaphthalene	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
2,6-Dimethylnaphthalene	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
2-Methylnaphthalene	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
3-beta-Coprostanol	2.0	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
3-Methyl-1(H)-indole (skatol)	1.0	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
3-tert-Butyl-4-hydroxy anisole (BHA)	5.0	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
4-Cumylphenol	1.0	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
4-n-Octylphenol	1.0	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
4-tert-Octylphenol	1.0	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
5-Methyl-1H-benzotriazole	2.0	7	1	E0.09	E0.09	E0.09	na	7	0	na	na	na	na	7	0	na	na	na	na
Acetophenone	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Acetyl hexamethyl tetrahydronaphthalene (AHTN)	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Anthracene	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Anthraquinone	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Benzo(a)pyrene	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Benzophenone	.50	7	1	E.04	E.04	E.04	na	7	0	na	na	na	na	7	0	na	na	na	na
beta-Sitosterol	2.0	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Bisphenol A	1.0	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Bromacil	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Bromoform	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Caffeine	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Camphor	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Carbaryl	1.0	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Carbazole	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Chlorpyrifos	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Cholesterol	2.0	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Cotinine	1.0	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Diazinon	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na

Table 21. Summary statistics of organic wastewater indicator compounds in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

Constituent	LRL	410322096191701 Well W90-1H						410349096202101 Well W49-9						410315096193501 Well W54-10					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Ground-water samples—Continued																			
Dichlorvos	1.0	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
d-Limonene	0.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Fluoranthene	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Hexahydrohexamethylcyclo-pentabenzopyran	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Indole	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Isoborneol	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Isophorone	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Isopropylbenzene (cumene)	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Isoquinoline	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Menthol	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Metalaxyl	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Methyl salicylate	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Metolachlor	.50	7	5	M	M	M	M	7	6	M	M	M	M	7	5	M	M	M	M
N,N'-diethyl-methyl-toluamide (DEET)	.50	7	3	M	M	M	M	7	4	M	M	M	M	7	3	M	M	M	M
Naphthalene	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Nonylphenol, diethoxy- (total)	5.0	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Monethoxyoctylphenol	1.0	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Octylphenol, diethoxy- 2	1.0	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
para-Cresol	1.0	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
para-Nonylphenol (total)	5.0	7	1	E2.4	E2.4	E2.4	na	7	1	6.4	6.4	6.4	na	7	1	E1.6	E1.6	E1.6	na
Pentachlorophenol	2.0	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Phenanthrene	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Phenol	.50	7	5	E0.57	E0.40	E0.37	E0.17	7	4	E0.51	E0.32	E0.34	E0.14	7	4	E0.50	E0.33	E0.30	E0.20
Prometon	.50	7	0	na	na	na	na	7	1	E.04	E.04	E.04	na	7	1	E.04	E.04	E.04	na
Pyrene	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Stigmastanol, beta-	2.0	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Tetrachloroethylene	.50	7	0	na	na	na	na	7	2	E.11	E.11	E.11	E.00	7	1	E.10	E.10	E.10	na
tri(2-Chloroethyl) phosphate	.50	7	0	na	na	na	na	7	1	E.04	E.04	E.04	na	7	0	na	na	na	na

Table 21. Summary statistics of organic wastewater indicator compounds in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

Constituent	LRL	410322096191701 Well W90-1H						410349096202101 Well W49-9						410315096193501 Well W54-10					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Ground-water samples—Continued																			
tri(Dichlorisopropyl phospate	0.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Tributylphosphate	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Triclosan	1.0	7	0	na	na	na	na	7	1	E0.04	E0.04	E0.04	na	7	0	na	na	na	na
Triethyl citrate (ethyl citrate)	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
Triphenyl phosphate	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na
tris(2-butoxyethyl) phosphate	.50	7	0	na	na	na	na	7	0	na	na	na	na	7	0	na	na	na	na

Constituent	LRL	410315096190101 Raw water						410315096190102 Finished water					
		n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Drinking-water samples													
1,4-Dichloro-benzene	.50	7	0	na	na	na	na	5	0	na	na	na	na
1-Methylnaphthalene	.50	7	0	na	na	na	na	5	0	na	na	na	na
2,6-Dimethylnaphthalene	.50	7	0	na	na	na	na	5	0	na	na	na	na
2-Methylnaphthalene	.50	7	0	na	na	na	na	5	0	na	na	na	na
3-beta-Coprostanol	2.0	7	0	na	na	na	na	5	0	na	na	na	na
3-Methyl-1(H)-indole (skatol)	1.0	7	0	na	na	na	na	5	0	na	na	na	na
3-tert-Butyl-4-hydroxy anisole (BHA)	5.0	7	0	na	na	na	na	5	0	na	na	na	na
4-Cumylphenol	1.0	7	0	na	na	na	na	5	0	na	na	na	na
4-n-Octylphenol	1.0	7	0	na	na	na	na	5	0	na	na	na	na
4-tert-Octylphenol	1.0	7	0	na	na	na	na	5	0	na	na	na	na
5-Methyl-1H-benzotriazole	2.0	7	0	na	na	na	na	5	0	na	na	na	na
Acetophenone	.50	7	0	na	na	na	na	5	0	na	na	na	na
Acetyl hexamethyl tetrahydronaphthalene (AHTN)	.50	7	0	na	na	na	na	5	0	na	na	na	na
Anthracene	.50	7	0	na	na	na	na	5	0	na	na	na	na
Anthraquinone	.50	7	0	na	na	na	na	5	0	na	na	na	na
Benzo(a)pyrene	.50	7	0	na	na	na	na	5	0	na	na	na	na
Benzophenone	.50	7	1	M	M	M	M	5	0	na	na	na	na

