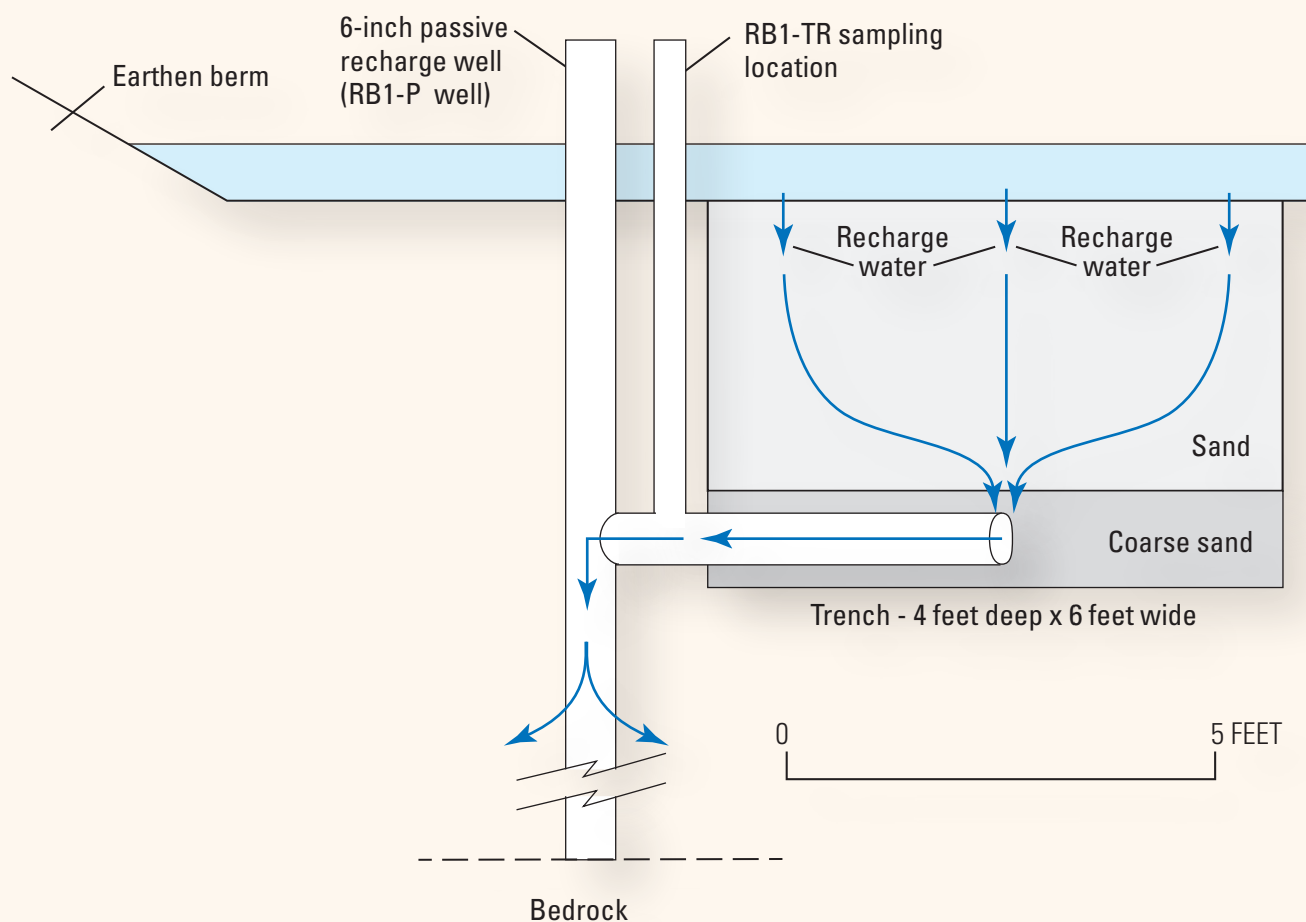


Prepared in cooperation with the City of Wichita, Kansas as part of the
Equus Beds Groundwater Recharge Project

Effects of Experimental Passive Artificial Recharge of Treated Surface Water on Water Quality in the *Equus* Beds Aquifer, 2009–2010



Scientific Investigations Report 2011–5070

Cover illustration: Part A from figure 2 in this report.

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By Linda Pickett Garinger, Aaron S. King, and Andrew C. Ziegler

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
Length		
inch (in.)	2.540	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Area		
square foot (ft ²)	0.09290	square meter (m ²)
Volume		
gallon (gal)	0.003785	cubic meter (m ³)
gallon (gal)	3.875	liter (L)
Flow rate		
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second (m ³ /s)
gallons per day per square foot (gal/d)/ft ²	40.74	Liters per day per square meter (L/day)/m ²
foot per day (ft/d)	.3048	meter per day (m/d)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
Mass		
ounce, avoirdupois (oz)	28.35	gram (g)
pound, avoirdupois (lb)	0.4536	kilogram (kg)
Concentration		
micrograms per liter (µg/L)	1.0	part per billion (ppb)
milligrams per liter (mg/L)	1.0	part per million (ppm)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
 $^{\circ}\text{F}=(1.8\times^{\circ}\text{C})+32$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:
 $^{\circ}\text{C}=(^{\circ}\text{F}-32)/1.8$

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

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

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

Acronyms and Abbreviations Used in This Report

ASR	aquifer storage and recovery
BART	biological activity reaction test
CBE	charge balance error
CFU	colony-forming unit
DO	dissolved oxygen
<i>E. coli</i>	<i>Escherichia coli</i>
ELISA	enzyme-linked immunosorbent assay

FID	floating intercedent device
FNU	Formazin Nephelometric Unit
GC/MS	gas chromatography/mass spectrometry
GMD2	Equus Beds Groundwater Management District 2
IRB	iron-related bacteria
IW	index well
K_{sp}	solubility product
LES Endo	membrane Endo agar, Lawrence Experimental Station
M-FC	membrane method fecal coliform
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MF	membrane filter
MN	upgradient well
MPN	most probable number
MPV	most probable value
MS	downgradient well
m-TEC	membrane-thermotolerant Escherichia coli
NTRU	nephelometric turbidity ratio units
NTU	nephelometric turbidity units
ORP	oxidation-reduction potential
PAC	powdered activated carbon
pe	oxidation-reduction potential
PFU	plaque-forming units
PHREEQC	USGS computer program used for low-temperature aqueous geochemistry calculations
QA/QC	quality assurance/quality control
RB1	recharge basin 1
RB2	recharge basin 2
SC	specific conductance
SDWR	secondary drinking water regulation
SI	saturation index
SRB	sulfate-reducing bacteria
SSC	suspended sediment concentration
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VBNC	viable but not culturable
WWWL	Wichita Municipal Water and Wastewater Laboratory

Effects of Experimental Passive Artificial Recharge of Treated Surface Water on Water Quality in the *Equus* Beds Aquifer, 2009–2010

By Linda Pickett Garinger, Aaron S. King, and Andrew C. Ziegler

Abstract

Declining water levels and concerns about the migration of a known saltwater plume upgradient from public supply wells prompted the City of Wichita to investigate the feasibility of using artificial recharge to replenish the water supply in the *Equus* Beds aquifer. After preliminary testing, the City of Wichita began Phase I of the *Equus* Beds Aquifer Storage and Recovery Project in 2006. In 2009, the City of Wichita installed an experimental passive gravity recharge well and trench system to increase artificial recharge at Recharge Basin 1, one of the six Phase I recharge sites.

The U.S. Geological Survey collected water samples from 13 sites and maintained 8 continuous monitors to test the recharge capacity of the experimental passive recharge system, the effect of the recharge on geochemistry of the aquifer, and the fate of bacteria and viruses present in the recharge water. About 576,000 gallons of treated surface water from the Little Arkansas River were recharged through the passive recharge well and trench system into the *Equus* Beds aquifer during April 2009. In May 2009, U.S. Geological Survey tests detected that bacterial and viral indicators (total coliform, fecal coliform, *Escherichia coli*, coliphage virus, and *Clostridium perfringens*) were entering the Recharge Basin 1 wells through the recharge system and recharge was discontinued. The City of Wichita disconnected the trench collection system from the passive gravity recharge well in July 2009, and in July and August 2009 withdrew 1,825,000 gallons of water from the aquifer at Recharge Basin 1 to remove the recharged water and avoid contamination of the aquifer.

The original recharge rate in Recharge Basin 1 was about 10.8 gallons per day per square foot. After installation of the passive recharge system, recharge water entered the aquifer through the passive well at a rate of about 19.2 gallons per day per square foot, a per unit area increase of about 78 percent.

During artificial recharge, continuous monitors recorded rising water-level altitudes in the passive gravity recharge well and nearby monitoring wells as water flowed at about 10 feet per day from the passive recharge well toward nearby

downgradient monitoring wells. The increase in water level in this area would have the effect of temporarily slowing the eastward migration of saltwater from the nearby Burrton plume.

Bacterial and viral indicators were detected in water samples from Recharge Basin 1 sites before and immediately after the installation of the passive gravity recharge well and trench system, during artificial recharge, and after artificial recharge. After water withdrawal in August 2009 and through the end of data collection in March 2010, detections of bacterial and viral indicators in groundwater decreased to densities similar to those before installation of the passive recharge system.

Concentrations of chloride in samples collected from the trench, passive gravity recharge well, and nearby monitoring wells increased from an average of 34 milligrams per liter before artificial recharge to an average of 64 milligrams per liter during artificial recharge, reflecting the addition of recharge water with measured chloride concentrations of 62 to 94 milligrams per liter. When water was being pumped out of the aquifer through the passive gravity recharge well, chloride concentrations increased to 94 milligrams per liter in the removed water and increased to 150 milligrams per liter in the deep monitoring well nearest the passive gravity recharge well, indicating that, as water was being pumped from the passive well, water with a large chloride concentration from elsewhere in the aquifer was flowing toward the passive well. Chloride concentrations did not exceed the U.S. Environmental Protection Agency Secondary Drinking Water Regulation of 250 milligrams per liter in any Recharge Basin 1 samples collected as part of the study.

Iron concentrations exceeded the U.S. Environmental Protection Agency Secondary Drinking Water Regulation of 300 micrograms per liter in three wells before, during, and after recharge, and were not substantially affected by the addition of oxygenated treated surface water into the system. Arsenic concentrations exceeded the U.S. Environmental Protection Agency Maximum Contaminant Level of 10 micrograms per liter in some deep wells, but did not exceed the Maximum Contaminant Level in shallow wells. The addition

of oxygenated treated surface water to the aquifer did not substantially change arsenic concentrations at Recharge Basin 1 monitoring sites.

Atrazine concentrations in samples collected from Recharge Basin 1 well sites during 2009–2010 did not exceed the Maximum Contaminant Level of 3 micrograms per liter and were largest in groundwater samples collected 4 to 6 days after artificial recharge was discontinued. Atrazine concentrations in samples collected after the passive gravity recharge well experiment were similar to those collected before the experiment began.

Saturation indices for calcite (CaCO_3), iron hydroxide ($\text{Fe}_3(\text{OH})_8$), and manganite (MnOOH) increased during artificial recharge while saturation indices for scorodite ($\text{FeAsO}_4 \cdot 2\text{H}_2\text{O}$) decreased, indicating that mixing oxygenated artificial recharge water with aquifer water caused conditions favorable for oversaturation and precipitation of some minerals. Saturation indices indicated the potential for calcite and iron hydroxide precipitation in some samples during the study period.

Introduction

Background

The *Equus* Beds aquifer, named for the Pleistocene horse fossils in the aquifer sediments, is the easternmost extension of the larger High Plains aquifer system (fig. 1). The *Equus* Beds aquifer consists of alluvial deposits of sand and gravel interbedded with clay or silt (Williams and Lohman, 1949). The general direction of groundwater movement within the study area is to the east (Aucott and others, 1998) except where the hydraulic gradient is altered by pumping wells and near a low-head dam on the Little Arkansas River at Halstead (fig. 1).

The *Equus* Beds aquifer is a primary water supply source for Wichita, Kansas, and the surrounding area because of shallow depth to water, large saturated thickness (Hansen and Aucott, 2004), and generally good water quality (Ziegler and others, 1999). The water table in the aquifer may be as little as 10 feet (ft) below land surface and saturated thickness as much as 250 ft (Myers and others, 1996). In 2008, about 40 percent of the water supply needs for the City of Wichita came from the *Equus* Beds aquifer (D. Ary, City of Wichita, oral commun., 2010).

The primary surface-water drainage for the *Equus* Beds aquifer is the Little Arkansas River (fig. 1). Land use in the Little Arkansas River Basin is primarily agricultural and includes the production of livestock (pasture and range) and field crops. Field crops include corn, grain sorghum, soybeans, and wheat (Kansas Department of Agriculture, 2009). Agricultural chemicals applied to enhance crop production in the basin include fertilizers (such as nitrate, ammonia, and

phosphorus), pesticides, herbicides, and fungicides (U.S. Department of Agriculture website, <http://quickstats.nass.usda.gov/results/2A9CA557-2896-3E90-BF69-DC85C1D98E49>).

The well field developed by the City of Wichita in the *Equus* Beds aquifer during the 1940s and 1950s is one of the primary sources of water for the city and the surrounding area (fig. 1). As of 2005, there were 55 active city public-supply wells in the Wichita *Equus* Beds well field. Numerous irrigation wells also withdraw water from the aquifer within the boundaries of Groundwater Management District No. 2 (GMD2) (*Equus* Beds Groundwater Management District No. 2, 1990) (fig. 1). Water use for irrigation and public supply has caused water levels to decline as much as 40 ft in some areas (Aucott and others, 1998). Declining water levels likely represent a diminished water supply. These, in turn, may accelerate migration of saltwater from the Burrton oil-field to the northwest and the Arkansas River to the southwest into the freshwater of the *Equus* Beds aquifer (fig. 1) (Hansen, 2007).

The City of Wichita began using water from Cheney Reservoir (fig. 1) in 1965 to supplement its supply from the *Equus* Beds aquifer. The proportion of the water supply obtained from Cheney Reservoir increased from 20 percent in 1965 to 44 percent in 1994. From 1995 through 2010, water from Cheney Reservoir ranged from 51 to 69 percent of Wichita's water supply (Ziegler and others, 2010). The increased reliance on surface water from Cheney Reservoir was part of Wichita's Integrated Local Water Supply Plan implemented in 1993 (Warren and others, 1995). This plan was initiated to ensure that the city's water-supply needs are met through 2050 by promoting conservation, increasing water use from Cheney Reservoir, and decreasing pumping from city wells in the Wichita *Equus* Beds well field. The plan also calls for investigating *Equus* Beds recharge using excess water from the Little Arkansas River. As the population in the Wichita area increases, demands for water could exceed existing supplies as early as 2050 if no additional water supply is acquired (Warren and others, 1995; J. Blain, oral commun., 2005).

In 1956, Stramel (1956, 1962a, b, 1967) proposed the artificial recharge of the *Equus* Beds groundwater reservoir by recharging the aquifer with runoff during periods of abundant precipitation. This artificially recharged water then could be recovered by pumping from the aquifer during periods of drought. Stramel proposed using a variety of techniques including water spreading, recharge pits or ponds, recharge wells, and induced recharge by pumping. He also suggested investigation of the relation between streamflow or stage and water quality for the Arkansas River, Little Arkansas River, and Kisiwa Creek as sources for artificial recharge. Of these streams, the Little Arkansas River had the best known water quality.

The *Equus* Beds Groundwater Recharge Demonstration Project began in 1995. The purpose of the demonstration project was to investigate the feasibility of artificial recharge and its effects on the water quantity and quality of the *Equus* Beds aquifer. A demonstration project conducted from 1995 to 2002

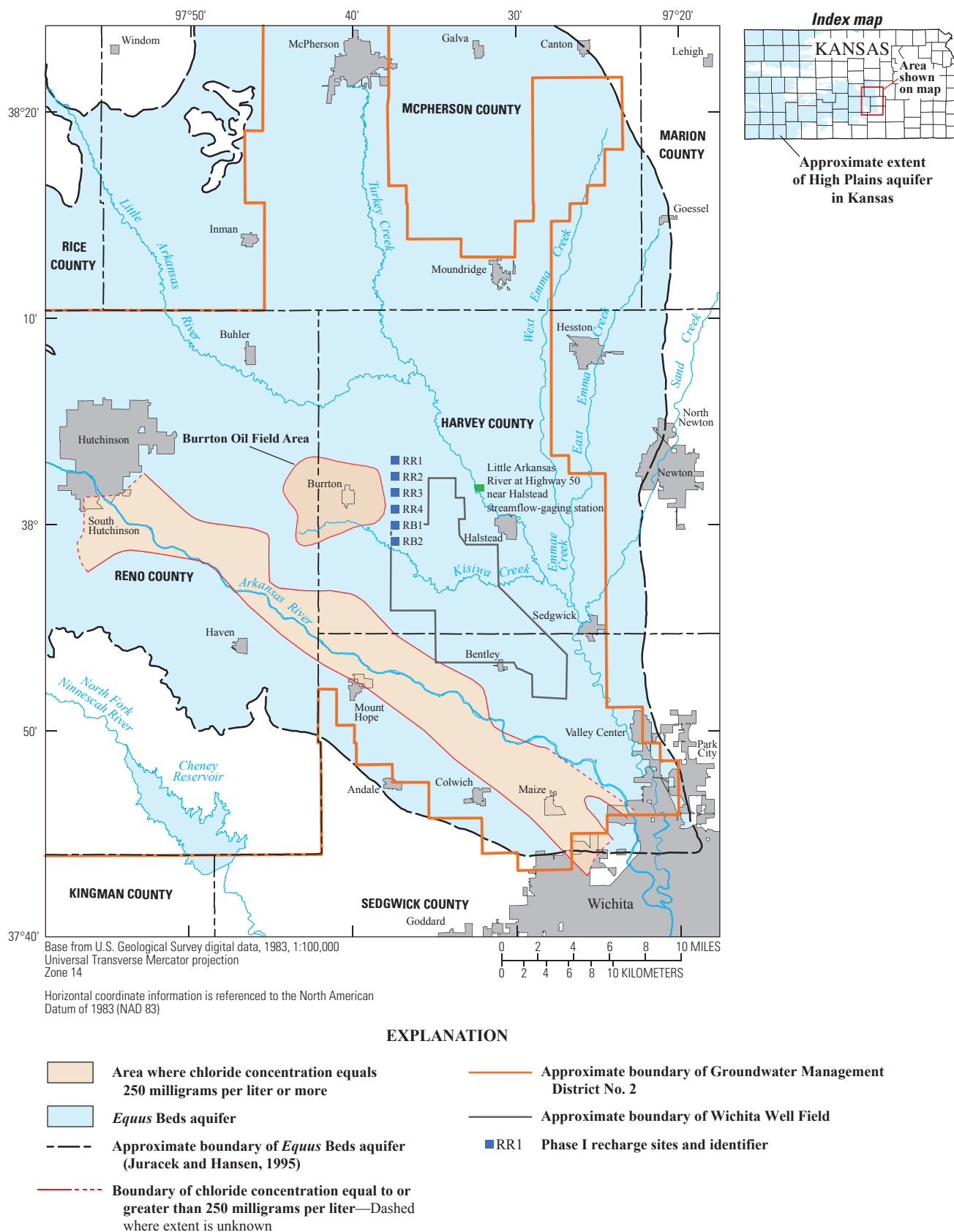


Figure 1. Extent of *Equus* Beds aquifer, areas where chloride concentrations equal 250 milligrams per liter or more, and location of artificial recharge sites and study area near Wichita, south-central Kansas. Modified from Ziegler and others, 2010.

determined that the sources of recharge water were chemically compatible with the receiving groundwater, and in 2007 full-scale recharge began. The role of the U.S. Geological Survey (USGS) in the study was to document hydrologic and water-quality changes and conditions within the study area, to identify probable causes, and to develop baseline conditions for evaluating the effects of larger full-scale artificial recharge. Ziegler and others (1999) reported that the sources of recharge water were chemically compatible with the receiving groundwater and that constituents of concern were sodium, chloride, nitrate, iron, manganese, atrazine, and total coliform bacteria. Ziegler and others (2001) reported that groundwater quality in the *Equus* Beds aquifer was not substantially changed by 3 years of recharge during the demonstration project. Schmidt and others (2007) determined that chemical precipitation of calcite and iron hydroxide are likely to occur, and that the potential for biofouling by iron-related bacteria exists when fully oxygenated treated stream water is injected into the aquifer.

Artificial recharge is being conducted by the City of Wichita through its *Equus* Beds Aquifer Storage and Recovery (ASR) Project Phase I to store and later recover groundwater and to form a hydraulic barrier to a known chloride-brine plume near Burrton, Kansas (fig. 1). Phase I of the *Equus* Beds ASR Project consists of providing as much as 10 million gallons per day recharge to the aquifer through four recharge wells and two recharge basins. The *Equus* Beds Aquifer Storage and Recovery Project Phase I pumps water from the Little Arkansas River or from streambank filtration wells when flow in the river exceeds base flow. Base flow is defined as 57 cubic feet per second (ft³/s) from April 1 through September 30, and 20 ft³/s from October 1 through March 31 as recorded at the USGS streamflow-gaging station on Little Arkansas River at Highway 50 near Halstead, Kansas (KS Permit No. KS-05-079-001, fig. 1). Surface water is processed through a treatment facility to remove suspended material and organic chemicals (powdered activated carbon treatment). This processed water is then recharged into the *Equus* Beds aquifer through two recharge basins, Recharge Basin 1 (RB1) and Recharge Basin 2 (RB2). Additionally, water from streambank filtration wells is artificially recharged through any of four injection wells (RR1-RR4) or through the recharge basins. The USGS has been monitoring the water-quality effects of artificial recharge on the *Equus* Beds as part of the Phase I project.

Primary constituents of concern for artificial recharge are sodium, chloride, nitrate (measured as nitrite plus nitrate), iron, manganese, atrazine, and total coliform bacteria (Ziegler and others, 1999). Chloride and atrazine are of particular concern because concentrations of these constituents in the Little Arkansas River frequently exceeded the Secondary Drinking Water Regulation (SDWR) of 250 milligrams per liter (mg/L) for chloride and the Maximum Contaminant Level (MCL) value of 3 micrograms per liter (µg/L) for atrazine established by the U.S. Environmental Protection Agency (USEPA) (Ziegler and others, 1999). Arsenic was added to the

constituents of concern list (Ziegler and others, 2001) after the USEPA lowered the arsenic MCL from 50 to 10 µg/L effective January 2006 (U.S. Environmental Protection Agency, 2001b). Of additional interest is the fate of viruses and bacteria during artificial recharge with treated surface water.

Information to address concerns related to the effectiveness of a passive recharge system at removing atrazine and microbes from treated surface water before it enters the aquifer, potential for changes in the microbial population in the aquifer resulting from the introduction of oxygenated surface water, and the potential effectiveness of using artificial recharge to stop or slow the migration of a chloride plume is needed. To address these needs the USGS, in cooperation with the City of Wichita, conducted a supplemental investigation as part of the *Equus* Beds groundwater recharge project designed to evaluate flow of recharge water through an experimental passive gravity recharge well system. The supplemental investigation is referred to as the RB1 project.

Related Studies

Ziegler and others (1999) described the baseline water quality (1995–98) and preliminary effects of artificial recharge on the water quality of the *Equus* Beds aquifer. The report indicated that the initial effects of artificial recharge were minimal, that the recharge and aquifer water types were compatible, and that sodium, chloride, nitrate, iron, manganese, atrazine, and total coliform bacteria were constituents of concern. Concentrations of chloride and atrazine in water from some wells increased slightly after the artificial recharge project began approximating the recharge water concentrations; however, these concentrations were within the variance of baseline concentrations in the aquifer and considerably less than the USEPA SDWR and MCL. Ziegler and others (2001) reported that the overall effects of 3 years of recharge did not substantially change groundwater quality.

Schmidt and others (2007) presented the results from a simple mixing model using chloride as a tracer that indicated that the water in shallow (less than 80 ft) monitoring wells adjacent to the Little Arkansas River was 80 percent stream water. The mixing model also indicated that about 25 percent of the pumping well water at Halstead was from the shallow part of the aquifer.

Christensen and others (2000, 2003) developed site-specific regression models to relate constituent concentrations from laboratory-analyzed samples to continuous in-stream sensor measurements of turbidity, specific conductance (SC), pH, water temperature, and dissolved oxygen (DO) by plotting each explanatory variable against the response variable for the Little Arkansas River. Regression models were developed based on physical properties and water-quality analyses of water samples collected from 1995 through 2002. These models were used to compute alkalinity, dissolved solids, total suspended solids, sulfate, chloride, arsenic, and atrazine

concentrations, and fecal coliform bacteria densities (Christensen and others, 2000, 2003).

Water quality in the Little Arkansas River and the *Equus* Beds aquifer from 1995 through 2005 before implementation of Phase I recharge was described by Ziegler and others (2010). Baseline sulfate and chloride concentrations frequently (in more than 5 percent of samples) exceeded the SDWR for these constituents. The trace elements arsenic, iron, and manganese frequently exceeded drinking water criteria. Atrazine, at concentrations much less than the MCL (< (less than) 0.05–0.09 µg/L), was detected in 55 percent of samples collected from shallow index wells, indicating infiltration of the chemical from nearby applications. Total coliform was detected in at least one sample from most wells, but other indicator organisms (*Clostridium perfringens* and *Escherichia coli* (*E. coli*) coliphage) were not detected. Total and fecal coliform bacteria were detected in treated stream water and water from diversion wells.

Because coliform bacteria was detected in water used to artificially recharge the *Equus* Beds aquifer before Phase I recharge, studies investigating the fate of bacteria that may enter the aquifer during artificial recharge are of interest. Anders and others (2004) measured bacteria concentrations in water samples collected from the unsaturated zone at an artificial recharge site in Los Angeles County, California immediately before, 48 hours after, and more than one month after recharge with treated municipal wastewater. Bacteria were not detected immediately before artificial recharge began (April 4, 1994), but increased to concentrations of 8 to > (greater than) 300 CFU/100mL (colony-forming units per 100 milliliters) (total coliform) and 0 to 18 CFU/100mL (fecal coliform) within 48 hours (April 6, 1994) after artificial recharge commenced. Concentrations returned to non-detectable levels about 2 months later (June 1, 1994). Anders and others (2003) found that bacteria moved with the recycled water about 3 meters within a few days. Subsequent controlled experiments using introduced bacteriophage as surrogates for human enteric viruses (viruses found in the intestines) and bromide as a tracer element indicated that the dominant mechanism for virus removal was adsorption not inactivation, although viruses can become inactivated following interaction with solid surfaces, particularly those of metal oxides. The quantity of virus removed increased with time, likely because of changes to the aquifer at the recharge site caused by the presence of entrapped air, sealing of the soil surface, and the presence of biofilms sealing the pores of the aquifer material (Anders and others, 2004).

In another study involving an artificial recharge system, Blanford and others (2005) evaluated the fate of a bacteriophage in a sandy aquifer at the U.S. Geological Survey Cape Cod Toxic-Substances Hydrology Research Site in Falmouth, Massachusetts. A bromide tracer and bacteriophage were injected into groundwater at the site. Water was collected from a set of downgradient multilevel monitoring wells and analyzed for bromide and bacteriophage concentrations. Results

indicated that a small fraction of the injected bacteriophage remained viable throughout the experiment (about 70 days) and traveled 13 meters (m) from the injection point. The conclusion is that if the bacteriophage behaves similarly to human infective virus, a potential health threat would exist downgradient from the point where the virus enters the groundwater.

The amount of time that bacteria and viruses will survive in a groundwater environment depends on many factors, including temperature, pH, light, type of aquifer material, substances toxic to the bacteria or virus, dissolved oxygen, type of bacteria or virus, nutrients available, and predators in the environment. In general, the low temperature, dark, low predator environment of an aquifer is conducive to the survival of bacteria and viruses (Keswiche and others, 1982; John and Rose, 2005; Foppen and Schijven, 2006; Cook and Bolster, 2007; Charles and others, 2009). Bacteria and viruses have been documented to survive in groundwater for extended periods of time. Estimates of times to inactivation range to as much as 250 days for bacteria at 10 °C, and 460 days for viruses at 4 °C (Keswiche and others, 1982; Nevecherya and others, 2005). Dillon and others (2005) summarized data from 10 sites and reported that pathogenic viruses, bacteria, and protozoa became inactivated fastest under aerobic conditions. For example, they report that the time necessary to attenuate 90 percent (one log unit) of viruses is 1 to 10 days in an aerobic aquifer and 8 to 143 in an anaerobic aquifer.

Additionally, research indicates that pathogenic bacteria are capable of entering a viable but not culturable (VBNC) state when stressed (Roszak and Colwell, 1987; Byrd and others, 1991; Barcina and others, 1997). In this state, the bacteria will not grow in a laboratory culture, but may still be viable if it enters a host organism. Some laboratory tests may be better detectors of bacteria that have entered the VBNC state.

Purpose and Scope

This report describes the results of a supplemental investigation conducted in addition to the ongoing USGS monitoring activities. The smaller scale project was an experiment at RB1 designed to evaluate the flow of recharge water through an experimental passive gravity recharge well system and into the *Equus* Beds aquifer.

The purpose of this report is to describe the effects of experimental artificial recharge through a passive gravity recharge well on water-quantity and quality of the *Equus* Beds aquifer. Water diverted from the Little Arkansas River was passed through a treatment plant and then pumped into the passive gravity recharge well system at RB1 where it entered the *Equus* Beds aquifer. Continuous monitors measured water levels and water quality physical properties (such as SC and water temperature) once per hour throughout the passive gravity recharge well experiment. Water quality was assessed by laboratory analysis of water samples collected of diverted surface water from the Little Arkansas River, treated water used for recharge (RB1 source water), and water samples from

11 monitoring sites located at the RB1 passive recharge site. Water samples collected before, during, and after the recharge process were analyzed for bacterial and viral indicators, major ions, trace elements, atrazine, and nutrients. Of primary concern was the effectiveness of the passive recharge system at removing atrazine and microbes from the surface water before it entered the aquifer. Another concern was the potential for changes in the microbial population in the aquifer resulting from the introduction of oxygenated surface water. Biological Activity Reaction Tests (BART) for iron-related bacteria and sulfate-reducing bacteria were conducted and were used in conjunction with geochemical speciation data and simulations to evaluate potential plugging of aquifer material resulting from precipitation of minerals. The effectiveness of using artificial recharge to effectively stop or slow the migration of a known chloride-brine plume immediately to the west of the recharge area was a third primary concern addressed in this report. The analysis of data collected by continuous monitors was evaluated to determine the local hydrogeologic effects of passive recharge on the *Equus* Beds aquifer at the RB1 site, specifically related to the chloride-brine plume.

Methods

Experimental Test Site: Recharge Basin 1

RB1 is the site for the investigation discussed in this report (fig. 2). RB1 was originally designed as an infiltration basin for the recharge of treated surface water. However, the clay content in the bottom material of the basin was greater than expected and the infiltration rate of recharge water was much less than the design rate of about 37.4 gallons per day per square foot (gal/d)/ft². In 2007, ring permeameter testing conducted at RB1 indicated average recharge rates of 16.5 (gal/d)/ft² through the basin floor (P. Higgins, Burns & McDonnell, written commun., 2010). However, observation of recharge at RB1 during artificial recharge in 2007 and 2008 indicated the true recharge capacity to be “substantially less” than 16.5 (gal/d)/ft² (P. Higgins, Burns & McDonnell, written commun., 2010). The pump supplying water to the basin during artificial recharge had an approximate capacity of 1,000 gallons per minute (gal/min) and could not be operated continuously because the infiltration rate was not sufficiently large (R. Robinson, oral commun., 2010). An upper estimate of the recharge capacity of the original RB1 basin is 1,400,000 gal/d or 10.8 (gal/d)/ft² averaged in the basin area of about 134,000 square feet (ft²).

RB1 was reconstructed to include an experimental 6-inch diameter passive gravity recharge well and trench system to facilitate the transport of recharge water into the aquifer. The original configuration of the basin with the approximate

location of monitoring wells and a diagram of the trench and passive gravity recharge well configuration is shown in figure 2. The linear trench was installed along the eastern side of the original basin, and the passive gravity recharge well was installed near the center of the trench. Recharge water flowed through the sand-filled filtration trench, into a collection pipe, and then into the passive gravity recharge well (figs. 2 and 3).

Fourteen sites were used for water-quality sampling or monitoring, or both. (table 1 and fig. 2). The USGS streamflow-gaging station on the Little Arkansas River at Highway 50 near Halstead, Kansas (site 07143672) continuously recorded physical measurements including precipitation and SC. Diverted surface-water samples were collected at the PAC Building, Burrton, Kansas (Diverted SW, table 1). The treated water used for recharge (RB1 source water) was collected from an access faucet at RB1. Water from the recharge trench (RB1-TR) was collected through an access pipe in the system (fig. 2). The passive gravity recharge well (RB1-P well) was sampled and monitored in two depths within the well, RB1-P well shallow (50 ft depth) and RB1-P well deep (169.5 ft depth). (Although the RB1-P well is a single well, for the purposes of this report each monitoring depth may be referred to individually, as if it were a single well. The description “RB1-P well shallow and deep monitoring depths” or “RB1-P well shallow and deep sampling depths” may be used when referring to the RB1-P well monitoring and sampling locations. During water withdrawal in July and August, the designation of “RB1-P deep well” refers to samples collected of water withdrawn from the aquifer.) Two 4-inch monitoring wells, RB1-PMS shallow (about 84 ft deep) and RB1-PMS deep (about 247 ft deep), were installed about 30 ft northeast of the RB1-P well. Three pairs of 2-inch diameter monitoring wells were already in place at RB1; an upgradient (MN shallow and deep) and two downgradient pairs (MS shallow and deep and IW-09 shallow and deep). Altitudes, screened intervals, depths, and USGS site identification numbers for the 14 sites sampled in this evaluation are shown in table 1. Figures 2 and 3 show the locations of the RB1-P well and monitoring wells located at RB1.

A total of 576,000 gallons (gal) of treated surface water were used to test the passive well and trench system at RB1: about 244,000 gal were pumped into the trench April 3–5, 2009; 292,000 gal April 13–17, 2009; and 40,000 gal on April 30, 2009 (R. Robinson, written commun., 2009).

The RB1 site was not recharged with treated surface water after April 30, 2009. The trench and passive well system received recharge by rainfall only after April 30, 2009.

The trench collection system was disconnected from the passive well on July 8, 2009. Approximately 1,500,000 gal of water were pumped out of the aquifer at the RB1 site through the RB1-P well July 7–21, 2009, and 325,000 gal August 11–14, 2009.

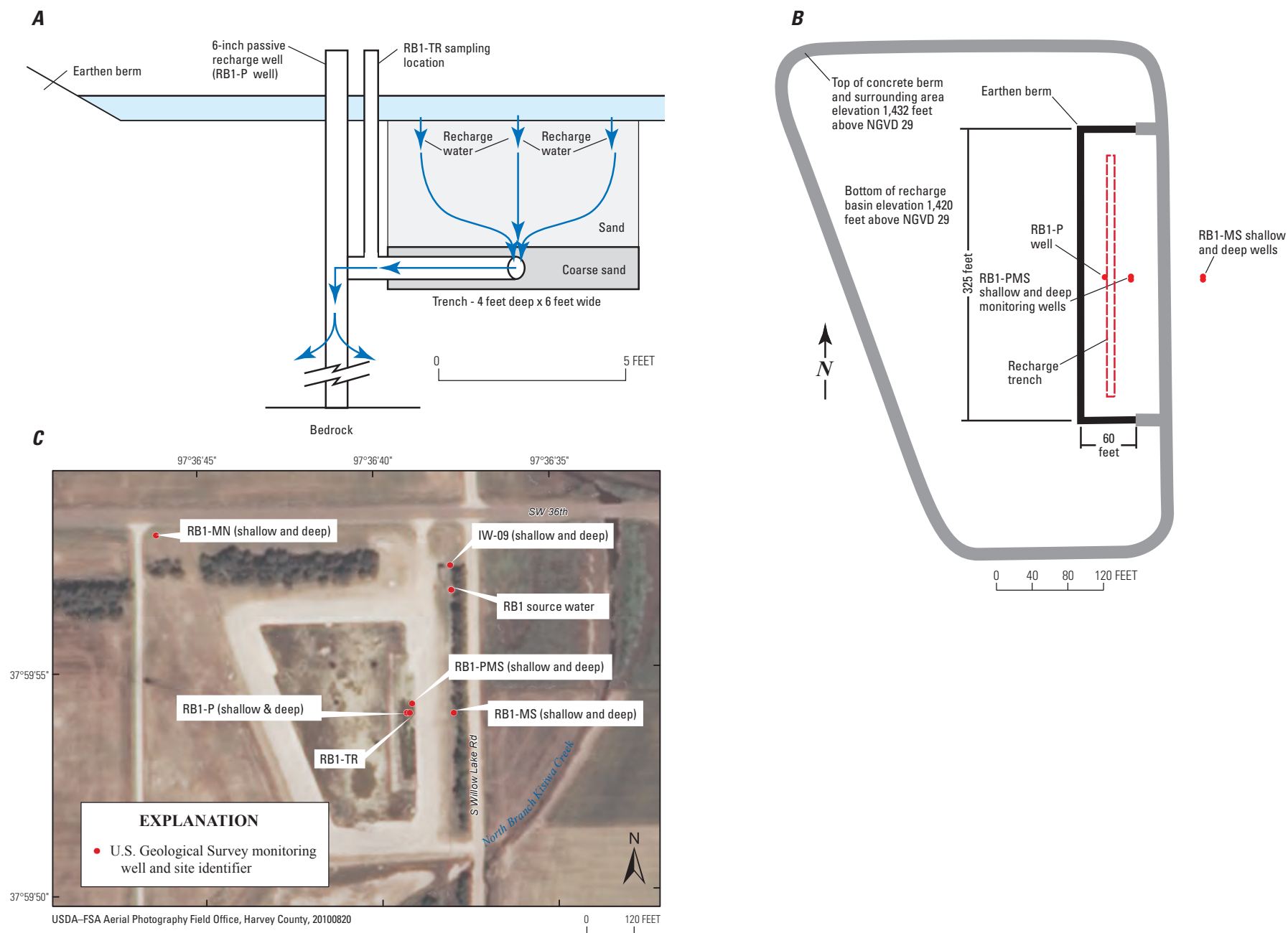


Figure 2. Test site details, including (A) schematic of experimental passive recharge system (B) schematic of RB1 basin and trench, and (C) aerial photo of test site with monitoring well locations. Adapted from drawing D005B, City of Wichita.



Figure 3. RB1-TR, RB1-P well, and RB1-PMS wells installed along the eastern edge of the original RB1 basin. Photographed from the northeast during artificial recharge when trench was flooded with treated surface water.

Geophysical Logging

Geophysical logging, including natural gamma radiation and vertical flow rates in the RB1-P well and RB1-PMS shallow and deep wells, was conducted by the USGS Texas Water Science Center during January, 2009. Natural gamma radiation is emitted by rocks surrounding a well borehole. Clay and shale-bearing rocks and sediments tend to be more radioactive than quartz sandstones or carbonates (Keys, 1990). Therefore, the amount of radiation emitted can be helpful in determining lithology in the borehole. The natural gamma sensor (sodium iodide detector) built into the Century Model 8144c multiparameter probe was used to log gamma radiation in the RB1 wells. The natural gamma log was recorded in natural gamma counts per second (CPS). The direction and rate of vertical water flow within the RB1-P well and RB1-PMS wells were measured with a Century Model 9721 electromagnetic (E-M) vertical flowmeter (Molz and others, 1994). Vertical flow, in

gal/min, was recorded during ambient and pumped conditions at approximate 10-ft intervals within wellbores. Upward flow is recorded as positive values and downward flow as negative values. A 3-inch submersible pump was used for pumping the RB1-PMS shallow and deep wells, and a 4-inch submersible pump was used for pumping the RB1-P well.

The USGS Wichita Field Office personnel used YSI continuous monitors to measure vertical profiles of temperature and DO under ambient conditions in the RB1-P well and RB1-PMS wells during February 2009. The monitors were lowered into the wellbore and measurements were recorded at 5 or 10-ft intervals to a depth of approximately 185 ft.

Water-Sample Collection

Discrete water-quality measurements and continuous water-level and real-time water-quality data are used in this report to describe water quality and hydrologic characteristics

Table 1. Data-collection sites for RB1 passive recharge investigation, south-central Kansas, 2009–2010.

[USGS, U.S. Geological Survey; NAVD 88, National Vertical Datum of 1988; NA, not applicable]

Data-collection site name (fig. 2)	USGS site identification number	Site name	Measurement type used	Gage datum or altitude of top of well casing (feet above NAVD 88)	Approximate well depth (feet)	Approximate depth of screened interval (feet)
Surface-water sites						
07143672	07143672	Little Arkansas River at Highway 50 near Halstead, Kansas	Continuous monitor	1,370.55	NA	NA
Diverted SW	380328097341400	Diverted SW at PAC building, Burrton, Kansas	Discrete samples	NA	NA	NA
Recharge water						
RB1 source water	375954097363803	24S 03W 02AAAA03 RB1 source water	Discrete samples	NA	NA	NA
Groundwater						
RB1-TR	375954097363808	24S 03W 02AADA08 RB1-TR	Discrete samples, continuous monitor	1,420.02	NA	NA
RB1-P shallow	375954097363806	24S 03W 02AADA06 RB1-P shallow	Discrete samples, continuous monitor	1,420.02	253	20–233
RB1-P deep	375954097363807	24S 03W 02AADA07 RB1-P deep	Discrete samples, continuous monitor	1,420.02	253	20–233
RB1-PMS shallow	375954097363804	24S 03W 02AADA04 RB1-PMS shallow	Discrete samples, continuous monitor	1,420.53	84	20–80
RB1-PMS deep	375954097363805	24S 03W 02AADA05 RB1-PMS deep	Discrete samples, continuous monitor	1,420.62	247	20–243
RB1-MS shallow	375954097363801	24S 03W 02AADA01 RB1-MS shallow	Discrete samples, continuous monitor	1,427.00	60	50–60
RB1-MS deep	375954097363802	24S 03W 02AADA02 RB1-MS deep	Discrete samples, continuous monitor	1,427.00	260	240–260
RB1-MN shallow	375958097364601	24S 03W 02AABB01 RB1-MN shallow	Discrete samples	1,430.00	60	50–60
RB1-MN deep	375958097364602	24S 03W 02AABB02 RB1-MN deep	Discrete samples	1,430.00	253	233–253
IW-09 shallow	375958097363801	24S 03W 02AAAA01 IW-09 shallow	Discrete samples	1,431.70	53	33–53
IW-09 deep	375958097363802	24S 03W 02AAAA02 IW-09 deep	Discrete samples	1,431.70	255	233–253

in the *Equus* Beds aquifer at RB1 during and after the passive recharge gravity well test period (January 2009 through March 2010). Water samples and physical measurements were collected from a total of 13 sites during the study period. In addition, 7 of the 13 sites were equipped with continuous real-time water-quality monitors. Rainfall was recorded at the “Little Arkansas River at Highway 50 near Halstead” streamflow-gaging station (fig. 1).

Discrete Water-Quality Samples

As part of this study, discrete water-quality samples were collected from Diverted SW, RB1 source water, and 11 groundwater monitoring sites in and near RB1 (table 1, and fig. 2) during the test period. In previous years, water-quality samples were collected from RB1-MS shallow and deep wells, RB1-MN shallow and deep wells, and IW-09 shallow and deep wells (Ziegler and others, 2010).

Water samples during artificial recharge were collected in sequence on days one and three of the artificial recharge application to follow the flow of the recharge water from the Little Arkansas River (Diverted SW, collected at the PAC Building, Burrton, Kansas), through the treatment plant (RB1 source water), into the trench (RB1-TR), RB1-P well (shallow and deep measurement depths), RB1-PMS wells (shallow and deep), and RB1-MS wells (shallow and deep). Samples were collected on day one and day three of artificial recharge when recharge was occurring. Other wells near the RB1 site, but not in the direct flow of the water, were sampled last (IW-09 shallow and deep, and RB1-MN shallow and deep wells). During water withdrawal the RB1-P well was not directly available because the pump removing water was in the well. Samples labeled RB1-P deep well (during water withdrawal only) were collected from the outflow of the pump. The continuous monitor for the RB1-P deep well was placed in a holding tank to monitor outflow water properties. The RB1-P shallow site was not sampled during water withdrawal.

Surface-water samples were collected using depth- and width-integrating techniques (Wilde and Radtke, 1998). Groundwater samples were collected with a noncontaminating submersible pump using methods described in Wood (1976), Koterba and others (1995), and Puls and Barcelona (1996). To obtain representative samples, at least three well volumes were purged before sample collection. SC, pH, water temperature, DO, oxidation-reduction potential (ORP), and turbidity were measured at 5-minute intervals. Water samples were collected after these properties stabilized (within 10 percent for three consecutive readings) and turbidity was less than 10 nephelometric turbidity units (NTUs). Biological activity reaction tests (BART) (described later in this section) were conducted and samples were analyzed for total coliform, fecal coliform and *E. coli* indicator bacteria at the USGS Wichita Field Office laboratory.

Water samples collected were analyzed for physical properties, major ions, nutrients, dissolved trace elements,

and bacterial and viral indicators (see table 4 at the back of this report). Water for analysis of dissolved trace elements was filtered through a 0.45-micrometer pore size filter. The City of Wichita Municipal Water and Wastewater Laboratory (WWWL) in Wichita, Kansas analyzed samples for physical properties, total dissolved solids, major ions, trace elements, nutrients, indicator bacteria, total suspended solids, and total organic carbon. The USGS Ohio Water Science Center Microbiology Laboratory in Columbus, OH analyzed samples for *E. coli* F-specific coliphage, *E. coli* somatic coliphage, and *Clostridium perfringens*. Methods used to analyze water samples for physical properties and to determine concentrations of dissolved solids, major ions, nutrients, dissolved trace elements, and coliform bacteria were described in Ziegler and Combs (1997). Methods used by the WWWL are described in detail in the City of Wichita Quality Assurance Plan 2010 (City of Wichita, written commun., 2011). Fecal and viral indicator bacteria analyses were done using methods described by Bisson and Cabelli (1979, 1980), Britton and Greeson (1987), Armon and Payment (1988), Payment and Franco (1993), and United States Environmental Protection Agency (1996, 2000, 2001a, 2006b-e). Methods used to analyze BART are described by Droycon Bioconcepts, Inc. (2004). The U.S. Geological Survey (USGS) Organic Geochemistry Research Laboratory, Lawrence, Kansas analyzed samples for atrazine using the enzyme-linked immunosorbent assay (ELISA) (Thurman and others, 1990). For the purposes of this report, dissolved triazine compounds detected by ELISA are referred to as atrazine. Samples for analyses of suspended sediment concentration (SSC) in surface water were sent to the USGS Sediment Laboratory in Iowa City, IA (Guy, 1969).

Several methods were used to quantify bacteria in water samples. Membrane filtration methods using M-Endo culture medium have historical reliability, but newer methods, including the defined substrate technology (Colilert Quantitray) methods and newer culture media (M-ColiBlue) for the traditional membrane filtration test offer some advantages. For example, bacteria that are stressed or injured are more likely to be effectively cultured by defined substrate technology tests (Covert and others, 1992; McFeters, 1993; McFeters and others, 1995), and the M-ColiBlue culture medium has been documented to be effective in suppressing the growth of background bacteria as well as successfully culturing stressed organisms, producing more accurate coliform counts (Hamilton and others, 2005; Wang and Fiessel, 2008). The USGS Wichita Field Office used a membrane filtration method with M-Endo and M-ColiBlue culture plates to measure total coliform, membrane filtration with M-FC medium to measure fecal coliform, and a modified m-TEC membrane filtration method to measure *E. coli*. The City of Wichita Municipal Water and Wastewater Laboratory (WWWL) used Standard LES Endo Method and Colilert Quantitray methods to test for total coliform, membrane filtration with M-FC medium to test for fecal coliform, and Colilert Quantitray method to measure counts of *E. coli*. Methods used by the WWWL are described

in detail in the City of Wichita Quality Assurance Plan 2010 (City of Wichita, written commun., 2011).

The Biological Activity Reaction Test (BART) for iron-related bacteria and sulfate-reducing bacteria, manufactured by Droycon Bioconcepts Inc., were used to evaluate the potential for plugging of the aquifer material and well fouling by iron-related and sulfate-reducing bacteria. The BART provides a semi-quantitative assessment of the select bacterial community in the water sample. The BART uses a bacteria-specific nutrient medium in combination with a floating intercedent device (FID) that acts as a barrier to oxygen diffusion into the sample, creating at least three distinct environments for bacterial growth. Above the FID, growth of aerobic bacteria occurs in the oxygen-rich environment; beneath the FID growth of anaerobic bacteria occurs in the anoxic environment; and at the interface of the two environments, facultative anaerobes grow at the oxidation-reduction (redox) front. The IRB-BART (Iron Related Bacteria Biological Activity Reaction Test) uses a ferric-iron nutrient media for select growth of iron-related bacteria and the SRB-BART (Sulfate Reducing Bacteria Biological Activity Reaction Test) uses a short-chain fatty-acid culture medium for the growth of sulfate-reducing bacteria. Distinct reactions defined by color and other visual properties indicate the type of bacteria present in the water sample. The order in which these reactions occur (reaction pattern signature) and the time to the first reaction indicate which bacteria are dominant and provide an estimate of the number of bacteria in the water sample.

In addition to the summary data presented in this report, data for individual sample analyses are available on the World Wide Web at <http://waterdata.usgs.gov/ks/nwis/qw>.

Continuous Water-Quality Monitoring

RB1-TR, RB1-P well (shallow and deep monitoring depths), RB1-PMS shallow and deep wells, and RB1-MS shallow and deep wells were equipped with multi-sensor water-quality monitors to continuously measure physical properties including water temperature, water altitude, SC, pH, DO, and ORP. In addition, monitors in RB1-TR, the RB1-P well (shallow and deep monitoring depths), and the RB1-PMS wells continuously monitored turbidity measurements. The sensors were calibrated and maintained according to methods presented in Wilde and Radke (1998) and Wagner and others (2006). Measurements from continuous monitoring sensors were checked against a calibrated field meter during site visits. These data were transmitted by satellite to a computer at the USGS Kansas Water Science Center. Real-time data are available on request.

Cristensen and others (2003) used continuous monitoring data and discrete measurements of constituents in the Little Arkansas River at Highway 50 near Halstead to develop site-specific equations relating SC or turbidity to constituent concentration. Water for artificial recharge at the RB1 site was diverted from the Little Arkansas River near USGS

site 07143672. For this study, estimates of chloride concentration in recharge water are calculated from continuous specific conductance measurements at this site according to equation 1:

$$Cl = -33.7 + 0.209 SC \quad (1)$$

where:

Cl is the concentration of chloride in mg/L; and
 SC is specific conductance measured in microsiemens per centimeter at 25 °C.

Quality Assurance and Quality Control

Replicate, blank, and standard reference samples were analyzed as a part of quality assurance/quality control (QA/QC) measures for the RB1 project. QA samples were collected according to protocols in the National Field Manual for the Collection of Water-Quality Data (U.S. Geological Survey, 2006). Quality-assurance and quality-control procedures outlined in "Baseline Data-Collection and Quality-Control Protocols and Procedures for the *Equus* Beds Ground-Water Recharge Demonstration Project near Wichita, Kansas, 1995–96" (Ziegler and Combs, 1997) and the written communication "Quality-Assurance Plan for the Water-Quality Activities by the U.S. Geological Survey in Kansas, 2008" were followed for sample collection protocols.

All types of replicate samples were analyzed using the relative percent difference between the environmental sample and the replicate sample. The precision of the replicate analysis is defined by equation 2:

$$RPD = \frac{(C_1 - C_2) \times 100}{\frac{(C_1 + C_2)}{2}} \quad (2)$$

where:

RPD is relative percentage difference;
 C_1 is the larger of two concentration values from the environmental or replicate sample; and
 C_2 is the smaller of two concentration values from the environmental or replicate sample (Ziegler and Combs, 1997).

For inorganic constituents, an onsite or laboratory replicate RPD within 10 percent was acceptable (Ziegler and Combs, 1997). For organic constituents and bacterial analysis, a replicate analytical result within 20 and 50 percent, respectively, was acceptable.

A summary of the analysis of replicate pairs collected from 2009 through March 2010 at RB1 sites is presented in table 2. Thirty-nine of 52 constituents had no relative percent differences (RPD 's) greater than the acceptable limit. Chloride, sulfate, nitrate, phosphorus, iron, and manganese all had RPD 's more than 10 percent in one out of 7 replicate pairs. Two of 7 replicate pairs analyzed for ammonia, nitrite, and

orthophosphate had *RPD*'s more than the acceptable limit. Five of 12 pairs analyzed for triazine had *RPD*'s greater than 20 percent. One of 5 pairs analyzed for fecal coliform, as well as one out of 8 pairs analyzed for coliphage had *RPD*'s above 50 percent.

A summary of results from blank samples is presented in table 3. Twenty-one of 28 analyzed constituents were not detected in blank samples. Seven blanks were tested for organic carbon, and three detections with concentrations of 0.38, 0.21, and 0.33 mg/L were made. Alkalinity was detected in seven out of eight blanks, and bicarbonate was detected in eight out of eight. The detections of alkalinity and bicarbonate were small and can be attributed to exposure of the blank samples to carbon dioxide in the atmosphere. *E. coli* and fecal coliform were each detected in two of four blank samples. All four detections of *E. coli* were 1 CFU/100 mL. Turbidity was detected in three blank samples (0.2, 0.16, and 0.44 NTU).

Standard reference water samples are used to determine the bias and variability associated with field-handling, shipping, and laboratory procedures (U.S. Geological Survey, 2006). A reference sample is a laboratory-prepared solution whose composition is certified for one or more properties so that it can be used to assess a measurement method (U.S. Geological Survey, 2006). The reference samples are typically submitted as blind samples to the laboratory and the concentration of the samples is known. The accuracy for standard reference samples is measured by equation 3:

$$\text{Percentage Recovery} = (C_{\text{measured}} \div C_{\text{actual}}) \times 100 \text{ percent} \quad (3)$$

where:

- C_{measured} is the measured concentration of the constituent; and
 C_{actual} is the most probable value (MPV) of the constituent concentration.

Two blind standard reference samples were submitted and analyzed as part of the RB1 project using standard references M-186 (U.S. Geological Survey, 2008a), T-193 (U.S. Geological Survey, 2008a), and N-99 (U.S. Geological Survey, 2008b). One blind sample was analyzed for pH and specific conductance. Both measurements were within acceptable range of percent recovery (80–120 percent). The other blind sample was analyzed for 17 constituents. Of those 17, there were 13 within the acceptable range of percent recovery. Chloride, fluoride, and sulfate were not detected, but the MPV was above the minimum reporting level. Ammonia had a percent recovery of 167 percent.

An ion balance was performed on all samples analyzed for major ions. The equation used to evaluate the error in the anion – cation balance is:

$$CBE = ((TC - TA) / (TC + TA)) * 100 \text{ percent} \quad (4)$$

where:

- CBE is the charge balance error;

- TC is the total cation equivalent weight in milliequivalents per liter (meq/L); and
 TA is the total anion equivalent weight in meq/L.

A *CBE* of 7 percent or less is considered acceptable in this study. The *CBE* on samples collected for the RB1 project were 7 percent or less for all samples except one. The sample collected from the RB1-PMS deep site on July 8, 2009 had a *CBE* of 12.3 percent. QA/QC data are available on request from the USGS, Lawrence, Kansas. The USGS Organic Geochemistry Research Laboratory, Lawrence, Kansas conducted a triazine herbicide screen on submitted samples. The ELISA method was used to screen samples for triazine herbicides in the study described in this report. Approximately 15 percent of samples collected as part of this study were also analyzed by the gas chromatography/ mass spectrometry (GC/MS) method for quality assurance. A linear regression of the data from this study indicates that a best fit line relates the two analysis methods with the equation:

$$y = 1.08 x \quad (5)$$

where:

- x is the triazine herbicide concentration from ELISA, in micrograms per liter; and
 y is the atrazine concentration from GC/MS, in micrograms per liter.

A previous study (Ziegler and others, 1999) using samples from the Little Arkansas River reported that for surface-water samples atrazine (detected by GC/MS) made up 81 percent of the triazine compound concentrations detected by ELISA. (Atrazine: GC/MS = 0.81 * Triazine: ELISA; Ziegler and others, 1999)

Geochemical Modeling

The purpose of geochemical modeling is to monitor changes in the water chemistry as a result of artificial recharge and water removal at the RB1 site. Changes in water chemistry might result in the precipitation or dissolution of minerals. Mineral precipitation may cause some aquifer pores to clog and mineral dissolution may release harmful constituents like arsenic into the aquifer.

PHREEQC (Parkhurst and Appelo, 1999) geochemical modeling software was used to calculate saturation indices. The program performs a large variety of low-temperature aqueous geochemical calculations including speciation and saturation index calculations. Data input to PHREEQC included water temperature, DO concentration, pH, alkalinity, and dissolved concentrations of calcium, magnesium, sodium, potassium, chloride, sulfate, nitrite, nitrate, orthophosphate, fluoride, silica, arsenic, iron, and manganese. The program calculated the oxidation-reduction potential (pe) of the solution based on the nitrate/nitrite oxidation-reduction

Table 2. Summary of replicate pairs analyzed as part of the *Equus* Beds Passive Recharge Project at RB1.

[*E. coli*, *Escherichia coli*; C13, *E. coli* culture resistant to naladixic acid and used to detect somatic coliphages; Famp, *E. coli* culture resistant to ampicillin and streptomycin and used to detect male-specific coliphages; M-FC, membrane method fecal coliform; MF, membrane filter; LES Endo method, membrane Endo agar Lawrence Experiment Station]

Constituent	Number of pairs	Percent of pairs over limit
Carbonate hardness, water, unfiltered	5	0
Hardness, water	7	0
Calcium, water, filtered	6	0
Magnesium, water	7	0
Potassium, water, filtered	7	0
Sodium, water, filtered	7	0
Alkalinity, water, filtered	5	0
Bicarbonate, water, filtered	5	0
Carbonate, water, filtered	5	0
Bromide, water, filtered	5	0
Chloride, water, filtered	7	14
Fluoride, water, filtered	7	0
Sulfate, water, filtered	7	14
Residue on evaporation	7	0
Residue, total nonfilterable	5	0
Ammonia, water, filtered	7	29
Nitrate plus nitrite, water, filtered	7	0
Nitrate, water, filtered	7	14
Nitrite, water, filtered	7	29
Orthophosphate, water, filtered	7	29
Phosphorus, water, filtered	7	14
Organic carbon, water, unfiltered	6	33
<i>Clostridium perfringens</i>	4	0
Coliphage, <i>E. coli</i> , C13 host	4	0
Coliphage, <i>E. coli</i> , Famp host	4	25
Fecal coliform, M-FC MF (0.7 micron) method	5	20
Total coliform, LES Endo method	4	0
Aluminum, water, filtered	1	0
Antimony, water, filtered	1	0
Arsenic, water, filtered	6	0
Barium, water, filtered	1	0
Beryllium, water, filtered	1	0
Boron, water, filtered	1	0
Cadmium, water, filtered	1	0
Chromium, water, filtered	1	0
Copper, water, filtered	1	0
Cyanide, water, filtered	1	0
Iron, water, filtered	7	14
Lead, water, filtered	1	0
Manganese, water, filtered	7	14
Mercury, water, filtered	1	0
Nickel, water, filtered	1	0
Selenium, water, filtered	1	0
Silver, water, filtered	1	0
Strontium, water, filtered	1	100
Thallium, water, filtered	1	0
Vanadium, water, filtered	1	0
Zinc, water, filtered	1	0
Atrazine, water, filtered	3	0
Triazine screen, water, filtered	12	42
Alpha radioactivity, water, filtered	1	100
Gross beta radioactivity, water, filtered	1	0

Table 3. Summary of blank samples analyzed as part of the *Equus* Beds Passive Recharge Project at RB1.[m-TEC, membrane-thermotolerant *Escherichia coli*; MF, membrane filter; M-FC, membrane method fecal coliform]

Constituent	Number of blank samples	Number of detections
Turbidity, water, unfiltered	3	3
Carbonate hardness, water, unfiltered	8	0
Dissolved solids dried at 180 degrees Celsius, water, filtered,	8	0
Suspended solids, water, unfiltered	7	0
Calcium, water, filtered	8	0
Magnesium, water, filtered	8	0
Potassium, water, filtered	8	0
Sodium, water, filtered	8	0
Alkalinity, water, filtered	8	7
Bicarbonate, water, filtered	8	8
Bromide, water, filtered	8	0
Carbonate, water, filtered	8	0
Chloride, water, filtered	8	0
Fluoride, water, filtered	8	0
Sulfate, water, filtered	8	0
Ammonia, water, filtered	8	0
Nitrate plus nitrite, water, filtered	8	0
Nitrate, water, filtered	8	0
Nitrite, water, filtered	8	0
Orthophosphate, water, filtered	8	0
Phosphorus, water, filtered	8	0
<i>Escherichia coli</i> , modified m-TEC MF method, water	4	2
Fecal coliform, M-FC MF (0.7 micron) method, water	4	2
Iron, water, filtered	8	0
Manganese, water, filtered	8	0
Arsenic, water, filtered	8	1
Triazine screen, water, filtered,	8	0
Organic carbon, water, unfiltered	7	3

pair. Concentrations below reporting levels were input as the reporting level value.

The saturation index (*SI*) indicates the extent of disequilibrium of a solution with respect to a mineral. A positive saturation index indicates the solution is oversaturated with respect to a mineral, and there is potential for the mineral to precipitate. Conversely, a negative saturation index indicates the solution to be undersaturated with respect to a mineral, and there is potential for the mineral to dissolve if it is present (Ross Schmidt and others, 2007). Saturation indices, though, are a result of equilibrium calculations and only indicate solubility constraints. Dissolution or precipitation kinetics, along with competition amongst species present in the water, also affect whether dissolution or precipitation actually occurs.

The *SI* is the log of the ion-activity product of a solution divided by the solubility product (K_{sp}). For example, the saturation index equation for calcite ($CaCO_3$) is:

$$SI = \text{Log} \frac{[Ca^{2+}][CO_3^{2-}]}{K_{sp}(\text{calcite})} \quad (6)$$

where:

$[Ca^{2+}]$ is the activity of the calcium ion;
 $[CO_3^{2-}]$ is the activity of the carbonate ion; and
 $K_{sp}(\text{calcite})$ is the solubility product of calcite.

Though neither *pe* nor pH is included in the numerator of the *SI* calculation, both can have a substantial effect on the *SI*. For example, in the *SI* calculation for carbonate, the activity of the carbonate ion is pH and concentration dependent. In the *SI* calculation for other minerals with redox-active elements like iron, manganese, and arsenic, the activity of redox-active element is *pe* and concentration dependent.

Saturation indices were calculated for all water samples during the study period. Calcium, iron, manganese, and arsenic are present in the aquifer and have been determined

to be constituents of concern in previous studies but they frequently exceeded USEPA drinking water criteria (Ross Schmidt and others, 2007; Ziegler and others, 2010). Monitoring saturation indices for minerals containing these elements provides information on whether passive recharge and water removal affected the water chemistry with respect to calcium, iron, manganese, and arsenic. The minerals for which saturation indices are reported here are calcite (CaCO_3), iron hydroxide ($\text{Fe}_3(\text{OH})_8$), manganite (MnOOH), and scorodite ($\text{FeAsO}_4 \cdot 2\text{H}_2\text{O}$). These were chosen to illustrate the changes in water chemistry with respect to major aquifer constituents in the study period.

Water Quantity

Hydrogeology

Borehole geophysical data consisting of natural gamma radiation collected in the RB1-P well and RB1-PMS wells, and vertical flow rates under ambient and pumped conditions in the RB1-P well were collected in January 2009. Gamma radiation logs indicate the presence of a lithologic layer with comparatively greater gamma radiation from 50 to 60 ft below ground surface (fig. 4A). This is interpreted as indicating the

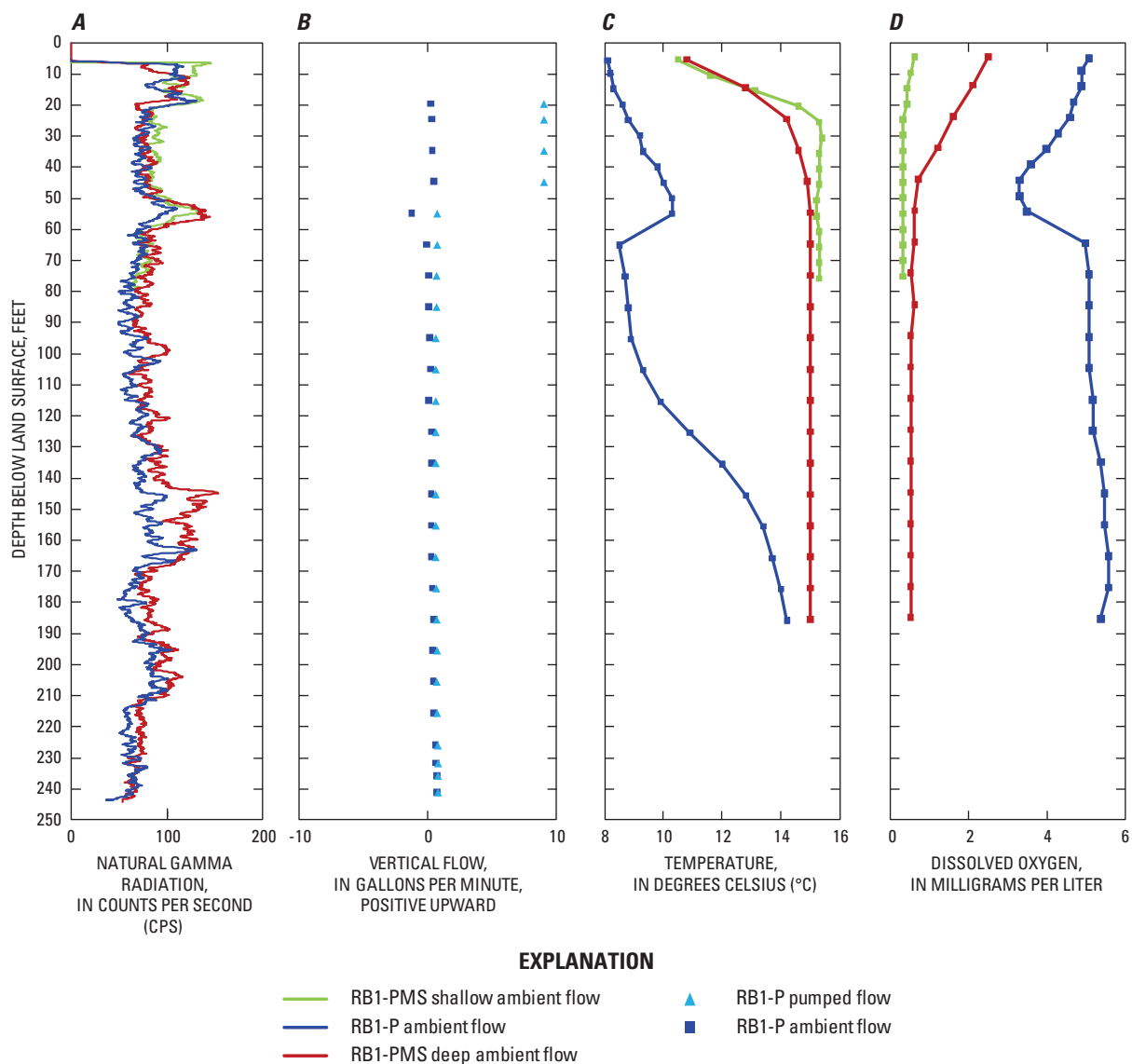


Figure 4. Borehole geophysical logs of (A) natural gamma radiation in RB1-P well and RB1-PMS shallow and deep wells (B) vertical flow in RB1-P well under ambient and pumped flow conditions (C) temperature in RB1-P well and RB1-PMS shallow and deep wells (D) dissolved oxygen in RB1-P well and RB1-PMS shallow and deep wells, before artificial recharge.

presence of a layer with a large amount of clay content (Keys, 1990; G. Stanton, USGS, written commun., 2011). Vertical flowmeter measurements collected in the RB1-P well under ambient conditions shift from small upward or no-flow conditions at a depth of approximately 45 ft to downward flow of approximately 1.2 gal/min at a depth of 55 ft, indicating that water is entering the wellbore at this location (Paillet, 2001; G. Stanton, USGS, written commun., 2011). Because water flows from high hydraulic head to low hydraulic head, the zone of inflow can be interpreted as a zone of higher hydraulic head. Vertical flowmeter measurements shift from downward flow of approximately 1.2 gal/min at a depth of 55 ft to no flow conditions at a depth of approximately 65 ft, indicating that water is leaving the wellbore at this location. Pumped conditions in the RB1-P well were achieved by setting the submersible pump in the borehole at approximately 11 ft below land surface. The pump discharged approximately 9 gal/min at the surface. During pumping, all flow in the RB1-P well measured by the vertical flowmeter was upward. From depths of 244 to 55 feet below land surface the upward flow was small (0.6 to 0.7 gal/min). Between depths of 55 and 45 ft below land surface the flow increases to approximately 9 gal/minute, indicating a zone of larger hydraulic conductivity compared to the depth interval from 244 to 55 ft below land surface is present at that depth (fig. 4B).