Table 21. Summary statistics of organic wastewater indicator compounds in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

		410315096190101 Raw water						410315096190102 Finished water					
Constituent	**LRL**	**n**	**det**	**max**	**med**	$\bar{x}$	s^2	**n**	**det**	**max**	**med**	$\bar{x}$	s^2
Drinking-water samples—Continued													
beta-Sitosterol	2.0	7	0	na	na	na	na	5	0	na	na	na	na
Bisphenol A	1.0	7	0	na	na	na	na	5	0	na	na	na	na
Bromacil	0.50	7	0	na	na	na	na	5	0	na	na	na	na
Bromoform	.50	7	0	na	na	na	na	5	5	16.0	8.70	8.98	5.65
Caffeine	.50	7	1	E0.06	E0.06	E0.06	na	5	0	na	na	na	na
Camphor	.50	7	0	na	na	na	na	5	0	na	na	na	na
Carbaryl	1.0	7	0	na	na	na	na	5	0	na	na	na	na
Carbazole	.50	7	0	na	na	na	na	5	0	na	na	na	na
Chlorpyrifos	.50	7	0	na	na	na	na	5	0	na	na	na	na
Cholesterol	2.0	7	0	na	na	na	na	5	0	na	na	na	na
Cotinine	1.0	7	0	na	na	na	na	5	0	na	na	na	na
Diazinon	.50	7	0	na	na	na	na	5	0	na	na	na	na
Dichlorvos	1.0	7	0	na	na	na	na	5	0	na	na	na	na
d-Limonene	.50	7	0	na	na	na	na	5	0	na	na	na	na
Fluoranthene	.50	7	0	na	na	na	na	5	0	na	na	na	na
Hexahydrohexamethylcyclo-pentabenzopyran	.50	7	0	na	na	na	na	5	0	na	na	na	na
Indole	.50	7	0	na	na	na	na	5	0	na	na	na	na
Isoborneol	.50	7	0	na	na	na	na	5	0	na	na	na	na
Isophorone	.50	7	3	E.30	E.19	E.23	E0.06	5	0	na	na	na	na
Isopropylbenzene (cumene)	.50	7	na	na	na	na	na	5	0	na	na	na	na
Isoquinoline	.50	7	na	na	na	na	na	5	0	na	na	na	na
Menthol	.50	7	na	na	na	na	na	5	0	na	na	na	na
Metalaxyl	.50	7	na	na	na	na	na	5	0	na	na	na	na
Methyl salicylate	.50	7	na	na	na	na	na	5	0	na	na	na	na
Metolachlor	.50	7	6	M	M	M	M	5	4	M	M	M	M
N,N'-diethyl-methyl-toluamide (DEET)	.50	7	4	E.18	E.05	E.07	E.07	5	2	M	M	M	M
Naphthalene	0.50	7	0	na	na	na	na	5	0	na	na	na	na
Nonylphenol, diethoxy- (total)	5.0	7	0	na	na	na	na	5	0	na	na	na	na

Table 21. Summary statistics of organic wastewater indicator compounds in samples collected during riverbank filtration study, Platte River, Nebraska.—Continued

		410315096190101 Raw water						410315096190102 Finished water					
Constituent	LRL	n	det	max	med	$\bar{x}$	s^2	n	det	max	med	$\bar{x}$	s^2
Drinking-water samples—Continued													
Monethoxyoctylphenol	1.0	7	0	na	na	na	na	5	0	na	na	na	na
Octylphenol, diethoxy- 2	1.0	7	0	na	na	na	na	5	0	na	na	na	na
para-Cresol	1.0	7	0	na	na	na	na	5	0	na	na	na	na
para-Nonylphenol (total)	5.0	7	1	7.0	7.0	7.0	na	5	0	na	na	na	na
Pentachlorophenol	2.0	7	0	na	na	na	na	5	0	na	na	na	na
Phenanthrene	0.50	7	0	na	na	na	na	5	0	na	na	na	na
Phenol	.50	7	5	E0.57	E0.44	E0.44	E0.10	5	0	na	na	na	na
Prometon	.50	7	0	na	na	na	na	5	0	na	na	na	na
Pyrene	.50	7	0	na	na	na	na	5	0	na	na	na	na
Stigmastanol	2.0	7	0	na	na	na	na	5	0	na	na	na	na
Tetrachloroethylene	.50	7	0	na	na	na	na	5	0	na	na	na	na
tri(2-Chloroethyl) phosphate	.50	7	1	E.04	E.04	E.04	na	5	0	na	na	na	na
tri(Dichloisopropyl phospahate	.50	7	0	na	na	na	na	5	0	na	na	na	na
Tributylphosphate	.50	7	1	E.10	E.10	E.10	na	5	0	na	na	na	na
Triclosan	1.0	7	0	na	na	na	na	5	0	na	na	na	na
Triethyl citrate (ethyl citrate)	.50	7	0	na	na	na	na	5	0	na	na	na	na
Triphenyl phosphate	.50	7	1	E.04	E.04	E.04	na	5	0	na	na	na	na
tris(2-butoxyethyl) phosphate	.50	7	0	na	na	na	na	5	0	na	na	na	na