YSI continuous monitors were used to measure vertical profiles of temperature and DO in the RB1-P well and RB1-PMS wells on February 11 and 12, 2009, before recharge began. Although artificial recharge water was not being pumped into the system, the RB1-P well was connected to the trench, and water from precipitation was able to infiltrate into the system. In the RB1-PMS shallow and deep wells, water temperature increased with depth in the shallow aquifer and then stabilized, as would be expected during winter months. However, the temperature in the RB1-P well increased until about 55 ft below the surface, decreased for about 10 ft, and then increased again. Water temperature in the RB1-P well was less than that in the RB1-PMS wells because of cold water infiltrating from the surface (fig. 4C). As indicated by vertical flowmeter measurements, groundwater (with a slightly greater temperature) enters the wellbore near a depth of 50 ft, and is reflected in the temperature profile of the RB1-P well. Profiles of DO also change rapidly in the upper 50 ft of the aquifer (all three wells) with an inversion from 50 to 65 ft in the RB1-P well only (fig. 4D). The RB1-PMS wells are not connected directly to the trench system and, when the profile was measured, represent conditions in the aquifer before artificial recharge began. Because the RB1-P well was connected to the surface through the trench system, small amounts of oxygenated surface water entered the well resulting in large DO values near the surface and throughout the well in general. Near a depth of 50 ft, water flowed into the RB1-P well from areas in the aquifer that have smaller amounts of DO. The RB1-P well temperature and DO profiles indicate that artificial recharge from the surface is occurring and water is flowing down into the deep aquifer. The decrease in temperature

and increase in DO below a depth of 55 ft in the RB1-P well indicate that some cold, oxygen-rich surface water is flowing downward from the surface into the deep aquifer even though an area of higher head exists near a depth of 50 ft.

Water-Level Altitude from Continuous Monitors

Water-level altitude recorded by continuous monitors at RB1 sites is shown on figure 5A. Water-level altitude in RB1-MS deep fluctuated between about 1,405 and 1,409 ft in February and March 2009 before artificial recharge began. Changes in altitude in the RB1-MS deep well were large and occurred quickly, indicating the change resulted from pumping from the aquifer at a nearby location. The water-level altitude in the RB1-MS shallow well did not change with the altitude of the RB1-MS deep well and remained nearly constant at about 1,416.5 ft before artificial recharge.

Water-level measurements recorded by the continuous monitors indicate an increase in water-level altitude in the RB1-P well (4.5 ft) when recharge water entered the system. A rise in RB1-P well water-level altitude occurred during artificial recharge but a smaller rise in altitude also occurred with rainfall events indicating that water was entering the system as a result of artificial recharge and rainfall. During May and June, when artificial recharge was not occurring, rainfall caused several small rises in the water-level altitude in the RB1-P well. Enough precipitation fell into the RB1 basin to raise the water level in the RB1-P well above the trench floor (1,420.0 ft on at least seven occasions in May and June, 2009 (fig. 5A)).

Water-level altitude in the RB1-PMS shallow and RB1-PMS deep wells were similar throughout the test because wells are screened above and below the clay layer near 50-ft depth, which separates the upper and lower parts of the aquifer at RB1. Water levels in the RB1-PMS shallow well and the RB1-MS shallow well rose by 0.1 to 0.25 ft when water entered the system through the RB1-P well and increased by about 1 ft total during the period of passive recharge (April 1 through June 30). The increase in water-level altitude in the RB1-PMS wells and RB1-MS shallow well during recharge decreases the west to east hydraulic gradient, and slows the eastward migration of saltwater from the Burrton oil-field disposal site.

Water levels in the RB1-MS shallow well were generally 0.3 to 0.5 ft higher than those in the RB1-PMS shallow well because the wells are screened at different depths, but changes in water-level altitude were similar. The screened interval for the RB1-MS shallow well included the depth interval with the high hydraulic head area discussed in the "Hydrogeology" section of this report. The RB1-MS deep well was connected only to a deeper part of the aquifer and indicates the lower hydraulic head values associated with the deeper part of the aquifer. Because the RB1-P well is screened from 20 to 233 ft, water entering through the RB1-P well will tend to flow downward to the lower parts of the well (and aquifer). Recharge water

entering the system may affect the lower parts of the aquifer more than the upper parts of the aquifer.

After installation of the passive recharge system, recharge water flowed through the sand filled filtration trench and entered the aquifer through the 6-inch passive gravity recharge well at a rate of 15 to 25 gal/min (R. Robinson, City of Wichita, written commun., 2010). Using the average recharge rate of 20 gal/min within the trench area of about 1,500 ft², the recharge for the trench and passive well system is about 19.2 (gal/d)/ft², about 78 percent greater than the original recharge rate.

Water Quality

Physical Properties

Water-Quality Monitor Data

Turbidity in surface water has been strongly correlated to *E. coli* bacteria concentration because bacteria readily attach to the sediment particles (Rasmussen and Ziegler, 2003). Turbidity in groundwater is generally less than 1 Formazin Nephelometric Unit (FNU) because the rate of groundwater flow is insufficient to keep particles in suspension. Large turbidity values may indicate that bacteria was entering or was present in the RB1 system. Turbidity values of 10–140 FNU were recorded during and immediately after the RB1-P and the RB1-PMS well profiling February 11–13, 2009, and are not representative of normal turbidity values in the wells (fig. 5B). Continuous monitors recorded increased turbidity values in RB1-TR and the RB1-P well (shallow and deep monitoring depths) during and after rainfall events and during artificial recharge. The increase in turbidity during rainfall events was likely caused by the suspension of small sediment particles in recharge water as the water passed through the trench sands which contained sand, silt, and clay-sized particles (see Feb 2009, fig. 5C). Continuous monitors recorded increased turbidity values in RB1-TR and RB1-P well (shallow and deep monitoring depths) during artificial recharge, especially the first few hours. After several hours of artificial recharge, suspended particles are deposited on the existing aquifer material and turbidity values in RB1-TR and RB1-P well (shallow and deep monitoring depths) were similar to those measured in the RB1 source water. During May and June 2009, turbidity values increased slightly in response to rain events.

A spike in turbidity in the RB1-P well (deep monitoring depth) coincided with the date the monitor was removed from the well and placed in a tank to take measurements in water being pumped out of the aquifer. After the passive recharge system was disconnected (July 8, 2009) and water was no longer flowing into the RB1-P well from the trench, turbidity

levels were small. A small increase in turbidity in the RB1-P well (deep monitoring depth) occurred in early October when monitors were removed for checking and calibration, and was because of the disturbance of aquifer sediment rather than the inflow of turbid water from the surface.

SC is a measure of the ability of a substance to conduct electricity (Hem, 1992). A larger SC indicates a larger amount of ions in solution (a larger amount of dissolved solids). Rainfall has small SC relative to groundwater, so SC can act as a tracer for rainwater that entered the RB1 recharge system, and thus can provide information about the speed and direction of groundwater flow in the RB1 recharge system. SC measurements in RB1-TR, RB1-P well (shallow and deep monitoring depths), RB1-PMS shallow and deep wells, and RB1-MS shallow and deep wells as recorded by continuous monitors, and discrete measurements of SC in RB1 source water are shown in figure 5C. SC in RB1-TR, the RB1-P shallow, and the RB1-P deep wells quickly decreased by as much as 500 microsiemens per centimeter at 25 degrees Celsius ($\mu\text{S}/\text{cm}$) immediately after precipitation events (for example March 7, April 12, April 26, April 27, and May 8). On some occasions, when artificial recharge was not occurring, but rainfall was infiltrating, RB1-PMS shallow and deep well monitors recorded a decrease in specific conductance about 3 days after the decrease recorded in RB1-TR and RB1-P well, supporting the hypothesis that water was entering the shallow and deep parts of the RB1-P well from the trench and was moving downgradient to the east at a rate of about 10 feet per day. Continuous monitors in RB1-TR and the RB1-P well (shallow and deep monitoring depths) recorded an increase in specific conductance to concentrations similar to that of the RB1 source water immediately after artificial recharge, again illustrating the flow of water from RB1-TR, through the RB1-P well, and into the aquifer. In general, SC values in the RB1-MS shallow well were near 500 $\mu\text{S}/\text{cm}$ throughout the study period. SC values in the RB1-MS deep well fluctuated between about 500 $\mu\text{S}/\text{cm}$ and 700 $\mu\text{S}/\text{cm}$, but these changes do not appear to be associated with rainfall or artificial recharge with treated surface water. SC values in the RB1-PMS deep well were consistently greater than those in the RB1-PMS shallow well and also decreased after rainfall events. During water withdrawal, SC values in the RB1-PMS deep well increased to values of 800 to 1,000 $\mu\text{S}/\text{cm}$ because of large concentrations of dissolved chloride in the groundwater at RB1-PMS deep when water withdrawal was occurring.

Passive recharge with treated surface water and recharge from rainfall resulted in an increase in DO (fig. 5D) because the recharge water contained a greater amount of DO. Concentrations of DO in the RB1-P well (shallow and deep monitoring depths) increased from about 4 mg/L to about 10 to 12 mg/L during recharge conditions. DO concentrations in the RB1-PMS deep well increased from less than 1 mg/L before recharge to about 5 mg/L after rainfall infiltrated into the basin. The RB1-MS shallow and deep wells had small concentrations of DO (0.0 to .3 mg/L) during the study period indicating that the oxygen-rich recharge water did not affect

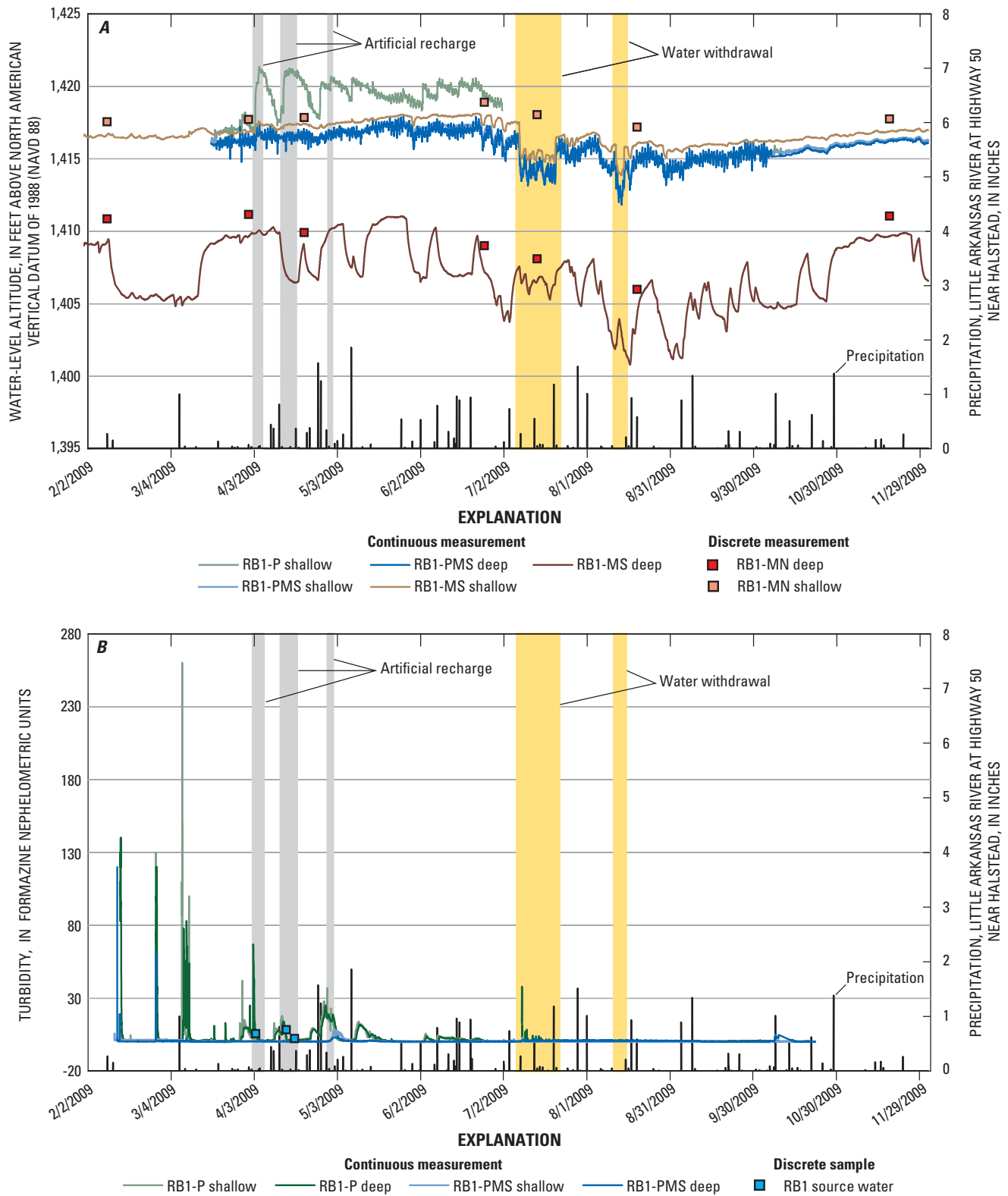


Figure 5. Continuous measurement of: (A) water-level altitude; (B) turbidity; (C) specific conductance; and (D) dissolved oxygen at RB1 monitoring sites.

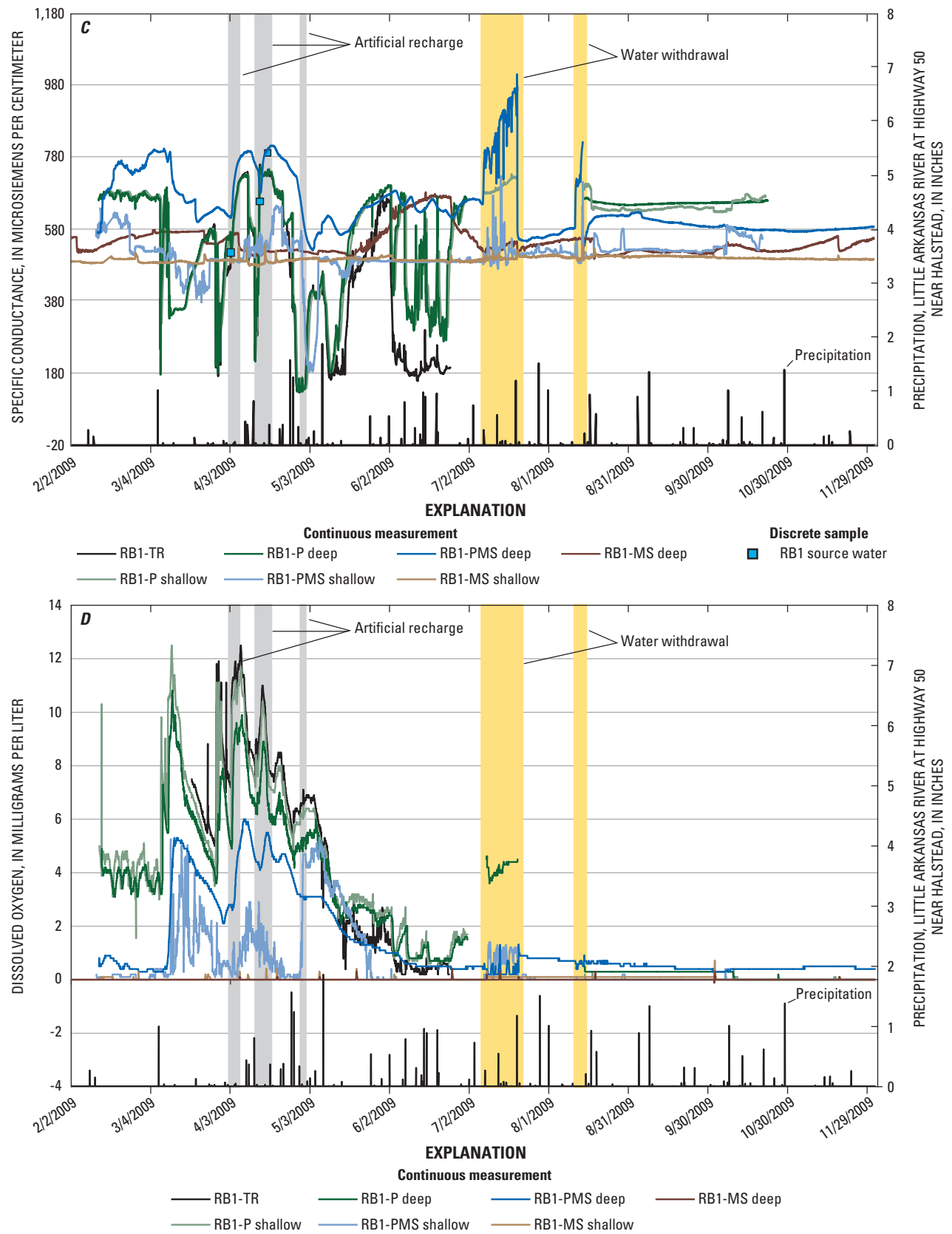


Figure 5. Continuous measurement of: (A) water-level altitude; (B) turbidity; (C) specific conductance; and (D) dissolved oxygen at RB1 monitoring sites.—Continued

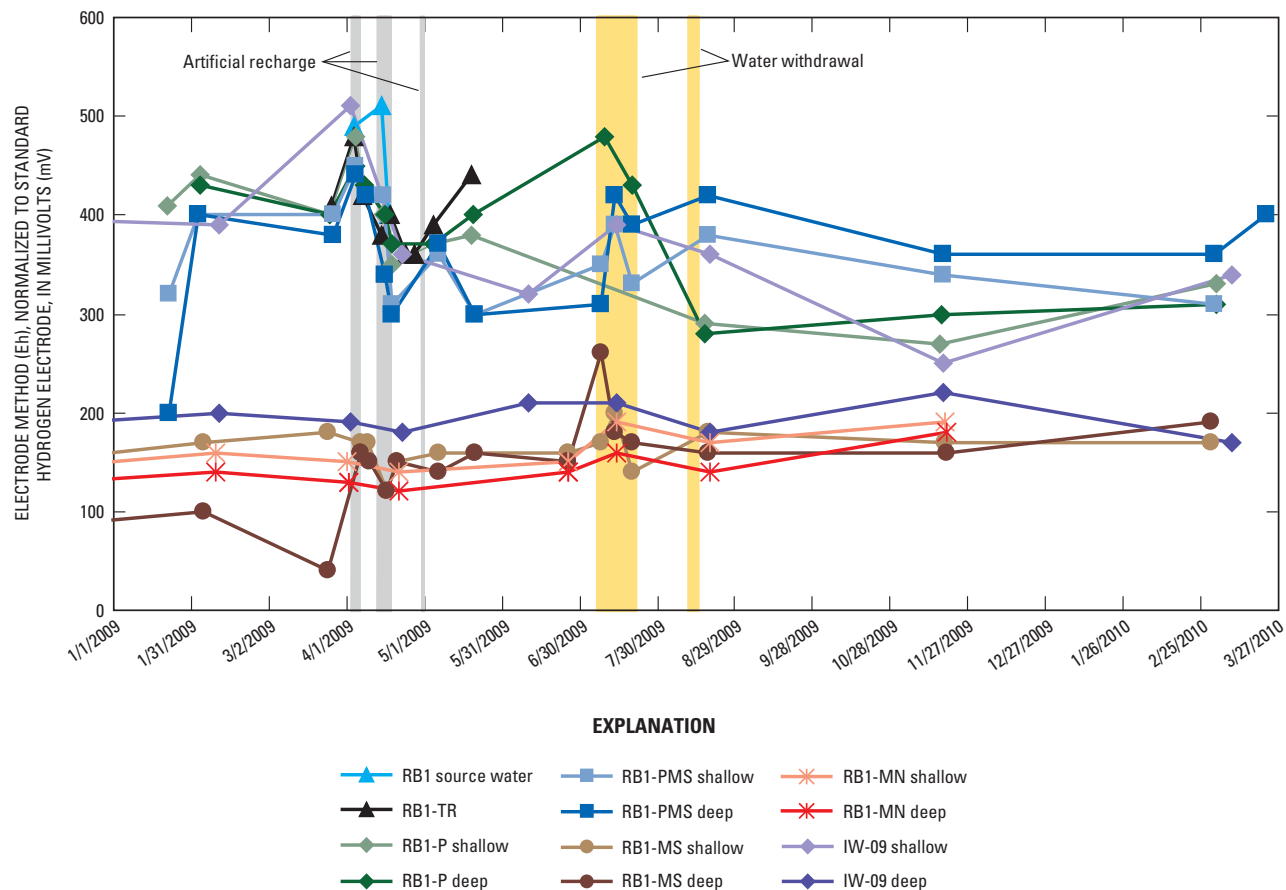


Figure 6. Oxidation-reduction potential from samples collected at RB1 sites during 2009–2010.

the aquifer in the area of the RB1-MS wells. During the period after artificial recharge and before water withdrawal, DO concentrations generally decreased in all wells. Concentrations in the RB1-PMS wells were near 0 mg/L immediately before water withdrawal and increased slightly to near 1 mg/L during water withdrawal. The increase in DO concentration in the RB1-PMS wells during water withdrawal is likely caused by previously recharged water (oxygenated surface water) entering the well, or by increased surface infiltration of standing water in the basin because of pumping conditions. After the RB1-P well and trench system was disconnected and after water was withdrawn, DO values in all wells decreased to pre-recharge conditions of less than 1 mg/L.

Discrete Samples

In addition to continuous monitoring, physical properties were measured as discrete samples were collected. Measured properties include groundwater altitude, SC, pH, water temperature, turbidity, DO, and ORP. Results are shown in table 5 at the back of this report. ORP is discussed below.

ORP is measured in millivolts (mV) relative to the standard hydrogen electrode and indicates the tendency of constituents in water to cause oxidation or reduction reactions

(Hem, 1992). The larger the ORP, the more oxidizing the conditions. For example, ORP values of more than 250 mV indicate that the dominant iron species in groundwater is ferric iron, which can lead to chemical precipitation of ferric iron oxides or hydroxides in aquifer material, which can decrease the effective porosity (Ross-Schmidt and others, 2007). If ORP is less than 250 mV, more reducing conditions may result in dissolution of arsenic, iron, and manganese in aquifer materials, thereby leading to larger dissolved concentrations of these constituents in groundwater. Even lower ORP indicates more reducing conditions that involve geochemical and biological processes which convert dissolved sulfate to hydrogen sulfide gas. Different communities of iron-related bacteria and sulfate-reducing bacteria survive and thrive under different ORP conditions (Cullimore, 2007). Iron-related bacteria and sulfate-reducing bacteria in RB1 water are of interest because of the potential to plug or foul wells.

Historic (before 2009) measurements of ORP were consistently less than 250mV for RB1-MN shallow and deep, RB1-MS shallow and deep and IW-09 deep wells (Ziegler and others, 2010). Historic ORP measurements from IW-09 shallow samples, which had values near or more than 400 mV, were substantially larger than those from other area wells. During artificial recharge with treated surface water, ORP in RB1-TR, RB1-P well (shallow and deep sampling depths),

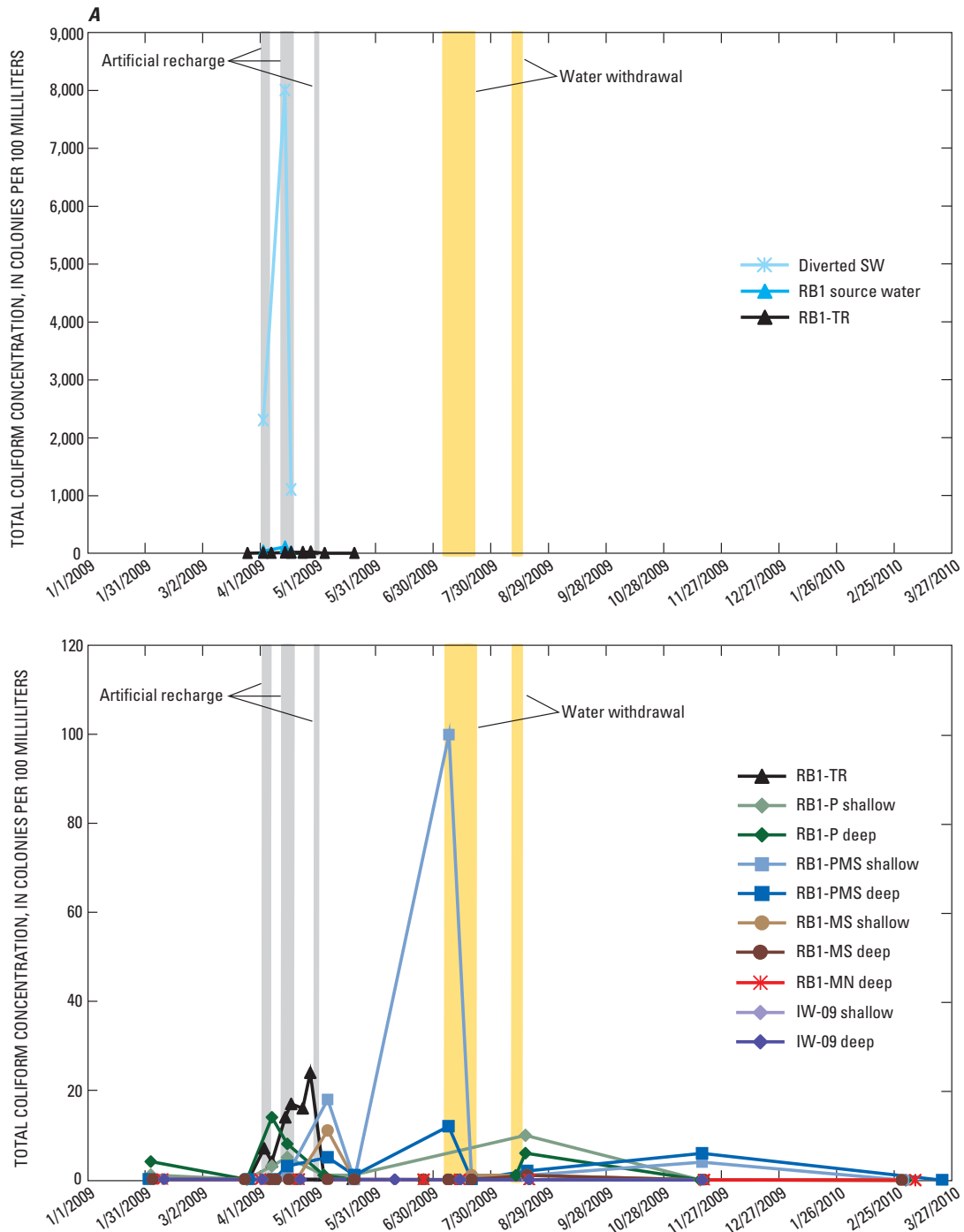


Figure 7. Indicator bacteria densities from selected analytical methods in water samples collected from study area during 2009–2010; (A) Total coliform LES Endo method (membrane Endo agar, Lawrence Experiment Station) (B) fecal coliform, M-FC MF (0.7-micron membrane filtration, Fecal Coliform agar) (C) *Escherichia coli* (modified thermotolerant *Escherichia coli* membrane filtration method).

and RB1-PMS shallow wells increased and then decreased, following the trend of the ORP value of the RB1 source water (fig. 6). All ORP values measured in samples from RB1-TR, RB1-P well (shallow and deep sampling depths), RB1-PMS shallow well, and IW-09 shallow well were larger than 300mV. ORP values for the RB1-MS shallow and deep wells decreased during recharge and increased during water

withdrawal, but values for RB1-MN and IW-09 deep well were relatively unchanged. The changing ORP is indicative of the mixing of oxygenated recharge water with aquifer water, and the travel of water through the system from RB1-TR, to RB1-P well to RB1-PMS wells and RB1-MS wells. After recharge and water withdrawal, ORP returned to values similar to those before recharge (fig. 6).

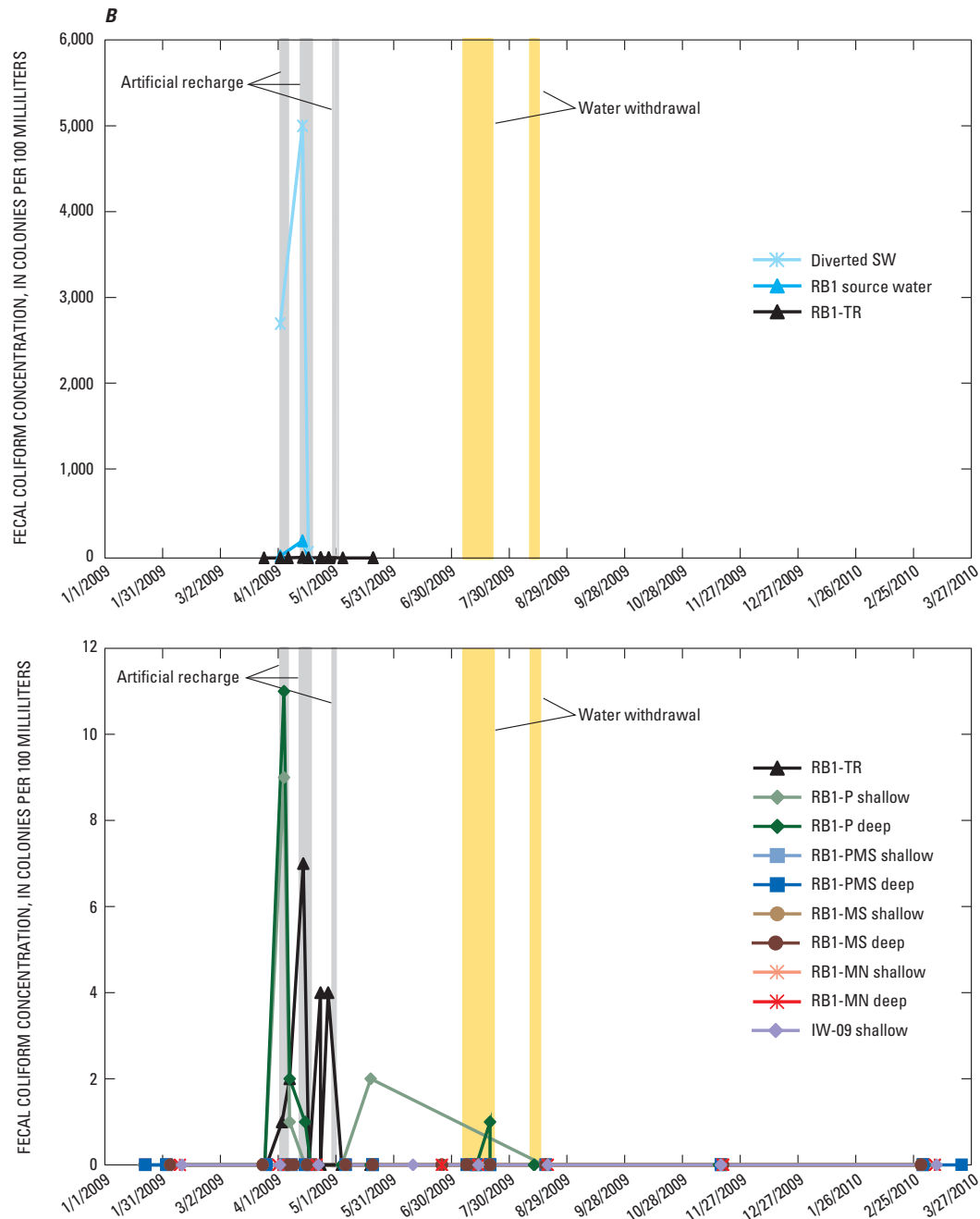


Figure 7. Indicator bacteria densities from selected analytical methods in water samples collected from study area during 2009–2010; (A) Total coliform LES Endo method (membrane Endo agar, Lawrence Experiment Station) (B) fecal coliform, M-FC MF (0.7-micron membrane filtration, Fecal Coliform agar) (C) *Escherichia coli* (modified thermotolerant *Escherichia coli* membrane filtration method).—Continued

Bacterial and Viral Indicators

Water samples were analyzed to determine concentrations of bacterial indicators (total coliform, fecal coliform, *E. coli*), viral indicators (coliphage virus), and a spore-forming bacterial indicator (*Clostridium perfringens*). The USEPA Maximum Contaminant Level Goal (MCLG) for total coliform (including fecal coliform and *E. coli*) is 0 CFU/100 mL in compliance with the USEPA National Primary Drinking

Water Regulations for Total Coliforms (U.S. Environmental Protection Agency, 1989). *Clostridium perfringens* is a sulfite reducing spore-forming bacterium normally present in human and animal feces. *Clostridial* spores are resistant to heating and survive longer than coliform bacteria and consequently are used as an indicator of past fecal contamination. Coliphage virus is a virus that infects coliform bacteria, and therefore, is an indicator of possible fecal contamination.