Stable Hydrogen and Oxygen Isotope Ratios

Stable hydrogen and oxygen isotope ratios were measured in surface-water and ground-water samples (table 23, on CD-ROM at back of report) and are shown in figure 9 for well field sites. Duplicate QA/QC samples from the Platte River and Memphis also were collected. Stable hydrogen isotope ratios of surface water showed seasonal variations of -73.6 per mill to -38.1 per mill relative to VSMOW reference water. Stable oxygen isotope ratios of surface water varied between -9.86 per mill and -5.05 per mill. Stable hydrogen isotope ratios of ground water showed seasonal variations of -69.2 per mill to -46.5 per mill relative to VSMOW reference water. Stable oxygen isotope ratios of ground waters varied between -9.62 per mill and -5.81 per mill.

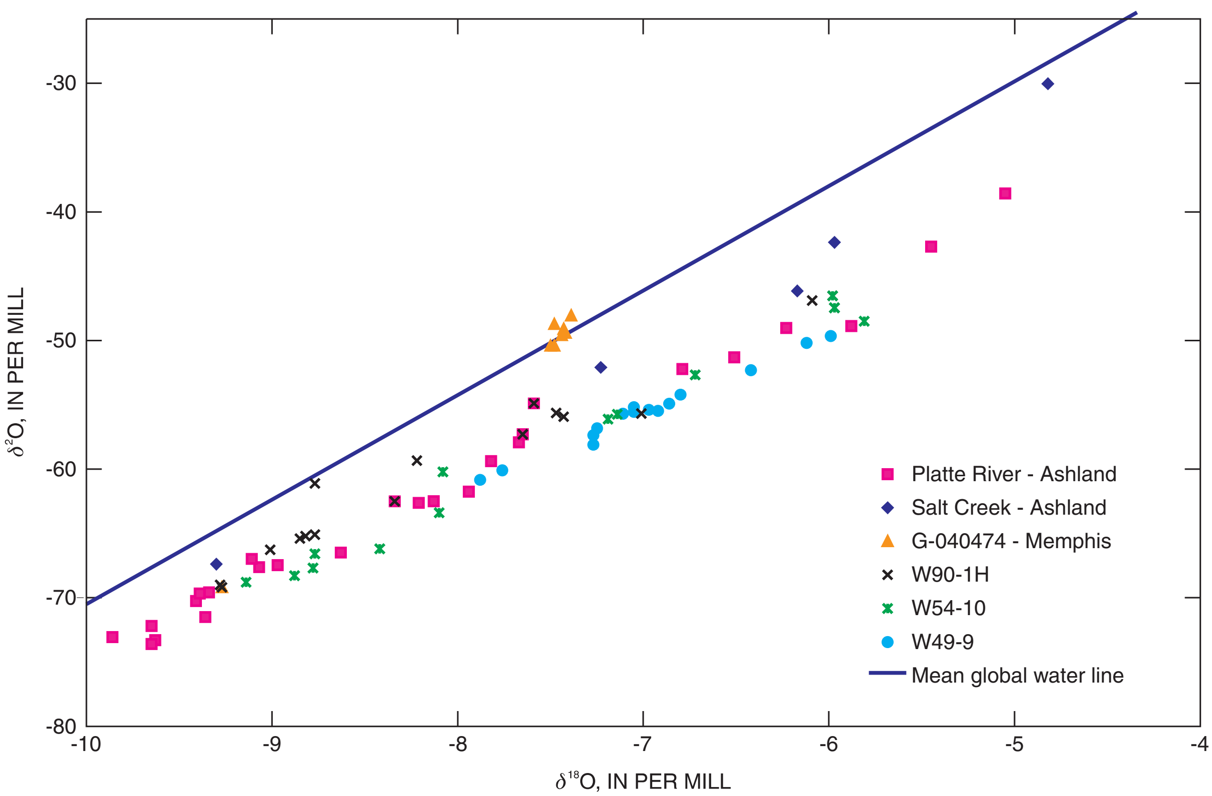

Figure 9. Stable hydrogen and oxygen ratios at water-quality sampling sites at the well field.

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