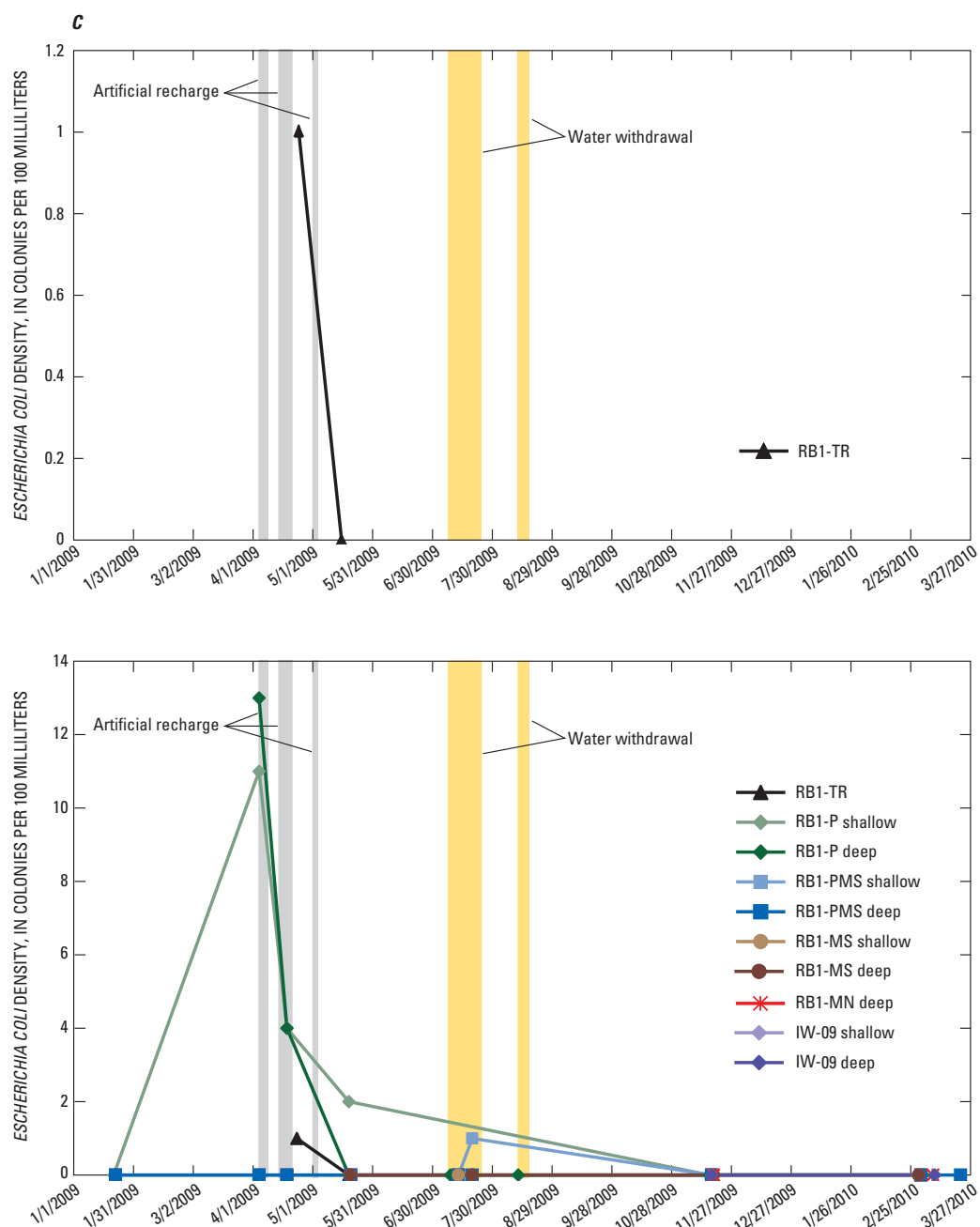


Figure 7. Indicator bacteria densities from selected analytical methods in water samples collected from study area during 2009–2010; (A) Total coliform LES Endo method (membrane Endo agar, Lawrence Experiment Station) (B) fecal coliform, M-FC MF (0.7-micron membrane filtration, Fecal Coliform agar) (C) *Escherichia coli* (modified thermotolerant *Escherichia coli* membrane filtration method).—Continued

Results from selected test methods are presented in figures 7 and 8. Data from all test methods are presented in table 6 at the back of this report.

Before Artificial Recharge

Before the recharge experiment, bacterial indicators had been detected in some water samples from RB1-MS, RB1-MN, and IW-09 wells. With the exception of a sample

collected from IW-09 on 3/19/2002, the detections of bacteria were small (6 or fewer CFU/100 ml).

During 2008, before installation of the passive gravity recharge well and trench system, coliform bacteria were detected in one sample from the RB1-MS deep well (1 CFU/100mL). Coliform bacteria were not detected in water samples from RB1-MS shallow, RB1-MN shallow and deep, or IW-09 shallow and deep wells (Ziegler and others, 2010).

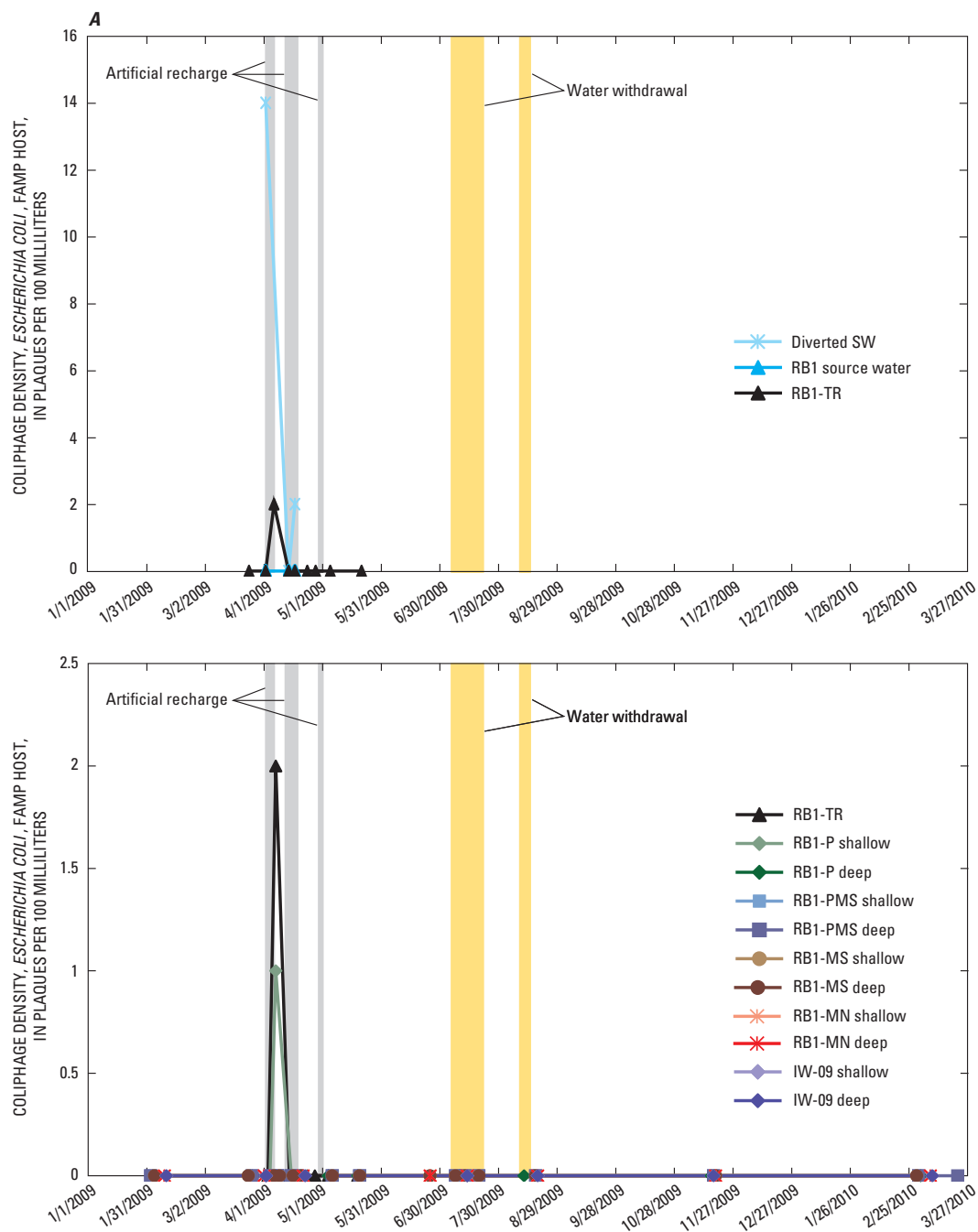


Figure 8. Indicator organism densities in water samples collected from study area during 2009–2010; (A) Coliphage, *Escherichia coli*, Famp host (single agar layer method) (B) Coliphage, *Escherichia coli*, C13 host (single agar layer method) (C) *Clostridium perfringens* (*Clostridium perfringens* agar membrane filtration method).

During January, February, and March of 2009, after installation of RB1-TR, RB1-P well, and RB1-PMS monitoring sites but before artificial recharge water was pumped into the trench, total coliform, fecal coliform, or *E. coli* bacteria were detected in about 28 percent of samples (12 of 43) from RB1-TR, RB1-P well (shallow and deep sampling depths), and RB1-PMS shallow and deep wells. Counts ranged from 1 to 59 CFU/100 mL. The count of 59 CFU/100 mL was measured in the RB1-P well (shallow sampling depth) immediately after

well installation. About 9 percent of samples (3 of 32) from the RB1-MS, RB1-MN and IW-09 wells had detectable total coliform, fecal coliform, or *E. coli* bacteria.

Neither *Clostridium perfringens* bacteria nor coliphage virus were detected in water from any wells. Infiltration of rainfall was the only source of water to the trench and passive recharge system during this time, indicating the likely source of the bacteria was the trench fill material.

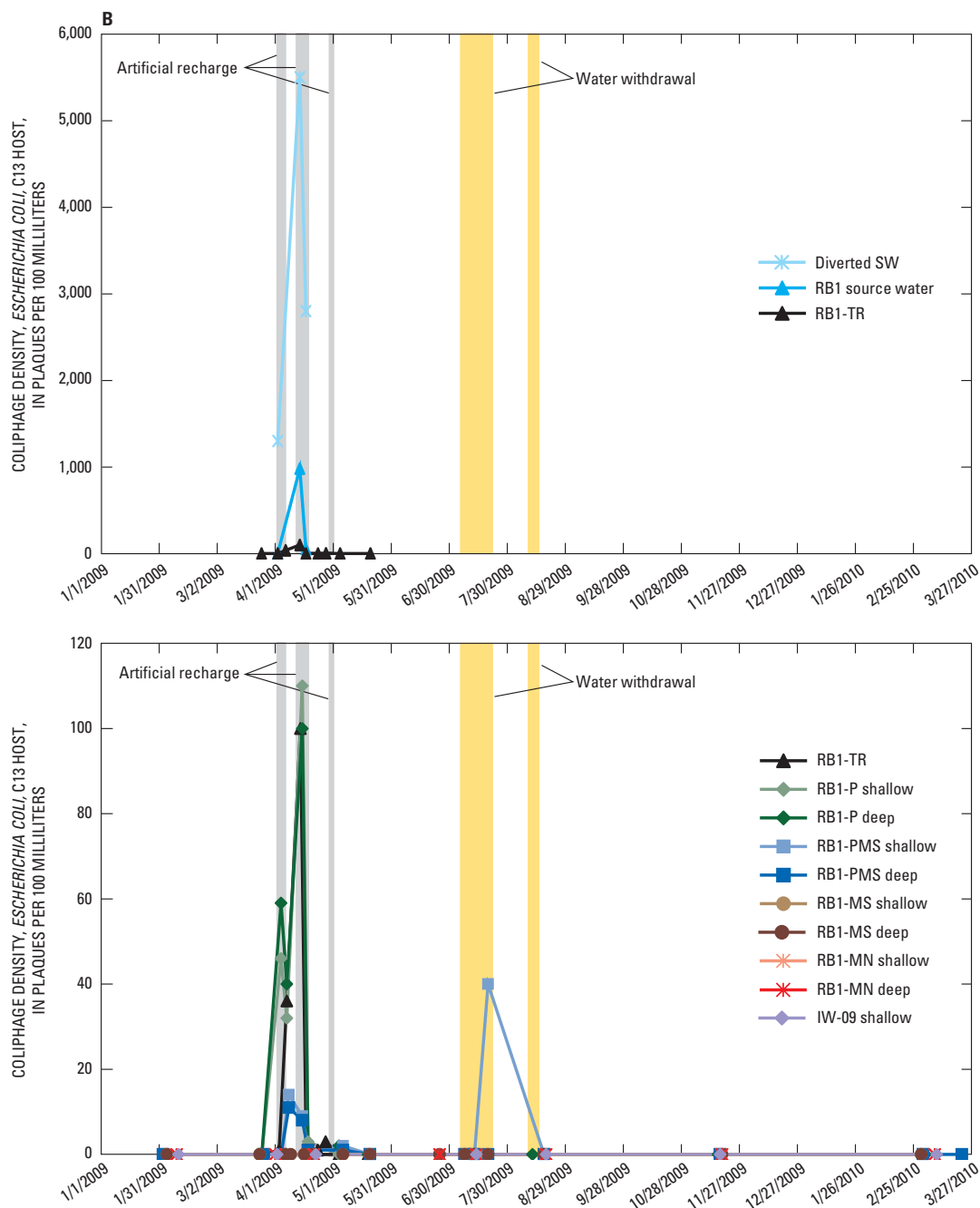


Figure 8. Indicator organism densities in water samples collected from study area during 2009–2010; (A) Coliphage, *Escherichia coli*, Famp host (single agar layer method) (B) Coliphage, *Escherichia coli*, C13 host (single agar layer method) (C) *Clostridium perfringens* (*Clostridium perfringens* agar membrane filtration method).—Continued

During Artificial Recharge

The City of Wichita reported that a total of 576,308 gal of treated surface water was used to test the passive well and trench system at RB1: 244,312 gal were recharged April 3–5, 2009; 291,578 gal April 13–17, 2009; and 40,418 gal on April 30, 2009. During the recharge period, water samples collected of RB1 source water had total coliform counts ranging

from 37 to 108 CFU/100 mL, and fecal coliform counts ranging from 22 to 196 CFU/100 mL.

Analysis of water samples collected from RB1-TR, RB1-P well (shallow and deep sampling depths), and RB1-PMS wells during April of 2009 had total coliform bacteria counts ranging from 7 to >120 CFU/100 mL of sample. Most of these samples also had detectable fecal coliform (<1 to 11 CFU/100 mL) and *E. coli* (<1 to 13 CFU/100 mL).

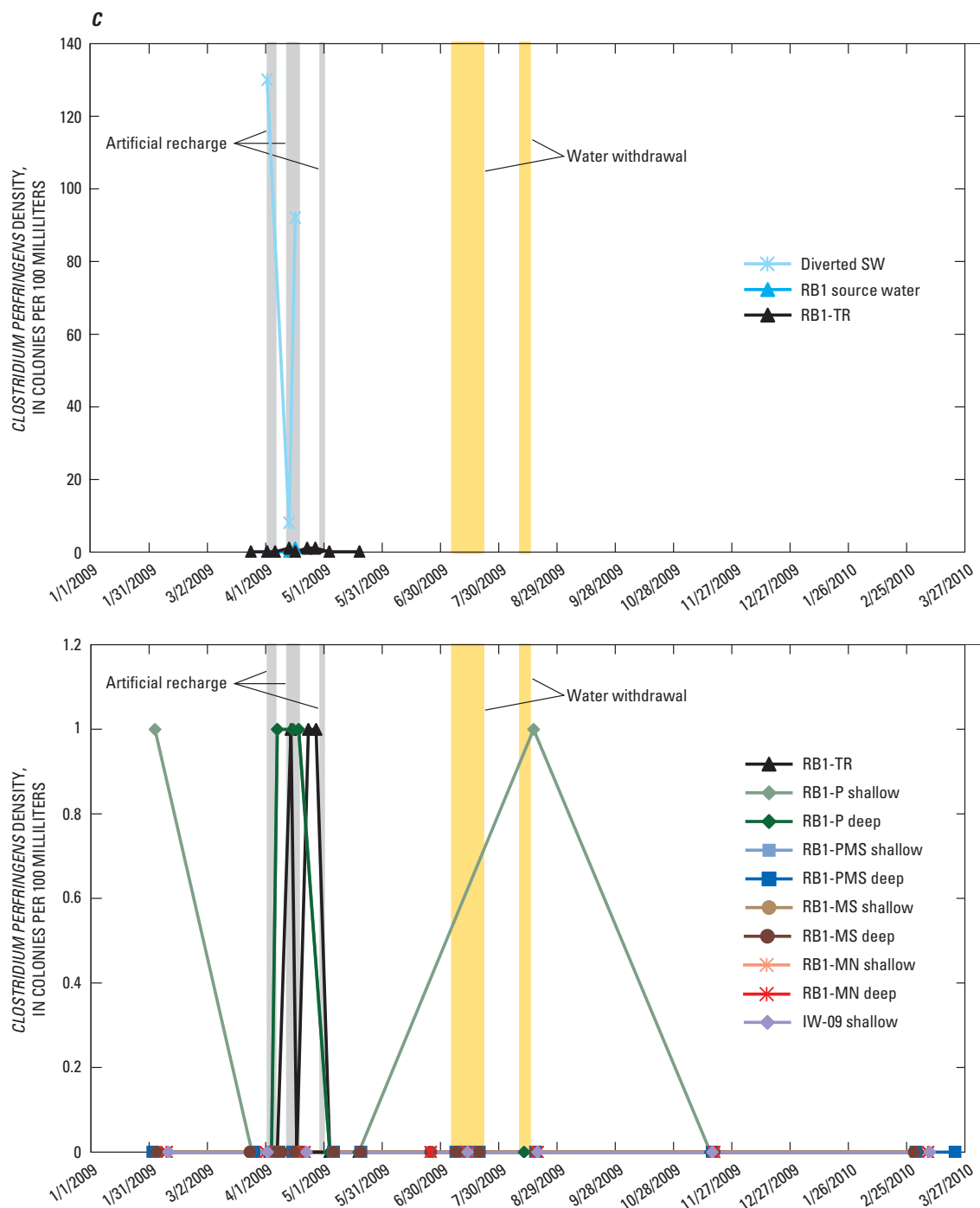


Figure 8. Indicator organism densities in water samples collected from study area during 2009–2010; (A) Coliphage, *Escherichia coli*, Famp host (single agar layer method) (B) Coliphage, *Escherichia coli*, C13 host (single agar layer method) (C) *Clostridium perfringens* (*Clostridium perfringens* agar membrane filtration method).—Continued

Coliphage virus was present in all samples (1 to 100 CFU/100 mL) from RB1-TR, RB1-P well (shallow and deep sampling depth), and RB1-PMS wells collected during April 2009. Water samples from the RB1-MS wells, the RB1-MN wells, and the IW-09 wells had no detectable indicator bacteria or coliphage virus during April 2009.

After Artificial Recharge and Before Water Withdrawal

Water samples collected from RB1-TR, RB1-P well (shallow and deep sampling depths), and RB1-PMS wells during May and June of 2009 had total coliform bacteria counts ranging from <1 to 50 CFU/100 mL of sample. One sample

also had detectable fecal coliform and *E. coli*. Coliphage virus was detected in three samples (one from RB1-P deep, one from RB1-PMS shallow, and one from RB1-PMS deep) collected in early May 2009. Coliform bacteria was detected in two samples collected from the RB1-MS shallow well during May 2009, but fecal coliform, *E. coli*, and coliphage virus were not detected. No detections of viruses or bacteria were measured in the RB1-MS deep well, the RB1-MN wells, or the IW-09 well during May and June, 2009.

During Water Withdrawal

The trench system was disconnected from the RB1-P well on July 8, 2009, and the passive well recharge system was no longer functional after this date. Approximately 1,500,000 gallons of water were pumped out of the *Equus* Beds aquifer at RB1 through the RB1-P well July 7–21, 2009, and 325,000 gallons were removed August 11–14, 2009. Samples were collected of water removed from the aquifer (labeled RB1-P deep well on figures 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15 during this time period) and from all RB1 monitoring wells. Water samples collected from the RB1-P well (labeled deep sampling depth) between July 1 and August 14 had total coliform detections ranging from <1 to 17 CFU/100 mL and from <1 to 5 MPN (most probable number)/100 mL of sample, and there was a detection of fecal coliform (1 CFU/100 mL) in the sample collected on July 20, 2009.

Total coliform bacteria were detected in water samples collected from RB1-PMS shallow well (<1 to 2,000 CFU/100 mL and >200 to >2,400 MPN/100 mL) and RB1-PMS deep well (43 to 690 MPN/100 mL and <1 to 37 CFU/100 mL) on July 8, 13, and 20, 2009. Fecal coliform bacteria were detected in the sample collected from the RB1-PMS shallow well on July 13, 2009 (3 CFU/100 mL), and coliphage virus (40 PFU/100mL (plaque-forming units per 100 milliliters)) and *E. coli* (1 CFU/100 mL) were detected in the July 20 sample.

Coliform bacteria were detected in the water samples collected from the RB1-MS shallow well (<1 to 32 MPN/100 mL and <1 to 17 CFU/100 mL) and RB1-MS deep well (15 to >200 MPN/100 mL and <1 to 8 CFU/100 mL) on July 13 and 20, 2009. Coliphage virus was not detected in samples from the RB1-MS, RB1-MN, or IW-09 wells. No virus or bacteria were detected in samples collected from RB1-MN or IW-09 wells during water withdrawal.

After Water Withdrawal

Pumping from the RB1-P well was discontinued on August 14. Coliform bacteria was detected in water samples collected from the P-well (shallow and deep sampling depths), RB1-PMS wells, and RB1-MS wells about 3 days after pumping was discontinued (1 to 20 CFU/100 mL and 1 to 200 MPN/100 mL). *Clostridium perfringens* was detected in the RB1-P well (shallow sampling depth) (1 CFU/100 mL).

There were no detections of coliphage virus, fecal coliform, or *E. coli* in late August samples. A sample set was collected November 16–18, 2009, about 3 months after pumping was discontinued. Total coliform bacteria ranging from 1 to 20 CFU/100 mL and 1 to 100 MPN/100 mL were measured in samples from the RB1-P well (shallow sampling depth), the RB1-PMS shallow and deep wells, and the RB1-MS deep well. Fecal coliform was detected in the IW-09 shallow and deep wells (1 to 2 CFU/100 mL) and in the RB1-PMS deep well (1 CFU/100 mL). *Clostridium perfringens*, coliphage virus, and *E. coli* were not detected in any samples collected November 16–19, 2009. Total coliform was detected (120 CFU/100 mL) in water from the RB1-PMS deep well in samples collected March 2, 2010, but a sample collected on March 22, 2010, had no detections. Coliphage and *Clostridium perfringens* were not detected in either sample collected from the RB1-PMS deep well during March 2010. No detections of bacterial or viral indicators were made in samples collected from RB1-P well (shallow and deep sampling depths), RB1-PMS shallow well, RB1-MS shallow and deep wells, RB1-MN shallow and deep wells, and IW-09 shallow and deep wells during on March 2010.

Biological Activity Reaction Tests (BART)

Iron-related and sulfate-reducing bacteria are a natural part of the environment and may enter an aquifer through wells or other interaction with the surface. When these bacteria enter an environment with conditions suitable to growth they multiply. The many types of iron-related bacteria use iron in their metabolism and grow best in water with large iron content. They tend to colonize on well and pump surfaces and can cause slime and unpleasant odors and tastes. They may deposit iron oxide on surfaces or produce corrosive acids. Many types can substitute nitrates for oxygen during metabolism, and therefore, can grow in aerobic or anaerobic environments. Enteric bacteria are bacteria that normally or pathogenically live in the intestines of animals. Some types of iron-related bacteria are also enteric bacteria. Sulfate-reducing bacteria reduce sulfates, usually in anaerobic and reducing conditions, to obtain energy. A by-product of their metabolism is corrosive hydrogen sulfide (Cullimore, 2007).

This report describes the results of the IRB-BART with respect to iron-related enteric bacteria and potential iron-related well-fouling bacteria and SRB-BART for potential well-fouling sulfate-reducing bacteria. Results of BART are shown in table 7 at the back of this report.

Enteric bacteria were detected by IRB-BART in about 12 percent (3 of 26) of water samples collected before artificial recharge (fig. 9A). During artificial recharge, the percentage of samples with detections of enteric bacteria increased to 43 percent (17 of 40), and decreased to about 21 percent (4 of 19) after artificial recharge was discontinued but before water was withdrawn from the aquifer at RB1. IRB-BART were positive for enteric bacteria in about 53 percent

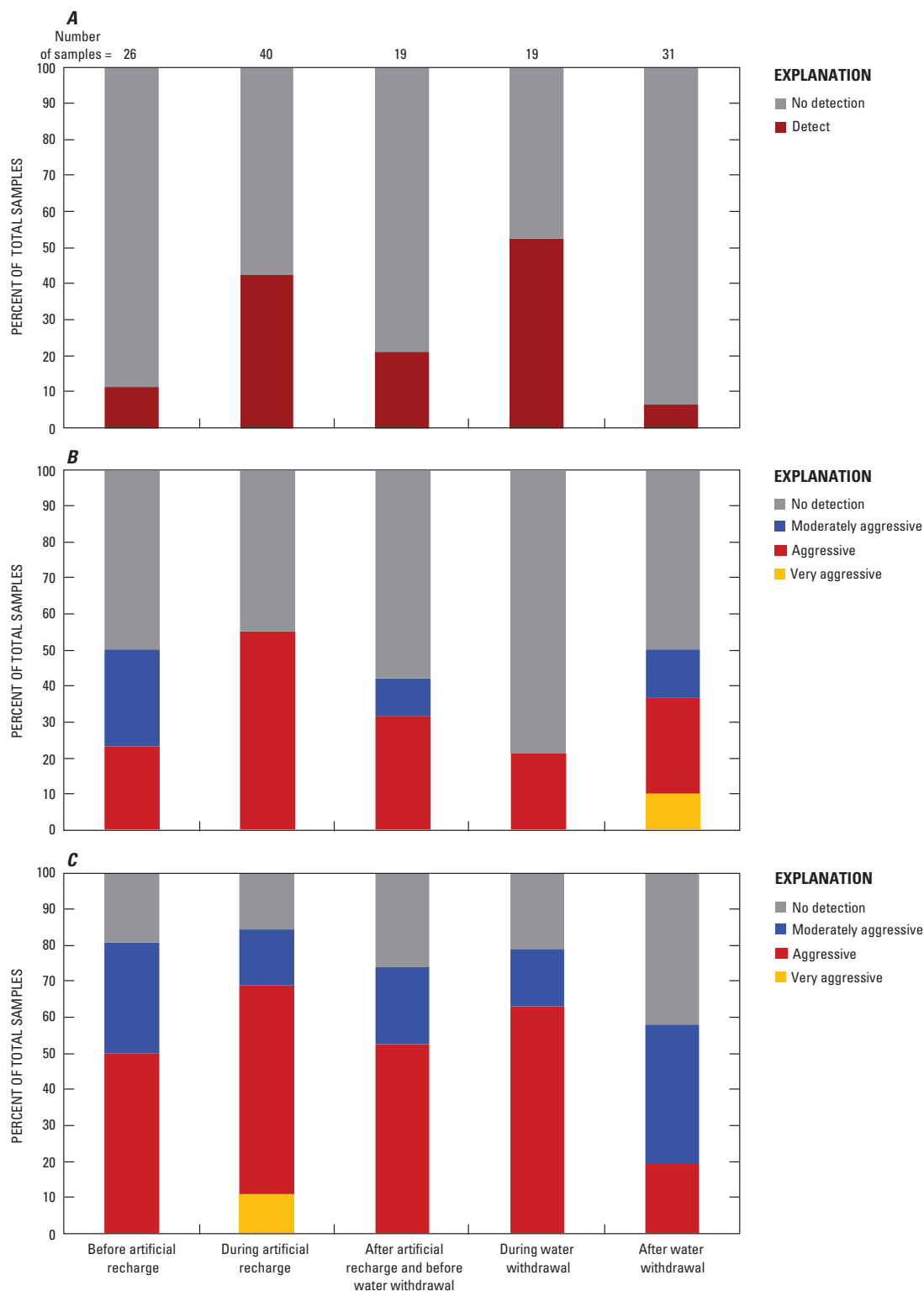


Figure 9. (A) IRB BART, Percentage of samples with detections of enteric bacteria; (B) IRB BART, Detections of potential well-fouling iron-related bacteria; (C) SRB BART, Detections of sulfate-reducing bacteria.

(10 of 19) of samples collected from the RB1 sites during water withdrawal from the aquifer. These detections were in samples collected from the RB1-P well (shallow and deep sampling depths), the RB1-PMS shallow and deep wells, and RB1-MS deep wells. About 6 percent (2 of 31) of IRB-BART

samples collected after water withdrawal had detections of enteric bacteria, less than the percentage of detections before artificial recharge.

IRB-BART results can also indicate the presence of slime- or corrosion-producing iron-related bacteria. When a

positive reaction for these iron-related bacteria occurred, the number of days from sample collection to the first reaction was recorded. If a positive reaction occurred within 2 days, the IRB bacteria were considered very aggressive; 3 or 4 days, aggressive; 5 to 8 days, moderately aggressive. Potentially well-fouling IRB were detected in 47 percent of IRB-BART samples (fig. 9B). Most of these populations were moderately aggressive to aggressive, although very aggressive populations were present in samples collected from the RB1-P well (shallow and deep sampling depths) and RB1-MS shallow well immediately after water withdrawal. In general, wells with smaller average numbers of IRB were those located upgradient or laterally removed from artificial recharge activities (IW-09 and RB1-MN wells) suggesting that the passive well artificial recharge activities increased the IRB populations in the aquifer, possibly because of additional nutrients and oxygen-rich water.

Sulfate-reducing bacteria were detected in most (78 percent) of the RB1 water samples tested with SRB-BART. Very aggressive populations (1 day to reaction) were found in water samples collected during artificial recharge. Aggressive populations (2 to 4 days to reaction) were found in all periods and were present in about one-half of all water samples tested. Although SRB grow in anaerobic environments, populations were smaller in water samples from wells located upgradient or laterally removed from the passive gravity recharge well artificial recharge (IW-09 and RB1-MN wells) and the oxygenated water.

Select Major Ions, Trace Elements, and Organic Compounds

Environmental changes that may occur as a result of artificial recharge activities are evaluated through analysis of major ions, trace metals, and organic compounds. Results of laboratory analysis for major ions (chloride), trace elements (arsenic and iron), and organic compounds (atrazine) in water samples collected as part of this evaluation are presented in tables 8 and 9 at the back of this report. Piper diagrams on figure 10 show the relative concentrations and changes in major ions that occur in the RB1 area during the evaluation of the passive gravity recharge well system. The water chemistry of the RB1-MN shallow and deep, and RB1-MS shallow and deep wells remained relatively constant through all periods (before artificial recharge, during artificial recharge, after artificial recharge and before water withdrawal, during water withdrawal, and after water withdrawal). The geochemistry of the water sampled from RB1-TR, RB1-P well (shallow and deep sampling depths), and RB1-PMS wells indicated evidence of having been affected by the recharge water after artificial recharge began with a greater percent concentration of chloride, sodium, and sulfate, and relatively lesser amounts of calcium and bicarbonate. After recharge ceased, but before water was withdrawn from the aquifer, concentrations returned to values similar to those before recharge. The group of points

visible on figure 10C that retain a greater proportion of sulfate represent samples collected 4 days after recharge was discontinued. When water was being withdrawn from the aquifer, concentrations of chloride increased in the withdrawn water (labeled RB1-P deep well on figures 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15 during this time period) and in the RB1-PMS shallow and deep wells. Although the Piper diagrams of the water samples collected from the RB1-P well (shallow and deep sampling depths), and the RB1-PMS shallow and deep wells are similar to the RB1-MN shallow well, the concentration of iron samples is dissimilar. This trend is discussed further in the “Chloride” and “Effects of Experimental Passive Artificial Recharge: Synthesis” sections of the report. In addition, during water withdrawal the water chemistry in the withdrawn water (RB1-P deep sampling depth) and RB1-PMS wells was similar. This trend may be the result of water “recycling”: water removed from the aquifer through the RB1-P well was placed in a basin adjacent to the trench and passive well, and then was drawn back into the aquifer because of pumping and later removed again.

After water withdrawal, concentrations of the major ions in the RB1 wells returned to values similar to those before artificial recharge through the passive well began. Before water withdrawal the trench was disconnected from the RB1-P well, and RB1-TR was not sampled.

Chloride

The USEPA recommends a maximum concentration of 250 mg/L for chloride ions to avoid undesirable taste (U.S. Environmental Protection Agency, 1986). In addition to a salty taste in drinking water, large concentrations of chloride (>350 mg/L) make water unusable for irrigation purposes (Bauder and others, 2007).

The primary sources of chloride to the *Equus* Beds aquifer are underlying rocks of the Wellington Formation, the Arkansas River, municipal wastewater treatment, and waste associated with previous oil and natural gas extraction near Burrton (Ziegler and others, 1999; Whittemore, 2007). The chloride plume near Burrton (fig. 1) has migrated downgradient about 3 miles in 40 to 45 years, but the migration has slowed since 1992 because of a decrease in hydraulic gradient caused by decreased pumping of wells downgradient from the plume. Geographic placement of the first phase of full-scale recharge facilities should further decrease the gradient and slow saltwater migration from the Burrton plume (Ziegler and others, 2010).

Chloride concentrations in samples collected from RB1 sites during 2009 were all less than 250 mg/L (fig. 11). The RB1-MN shallow well (60 ft depth) consistently had the greatest chloride concentration with values ranging from 150 to 170 mg/L. This well is located in the northwest part of the RB1 study area (fig. 2) and is the closest to the Burrton brine plume, geographically. Ziegler and others (2010) report that the Burrton chloride plume has reached the RB1 area in the shallow aquifer before the deep aquifer. The larger

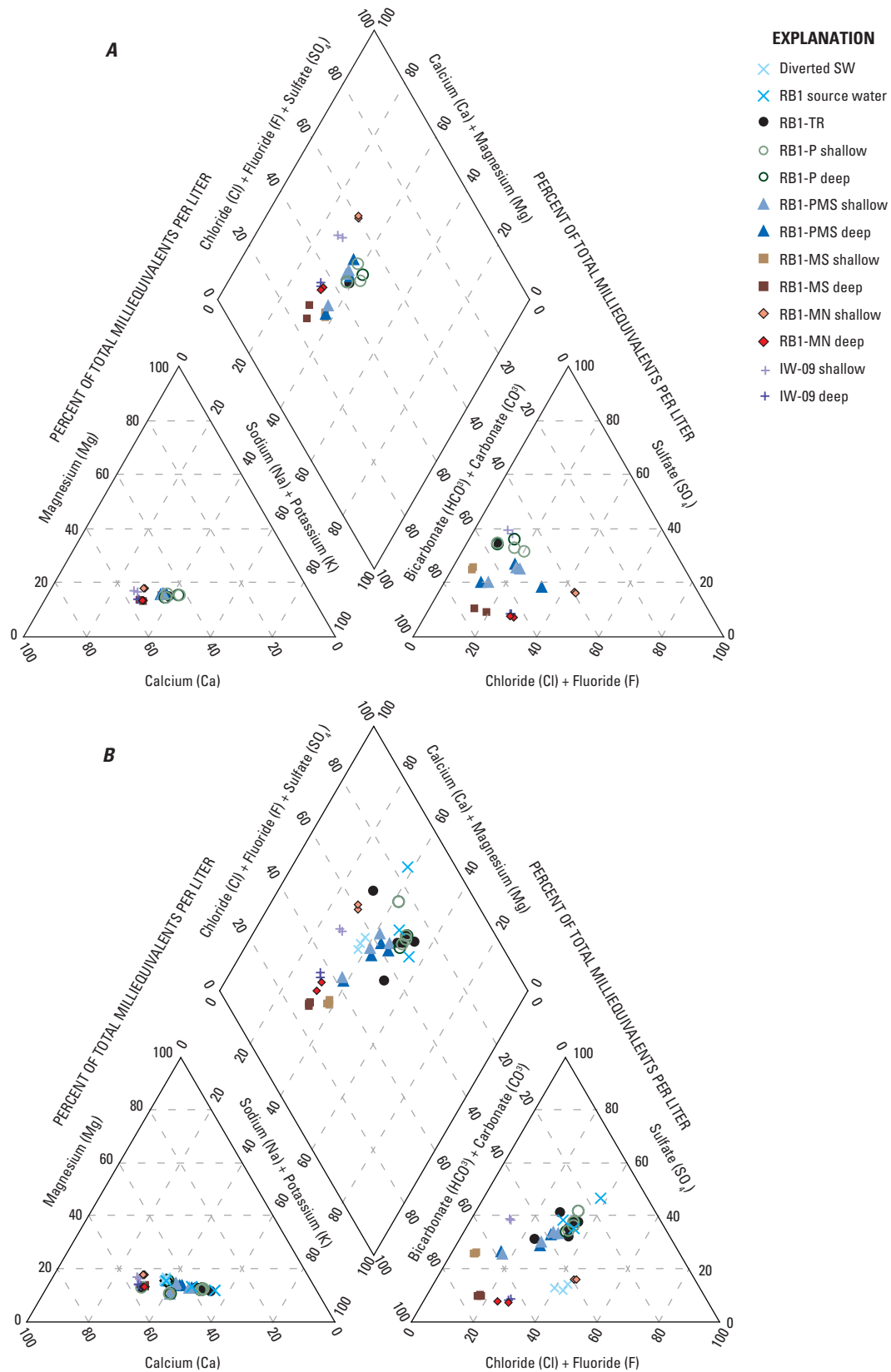


Figure 10. Major ion chemistry of water samples from RB1 area wells (A) before artificial recharge (B) during artificial recharge (C) after artificial recharge and before water withdrawal (D) during water withdrawal (E) after water withdrawal.

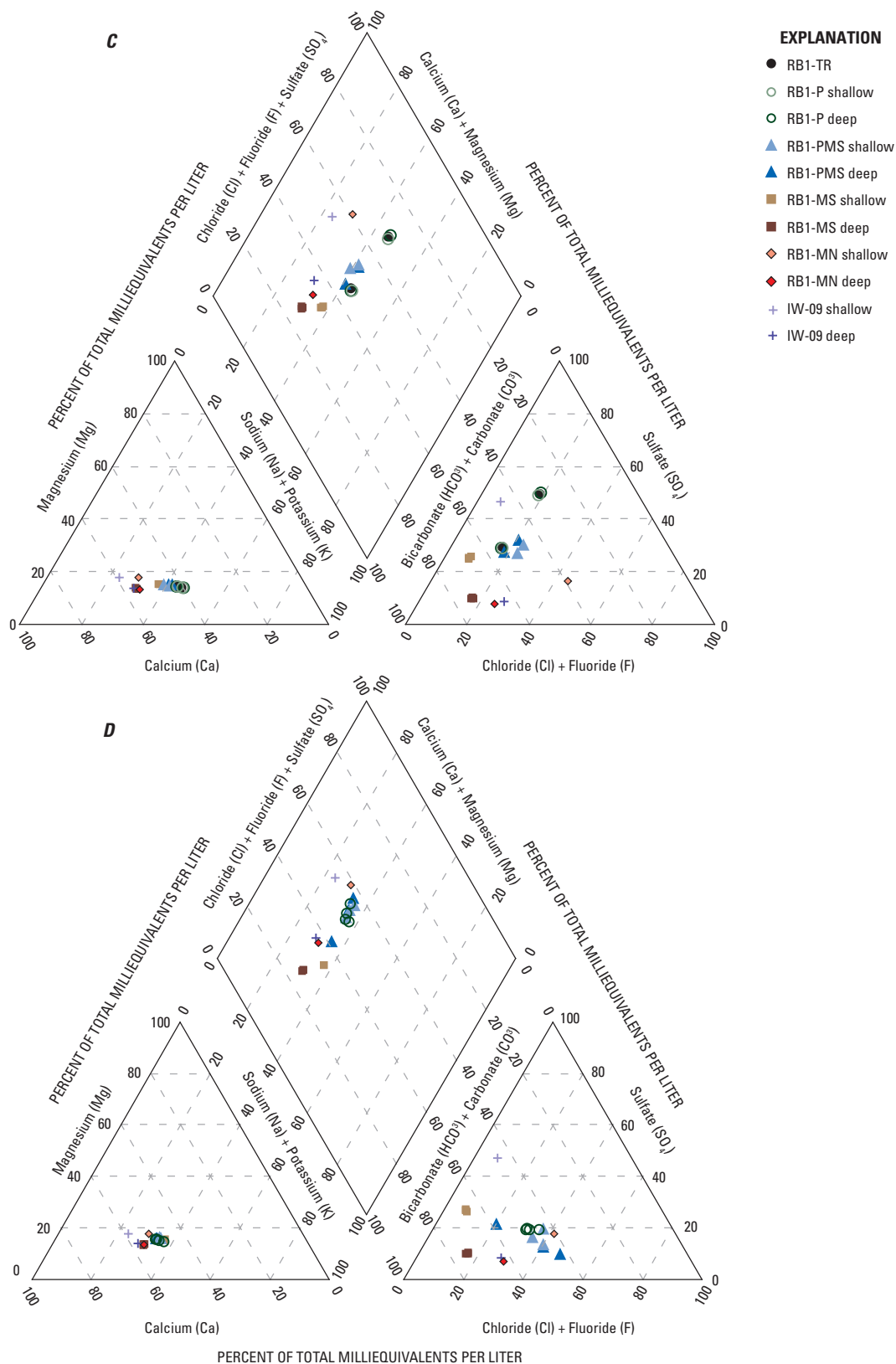


Figure 10. Major ion chemistry of water samples from RB1 area wells (A) before artificial recharge (B) during artificial recharge (C) after artificial recharge and before water withdrawal (D) during water withdrawal (E) after water withdrawal.—Continued

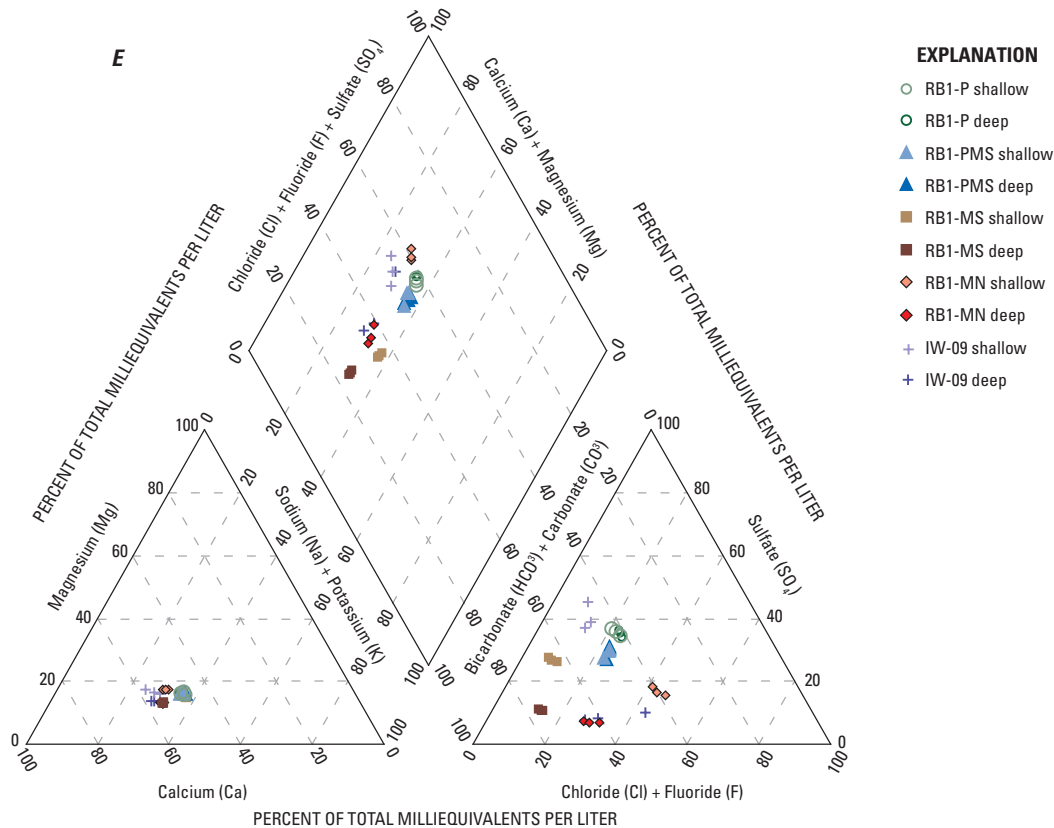


Figure 10. Major ion chemistry of water samples from RB1 area wells (A) before artificial recharge (B) during artificial recharge (C) after artificial recharge and before water withdrawal (D) during water withdrawal (E) after water withdrawal.—Continued

concentration of chloride in the shallow zone of some parts of the aquifer may be because of the hydraulic gradient or discontinuous clay layers that locally limit the downward migration of saltwater (Ziegler and others, 2010).

Baseline water samples collected from IW-09 shallow and deep wells, RB1-MN shallow and deep wells, and RB1-MS shallow and deep wells, before artificial recharge had chloride concentrations ranging from 12 to 160 mg/L (table 8, at the back of this report). The concentration of 160 mg/L was measured in the RB1-MN shallow well; all other concentration values were 75 mg/L or less. Chloride concentrations in the Little Arkansas River, calculated from specific conductance values, changed rapidly when precipitation occurred. During the period of artificial recharge, chloride concentrations of 8.5 to 202.0 mg/L were calculated from measurements of SC in the river. Average concentrations for the three recharge periods, as calculated from SC, were 92.6, 93.5, and 33.1 mg/L respectively. Chloride concentrations in RB1 source water were 62–94 mg/L. When this water entered the RB1 passive recharge system during artificial recharge, chloride concentrations increased from an average of 34 mg/L to an average of 64 mg/L in RB1-TR, RB1-P well (shallow and deep sampling depths). Concentrations in other RB1 wells did not change substantially. During May and June 2009, after artificial

recharge and before water withdrawal, concentrations of chloride in water samples returned to pre-recharge levels.

During water withdrawal, chloride concentrations in the RB1-PMS wells increased to values larger than those in RB1 source water. A mass-balance calculation was performed to ascertain whether this large chloride concentration could be because of artificial recharge. The overall equation used to evaluate the balance of chloride into or out of the aquifer at RB1 is:

$$Cl_w = Cl_{bg} + Cl_r + Cl_o \quad (7)$$

where:

- Cl_w is the quantity of dissolved chloride withdrawn from the aquifer (grams);
- Cl_{bg} is the background quantity of dissolved chloride present in the groundwater before artificial recharge (grams);
- Cl_r is the quantity of chloride in water artificially recharged (grams); and
- Cl_o is the quantity of dissolved chloride from other source (grams).

Values of SC in the Little Arkansas River were used to calculate chloride concentrations in the treated water used

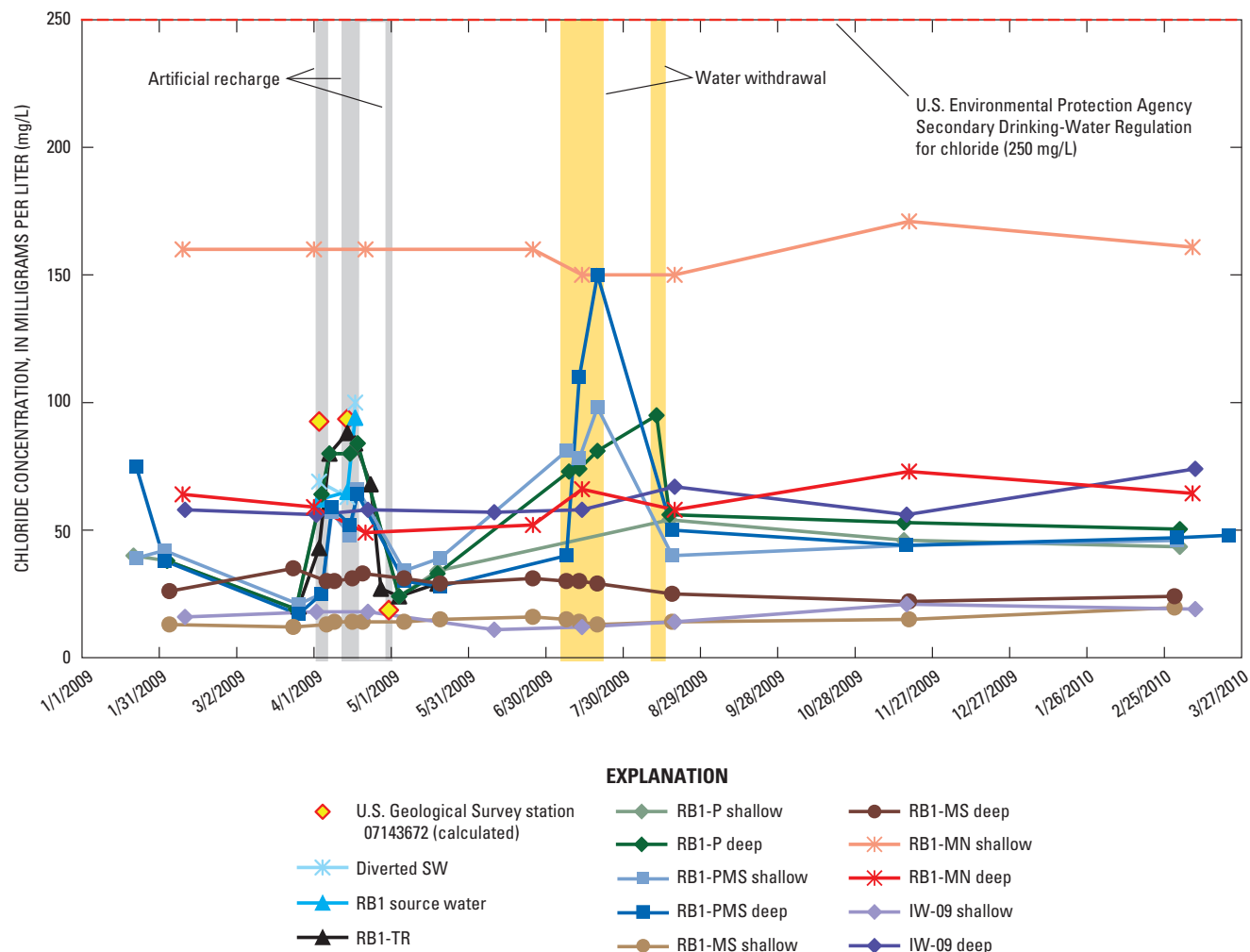


Figure 11. Measured chloride concentrations in water samples collected from RB1 monitoring sites, January 2009 through March 2010.

for recharge. The approximate mass of chloride in the water pumped out of the aquifer in July and August (Cl_w) was 524,400 grams (g) (computed from the quantity of water pumped out and laboratory measurements of chloride concentration in samples collected of the withdrawn water). The approximate mass of chloride added to the aquifer in the artificial recharge water (Cl_r) was 191,700 g (calculated from the quantity of water recharged and the average chloride concentration in the Little Arkansas River during times of recharge). The average background concentration of chloride in groundwater at RB1 (Cl_{bg}), estimated from values measured in water samples collected from the RB1-MS shallow and deep wells before artificial recharge began, is 31 mg/L, and the estimated background mass of chloride in the water pumped from the aquifer is 216,000 g. The difference between the total mass pumped from the aquifer and the background mass of chloride is 308,400 g. The difference between the mass of chloride added, and the mass pumped out (greater than the background mass) is 116,700 g (308,400–191,700). In other words, 116,700 g (257 pounds (lb)) more chloride was pumped from

the aquifer than can be accounted for by artificial recharge water and the background concentration. This indicates that an additional source of water with large chloride concentration relative to that at the RB1-MS wells exists in the aquifer at the RB1 site.

When water was being pumped out of the aquifer through the RB1-P well, chloride concentrations in the RB1-P well (measured in the water withdrawn), and in the RB1-PMS shallow and deep wells increased. One sample from the RB1-PMS deep well had a concentration of 150 mg/L, substantially more than the chloride concentration in the recharge water and the average computed chloride values in the Little Arkansas River, and similar to the concentration in the RB1-MN shallow. This large chloride concentration and the mass balance exercise indicate that as water was being pumped out of the RB1-P well, water with a large chloride concentration from elsewhere in the aquifer was flowing toward the RB1-P and RB1-PMS wells. Although chloride concentrations were similar in samples collected from the RB1-PMS deep well and RB1-MN shallow well during water withdrawal in July (150 mg/L and

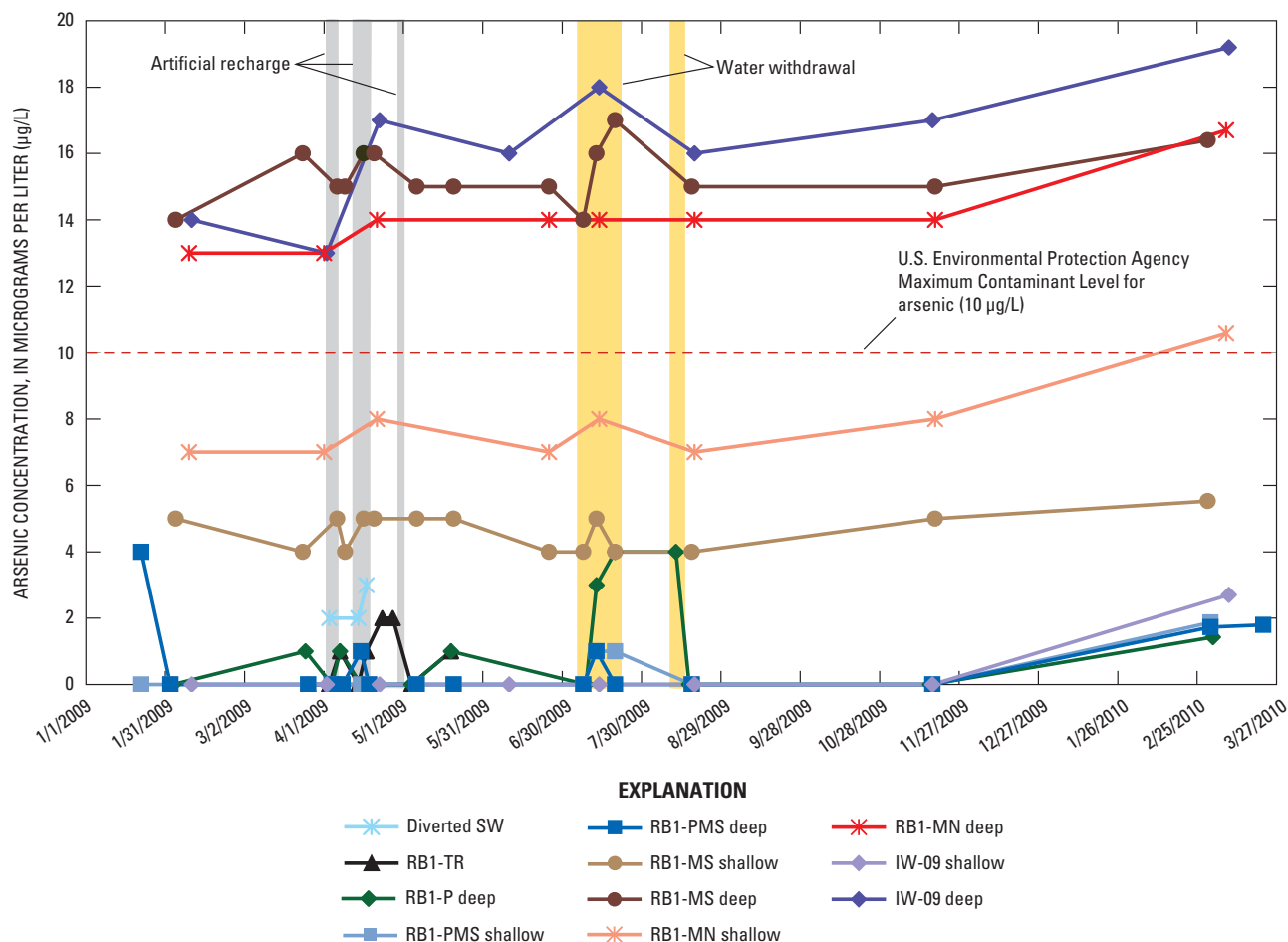


Figure 12. Measured arsenic concentrations in water samples collected from RB1 monitoring sites, January 2009 through March 2010.

160 mg/L, respectively), iron concentrations were not similar (<100 micrograms per liter (µg/L) and 4,370 µg/L, respectively). Samples collected from the RB1-PMS deep well were all undersaturated with respect to iron hydroxide, indicating that precipitation of iron hydroxide had not recently occurred, and suggesting that the water sample from the RB1-PMS deep well with the unusually large chloride value was not from the RB1-MN shallow area. Current data indicates that short-term chloride concentrations in groundwater in the RB1 area have not been affected by passive-recharge activities.

Arsenic

Arsenic is an undesirable constituent in drinking water because it is toxic to humans in small amounts. Exposure to arsenic has been linked to an increased risk of cancer, circulatory problems, and skin damage (U.S. Environmental Protection Agency, 2005). In 2006, the USEPA reduced the Federal MCL for arsenic from 50 to 10 µg/L. Arsenic occurs as a natural part of the environment and is thought to occur naturally in clay layers in the *Equus* Beds aquifer (Schmidt and others, 2007). The mobility and dissolution of arsenic

in a groundwater environment is largely dependent on pH, redox reactions, and competing ions in the environment (Hem, 1992). Artificial recharge activities can alter these properties and increase or decrease the concentration of arsenic in the groundwater through dissolution, precipitation, adsorption, or desorption of arsenic compounds.

Concentrations of arsenic in the Diverted SW samples collected during April 2009 were 2 to 3 µg/L (fig. 12). Arsenic concentrations from RB1 source water samples were less than the reporting level of 1 µg/L. Concentrations of arsenic in samples collected from the deeper part of the aquifer at RB1 (IW-09 deep, RB1-MS deep, and RB1-MN deep) were above the MCL and ranged from 13 to 18 µg/L. Concentrations do not change substantially with time and do not appear to have been affected by artificial recharge activities. Concentrations of arsenic in all wells were less than the MCL of 10 µg/L and ranged from <1 µg/L to 8 µg/L. The concentration of arsenic in the RB1-P well (deep sampling depth) increased when water was being pumped from the aquifer, yet saturation indices indicate that the water is undersaturated with respect to the arsenic-containing mineral scorodite (details in the “Geochemical Simulations” section), indicating that water from

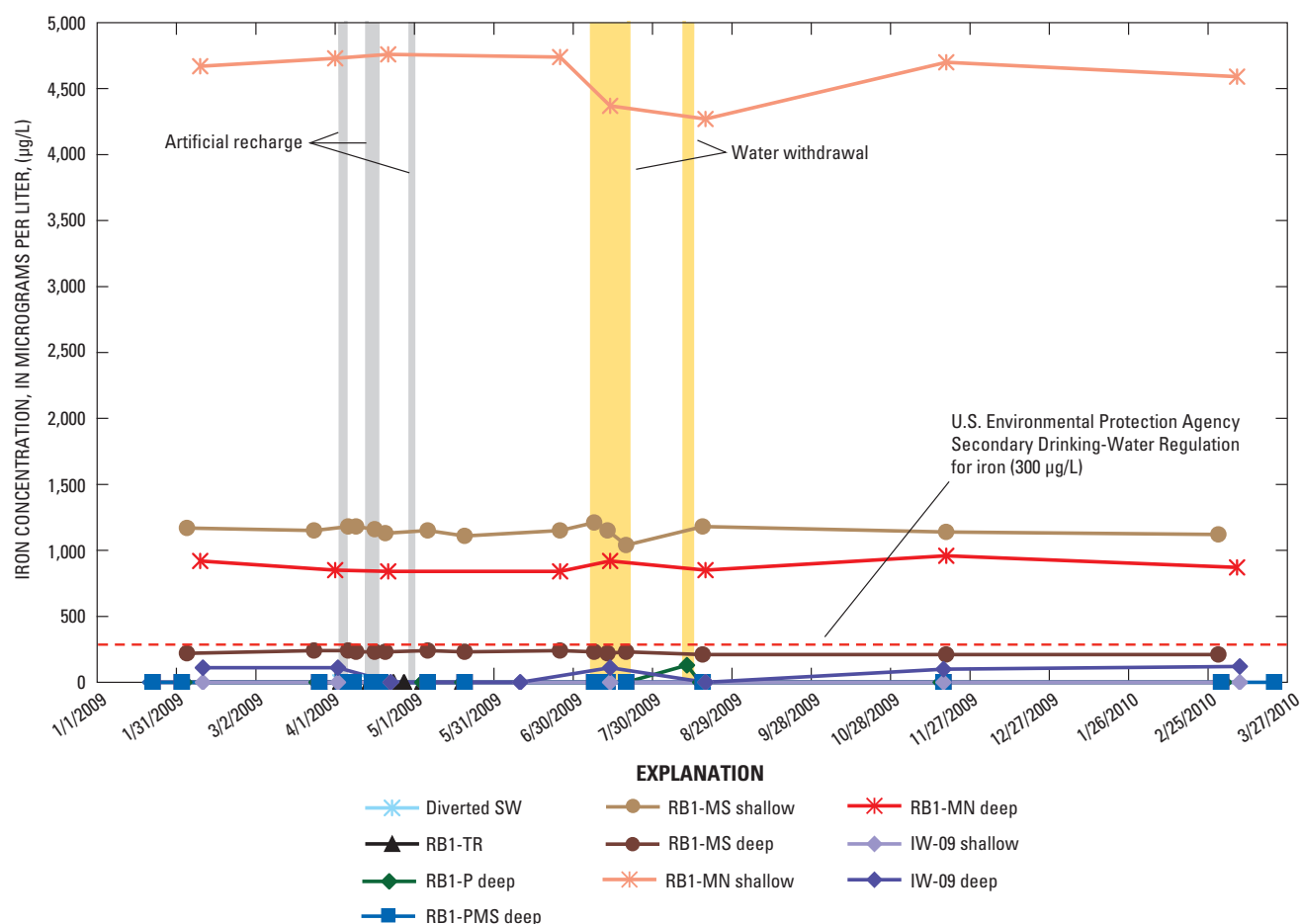


Figure 13. Measured iron concentrations in water samples collected from RB1 monitoring sites, January 2009 through March 2010.

other parts of the aquifer with greater concentrations of arsenic replaced water being pumped out. The oxygenated source water and rainwater that infiltrated into the aquifer at RB1 did not cause substantial changes in arsenic concentrations in any well in the RB1 area.

Iron

Iron is a constituent of concern in the *Equus* Beds aquifer. Water containing excessive concentrations of iron is unpleasant to drink because of odor, metallic taste, and rusty color. The SDWR for iron is 300 µg/L (U.S. Environmental Protection Agency, 2005). At concentrations exceeding the USEPA SDWR, iron forms red hydroxide precipitates in water that stain laundry and plumbing fixtures. Iron dissolved in groundwater is greatly affected by environmental conditions, especially ORP and pH (Hem, 1992), which in turn can be affected by the introduction of oxygenated recharge water. Bacterial activity also may affect the concentration of iron in water (Hem, 1992) and can be of particular concern in artificial recharge operations. The addition of oxygenated water to a system can create favorable conditions for increased bacterial

activity, which can produce biofilms that can clog well screens (Ross Schmidt and others, 2007).

Concentrations of iron in water RB1 samples collected before artificial recharge range from below the reporting level of 100 µg/L (RB1-P (shallow and deep sampling depths), RB1-PMS shallow) to 4,670 µg/L (MN shallow) (fig. 13). Samples from RB1 recharge water contained no measurable iron in solution. During artificial recharge, iron concentrations in all wells remained similar. Groundwater samples from RB1-MN shallow, RB1-MN deep, and RB1-MS shallow wells maintained concentrations of dissolved iron greater than the SDWR of 300 µg/L, and those from RB1-TR, RB1-P well (shallow and deep sampling depths), RB1-PMS wells, RB1-MS deep and IW-09 wells were less than the SDWR with detections ranging from no detection to 240 µg/L. Iron concentrations in groundwater samples collected after artificial recharge and before water withdrawal remained similar for each site; however, IRB BART suggest that IRB populations are affected and are more aggressive after recharge. This indicates artificial recharge may result in some clogging of well screens at locations with similar geochemistry.

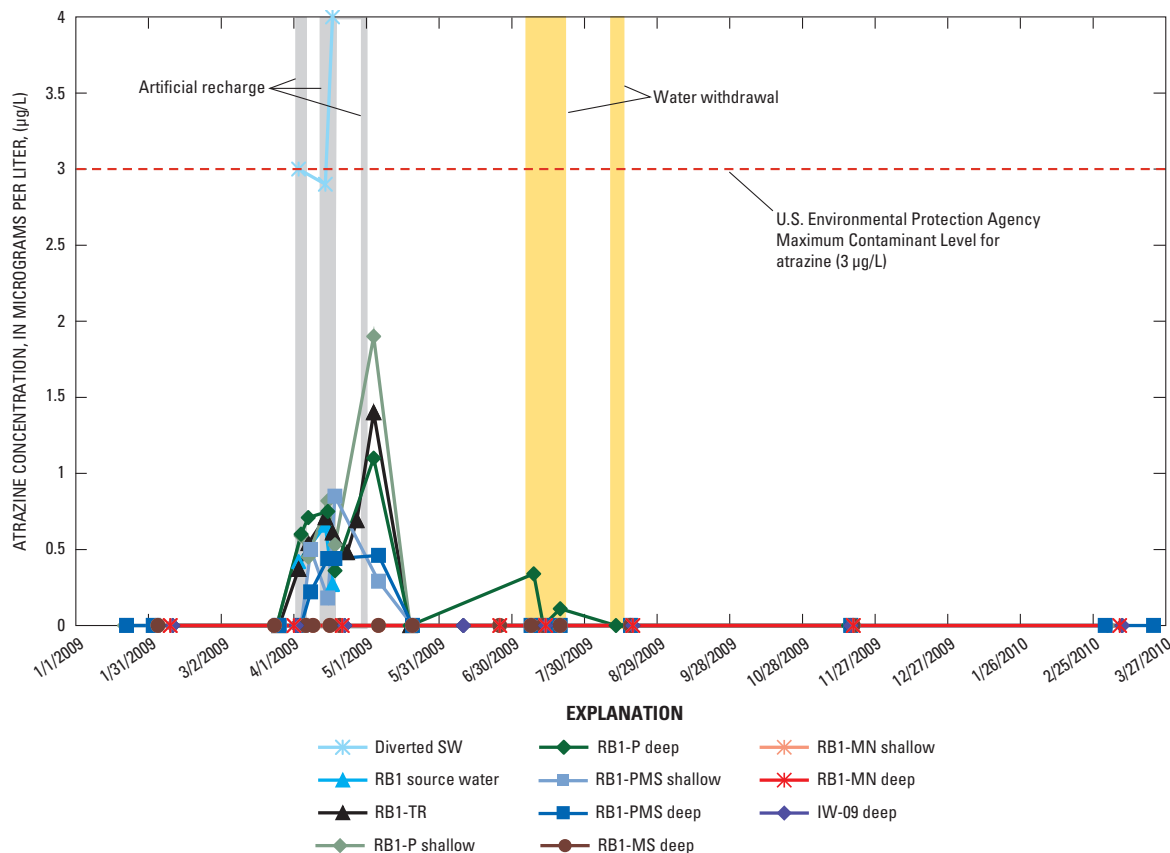


Figure 14. Measured atrazine concentrations in water samples collected from RB1 monitoring sites, January 2009 through March 2010.

Atrazine

Atrazine is a manmade herbicide used for control of broadleaf and grassy weeds in food crops such as corn and grain sorghum. It does not occur naturally in the environment. Atrazine can cause damage to internal organs in humans (USEPA Web site <http://www.epa.gov/ogwdw000/pdfs/factsheets/soc/tech/altrazine.pdf>). The Federal MCL in drinking water for atrazine is 3.0 µg/L as an annual average (U.S. Environmental Protection Agency, 2006a). The USEPA continues to investigate atrazine as a potential carcinogen (U.S. Environmental Protection Agency, 2009). Atrazine concentrations in samples collected from RB1 sites during the passive recharge well system test period did not exceed the MCL of 3 µg/L.

Atrazine was not detectable in RB1 groundwater samples collected before artificial recharge. Diverted SW samples had atrazine concentrations ranging from 2.9 to 4 µg/L in three samples collected on April 3, 14, and 17, 2009. Concentrations of atrazine in samples of RB1 source water used for artificial recharge were .27 to .66 µg/L, indicating that water treatment removed much (77 to 93 percent) of the atrazine. During passive recharge, water samples from RB1-TR, RB1-P well (shallow and deep sampling depths), and RB1-PMS wells had concentrations of atrazine from .22 to .85 µg/L. Atrazine was

not detected in the RB1-MS, RB1-MN, and IW-09 wells during passive recharge (fig. 14).

Samples collected 5 days after passive recharge was discontinued on May 4 and 5 from RB1-TR, RB1-P well (shallow and deep sampling depths), and RB1-PMS wells contained the largest concentrations of atrazine detected in the RB1 sites. Concentrations of atrazine measured in samples collected on May 4 and 5 had values from .29 to 1.9 µg/L.

Samples were not collected from Diverted SW or from RB1 source water after April 17, 2009; therefore, the concentration of atrazine in the recharge water used for the third recharge period is not known. However, the concentration of atrazine in the Little Arkansas River at Hwy 50 near Halstead was 4.4 µg/L on April 28, 2009, 5.0 µg/L on April 30, 2009, and 2.5 µg/L on May 4, 2009. If the treatment process removed 75 percent of the atrazine the concentration in the recharge water would have been about .62 to 1.25 µg/L, which is less than the concentration measured in the samples. Field notes indicate that although RB1 source water was not being pumped into the basin, there was standing water in the basin. Precipitation was recorded at the Little Arkansas near Halstead continuous monitoring site on May 2 and 3 (.09 and .14 inches respectively). It is likely that the standing

water in the RB1 basin was a combination of recharge water from artificial recharge on April 30 and rainfall runoff.

Atrazine was not detected in any samples collected from RB1-TR, the RB1-P well (shallow and deep sampling depths), or the RB1-PMS wells on May 19 and 20. There was no detection of atrazine in the RB1-MS, RB1-MN, or IW-09 wells during the period after recharge and before water withdrawal.

During water withdrawal, small concentrations (.34 and .11 $\mu\text{g/L}$) of atrazine were detected in samples collected of the withdrawn water (labeled RB1-P deep well on fig. 14). There were no detections in samples from other sites during water withdrawal, and there were no detections from any samples collected after water withdrawal was complete (August 2009 through March 2010).

Geochemical Simulations

Many of the changes in mineral saturation indices can be explained by changes in pH. In general, the pH fluctuated at all sites during recharge, after artificial recharge and before water withdrawal, and during water withdrawal. The pH of recharge water was 5.9 on April 3, 2009, and increased rapidly to a value of 7.7 on April 14, 2009. It then decreased again to a value of 6.9 on April 17, 2009. This rapid increase and decrease caused associated changes in pH in the RB1 measurement sites, especially RB1-TR and RB1-P well (shallow and deep sampling depths). Additionally, while the trench and passive well were operational (January 1 through July 8, 2009) rainfall infiltration may have caused a decrease in pH. During water withdrawal, pH also fluctuated, especially in the withdrawn water (labeled RB1-P deep well during this time period on all figures)

Saturation indices with respect to calcite (fig. 15A) generally indicated calcite undersaturation at all sites, indicating the potential for calcite dissolution if calcite is present; however, saturation indices for samples on June 25, 2009, at RB1-MS deep well, July 20, 2009, at RB1-P well (deep sampling depth), and November 17, 2009, at RB1-MN deep well and IW-09 deep well indicate the potential for calcite precipitation. Calcite saturation indices generally increased at all sites during artificial recharge, although overall the water remained undersaturated with respect to calcite. This is likely a result of increased pH values; the calcite saturation indices closely mirrored the sample pH measurements. In conjunction with the saturation index peaks during artificial recharge, the changing pH of RB1 source water indicates that mixing recharge water with aquifer water may have changed the water chemistry at RB1 sites, if only temporarily. All calculated saturation indices are provided in table 10 at the back of this report.

Saturation indices with respect to iron hydroxide (fig. 15B) indicate, in general, the water was undersaturated at RB1 source water, RB1-TR, RB1-P well (shallow and deep sampling depths), RB1-PMS shallow and deep wells, and IW-09 shallow and deep wells for most of the sampling period. Dissolved iron concentrations at these sites were equal

to or near the reporting level and did not vary substantially; any changes in the saturation indices are likely because of changes in sample pH. Iron hydroxide saturation indices for RB1-MN shallow and deep and RB1-MS shallow and deep indicate the water was oversaturated with respect to iron hydroxide and there is potential for iron hydroxide precipitation. Greater dissolved iron concentrations at these sites are the reason for oversaturation. Dissolved iron concentrations at these four sites remained relatively steady throughout the sampling period, so differences in the saturation indices are likely because of small variations in dissolved iron concentration and variations in pH. However, if iron hydroxide precipitates and there is no direct source of dissolved iron, the observed dissolved iron concentrations should decrease. Because the observed dissolved iron concentrations remained relatively steady, iron hydroxide precipitation may have occurred if the surrounding aquifer acts as a source for dissolved iron. As with calcite, saturation indices with respect to iron hydroxide increased for all sites during artificial recharge because of increasing pH in the source water.

Similar to calcite, saturation indices with respect to manganite (fig. 15C) indicate the water was undersaturated at all sites, and there is the potential for manganite to dissolve if it is present. The dissolved manganese concentrations were more variable than dissolved iron and arsenic concentrations. Sample pH measurements more closely reflected the manganite saturation indices than did dissolved manganese concentrations. Like calcite and iron hydroxide, manganite saturation indices at all sites increased during artificial recharge, again possibly indicating a temporary change in the water chemistry likely because of the introduction of recharge water.

Saturation indices with respect to scorodite (fig. 15D) indicate the water was undersaturated at all sites. If scorodite is present, scorodite dissolution might occur and arsenic could be released to the aquifer. The presence of scorodite, though, is unlikely as it is too soluble under the conditions at the RB1 sites; however, scorodite saturation indices generally seem to decrease during the period of artificial recharge. This may indicate the changes in water chemistry associated with mixing recharge water with aquifer water cause the water to become less saturated for scorodite, which is opposite to the trends observed for calcite, iron hydroxide, and manganite in the same period.

Calcite and iron hydroxide precipitation and aquifer pore clogging are the primary concerns. In general, the saturation indices with respect to calcite and iron hydroxide increased in the study period. The calcite and iron hydroxide saturation indices indicate that calcite and iron hydroxide might have precipitated during the study period at some sites, and the potential for precipitation may be increasing. If calcite or iron hydroxide precipitation occurs, some aquifer pores may become clogged. The saturation indices with respect to manganite indicate that the potential for manganite dissolution is decreasing. If the trend were to continue, manganite might begin to precipitate and contribute to clogging of aquifer pores. The dissolution of scorodite is unlikely to have occurred

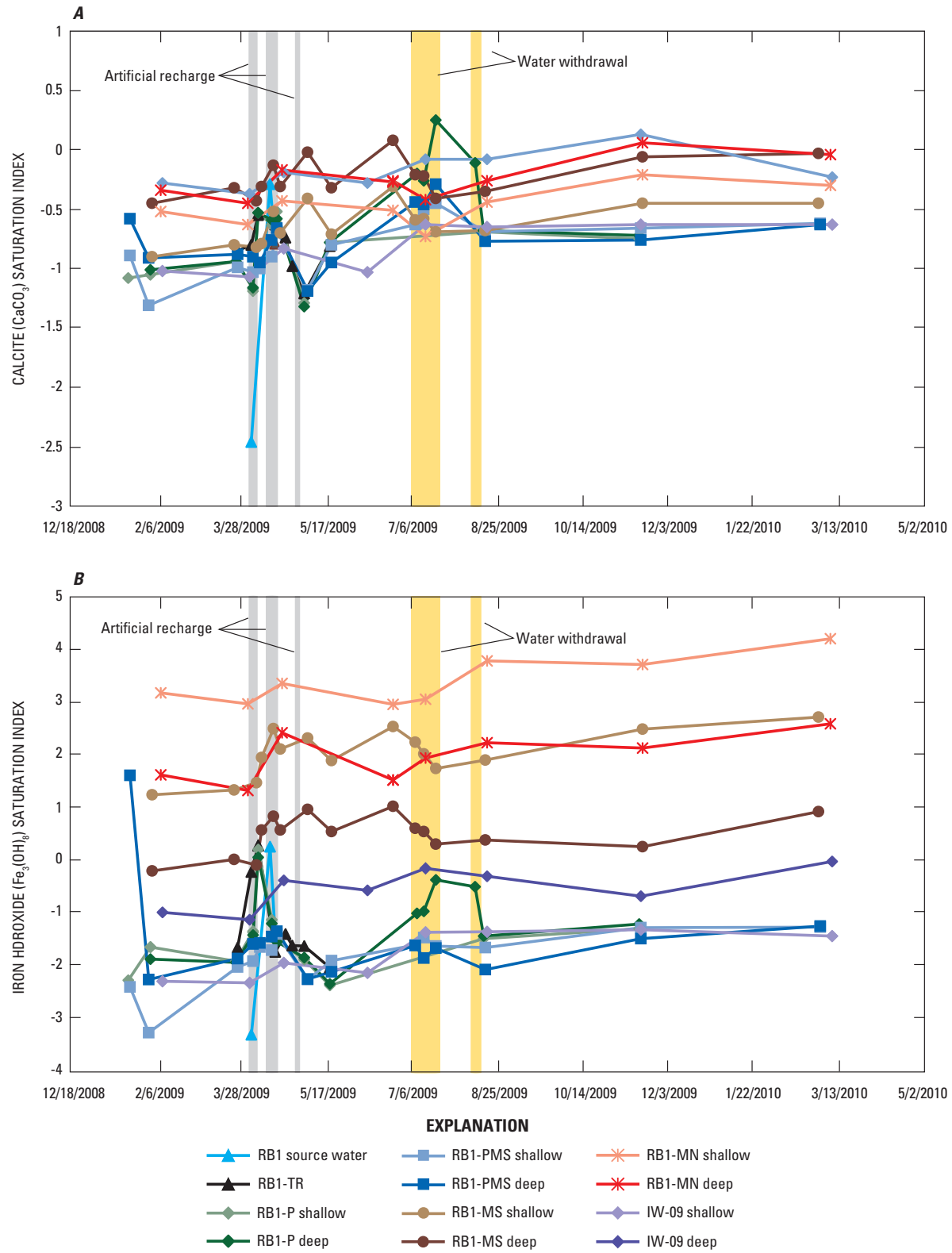


Figure 15. Saturation indices with respect to: (A) calcite (B) iron hydroxide (C) manganite (D) scorodite calculated for groundwater samples collected from RB1 site, 2009–2010.

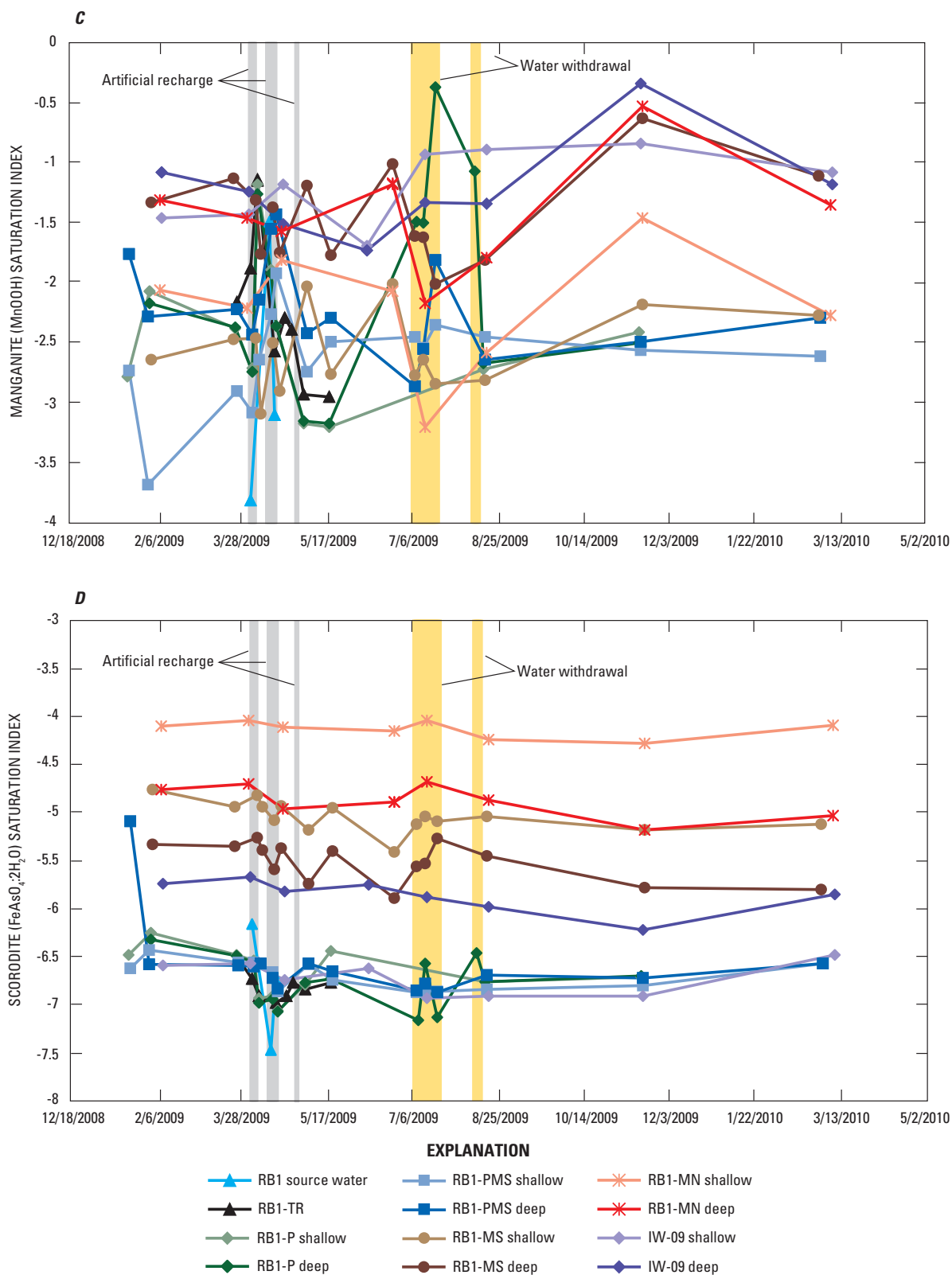


Figure 15. Saturation indices with respect to: (A) calcite (B) iron hydroxide (C) manganite (D) scorodite calculated for groundwater samples collected from RB1 site, 2009–2010.—Continued

during the study period because its presence in the aquifer is unlikely.

Variations in saturation indices for calcite, iron hydroxide, manganite, and scorodite seem largely a result of changes in factors like pH rather than differences in dissolved concentrations of calcium, iron, manganese, and arsenic. Changes in pH throughout the period of artificial recharge likely occurred because of the introduction of recharge water.

Effects of Experimental Passive Artificial Recharge: Synthesis

Five distinct periods have been identified during the passive recharge experiment at RB1; before artificial recharge, during artificial recharge, after artificial recharge and before water withdrawal, during water withdrawal, and after water withdrawal. Piper diagrams show little change in water composition throughout the course of the experiment in IW-09 shallow, IW-09 deep (except for the sample collected on March 9, 2010 reporting a higher percentage of chloride), RB1-MN shallow, RB1-MN deep, RB1-MS shallow, and RB1-MS deep. Iron concentrations for individual sites remain similar throughout the study period. Saturation indices indicate that, in general, water is undersaturated with respect to calcite, iron hydroxide, manganite, and scorodite. The exception is that water samples from RB1-MN shallow and deep and RB1-MS shallow wells were oversaturated with respect to iron hydroxide during the entire study period, and that water samples from RB1-P well (deep sampling depth) were oversaturated with respect to calcite during water withdrawal. Changes in water properties that occurred as a result of the passive artificial recharge include changes in DO, ORP, pH, water level, the populations of bacterial and viral indicators, and concentrations of major ions, trace elements, and organic constituents. A summary of the changes that occurred during the five periods follows.

Before Artificial Recharge (January 1 Through April 2, 2009)

Before treated surface water was introduced into the system, some surface water entered the trench and passive well system when rain fell into the basin area. Water-level altitude did not change substantially in any RB1 wells except RB1-MS deep. Large water-level changes in RB1-MS deep are related to nearby pumping and not related to artificial recharge. There were some detections of bacteria in groundwater from RB1-P well (shallow and deep sampling depths), RB1-PMS shallow and deep wells, and RB1-MS shallow well. IRB and SRB were detected in BART in samples from all sampled locations.

The piper diagram (fig. 10A) shows that the water generally includes a large amount of calcium and bicarbonate. There were no detections of atrazine in any RB1 samples collected

in January, February, or March of 2009. Water samples from RB1-MN deep, RB1-MS deep, and IW-09 deep wells had dissolved arsenic concentrations above the MCL of 10 µg/L. ORP was 100–200 mV in samples collected from the RB1-MS shallow and deep wells, the RB1-MN shallow and deep wells, and the IW-09 deep well. ORP was near 400–500 mV in samples collected from RB1-TR, the RB1-P well (shallow and deep sampling depths), and the RB1-PMS wells.

The RB1-PMS deep well was drilled in January 2009, and is screened through the shallow and deep zones of the aquifer. The first set of samples collected from the RB1-PMS deep well have chloride, arsenic, and ORP concentrations similar to other deep wells, but subsequent samples are similar to the RB1-PMS shallow well. Profiles of physical properties and water levels (figs. 4 and 5A) indicate that water flows down the well from the shallow to the deep zone. This indication is supported by changing ORP, chloride concentrations, and arsenic concentrations in the RB1-PMS deep well (figs. 6, 11, and 12).

During Artificial Recharge (April 3 Through April 30, 2009)

During artificial recharge water levels increased rapidly in the RB1-P well and more slowly in the RB1-PMS wells when recharge water was added to the trench (fig. 5). ORP in these wells increased to values similar to RB1 source water (about 500 mV). Continuous monitors in RB1-TR, the RB1-P well (shallow and deep monitoring depths), and the RB1-PMS shallow and deep wells recorded a substantial increase in DO during artificial recharge because of the influx of oxygenated recharge water (table 5).

Coliform bacteria, fecal coliform bacteria, *E. coli* bacteria, coliphage virus, and *clostridium perfringens* bacteria were present in RB1 source water, and were detected in RB1-TR, the RB1-P well (shallow and deep sampling depths), and RB1-PMS shallow and deep well samples (figs. 7 and 8, table 6). The percentage of samples with BART detections of iron-related bacteria and sulfate-reducing bacteria increased, probably because of the presence of the bacteria in the recharge water. Larger sulfate concentrations (table 8) may have contributed to the greater aggressiveness of SRB in the BART.

Piper diagrams (fig. 10B) show that the water in most samples from RB1-TR and the RB1-P well (shallow and deep sampling depths) increased in sulfate and chloride content. Concentrations of chloride and atrazine in RB1-TR, the RB1-P well (shallow and deep sampling depths), and the RB1-PMS wells increased to values similar to RB1 source water. Concentrations of chloride and atrazine in water samples from other wells in the system (the RB1-MS wells, the RB1-MN wells, and the IW-09 wells) remained similar to values before artificial recharge. Concentrations of iron and arsenic did not change substantially from pre-recharge concentrations in any RB1 samples collected during recharge. Overall, the properties

of the treated surface water used for artificial recharge affected the water quality in the aquifer nearest the point of recharge (RB1-TR, the RB1-P well (shallow and deep sampling depths), and the RB1-PMS wells).

After Artificial Recharge and Before Water Withdrawal (May 1 Through July 6, 2009)

After artificial recharge and before water withdrawal, water was entering the system from rainfall only. Water levels in RB1-TR, the RB1-P well, and the RB1-PMS shallow and deep wells remained the same or rose slightly in response to rainfall. Values of SC in RB1-TR and the RB1-P well (shallow and deep monitoring depths) decreased when precipitation fell into the basin (fig. 5C). A decrease in SC in the RB1-PMS shallow and deep wells was measured 1 to 3 days after the decrease in RB1-TR and the RB1-P well (shallow and deep monitoring depths). DO (fig. 5D) and ORP (fig. 6) measurements decreased in response to the limited influx of oxygenated water.

Bacteria were detected in samples collected from RB1-TR, the RB1-P well (shallow and deep sampling depths), the RB1-PMS shallow and deep wells, and the RB1-MS shallow wells (fig. 7 and table 6). Coliphage virus was detected in the RB1-PMS shallow and deep wells in early May 2009 (fig. 8 and table 6). It is likely that the recharged water flowed down-gradient from the RB1-P well to the RB1-PMS wells, transporting bacterial and viral indicators to the RB1-PMS wells. The percentage of samples with IRB and SRB detections from BART decreased slightly during the period after artificial recharge and before water withdrawal.

Chloride concentrations in all wells either returned to, or remained near, pre-recharge values. Arsenic and iron concentrations in water samples from all wells remained similar to values before and during artificial recharge. After artificial recharge and before water withdrawal, concentrations of atrazine in samples from RB1-TR and the RB1-P well (shallow and deep sampling depths) increased to values larger than the RB1 source water that had previously entered the system.

During Water Withdrawal (July 7 Through 21, 2009 and August 11 Through 14, 2009)

Detections of bacterial and viral indicators in the recharge water and groundwater at RB1 prompted the City of Wichita to withdraw water from the site to remove the recharged water. About 1,825,000 gal of groundwater (more than three times the amount recharged) were withdrawn through the RB1-P well and deposited in an adjacent basin to allow for slow infiltration back into the aquifer. Water-level altitude decreased in all wells in response to the water withdrawal (fig. 5A).

Total coliform bacteria were detected in samples collected from the RB1-PMS shallow and deep wells, the RB1-MS shallow and deep wells, and the withdrawn water

(labeled RB1-P deep well on figures and tables during water withdrawal). Fecal coliform bacteria were detected in a sample from the withdrawn water. *E. coli* and coliphage virus were detected in the RB1-PMS shallow well water sample. (figs. 7 and 8 and table 6). Detections of enteric bacteria from BART also increased, but the percentage of samples with detections of well-fouling IRB bacteria decreased, possibly because of the aggressiveness of the enteric bacteria. SRB detections also increased and were more aggressive. The presence of bacteria in groundwater samples can be attributed to the presence of bacteria in the recharge water. It is also likely that continuous pumping from the RB1-P well during this time created a steep hydraulic gradient (cone of depression) that increased surface water (previously withdrawn water) influx through the bottom of the basin and trench.

Relative concentrations of major ions in the IW-09 shallow and deep wells, RB1-MN shallow and deep wells, and RB1-MS shallow and deep wells changed little (fig. 10) from previous periods. Concentrations of chloride increased (fig. 11), and the relative percentage of the chloride ion increased (fig. 10) in samples collected from the RB1-PMS shallow and deep wells and the withdrawn water. The concentration of chloride in a sample collected from the RB1-PMS deep well on July 20, 2009 was 150 mg/L, 20 mg/L greater than the greatest concentration measured in the RB1 source water. A mass-balance calculation (see "Chloride" section in this report) indicated that during water withdrawal, about 116,700 g (257 lb) more chloride was pumped out of the aquifer than was introduced by artificial recharge. Although the concentration of chloride in the July 20, 2009 sample collected from the RB1-PMS deep well is similar to the concentration in the RB1-MN shallow well (fig. 11), concentrations of iron and arsenic (figs. 12 and 13) are not similar. This suggests that the source of the water with a greater chloride concentration is not from the area of the RB1-MN shallow well, but possibly from the deep aquifer near the RB1-PMS deep well.

Arsenic concentrations increased slightly in some water samples, most notably the withdrawn water samples (labeled RB1-P deep well on fig. 12), and is likely because of the flow of water with greater concentrations of arsenic flowing toward the RB1-P well in response to pumping. Arsenic concentrations remained greater than the MCL of 10 µg/L in the RB1-MS deep, RB1-MN deep, and RB1-MN deep wells.

Small concentrations of atrazine were detected in samples collected from the withdrawn water (labeled RB1-P deep on fig. 14). Atrazine was not detected in any other RB1 wells during water withdrawal.

After Water Withdrawal (August 15, 2009 Through March 22, 2010)

Water-level altitude increased in RB1-PMS shallow and deep wells and the RB1-MS shallow well after water withdrawal ceased (fig. 5A). In March 2010, water-level altitudes were similar to those before artificial recharge. There were

detections of total coliform bacteria in water samples collected from RB1-P well (shallow and deep sampling depths), the RB1-PMS shallow and deep wells, and the RB1-MS shallow and deep wells immediately after water withdrawal stopped (late August, 2009). There were detections of total coliform bacteria in samples collected during November, 2009, from the RB1-PMS shallow and deep wells. Total coliform was detected in one sample collected during March 2010 from the RB1-PMS deep well. When the RB1-PMS deep well was resampled 2 weeks later, there were no detections of bacteria or viral indicators. There were no detections of bacteria or viral indicators in the most recent samples from all RB1 sites (figs. 7 and 8, and table 6). A shift in bacterial populations after water withdrawal was indicated by BART, with fewer detections of SRB and enteric bacteria and greater detections of well-fouling IRB bacteria – similar to conditions before artificial recharge began.

Major ion chemistry as shown on Piper diagrams (fig. 10E) became similar to conditions observed before artificial recharge began (fig. 10A). Concentrations of chloride in samples from all RB1 wells were similar to concentrations measured before recharge began. Atrazine was not detected in samples from any RB1 wells after water withdrawal. Arsenic concentrations were similar to pre-recharge conditions in RB1 groundwater samples collected in November, 2009, and increased by about 1.0–2.5 $\mu\text{g/L}$ in all RB1 groundwater samples collected in March 2010. The cause of the increased concentration of arsenic is not clear because pH or ORP values remained nearly constant after water withdrawal stopped at RB1.

Summary and Conclusions

The *Equus* Beds aquifer is a primary water supply source for Wichita, Kansas, and the surrounding area. Declining water levels in some parts of the *Equus* Beds aquifer and concerns about migration of a known saltwater plume upgradient from public supply wells prompted the City of Wichita to investigate the feasibility of using artificial recharge to replenish the water supply in the aquifer. A demonstration project conducted from 1995 to 2002 determined that the sources of recharge water were chemically compatible with the receiving groundwater, and in 2007 full-scale recharge began.

Recharge Basin 1 (RB1) was originally designed as a recharge basin into which treated surface water was to be discharged; however, because of greater than expected clay content in the bottom material of the basin, the infiltration rate of recharge water was less than required. Observation of recharge at RB1 during artificial recharge in 2007 and 2008 indicated the recharge capacity to be about 10.8 (gal/d)/ft², “substantially less” than the design rate of 37.4 (gal/d)/ft². The basin was reconstructed to include a 6-inch diameter passive gravity recharge well and trench system to facilitate the transport of recharge water into the aquifer and from 2009 to

2010 the system was tested. Information to address concerns related to the effectiveness of a passive recharge system at removing atrazine and microbes from treated surface water before it enters the aquifer, potential for changes in the microbial population in the aquifer resulting from the introduction of oxygenated surface water, and the potential effectiveness of using artificial recharge to stop or slow the migration of a chloride plume is needed. To address these needs the USGS, in cooperation with the City of Wichita, conducted a supplemental investigation as part of the *Equus* Beds groundwater recharge project designed to evaluate flow of recharge water through an experimental passive gravity recharge well system. About 576,000 gal of treated surface water were recharged through the passive gravity recharge system into the *Equus* Beds aquifer during April 2009. In July 2009, when laboratory test results indicated that bacteria were entering the aquifer through the passive recharge well, the trench collection system was disconnected from the passive gravity recharge well and 1,825,000 gal of water were pumped out of the aquifer through the passive gravity recharge well in July and August, 2010. The water was deposited in a part of the RB1 basin separated from the passive gravity recharge well and trench by a berm.

Water samples were collected from Diverted SW, the RB1 source water, RB1-TR, the RB1-P well (shallow and deep sampling depths), the RB1-PMS shallow and deep wells, the RB1-MS shallow and deep wells, the RB1-MN shallow and deep wells, and the IW-09 shallow and deep wells. Continuous water-quality and water-level monitors were installed in RB1-TR, the RB1-P well (shallow and deep monitoring depths), the RB1-PMS shallow and deep wells, and the RB1-MS shallow and deep wells during 2009–2010.

Continuous monitors recorded rising water-level altitudes in the RB1-P well (shallow and deep monitoring depths) (4.5 ft increase in altitude during artificial recharge) and nearby RB1-PMS and RB1-MS well pairs (about 1 ft rise from April to July) during artificial recharge and precipitation events. The increase in water-level altitude decreased the hydraulic gradient to the west (upgradient) which would have the effect of slowing eastern migration of a known saltwater plume. The recharge rate in the original basin configuration at RB1 was about 10.8 (gal/d)/ft². After installation of the passive recharge system, recharge water flowed through the sand filled filtration trench and entered the aquifer through the 6-inch passive well at a rate of about 19.2 (gal/d)/ft². Recharge per unit area into the aquifer through the trench and passive gravity recharge well increased about 78 percent.

Turbidity values recorded by continuous monitors in the passive gravity recharge well increased immediately after artificial recharge and precipitation events indicating that turbid water was entering the passive gravity recharge well through the trench. Specific conductance values recorded by continuous monitors indicate larger specific conductance values during artificial recharge with treated surface water and smaller specific conductance values after precipitation entered the system. The decrease in specific conductance because of rainfall events was used to trace the flow of water from the trench

through the passive gravity recharge well to the monitoring well pair about 30 ft away in about 3 days.

Bacterial and viral indicators were detected in water samples collected before and after the installation of the passive gravity recharge well and trench system (when precipitation was the only source of recharge water), during artificial recharge with treated surface water, and after recharge. Large concentrations of total coliform, fecal coliform, *Escherichia coli* (*E. coli*), and coliphage virus were detected in the treated surface water used for recharge. The trench system at the RB1 passive recharge site did not remove all bacteria and viruses from water before water entered the aquifer. After the trench and passive gravity recharge well were disconnected and water was removed from the aquifer, detections of bacteria and indicator viruses decreased to concentrations similar to those before installation of the passive recharge system. Iron-related bacteria and sulfate-reducing bacteria concentrations were similar in samples collected during all periods of the evaluation. Enteric bacteria were detected more often during artificial recharge and water withdrawal than before artificial recharge, after artificial recharge and before water withdrawal, and after water withdrawal.

Concentrations of chloride in samples collected from the trench, passive gravity recharge well, and nearby monitoring wells increased from an average of 34 milligrams per liter (mg/L) before artificial recharge to an average of 64 mg/L during artificial recharge, reflecting the addition of recharge water with measured concentrations of 62 to 94 mg/L. When water was pumped out of the RB1 site through the RB1-P well, chloride concentrations increased to 94 mg/L in the extracted water. During water withdrawal chloride concentrations increased (40–150 mg/L) in the RB1-PMS deep well, even though a mass balance indicates that an additional 116,700 g (257 lb) more chloride was removed from the aquifer than was added by artificial recharge water. The large chloride concentration in the RB1-PMS deep well of 150 mg/L and the mass-balance calculation suggest that as water was being pumped out of the RB1-P well, water with a large chloride concentration from elsewhere in the aquifer was flowing toward the RB1-P and RB1-PMS wells. Chloride concentrations did not exceed the United States Environmental Protection Agency (USEPA) Secondary Drinking Water Regulation (SDWR) of 250 mg/L.

Passive artificial recharge and water withdrawal did not cause large changes in iron or arsenic concentrations in the RB1 wells. In the treated surface water used for artificial recharge, arsenic concentrations were less than the USEPA Maximum Contaminant Level (MCL) of 10 µg/L and iron concentrations were less than the SDWR of 300 µg/L.

Atrazine concentrations in samples from RB1 sites did not exceed the USEPA MCL of 3 µg/L. Atrazine concentrations in diverted surface water were greater than the USEPA MCL, but those in the treated water were less than the MCL, indicating the treatment process effectively reduced the concentration of atrazine in the recharge water. Atrazine concentrations in RB1 wells increased during artificial recharge with

treated water, and after artificial recharge when precipitation was the only source of water to the passive recharge system. Concentrations of atrazine in RB1 wells returned to values similar to pre-recharge conditions after passive recharge was discontinued and water withdrawal was complete.

Saturation indices indicate the potential for calcite (CaCO_3) precipitation in one sample each at four deep wells during the study period. Calcite precipitation may cause the clogging of aquifer pores. Saturation indices indicate that water was oversaturated with respect to iron hydroxide ($\text{Fe}_3(\text{OH})_8$) at RB1-MN shallow and deep, and RB1-MS shallow and deep wells, and precipitation may have occurred. Water was undersaturated with respect to scorodite ($\text{FeAsO}_4 \cdot 2\text{H}_2\text{O}$) and manganite (MnOOH) and would likely have dissolved at the RB1 sites if either were present in aquifer material. During artificial recharge, saturation indices for calcite, iron hydroxide, and manganite increased while saturation indices for scorodite decreased, indicating that mixing artificial recharge water with aquifer water affected the water chemistry. Variations in saturation indices likely occurred because of changes in pH, which could be affected by artificial recharge or rainfall events.

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Supplemental Information

Table 4. Water-quality constituents analyzed in water samples collected from RB1 sites, 2009–2010.

[ELISA, enzyme-linked immunosorbent assay; m-TEC, membrane-thermotolerant *Escherichia coli*; BART, Biological Activity Reaction Test; C13, *E. coli* culture resistant to naladixic acid and used to detect somatic coliphages; Famp, *E. coli* culture resistant to ampicillin and streptomycin and used to detect male-specific coliphages; MF, membrane filter]

Physical properties, dissolved and suspended solids, and suspended sediment			
Oxidation reduction potential	Specific conductance	Alkalinity, dissolved	
Turbidity	Water temperature	Total dissolved solids	
Oxygen, dissolved	Carbonate hardness, total	Suspended solids	
pH	Hardness	Suspended sediment	
Major ions and nutrients			
Calcium, dissolved	Bicarbonate, dissolved	Fluoride, dissolved	Nitrite plus nitrate, dissolved
Magnesium, dissolved	Carbonate, dissolved	Sulfate, dissolved	Phosphorous, dissolved
Potassium, dissolved	Bromide, dissolved	Ammonia, dissolved	Orthophosphate, dissolved
Sodium, dissolved	Chloride, dissolved	Nitrate, dissolved	Organic carbon, total
Trace elements and organic compounds			
Arsenic, dissolved	Iron, dissolved	Manganese, dissolved	Triazine screen, dissolved, ELISA
Bacterial and viral indicators			
<i>Clostridium perfringens</i>	<i>Escherichia coli</i> , m-TEC method	Iron-related bacteria, BART	
Coliphage, <i>Escherichia coli</i> , C13 host	Fecal coliform	Sulfate-reducing bacteria, BART	
Coliphage, <i>Escherichia coli</i> , Famp host	Total coliform		
<i>Escherichia coli</i> , modified m-TEC MF method			

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.

[mg/L, milligrams per liter; $\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; $^{\circ}\text{C}$, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO_3 , calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance ($\mu\text{S}/\text{cm}$)	Water temperature ($^{\circ}\text{C}$)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO_3 (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO_3 (mg/L)
IW-09 shallow												
3/19/2002	1100	1.4	6.9	558	15.2	--	<0.1	530	--	--	--	--
3/19/2002	1101	--	--	--	--	0.2	--	--	392	220	<4	143
6/20/2002	0935	1.5	7.0	595	15.8	--	0.3	370	--	--	--	--
6/20/2002	0936	--	--	--	--	0.2	--	--	374	210	4	144
6/20/2002	0940	--	--	--	--	--	--	--	--	--	--	--
2/14/2003	1035	1.5	6.9	571	15.6	--	<0.1	600	--	--	--	--
2/14/2003	1036	--	--	--	--	0.2	--	--	380	210	<4	131
2/14/2003	1037	--	--	--	--	--	--	--	--	--	--	--
6/25/2003	0855	0.3	7.0	579	16.1	--	0.3	560	--	--	--	--
6/25/2003	0856	--	--	--	--	0.4	--	--	382	230	<4	121
6/25/2003	0900	0.3	7.0	579	16.1	--	0.3	560	--	--	--	--
6/25/2003	0905	0.3	7.0	579	16.1	--	0.3	560	392	230	--	--
6/25/2003	0906	--	--	--	--	--	1.0	--	--	--	--	--
2/10/2004	1030	1.1	7.0	563	15.3	--	0.3	320	--	--	--	--
2/10/2004	1031	--	--	--	--	0.3	--	--	366	210	<4	126
6/25/2004	0925	0.6	7.0	563	15.5	--	0.6	410	--	--	--	--
6/25/2004	0926	--	--	--	--	1.0	--	--	372	220	<4	118
7/11/2005	1200	0.3	7.0	546	15.9	--	2.4	330	--	--	--	--
7/11/2005	1201	--	--	--	--	0.5	--	--	362	220	<4	110
6/14/2006	1045	1.8	6.6	566	15.7	--	1.4	400	--	--	--	--
6/14/2006	1046	--	--	--	--	1.8	--	--	379	210	<4	129
6/14/2006	1050	1.8	6.6	566	15.7	--	1.4	400	385	200	--	--
6/14/2006	1051	--	--	--	--	--	2.6	--	--	--	--	--
6/20/2007	1020	0.4	6.9	524	16.0	--	4.5	480	--	--	--	--
6/20/2007	1021	--	--	--	--	0.4	--	--	353	200	<10	116
6/20/2007	1025	0.4	6.9	524	16.0	--	4.5	480	--	--	--	--
6/12/2008	0940	0.8	6.7	512	15.7	--	0.9	410	--	--	--	--
6/12/2008	0941	--	--	--	--	0.2	--	--	337	190	<4	117
2/10/2009	0955	0.4	6.7	486	15.4	--	0.3	390	--	--	--	--
2/10/2009	0956	--	--	--	--	<0.1	--	--	314	190	<4	108
4/2/2009	1055	0.5	6.7	479	14.8	--	0.7	510	--	--	--	--
4/2/2009	1056	--	--	--	--	0.8	--	--	289	180	<4	102

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; μ S/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO₃, calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance (μ S/cm)	Water temperature (°C)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO ₃ (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO ₃ (mg/L)
IW-09 shallow—Continued												
4/2/2009	1100	0.5	6.7	479	14.8	--	0.7	510	--	--	--	--
4/22/2009	1020	0.4	6.9	482	15.7	--	0.9	360	--	--	--	--
4/22/2009	1021	--	--	--	--	0.4	--	--	297	180	<4	107
6/10/2009	0955	0.2	6.7	482	16.0	--	1.2	320	--	--	--	--
6/10/2009	0956	--	--	--	--	0.3	--	--	306	190	<4	104
6/10/2009	1000	0.2	6.7	482	16.0	--	1.2	320	330	180	--	--
6/10/2009	1001	--	--	--	--	--	--	--	--	--	--	--
7/14/2009	1020	--	7.1	488	15.8	--	0.6	390	--	--	--	--
7/14/2009	1021	--	--	--	--	0.3	--	--	300	200	<4	102
7/14/2009	1025	--	7.1	488	15.8	--	0.6	390	--	--	--	--
8/19/2009	1000	0.2	7.1	483	15.4	--	0.6	360	--	--	--	--
8/19/2009	1001	--	--	--	--	0.1	--	--	317	190	<4	102
8/19/2009	1005	0.2	7.1	483	15.4	--	0.6	360	--	--	--	--
11/17/2009	1005	0.5	7.1	491	15.4	--	0.7	250	--	--	--	--
11/17/2009	1006	--	--	--	--	0.2	--	--	310	190	<4	109
11/17/2009	1010	0.5	7.1	491	15.4	--	0.7	250	--	--	--	--
3/9/2010	1010	0.7	7.1	496	15.8	--	1.0	340	--	--	--	--
3/9/2010	1011	--	--	--	--	0.2	--	--	307	180	<10	113
3/9/2010	1015	0.7	7.1	496	15.8	--	1.0	340	--	--	--	--
IW-09 deep												
3/19/2002	1305	0.2	7.2	404	15.7	--	5.2	190	--	--	--	--
3/19/2002	1306	--	--	--	--	23.0	--	--	299	180	28	194
6/24/2002	1045	0.2	7.6	516	16.0	--	1.1	180	--	--	--	--
6/24/2002	1046	--	--	--	--	27.0	--	--	294	190	40	197
2/14/2003	1335	0.2	7.3	513	16.0	--	15.0	150	--	--	--	--
2/14/2003	1336	--	--	--	--	13.0	--	--	292	190	10	195
6/25/2003	1135	M	7.3	488	16.2	--	2.5	190	--	--	--	--
6/25/2003	1136	--	--	--	--	2.5	--	--	306	180	4	196
6/25/2003	1140	M	7.3	488	16.2	--	2.5	190	--	--	--	--
6/25/2003	1145	M	7.3	488	16.2	--	2.5	190	312	180	--	--
6/25/2003	1146	--	--	--	--	--	5.0	--	--	--	--	--
2/10/2004	1225	0.1	7.3	575	15.9	--	6.0	160	--	--	--	--

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; μ S/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO₃, calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance (μ S/cm)	Water temperature (°C)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO ₃ (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO ₃ (mg/L)
IW-09 deep—Continued												
2/10/2004	1226	--	--	--	--	2.9	--	--	336	210	6	196
2/10/2004	1227	--	--	--	--	--	--	--	--	--	--	--
6/25/2004	1130	--	7.4	552	16.1	--	4.2	140	--	--	--	--
6/25/2004	1131	--	--	--	--	3.4	--	--	328	210	6	192
6/25/2004	1132	--	--	--	--	--	--	--	--	--	--	--
6/25/2004	1135	0.1	7.4	552	16.1	--	4.2	140	--	--	--	--
7/11/2005	1030	0.1	7.3	579	16.2	--	2.5	120	--	--	--	--
7/11/2005	1031	--	--	--	--	3.6	--	--	318	210	13	188
6/14/2006	1235	0.3	7.1	567	16.2	--	1.9	240	--	--	--	--
6/14/2006	1236	--	--	--	--	1.3	--	--	318	210	8	187
6/20/2007	1220	0.1	7.3	550	16.1	--	3.5	140	--	--	--	--
6/20/2007	1221	--	--	--	--	0.6	--	--	323	200	<10	194
6/20/2007	1225	0.1	7.3	550	16.1	--	3.5	140	--	--	--	--
6/12/2008	1110	0.1	7.0	593	16.0	--	4.4	160	--	--	--	--
6/12/2008	1111	--	--	--	--	1.6	--	--	339	210	5	194
2/10/2009	1125	0.1	7.1	598	15.7	--	9.2	200	--	--	--	--
2/10/2009	1126	--	--	--	--	3.7	--	--	350	220	9	191
4/2/2009	1215	0.1	7.0	600	15.5	--	13.0	190	--	--	--	--
4/2/2009	1216	--	--	--	--	6.2	--	--	323	230	9	190
4/2/2009	1220	0.1	7.0	600	15.5	--	13.0	190	--	--	--	--
4/22/2009	1200	0.1	7.2	603	15.9	--	8.0	180	--	--	--	--
4/22/2009	1201	--	--	--	--	1.3	--	--	340	220	6	188
6/10/2009	1120	0.2	7.1	604	16.2	--	4.2	210	--	--	--	--
6/10/2009	1121	--	--	--	--	2.1	--	--	342	220	<4	188
6/10/2009	1125	0.2	7.1	604	16.2	--	4.2	210	347	210	--	--
6/10/2009	1126	--	--	--	--	--	E3.5	--	--	--	--	--
7/14/2009	1150	0.6	7.3	613	16.0	--	3.3	210	--	--	--	--
7/14/2009	1151	--	--	--	--	1.1	--	--	332	230	<4	188
7/14/2009	1155	0.6	7.3	613	16.0	--	3.3	210	--	--	--	--
8/19/2009	1150	0.2	7.3	652	16.2	--	7.5	180	--	--	--	--
8/19/2009	1151	--	--	--	--	2.2	--	--	363	230	6	188
8/19/2009	1155	0.2	7.3	652	16.2	--	7.5	180	--	--	--	--

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; $\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; $^{\circ}\text{C}$, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO_3 , calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance ($\mu\text{S}/\text{cm}$)	Water temperature ($^{\circ}\text{C}$)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO_3 (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO_3 (mg/L)
RB1-MN shallow—Continued												
8/29/2007	1020	0.1	6.7	978	15.8	--	0.8	110	--	--	--	--
8/29/2007	1021	--	--	--	--	--	--	--	559	330	4	200
8/29/2007	1025	0.1	6.7	978	15.8	--	0.8	110	--	--	--	--
8/29/2007	1030	0.1	6.7	978	15.8	--	0.8	110	--	--	--	--
8/29/2007	1031	--	--	--	--	--	--	--	579	330	4	204
8/29/2007	1035	0.1	6.7	978	15.8	--	0.8	110	--	--	--	--
3/5/2008	1025	0.1	7.0	1,040	15.0	--	0.8	130	--	--	--	--
3/5/2008	1026	--	--	--	--	--	--	--	593	370	4	196
3/5/2008	1030	0.1	7.0	1,040	15.0	--	0.8	130	--	--	--	--
3/5/2008	1031	--	--	--	--	--	--	--	599	380	4	196
8/19/2008	1010	0.1	6.8	993	15.6	--	1.1	120	--	--	--	--
8/19/2008	1011	--	--	--	--	--	--	--	591	360	<4	202
8/19/2008	1015	0.1	6.8	993	15.6	--	1.1	120	--	--	--	--
2/9/2009	1020	0.1	6.7	1,040	15.1	--	0.4	160	--	--	--	--
2/9/2009	1021	--	--	--	--	--	--	--	582	380	<4	207
4/1/2009	1110	0.9	6.6	1,020	14.9	--	0.5	150	--	--	--	--
4/1/2009	1111	--	--	--	--	--	--	--	582	380	6	201
4/1/2009	1115	0.9	6.6	1,020	14.9	--	0.5	150	--	--	--	--
4/21/2009	0955	0.2	6.8	1,060	15.2	--	0.6	140	--	--	--	--
4/21/2009	0956	--	--	--	--	--	--	--	332	380	9	200
6/25/2009	1000	0.2	6.7	1,050	16.6	--	0.3	150	--	--	--	--
6/25/2009	1001	--	--	--	--	--	--	--	635	380	8	200
6/25/2009	1005	0.2	6.7	1,050	16.6	--	0.3	150	--	--	--	--
6/25/2009	1010	0.2	6.7	1,050	16.6	--	0.3	150	--	--	--	--
7/14/2009	1025	0.4	6.5	1,010	16.7	--	0.6	190	--	--	--	--
7/14/2009	1026	--	--	--	--	--	--	--	570	360	5	204
7/14/2009	1030	0.4	6.5	1,010	16.7	--	0.6	190	--	--	--	--
8/19/2009	0955	0.1	6.8	997	16.0	--	0.6	170	--	--	--	--
8/19/2009	0956	--	--	--	--	--	--	--	588	360	7	202
8/19/2009	0957	--	--	--	--	--	--	--	--	--	--	--
8/19/2009	1000	0.1	6.8	997	16.0	--	0.6	170	--	--	--	--
11/18/2009	1000	0.4	7.0	1,070	15.4	--	0.2	190	--	--	--	--

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; μ S/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO₃, calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance (μ S/cm)	Water temperature (°C)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO ₃ (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO ₃ (mg/L)
RB1-MN shallow—Continued												
11/18/2009	1001	--	--	--	--	--	--	--	610	390	5	203
11/18/2009	1005	0.4	7.0	1,070	15.4	--	0.2	190	--	--	--	--
3/8/2010	1005	0.4	6.9	1,050	15.2	--	0.5	--	--	--	--	--
3/8/2010	1006	--	--	--	--	--	--	--	593	370	<10	212
3/8/2010	1010	0.4	6.9	1,050	15.2	--	0.5	--	--	--	--	--
RB1-MN deep												
8/30/2006	1155	0.1	7.1	596	16.0	--	0.3	120	--	--	--	--
8/30/2006	1156	--	--	--	--	--	--	--	339	210	<4	203
8/30/2006	1200	0.1	7.1	596	16.0	--	0.3	120	--	--	--	--
11/29/2006	0955	0.1	7.3	623	15.0	--	0.1	110	--	--	--	--
11/29/2006	0956	--	--	--	--	--	--	--	365	220	<4	206
2/23/2007	1205	0.1	7.3	565	15.7	--	0.6	100	--	--	--	--
2/23/2007	1206	--	--	--	--	--	--	--	319	200	<4	204
6/4/2007	1140	0.1	7.5	563	16.0	--	0.5	110	--	--	--	--
6/4/2007	1141	--	--	--	--	--	--	--	341	190	<10	204
6/4/2007	1145	0.1	7.5	563	16.0	--	0.5	110	--	--	--	--
6/4/2007	1146	--	--	--	--	--	--	--	338	190	<10	202
8/29/2007	1230	0.1	7.1	631	16.0	--	0.2	100	--	--	--	--
8/29/2007	1231	--	--	--	--	--	--	--	324	210	<4	200
8/29/2007	1235	0.1	7.1	631	16.0	--	0.2	100	--	--	--	--
3/5/2008	1155	0.2	7.4	625	15.5	--	0.1	110	--	--	--	--
3/5/2008	1156	--	--	--	--	--	--	--	352	230	<4	194
8/19/2008	1150	M	7.1	642	15.8	--	0.6	110	--	--	--	--
8/19/2008	1151	--	--	--	--	--	--	--	370	230	<4	202
8/19/2008	1155	M	7.1	642	15.8	--	0.6	110	--	--	--	--
2/9/2009	1150	0.1	7.0	635	15.6	--	0.3	140	--	--	--	--
2/9/2009	1151	--	--	--	--	--	--	--	360	230	<4	201
4/1/2009	1240	0.1	6.9	625	15.5	--	0.3	130	--	--	--	--
4/1/2009	1241	--	--	--	--	--	--	--	346	230	<4	199
4/1/2009	1242	--	--	--	--	--	--	--	--	--	--	--
4/1/2009	1245	0.1	6.9	625	15.5	--	0.3	130	--	--	--	--
4/21/2009	1115	0.1	7.2	584	15.6	--	0.4	120	--	--	--	--

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; μ S/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO₃, calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance (μ S/cm)	Water temperature (°C)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO ₃ (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO ₃ (mg/L)
RB1-MN deep—Continued												
4/21/2009	1115	0.1	7.2	584	15.6	--	0.4	120	--	--	--	--
4/21/2009	1116	--	--	--	--	--	--	--	331	210	<4	202
6/25/2009	1200	0.1	7.1	593	16.5	--	0.2	140	--	--	--	--
6/25/2009	1201	--	--	--	--	--	--	--	347	220	<4	198
6/25/2009	1205	0.1	7.1	593	16.5	--	0.2	140	--	--	--	--
6/25/2009	1210	0.1	7.1	593	16.5	--	0.2	140	--	--	--	--
6/25/2009	1211	--	--	--	--	--	--	--	347	220	<4	198
6/25/2009	1215	0.1	7.1	593	16.5	--	0.2	140	--	--	--	--
7/14/2009	1200	0.2	6.9	648	16.5	--	0.3	160	--	--	--	--
7/14/2009	1201	--	--	--	--	--	--	--	363	240	<4	202
7/14/2009	1205	0.2	6.9	648	16.5	--	0.3	160	--	--	--	--
8/19/2009	1125	0.1	7.1	600	16.1	--	0.1	140	--	--	--	--
8/19/2009	1126	--	--	--	--	--	--	--	358	220	<4	200
8/19/2009	1130	0.1	7.1	600	16.1	--	0.1	140	--	--	--	--
11/18/2009	1130	0.2	7.4	655	16.0	--	0.1	180	--	--	--	--
11/18/2009	1131	--	--	--	--	--	--	--	386	240	<4	197
11/18/2009	1135	0.2	7.4	655	16.0	--	0.1	180	--	--	--	--
3/8/2010	1145	0.2	7.3	624	15.7	--	0.1	--	--	--	--	--
3/8/2010	1146	--	--	--	--	--	--	--	350	220	<10	204
3/8/2010	1150	0.2	7.3	624	15.7	--	0.1	--	--	--	--	--
RB1-MS shallow												
8/29/2006	1200	--	--	--	--	--	--	--	--	--	--	--
8/30/2006	1030	M	7.1	573	16.1	--	5.6	150	--	--	--	--
8/30/2006	1031	--	--	--	--	--	--	--	356	180	<4	184
8/30/2006	1035	M	7.1	573	16.1	--	5.6	150	--	--	--	--
11/29/2006	1010	0.1	7.1	566	15.3	--	5.4	120	--	--	--	--
11/29/2006	1011	--	--	--	--	--	--	--	325	180	<4	178
2/23/2007	1030	0.2	7.0	563	15.6	--	2.5	150	--	--	--	--
2/23/2007	1031	--	--	--	--	--	--	--	336	180	4	180
2/23/2007	1032	--	--	--	--	--	--	--	--	--	--	--
6/4/2007	1020	0.6	7.0	561	16.3	--	0.4	140	--	--	--	--
6/4/2007	1021	--	--	--	--	--	--	--	347	180	<10	176

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; μ S/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO₃, calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance (μ S/cm)	Water temperature (°C)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO ₃ (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO ₃ (mg/L)
RB1-MS shallow—Continued												
8/29/2007	1015	0.4	7.1	541	16.3	--	0.5	150	--	--	--	--
8/29/2007	1016	--	--	--	--	--	--	--	334	180	<4	184
8/29/2007	1020	0.4	7.1	541	16.3	--	0.5	150	--	--	--	--
3/4/2008	1015	0.1	7.0	526	15.5	--	0.9	150	--	--	--	--
3/4/2008	1016	--	--	--	--	--	--	--	323	180	<4	176
8/18/2008	1030	0.1	6.9	527	16.2	--	2.6	120	--	--	--	--
8/18/2008	1031	--	--	--	--	--	--	--	326	180	<4	184
8/18/2008	1032	--	--	--	--	--	--	--	--	--	--	--
8/18/2008	1035	0.1	6.9	527	16.2	--	2.6	120	--	--	--	--
2/4/2009	1005	0.5	6.6	531	14.9	--	1.4	170	--	--	--	--
2/4/2009	1006	--	--	--	--	--	--	--	329	180	<4	192
3/24/2009	1135	3.0	6.7	530	15.6	--	2.1	180	--	--	--	--
3/24/2009	1136	--	--	--	--	--	--	--	333	190	<4	184
3/24/2009	1140	3.0	6.7	530	15.6	--	2.1	180	--	--	--	--
4/6/2009	1010	0.3	6.7	531	15.1	--	2.3	170	--	--	--	--
4/6/2009	1011	--	--	--	--	--	--	--	331	190	9	180
4/6/2009	1015	0.3	6.7	531	15.1	--	2.3	170	--	--	--	--
4/9/2009	1005	0.2	6.7	528	15.8	--	0.9	170	--	--	--	--
4/9/2009	1006	--	--	--	--	--	--	--	326	190	<4	188
4/9/2009	1010	0.2	6.7	528	15.8	--	0.9	170	--	--	--	--
4/16/2009	1015	0.1	7.0	537	15.9	--	0.7	120	--	--	--	--
4/16/2009	1016	--	--	--	--	--	--	--	330	180	<4	178
4/20/2009	1005	0.2	6.8	531	15.8	--	0.5	150	--	--	--	--
4/20/2009	1006	--	--	--	--	--	--	--	329	190	<4	183
5/6/2009	1025	0.1	7.1	538	16.1	--	1.5	160	--	--	--	--
5/6/2009	1026	--	--	--	--	--	--	--	318	180	<4	182
5/6/2009	1030	0.1	7.1	538	16.1	--	1.5	160	--	--	--	--
5/20/2009	1005	0.1	6.8	529	16.2	--	0.8	160	--	--	--	--
5/20/2009	1006	--	--	--	--	--	--	--	328	180	<4	180
5/20/2009	1010	0.1	6.8	529	16.2	--	0.8	160	--	--	--	--
6/25/2009	1000	0.1	7.2	533	16.6	--	0.9	160	--	--	--	--
6/25/2009	1001	--	--	--	--	--	--	--	335	180	<4	180

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; $\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; $^{\circ}\text{C}$, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO_3 , calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance ($\mu\text{S}/\text{cm}$)	Water temperature ($^{\circ}\text{C}$)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO_3 (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO_3 (mg/L)
RB1-MS shallow—Continued												
6/25/2009	1005	0.1	7.2	533	16.6	--	0.9	160	--	--	--	--
6/25/2009	1010	0.1	7.2	533	16.6	--	0.9	160	--	--	--	--
7/8/2009	1020	0.2	6.9	533	17.0	--	1.4	170	--	--	--	--
7/8/2009	1021	--	--	--	--	--	--	--	333	190	<4	182
7/8/2009	1025	0.2	6.9	533	17.0	--	1.4	170	--	--	--	--
7/13/2009	1015	0.2	6.9	546	17.0	--	0.6	200	--	--	--	--
7/13/2009	1016	--	--	--	--	--	--	--	331	190	<4	184
7/13/2009	1020	0.2	6.9	546	17.0	--	0.6	200	--	--	--	--
7/20/2009	1015	0.3	6.8	545	16.7	--	0.8	140	--	--	--	--
7/20/2009	1016	--	--	--	--	--	--	--	332	190	6	185
7/20/2009	1020	0.3	6.8	545	16.7	--	0.8	140	--	--	--	--
8/18/2009	1010	0.1	6.8	540	16.7	--	1.1	180	--	--	--	--
8/18/2009	1011	--	--	--	--	--	--	--	328	190	4	183
8/18/2009	1015	0.1	6.8	540	16.7	--	1.1	180	--	--	--	--
11/18/2009	1005	2.7	7.1	528	15.9	--	1.4	170	--	--	--	--
11/18/2009	1006	--	--	--	--	--	--	--	327	180	4	170
11/18/2009	1010	2.7	7.1	528	15.9	--	1.4	170	--	--	--	--
3/1/2010	1130	0.2	7.1	529	15.2	--	2.4	170	--	--	--	--
3/1/2010	1131	--	--	--	--	--	--	--	314	170	<10	173
3/1/2010	1135	0.2	7.1	529	15.2	--	2.4	170	--	--	--	--
RB1-MS deep												
8/29/2006	1200	--	--	--	--	--	--	--	--	--	--	--
8/30/2006	1245	M	7.3	551	16.0	--	0.6	150	--	--	--	--
8/30/2006	1246	--	--	--	--	--	--	--	330	200	<4	197
8/30/2006	1250	M	7.3	551	16.0	--	0.6	150	--	--	--	--
12/4/2006	1000	0.1	7.1	563	15.6	--	0.7	130	--	--	--	--
12/4/2006	1001	--	--	--	--	--	--	--	357	200	<4	193
2/23/2007	1145	0.1	7.3	561	15.8	--	0.7	140	--	--	--	--
2/23/2007	1146	--	--	--	--	--	--	--	324	190	<4	194
6/4/2007	1150	0.1	7.2	554	16.2	--	0.2	130	--	--	--	--
6/4/2007	1151	--	--	--	--	--	--	--	324	190	<10	194
8/29/2007	1205	0.1	7.3	550	16.2	--	0.2	150	--	--	--	--

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; μ S/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO₃, calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance (μ S/cm)	Water temperature (°C)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO ₃ (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO ₃ (mg/L)
RB1-MS deep—Continued												
8/29/2007	1206	--	--	--	--	--	--	--	321	190	<4	192
8/29/2007	1210	0.1	7.3	550	16.2	--	0.2	150	--	--	--	--
3/4/2008	1200	0.1	7.1	540	15.6	--	0.2	150	--	--	--	--
3/4/2008	1201	--	--	--	--	--	--	--	309	200	<4	188
8/18/2008	1230	0.1	7.2	562	16.0	--	0.3	60	--	--	--	--
8/18/2008	1231	--	--	--	--	--	--	--	326	210	<4	194
8/18/2008	1235	0.1	7.2	562	16.0	--	0.3	60	--	--	--	--
2/4/2009	1140	0.1	7.0	503	15.4	--	0.3	100	--	--	--	--
2/4/2009	1141	--	--	--	--	--	--	--	283	190	<4	192
3/24/2009	1305	0.1	7.1	536	15.8	--	0.4	40	--	--	--	--
3/24/2009	1306	--	--	--	--	--	--	--	311	200	<4	188
3/24/2009	1310	0.1	7.1	536	15.8	--	0.4	40	--	--	--	--
4/6/2009	1140	0.2	7.0	517	15.4	--	0.3	160	--	--	--	--
4/6/2009	1141	--	--	--	--	--	--	--	303	200	<4	187
4/6/2009	1145	0.2	7.0	517	15.4	--	0.3	160	--	--	--	--
4/9/2009	1135	0.1	7.1	513	15.8	--	0.3	150	--	--	--	--
4/9/2009	1136	--	--	--	--	--	--	--	301	200	<4	194
4/9/2009	1140	0.1	7.1	513	15.8	--	0.3	150	--	--	--	--
4/16/2009	1140	0.1	7.3	519	15.8	--	0.2	120	--	--	--	--
4/16/2009	1141	--	--	--	--	--	--	--	304	200	<4	188
4/20/2009	1135	0.1	7.1	521	15.8	--	0.3	150	--	--	--	--
4/20/2009	1136	--	--	--	--	--	--	--	309	200	<4	192
5/6/2009	1150	0.1	7.4	528	16.0	--	0.1	140	--	--	--	--
5/6/2009	1151	--	--	--	--	--	--	--	314	200	<4	192
5/6/2009	1155	0.1	7.4	528	16.0	--	0.1	140	--	--	--	--
5/20/2009	1140	M	7.1	519	16.0	--	0.4	160	--	--	--	--
5/20/2009	1141	--	--	--	--	--	--	--	300	200	<4	192
5/20/2009	1145	M	7.1	519	16.0	--	0.4	160	--	--	--	--
6/25/2009	1145	0.2	7.5	532	16.2	--	0.5	150	--	--	--	--
6/25/2009	1146	--	--	--	--	--	--	--	311	200	<4	192
6/25/2009	1150	0.2	7.5	532	16.2	--	0.5	150	--	--	--	--
6/25/2009	1155	0.2	7.5	532	16.2	--	0.5	150	--	--	--	--

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; $\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; $^{\circ}\text{C}$, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO_3 , calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance ($\mu\text{S}/\text{cm}$)	Water temperature ($^{\circ}\text{C}$)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO_3 (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO_3 (mg/L)
RB1-MS deep—Continued												
7/8/2009	1205	0.1	7.2	522	16.6	--	0.3	260	--	--	--	--
7/8/2009	1206	--	--	--	--	--	--	--	307	190	<4	193
7/8/2009	1210	0.1	7.2	522	16.6	--	0.3	260	--	--	--	--
7/13/2009	1155	0.1	7.2	522	16.6	--	0.4	180	--	--	--	--
7/13/2009	1156	--	--	--	--	--	--	--	286	190	<4	192
7/13/2009	1200	0.1	7.2	522	16.6	--	0.4	180	--	--	--	--
7/20/2009	1240	0.2	7.0	515	16.6	--	0.4	170	--	--	--	--
7/20/2009	1241	--	--	--	--	--	--	--	297	190	<4	195
7/20/2009	1245	0.2	7.0	515	16.6	--	0.4	170	--	--	--	--
8/18/2009	1145	0.1	7.1	496	16.3	--	0.1	160	--	--	--	--
8/18/2009	1146	--	--	--	--	--	--	--	294	180	<4	188
8/18/2009	1150	0.1	7.1	496	16.3	--	0.1	160	--	--	--	--
11/18/2009	1135	0.1	7.4	488	15.7	--	0.6	160	--	--	--	--
11/18/2009	1136	--	--	--	--	--	--	--	331	180	<4	188
11/18/2009	1140	0.1	7.4	488	15.7	--	0.6	160	--	--	--	--
3/1/2010	1255	0.2	7.5	495	15.5	--	0.4	190	--	--	--	--
3/1/2010	1256	--	--	--	--	--	--	--	276	180	<10	189
3/1/2010	1300	0.2	7.5	495	15.5	--	0.4	190	--	--	--	--
RB1-PMS shallow												
1/22/2009	1415	0.3	6.7	556	16.1	--	0.3	320	--	--	--	--
1/22/2009	1416	--	--	--	--	--	--	--	343	190	<4	148
2/2/2009	1035	0.3	6.3	563	15.2	--	0.5	400	--	--	--	--
2/2/2009	1036	--	--	--	--	--	--	--	331	190	<4	147
2/11/2009	1146	0.6	6.8	485	10.5	--	--	--	--	--	--	--
2/11/2009	1147	0.5	6.8	486	11.6	--	--	--	--	--	--	--
2/11/2009	1148	0.4	6.8	486	13.1	--	--	--	--	--	--	--
2/11/2009	1149	0.4	6.8	490	14.6	--	--	--	--	--	--	--
2/11/2009	1150	0.3	7.3	490	15.3	--	--	--	--	--	--	--
2/11/2009	1151	0.3	7.5	489	15.4	--	--	--	--	--	--	--
2/11/2009	1152	0.3	7.5	494	15.3	--	--	--	--	--	--	--
2/11/2009	1153	0.3	7.2	506	15.3	--	--	--	--	--	--	--
2/11/2009	1154	0.3	7.2	543	15.3	--	--	--	--	--	--	--

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; μ S/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO₃, calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance (μ S/cm)	Water temperature (°C)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO ₃ (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO ₃ (mg/L)
RB1-PMS shallow—Continued												
2/11/2009	1155	0.3	7.2	571	15.2	--	--	--	--	--	--	--
2/11/2009	1156	0.3	7.2	571	15.2	--	--	--	--	--	--	--
2/11/2009	1157	0.3	7.2	571	15.3	--	--	--	--	--	--	--
2/11/2009	1158	0.3	7.2	573	15.3	--	--	--	--	--	--	--
2/11/2009	1159	0.3	7.2	575	15.3	--	--	--	--	--	--	--
2/11/2009	1200	0.3	7.2	576	15.3	--	--	--	--	--	--	--
3/9/2009	1030	1.0	7.2	525	11.5	--	--	--	--	--	--	--
3/9/2009	1032	0.8	7.2	524	11.6	--	--	--	--	--	--	--
3/9/2009	1034	0.3	7.1	522	12.4	--	--	--	--	--	--	--
3/9/2009	1035	0.2	7.1	521	13.7	--	--	--	--	--	--	--
3/9/2009	1037	0.1	7.1	523	14.7	--	--	--	--	--	--	--
3/9/2009	1038	0.1	7.1	522	15.2	--	--	--	--	--	--	--
3/9/2009	1040	0.1	7.1	515	15.2	--	--	--	--	--	--	--
3/9/2009	1042	0.1	7.1	528	15.2	--	--	--	--	--	--	--
3/9/2009	1043	0.1	7.1	546	15.2	--	--	--	--	--	--	--
3/9/2009	1044	0.1	7.1	539	15.2	--	--	--	--	--	--	--
3/9/2009	1045	0.2	7.1	588	15.2	--	--	--	--	--	--	--
3/26/2009	1115	4.0	6.7	469	14.7	--	1.2	400	--	--	--	--
3/26/2009	1116	--	--	--	--	--	--	--	264	150	<4	140
3/26/2009	1120	4.0	6.7	469	14.7	--	1.2	400	--	--	--	--
4/4/2009	1005	3.1	6.7	482	14.6	--	1.6	450	--	--	--	--
4/4/2009	1006	--	--	--	--	--	--	--	--	--	--	--
4/4/2009	1010	3.1	6.7	482	14.6	--	1.6	450	--	--	--	--
4/8/2009	1005	6.9	6.8	619	13.2	--	1.2	420	--	--	--	--
4/8/2009	1006	--	--	--	--	--	--	--	360	190	<4	104
4/8/2009	1010	6.9	6.8	619	13.2	--	1.2	420	--	--	--	--
4/15/2009	1045	5.6	6.9	582	13.5	--	4.9	420	--	--	--	--
4/15/2009	1046	--	--	--	--	--	--	--	326	170	<4	109
4/18/2009	1010	5.9	7.1	664	13.9	--	0.9	310	--	--	--	--
4/18/2009	1011	--	--	--	--	--	--	--	403	180	<4	109
5/6/2009	1015	2.9	6.7	500	15.2	--	2.1	360	--	--	--	--
5/6/2009	1016	--	--	--	--	--	--	--	272	140	<4	100

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; $\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; $^{\circ}\text{C}$, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO_3 , calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance ($\mu\text{S}/\text{cm}$)	Water temperature ($^{\circ}\text{C}$)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO_3 (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO_3 (mg/L)
RB1-PMS shallow—Continued												
5/6/2009	1020	2.9	6.7	500	15.2	--	2.1	360	--	--	--	--
5/20/2009	1020	0.7	6.9	798	15.7	--	0.5	300	--	--	--	--
5/20/2009	1021	--	--	--	--	--	--	--	338	170	<4	125
5/20/2009	1025	--	--	--	--	--	--	--	--	--	--	--
7/8/2009	1125	0.7	7.0	517	16.6	--	0.7	350	--	--	--	--
7/8/2009	1126	--	--	--	--	--	--	--	322	180	<4	137
7/8/2009	1135	0.7	7.0	517	16.6	--	0.7	350	--	--	--	--
7/13/2009	1015	0.1	7.0	669	16.0	--	1.7	390	--	--	--	--
7/13/2009	1016	--	--	--	--	--	--	--	373	230	<4	156
7/13/2009	1020	0.1	7.0	669	16.0	--	1.7	390	--	--	--	--
7/20/2009	1025	0.5	7.0	767	16.0	--	1.1	330	--	--	--	--
7/20/2009	1026	--	--	--	--	--	--	--	423	240	<4	162
7/20/2009	1035	0.5	7.0	767	16.0	--	1.1	330	--	--	--	--
8/18/2009	1010	0.2	7.0	541	16.1	--	1.4	380	--	--	--	--
8/18/2009	1011	--	--	--	--	--	--	--	320	180	<4	126
8/18/2009	1015	0.2	7.0	541	16.1	--	1.4	380	--	--	--	--
11/17/2009	0950	0.1	7.0	574	14.9	--	5.8	340	--	--	--	--
11/17/2009	0951	--	--	--	--	--	--	--	338	200	<4	128
11/17/2009	0955	0.1	7.0	574	14.9	--	5.8	340	--	--	--	--
3/2/2010	1045	3.0	7.0	682	15.2	--	4.2	310	--	--	--	--
3/2/2010	1046	--	--	--	--	--	--	--	345	190	<10	133
3/2/2010	1050	3.0	7.0	682	15.2	--	4.2	310	--	--	--	--
3/2/2010	1051	--	--	--	--	--	--	--	350	190	<10	132
RB1-PMS deep												
1/22/2009	1300	0.3	6.9	670	15.9	--	0.5	200	--	--	--	--
1/22/2009	1301	--	--	--	--	--	--	--	394	230	<4	164
2/2/2009	1205	0.4	6.7	568	15.0	--	1.3	400	--	--	--	--
2/2/2009	1206	--	--	--	--	--	--	--	339	190	<4	150
2/12/2009	1035	2.5	6.8	568	10.8	--	--	--	--	--	--	--
2/12/2009	1037	2.1	6.8	566	12.8	--	--	--	--	--	--	--
2/12/2009	1038	1.6	6.8	560	14.2	--	--	--	--	--	--	--
2/12/2009	1040	1.2	6.9	536	14.6	--	--	--	--	--	--	--

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; μ S/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO₃, calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance (μ S/cm)	Water temperature (°C)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO ₃ (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO ₃ (mg/L)
RB1-PMS deep—Continued												
2/12/2009	1041	0.7	7.0	549	14.9	--	--	--	--	--	--	--
2/12/2009	1042	0.6	7.0	571	15.0	--	--	--	--	--	--	--
2/12/2009	1043	0.6	7.0	574	15.0	--	--	--	--	--	--	--
2/12/2009	1044	0.5	7.0	572	15.0	--	--	--	--	--	--	--
2/12/2009	1045	0.6	7.0	571	15.0	--	--	--	--	--	--	--
2/12/2009	1046	0.5	7.0	570	15.0	--	--	--	--	--	--	--
2/12/2009	1047	0.5	7.0	570	15.0	--	--	--	--	--	--	--
2/12/2009	1048	0.5	7.0	570	15.0	--	--	--	--	--	--	--
2/12/2009	1049	0.5	7.0	570	15.0	--	--	--	--	--	--	--
2/12/2009	1050	0.5	7.0	571	15.0	--	--	--	--	--	--	--
2/12/2009	1051	0.5	7.0	571	15.0	--	--	--	--	--	--	--
2/12/2009	1052	0.5	7.0	573	15.0	--	--	--	--	--	--	--
2/12/2009	1053	0.5	7.0	570	15.0	--	--	--	--	--	--	--
2/12/2009	1054	0.5	7.0	570	15.0	--	--	--	--	--	--	--
2/12/2009	1055	0.5	7.0	570	15.0	--	--	--	--	--	--	--
3/9/2009	1048	3.0	6.9	577	11.3	--	--	--	--	--	--	--
3/9/2009	1049	1.8	6.9	576	12.0	--	--	--	--	--	--	--
3/9/2009	1050	1.5	6.9	573	13.5	--	--	--	--	--	--	--
3/9/2009	1051	1.1	6.9	555	14.1	--	--	--	--	--	--	--
3/9/2009	1052	0.7	7.0	547	14.6	--	--	--	--	--	--	--
3/9/2009	1053	0.3	7.1	583	14.6	--	--	--	--	--	--	--
3/9/2009	1054	0.3	7.1	586	14.8	--	--	--	--	--	--	--
3/9/2009	1055	0.3	7.1	581	14.8	--	--	--	--	--	--	--
3/9/2009	1056	0.3	7.1	581	14.8	--	--	--	--	--	--	--
3/9/2009	1057	0.3	7.1	580	14.8	--	--	--	--	--	--	--
3/9/2009	1058	0.3	7.1	580	14.8	--	--	--	--	--	--	--
3/9/2009	1059	0.3	7.1	581	14.8	--	--	--	--	--	--	--
3/9/2009	1100	0.3	7.1	581	14.8	--	--	--	--	--	--	--
3/9/2009	1101	0.2	7.1	582	14.8	--	--	--	--	--	--	--
3/9/2009	1102	0.2	7.1	582	14.8	--	--	--	--	--	--	--
3/9/2009	1103	0.2	7.1	582	14.8	--	--	--	--	--	--	--
3/9/2009	1104	0.2	7.1	583	14.8	--	--	--	--	--	--	--

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; $\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; $^{\circ}\text{C}$, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO_3 , calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance ($\mu\text{S}/\text{cm}$)	Water temperature ($^{\circ}\text{C}$)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO_3 (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO_3 (mg/L)
RB1-PMS deep—Continued												
3/9/2009	1105	0.2	7.1	589	14.8	--	--	--	--	--	--	--
3/26/2009	1240	3.8	6.8	454	13.9	--	3.8	380	--	--	--	--
3/26/2009	1241	--	--	--	--	--	--	--	269	160	<4	149
3/26/2009	1245	3.8	6.8	454	13.9	--	3.8	380	--	--	--	--
4/4/2009	1130	3.5	6.8	491	13.9	--	1.4	440	--	--	--	--
4/4/2009	1131	--	--	--	--	--	--	--	453	170	<4	135
4/4/2009	1135	3.5	6.8	491	13.9	--	1.4	440	--	--	--	--
4/8/2009	1130	6.4	6.8	625	12.8	--	1.0	420	--	--	--	--
4/8/2009	1131	--	--	--	--	--	--	--	374	190	<4	115
4/8/2009	1135	6.4	6.8	625	12.8	--	1.0	420	--	--	--	--
4/15/2009	1215	5.1	7.0	592	12.9	--	1.1	340	--	--	--	--
4/15/2009	1216	--	--	--	--	--	--	--	351	170	<4	120
4/15/2009	1217	--	--	--	--	--	--	--	--	--	--	--
4/18/2009	1145	5.3	7.1	668	13.3	--	0.4	300	--	--	--	--
4/18/2009	1146	--	--	--	--	--	--	--	400	190	<4	117
5/6/2009	1140	3.3	6.7	466	15.0	--	1.2	370	--	--	--	--
5/6/2009	1141	--	--	--	--	--	--	--	272	140	<4	101
5/6/2009	1145	3.3	6.7	466	15.0	--	1.2	370	--	--	--	--
5/20/2009	1150	1.3	6.8	726	15.4	--	0.4	300	--	--	--	--
5/20/2009	1151	--	--	--	--	--	--	--	296	160	<4	123
5/20/2009	1155	1.3	6.8	726	15.4	--	0.4	300	--	--	--	--
7/8/2009	1005	0.2	7.0	716	15.9	--	1.1	310	--	--	--	--
7/8/2009	1006	--	--	--	--	--	--	--	423	240	<4	168
7/8/2009	1015	0.2	7.0	716	15.9	--	1.1	310	--	--	--	--
7/13/2009	1140	0.4	6.9	801	16.0	--	3.2	420	--	--	--	--
7/13/2009	1141	--	--	--	--	--	--	--	455	270	<4	182
7/13/2009	1145	0.4	6.9	801	16.0	--	3.2	420	--	--	--	--
7/20/2009	1200	0.5	7.0	927	16.1	--	1.2	390	--	--	--	--
7/20/2009	1201	--	--	--	--	--	--	--	561	310	<4	190
7/20/2009	1210	0.5	7.0	927	16.1	--	1.2	390	--	--	--	--
8/18/2009	1145	0.5	6.8	629	16.1	--	0.8	420	--	--	--	--
8/18/2009	1146	--	--	--	--	--	--	--	357	210	<4	146

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; μ S/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO₃, calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance (μ S/cm)	Water temperature (°C)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO ₃ (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO ₃ (mg/L)
RB1-PMS deep—Continued												
8/18/2009	1150	0.5	6.8	629	16.1	--	0.8	420	--	--	--	--
11/17/2009	1120	0.3	6.9	578	15.1	--	3.0	360	--	--	--	--
11/17/2009	1121	--	--	--	--	--	--	--	346	190	<4	132
11/17/2009	1125	0.3	6.9	578	15.1	--	3.0	360	--	--	--	--
3/2/2010	1255	M	7.0	709	14.8	--	0.8	360	--	--	--	--
3/2/2010	1256	--	--	--	--	--	--	--	373	200	<10	138
3/2/2010	1300	M	7.0	709	14.8	--	0.8	360	--	--	--	--
3/22/2010	1025	0.3	6.9	611	14.6	--	1.1	400	--	--	--	--
3/22/2010	1026	--	--	--	--	--	--	--	363	200	<10	140
3/22/2010	1030	0.3	6.9	611	14.6	--	1.1	400	--	--	--	--
RB1-P shallow												
1/21/2009	1500	1.9	6.6	583	13.6	--	1.1	410	--	--	--	--
1/21/2009	1501	--	--	--	--	--	--	--	359	190	<4	136
2/3/2009	1015	5.3	6.6	674	7.2	--	0.4	440	--	--	--	--
2/3/2009	1016	--	--	--	--	--	--	--	403	210	<4	172
2/3/2009	1017	--	--	--	--	--	--	--	--	--	--	--
2/3/2009	1020	5.3	6.6	674	7.2	--	0.4	440	--	--	--	--
2/3/2009	1021	--	--	--	--	--	--	--	418	210	<4	174
3/25/2009	1035	5.3	6.7	561	12.3	--	0.5	400	--	--	--	--
3/25/2009	1036	--	--	--	--	--	--	--	351	190	<4	152
3/25/2009	1040	5.3	6.7	561	12.3	--	0.5	400	--	--	--	--
4/4/2009	1310	10.4	6.8	604	12.3	--	0.9	480	--	--	--	--
4/4/2009	1311	--	--	--	--	--	--	--	369	190	<4	67
4/4/2009	1315	10.4	6.8	604	12.3	--	0.9	480	--	--	--	--
4/4/2009	1316	--	--	--	--	--	--	--	372	180	<4	65
4/7/2009	1155	10.7	7.4	722	7.9	--	1.1	430	--	--	--	--
4/7/2009	1156	--	--	--	--	--	--	--	423	190	<4	96
4/7/2009	1200	10.7	7.4	722	7.9	--	1.1	430	--	--	--	--
4/15/2009	1040	10.3	7.2	729	12.7	--	1.3	400	--	--	--	--
4/15/2009	1041	--	--	--	--	--	--	--	447	180	<4	106
4/18/2009	1010	7.0	7.2	730	16.0	--	1.5	350	--	--	--	--
4/18/2009	1011	--	--	--	--	--	--	--	454	190	<4	102

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; $\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; $^{\circ}\text{C}$, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO_3 , calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance ($\mu\text{S}/\text{cm}$)	Water temperature ($^{\circ}\text{C}$)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO_3 (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO_3 (mg/L)
RB1-P shallow—Continued												
5/4/2009	1225	6.3	6.9	406	17.1	--	1.2	370	--	--	--	--
5/4/2009	1226	--	--	--	--	--	--	--	237	110	<4	60
5/4/2009	1230	6.3	6.9	406	17.1	--	1.2	370	--	--	--	--
5/19/2009	1145	3.5	6.8	595	17.4	--	1.2	380	--	--	--	--
5/19/2009	1146	--	--	--	--	--	--	--	363	180	<4	157
5/19/2009	1150	3.5	6.8	595	17.4	--	1.2	380	--	--	--	--
8/17/2009	1050	0.3	6.9	657	15.8	--	1.3	290	--	--	--	--
8/17/2009	1051	--	--	--	--	--	--	--	390	230	<4	134
8/17/2009	1055	0.3	6.9	657	15.8	--	1.3	290	--	--	--	--
11/16/2009	1015	0.2	6.9	624	14.6	--	1.8	270	--	--	--	--
11/16/2009	1016	--	--	--	--	--	--	--	378	210	<4	128
11/16/2009	1017	--	--	--	--	--	--	--	--	--	--	--
11/16/2009	1020	0.2	6.9	624	14.6	--	1.8	270	--	--	--	--
3/3/2010	1020	--	7.0	733	15.2	--	4.6	330	--	--	--	--
3/3/2010	1021	--	--	--	--	--	--	--	373	200	<10	130
3/3/2010	1025	--	7.0	733	15.2	--	4.6	330	--	--	--	--
RB1-P deep												
2/3/2009	1150	4.9	6.6	670	9.1	--	12.0	430	--	--	--	--
2/3/2009	1151	--	--	--	--	--	--	--	417	210	6	178
2/12/2009	1240	5.1	6.9	647	8.1	--	--	--	--	--	--	--
2/12/2009	1242	4.9	6.8	657	8.2	--	--	--	--	--	--	--
2/12/2009	1244	4.9	6.8	657	8.3	--	--	--	--	--	--	--
2/12/2009	1245	4.7	6.8	653	8.6	--	--	--	--	--	--	--
2/12/2009	1246	4.6	6.8	649	8.8	--	--	--	--	--	--	--
2/12/2009	1247	4.3	6.8	642	9.2	--	--	--	--	--	--	--
2/12/2009	1248	4.0	6.8	640	9.3	--	--	--	--	--	--	--
2/12/2009	1249	3.6	6.8	636	9.8	--	--	--	--	--	--	--
2/12/2009	1250	3.3	6.8	635	10.0	--	--	--	--	--	--	--
2/12/2009	1251	3.3	6.8	636	10.3	--	--	--	--	--	--	--
2/12/2009	1252	3.5	6.8	639	10.3	--	--	--	--	--	--	--
2/12/2009	1253	5.0	6.9	655	8.5	--	--	--	--	--	--	--
2/12/2009	1254	5.1	6.9	654	8.7	--	--	--	--	--	--	--

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; μ S/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO₃, calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance (μ S/cm)	Water temperature (°C)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO ₃ (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO ₃ (mg/L)
RB1-P deep—Continued												
2/12/2009	1255	5.1	6.9	653	8.8	--	--	--	--	--	--	--
2/12/2009	1256	5.1	6.9	653	8.9	--	--	--	--	--	--	--
2/12/2009	1257	5.1	6.9	652	9.3	--	--	--	--	--	--	--
2/12/2009	1258	5.2	6.9	652	9.9	--	--	--	--	--	--	--
2/12/2009	1259	5.2	6.9	650	10.9	--	--	--	--	--	--	--
2/12/2009	1300	5.4	6.9	646	12.0	--	--	--	--	--	--	--
2/12/2009	1301	5.5	7.0	641	12.8	--	--	--	--	--	--	--
2/12/2009	1302	5.5	7.0	635	13.4	--	--	--	--	--	--	--
2/12/2009	1303	5.6	7.0	629	13.7	--	--	--	--	--	--	--
2/12/2009	1304	5.6	7.0	626	14.0	--	--	--	--	--	--	--
2/12/2009	1305	5.4	7.0	630	14.2	--	--	--	--	--	--	--
3/9/2009	1110	7.4	7.1	599	10.0	--	--	--	--	--	--	--
3/9/2009	1111	7.3	7.1	619	9.9	--	--	--	--	--	--	--
3/9/2009	1112	6.8	7.0	643	10.0	--	--	--	--	--	--	--
3/9/2009	1113	6.7	7.0	650	10.1	--	--	--	--	--	--	--
3/9/2009	1114	6.5	7.0	657	10.1	--	--	--	--	--	--	--
3/9/2009	1115	6.2	7.0	667	10.0	--	--	--	--	--	--	--
3/9/2009	1116	5.6	7.0	623	10.4	--	--	--	--	--	--	--
3/9/2009	1117	5.4	7.0	610	10.5	--	--	--	--	--	--	--
3/9/2009	1118	5.9	7.0	687	10.1	--	--	--	--	--	--	--
3/9/2009	1119	6.0	7.0	684	10.2	--	--	--	--	--	--	--
3/9/2009	1120	6.0	7.0	678	10.4	--	--	--	--	--	--	--
3/9/2009	1121	6.1	7.0	668	10.8	--	--	--	--	--	--	--
3/9/2009	1122	6.2	7.0	654	11.3	--	--	--	--	--	--	--
3/9/2009	1123	6.3	7.0	631	12.1	--	--	--	--	--	--	--
3/9/2009	1124	6.4	7.0	609	12.7	--	--	--	--	--	--	--
3/9/2009	1125	6.5	7.0	582	13.2	--	--	--	--	--	--	--
3/9/2009	1126	6.6	7.1	560	13.5	--	--	--	--	--	--	--
3/25/2009	1205	5.3	6.7	558	12.5	--	1.3	400	--	--	--	--
3/25/2009	1206	--	--	--	--	--	--	--	351	190	<4	150
3/25/2009	1210	5.3	6.7	558	12.5	--	1.3	400	--	--	--	--
4/4/2009	1440	10.2	6.8	601	12.7	--	1.6	450	--	--	--	--

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; $\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; $^{\circ}\text{C}$, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO_3 , calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance ($\mu\text{S}/\text{cm}$)	Water temperature ($^{\circ}\text{C}$)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO_3 (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO_3 (mg/L)
RB1-P deep—Continued												
4/4/2009	1441	--	--	--	--	--	--	--	354	190	<4	68
4/4/2009	1445	10.2	6.8	601	12.7	--	1.6	450	--	--	--	--
4/7/2009	1320	10.5	7.4	718	8.9	--	1.5	430	--	--	--	--
4/7/2009	1321	--	--	--	--	--	--	--	437	190	<4	94
4/7/2009	1325	10.5	7.4	718	8.9	--	1.5	430	--	--	--	--
4/15/2009	1210	10.4	7.2	726	13.2	--	1.5	400	--	--	--	--
4/15/2009	1211	--	--	--	--	--	--	--	437	180	<4	112
4/18/2009	1130	7.0	7.2	734	16.2	--	1.5	370	--	--	--	--
4/18/2009	1131	--	--	--	--	--	--	--	448	190	<4	102
4/18/2009	1132	--	--	--	--	--	--	--	--	--	--	--
5/4/2009	1335	6.4	6.9	409	16.8	--	2.5	370	--	--	--	--
5/4/2009	1336	--	--	--	--	--	--	--	231	110	<4	56
5/4/2009	1340	6.4	6.9	409	16.8	--	2.5	370	--	--	--	--
5/19/2009	1300	3.5	6.8	598	17.1	--	5.2	400	--	--	--	--
5/19/2009	1301	--	--	--	--	--	--	--	363	180	<4	156
5/19/2009	1302	--	--	--	--	--	--	--	--	--	--	--
5/19/2009	1305	3.5	6.8	598	17.1	--	5.2	400	--	--	--	--
7/9/2009	1055	3.8	7.3	675	15.6	--	1.3	480	--	--	--	--
7/9/2009	1056	--	--	--	--	--	--	--	391	220	<4	160
7/9/2009	1100	3.8	7.3	675	15.6	--	1.3	480	--	--	--	--
7/13/2009	1235	3.9	7.2	684	15.8	--	<0.1	--	--	--	--	--
7/13/2009	1236	--	--	--	--	--	--	--	400	230	<4	166
7/13/2009	1240	3.9	7.2	684	15.8	--	<0.1	--	--	--	--	--
7/20/2009	1000	6.4	7.7	650	15.2	--	--	430	--	--	--	--
7/20/2009	1001	--	--	--	--	--	--	--	423	250	<4	168
7/20/2009	1005	6.4	7.7	650	15.2	--	--	430	--	--	--	--
8/12/2009	1020	5.0	7.3	761	15.8	--	1.1	--	--	--	--	--
8/12/2009	1021	--	--	--	--	--	--	--	441	270	<4	170
8/12/2009	1025	5.0	7.3	761	15.8	--	1.1	--	--	--	--	--
8/17/2009	1210	0.1	6.9	668	15.7	--	0.8	280	--	--	--	--
8/17/2009	1211	--	--	--	--	--	--	--	398	230	<4	135
8/17/2009	1215	0.1	6.9	668	15.7	--	0.8	280	--	--	--	--

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; $\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; $^{\circ}\text{C}$, degrees Celsius; \pm , plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO_3 , calcium carbonate; --, not determined or not applicable; $<$, less than; M*, presence of material verified, but not quantified; E**, estimated]

[illegible]

Table 5. Summary of physical property data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; $\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; $^{\circ}\text{C}$, degrees Celsius; +/-, plus or minus; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity radiometric units; mV, millivolts; CaCO_3 , calcium carbonate; --, not determined or not applicable; <, less than; M*, presence of material verified, but not quantified; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Dissolved oxygen (mg/L)	pH, field (standard units)	Specific conductance ($\mu\text{S}/\text{cm}$)	Water temperature ($^{\circ}\text{C}$)	Turbidity, detection angle 90 +/- 30 degrees (NTU)	Turbidity, detectors at multiple angles including 90 +/- 30 degrees, radiometric correction (NTRU)	Oxidation-reduction (redox) potential (mV relative to the standard hydrogen electrode)	Dissolved solids (mg/L)	Hardness as CaCO_3 (mg/L)	Suspended solids (mg/L)	Alkalinity as CaCO_3 (mg/L)
RB1-TR—Continued												
5/4/2009	1100	6.6	7.0	407	16.5	--	0.9	390	--	--	--	--
5/19/2009	1020	2.9	6.9	493	16.4	--	1.4	440	--	--	--	--
5/19/2009	1021	--	--	--	--	--	--	--	306	160	<4	132
5/19/2009	1025	2.9	6.9	493	16.4	--	1.4	440	--	--	--	--
Diverted SW, PAC building												
4/3/2009	1010	10.4	7.4	522	7.0	--	215.0	430	--	--	--	--
4/3/2009	1011	--	--	--	--	--	--	--	314	169	176	96
4/3/2009	1015	10.4	7.4	522	7.0	--	215.0	430	--	--	--	--
4/14/2009	1010	10.1	7.4	496	8.7	--	274.0	550	--	--	--	--
4/14/2009	1011	--	--	--	--	--	--	--	322	153	317	106
4/17/2009	0950	8.7	7.5	721	14.5	--	105.0	390	--	--	--	--
4/17/2009	0951	--	--	--	--	--	--	--	450	245	75	154

* National Water Information System: Web Interface Help System, accessed March 17, 2011, at http://nwis.waterdata.usgs.gov/nwis/help/help?codes_help#remark_cd.

** Values may be reported as estimated (E) if values are out of instrument calibration range, data quantification was not performed according to method specific criteria, or deviation for the standard operating procedure was required. Values are considered detections. (Childress and others, 1999).

Table 6. Summary of bacterial and viral indicator data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.

[mCP, membrane filtration *Clostridium perfringens* agar; MF, membrane filter; CFU/100 mL, colony forming units per 100 milliliters; *E. coli*, *Escherichia coli*; C13, *E. coli* culture resistant to naladixic acid and used to detect somatic coliphages; PFU/100 milliliters, plaque forming units per 100 milliliters; Famp, *E. coli* culture resistant to ampicillin and streptomycin and used to detect male-specific coliphages; MPN/100 mL, most probable number per 100 milliliters; m-TEC, membrane-thermotolerant *Escherichia coli*; M-FC, membrane method fecal coliform; LES, Lawrence Experiment Station; --, not determined or not applicable; <, less than; E**, estimated; >, greater than]

Date of sample collection (month/day/year)	Sample start time	<i>Clostridium perfringens</i> , mCP MF method (CFU/100 mL)	Coliphage, <i>E. coli</i> , C13 host, MF method (PFU/100 mL)	Coliphage, <i>E. coli</i> , Famp host, MF method (PFU/100 mL)	<i>Escherichia coli</i> , defined substrate technology (MPN/100 mL)	<i>Escherichia coli</i> , modified m-TEC MF method (CFU/100 mL)	Fecal coliform, M-FC MF (0.7 micron) method (CFU/100 mL)	Total coliform, defined substrate technology (MPN/100 mL)	Total coliform, LES Endo method (CFU/100 mL)	Total coliform (CFU/100 mL)	Total coliform, water, m-ColiBlue method (CFU/100 mL)
IW-09 shallow											
3/19/2002	1101	--	--	--	--	--	1	--	99	--	--
6/20/2002	0936	--	--	--	--	--	<1	--	2	--	--
2/14/2003	1036	--	--	--	--	--	<1	--	<1	--	--
6/25/2003	0856	--	--	--	--	--	<1	--	2	--	--
2/10/2004	1030	<1	<1	<1	--	--	--	--	--	--	--
6/25/2004	0926	--	--	--	--	--	<1	--	6	--	--
7/11/2005	1201	--	--	--	--	--	<1	--	<1	--	--
6/14/2006	1046	--	--	--	--	--	<1	--	<1	--	--
6/20/2007	1020	--	<1	<1	--	--	--	--	--	--	--
6/20/2007	1021	--	--	--	--	--	<1	--	<1	--	--
6/12/2008	0941	--	--	--	--	--	<1	--	<1	--	--
2/10/2009	0955	<1	<1	<1	--	--	--	--	--	--	--
2/10/2009	0956	--	--	--	<1	--	<1	1	<1	--	--
4/2/2009	1055	<1	<1	<1	--	--	--	--	--	--	--
4/2/2009	1056	--	--	--	<1	--	<1	<1	<1	--	--
4/22/2009	1020	<1	<1	<1	--	--	--	--	--	--	--
4/22/2009	1021	--	--	--	<1	--	<1	<1	<1	--	--
6/10/2009	0956	--	--	--	<1	--	<1	<1	<1	--	--
7/14/2009	1020	<1	<1	<1	--	--	--	--	--	--	--
7/14/2009	1021	--	--	--	<1	--	<1	<1	<1	--	--
8/19/2009	1000	<1	<1	<1	--	--	--	--	--	--	--
8/19/2009	1001	--	--	--	<1	--	<1	<1	<1	--	--
11/17/2009	1005	<1	<1	<1	--	<1	E2	--	--	--	--
11/17/2009	1006	--	--	--	<1	--	<1	<1	<1	--	--
3/9/2010	1010	<1	<1	<1	--	<1	<1	--	--	--	--
3/9/2010	1011	--	--	--	<1	--	<1	<1	<1	--	--

Table 6. Summary of bacterial and viral indicator data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mCP, membrane filtration *Clostridium perfringens* agar; MF, membrane filter; CFU/100 mL, colony forming units per 100 milliliters; *E. coli*, *Escherichia coli*; C13, *E. coli* culture resistant to naladixic acid and used to detect somatic coliphages; PFU/100 milliliters, plaque forming units per 100 milliliters; Famp, *E. coli* culture resistant to ampicillin and streptomycin and used to detect male-specific coliphages; MPN/100 mL, most probable number per 100 milliliters; m-TEC, membrane-thermotolerant *Escherichia coli*; M-FC, membrane method fecal coliform; LES, Lawrence Experiment Station; --, not determined or not applicable; <, less than; E**, estimated; >, greater than]

Date of sample collection (month/day/year)	Sample start time	<i>Clostridium perfringens</i> , mCP MF method (CFU/100 mL)	Coliphage, <i>E. coli</i> , C13 host, MF method (PFU/100 mL)	Coliphage, <i>E. coli</i> , Famp host, MF method (PFU/100 mL)	<i>Escherichia coli</i> , defined substrate technology (MPN/100 mL)	<i>Escherichia coli</i> , modified m-TEC MF method (CFU/100 mL)	Fecal coliform, M-FC MF (0.7 micron) method (CFU/100 mL)	Total coliform, defined substrate technology (MPN/100 mL)	Total coliform, LES Endo method (CFU/100 mL)	Total coliform (CFU/100 mL)	Total coliform, water, m-ColiBlue method (CFU/100 mL)
IW-09 deep											
3/19/2002	1306	--	--	--	--	--	<1	--	20	--	--
6/24/2002	1046	--	--	--	--	--	<1	--	5	--	--
2/14/2003	1336	--	--	--	--	--	<1	--	<1	--	--
6/25/2003	1136	--	--	--	--	--	<1	--	<1	--	--
2/10/2004	1225	<1	<1	<1	--	--	--	--	--	--	--
2/10/2004	1226	--	--	--	--	--	<1	--	<1	--	--
6/25/2004	1131	--	--	--	--	--	<1	--	1	--	--
7/11/2005	1031	--	--	--	--	--	<1	--	<1	--	--
6/14/2006	1236	--	--	--	--	--	<1	--	<1	--	--
6/20/2007	1221	--	--	--	--	--	<1	--	<1	--	--
6/12/2008	1111	--	--	--	--	--	<1	--	<1	--	--
2/10/2009	1125	<1	<1	<1	--	--	--	--	--	--	--
2/10/2009	1126	--	--	--	<1	--	<1	<1	<1	--	--
4/2/2009	1215	<1	<1	<1	--	--	--	--	--	--	--
4/2/2009	1216	--	--	--	<1	--	<1	<1	<1	--	--
4/22/2009	1200	<1	<1	<1	--	--	--	--	--	--	--
4/22/2009	1201	--	--	--	<1	--	<1	<1	<1	--	--
6/10/2009	1121	--	--	--	<1	--	<1	<1	<1	--	--
7/14/2009	1150	<1	<1	<1	--	--	--	--	--	--	--
7/14/2009	1151	--	--	--	<1	--	<1	<1	<1	--	--
8/19/2009	1150	<1	<1	<1	--	--	--	--	--	--	--
8/19/2009	1151	--	--	--	<1	--	<1	<1	<1	--	--
11/17/2009	1146	--	--	--	<1	--	2	<1	<1	--	--
3/9/2010	1155	<1	<1	<1	--	<1	<1	--	--	<1	--
3/9/2010	1156	--	--	--	<1	--	<1	<1	<1	--	--

Table 6. Summary of bacterial and viral indicator data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mCP, membrane filtration *Clostridium perfringens* agar; MF, membrane filter; CFU/100 mL, colony forming units per 100 milliliters; *E. coli*, *Escherichia coli*; C13, *E. coli* culture resistant to naladixic acid and used to detect somatic coliphages; PFU/100 milliliters, plaque forming units per 100 milliliters; Famp, *E. coli* culture resistant to ampicillin and streptomycin and used to detect male-specific coliphages; MPN/100 mL, most probable number per 100 milliliters; m-TEC, membrane-thermotolerant *Escherichia coli*; M-FC, membrane method fecal coliform; LES, Lawrence Experiment Station; --, not determined or not applicable; <, less than; E**, estimated; >, greater than]

Date of sample collection (month/day/year)	Sample start time	<i>Clostridium perfringens</i> , mCP MF method (CFU/100 mL)	Coliphage, <i>E. coli</i> , C13 host, MF method (PFU/100 mL)	Coliphage, <i>E. coli</i> , Famp host, MF method (PFU/100 mL)	<i>Escherichia coli</i> , defined substrate technology (MPN/100 mL)	<i>Escherichia coli</i> , modified m-TEC MF method (CFU/100 mL)	Fecal coliform, M-FC MF (0.7 micron) method (CFU/100 mL)	Total coliform, defined substrate technology (MPN/100 mL)	Total coliform, LES Endo method (CFU/100 mL)	Total coliform (CFU/100 mL)	Total coliform, water, m-ColiBlue method (CFU/100 mL)
RB1 source water											
8/3/2007	1106	--	--	--	--	--	120	--	180	--	--
8/3/2007	1116	--	--	--	--	--	120	--	180	--	--
4/3/2009	1215	<1	1	<1	--	--	--	--	--	--	--
4/3/2009	1216	--	--	--	34	--	22	>200	37	--	--
4/14/2009	1140	<1	980	<1	--	--	--	--	--	--	--
4/14/2009	1141	--	--	--	390	--	200	>2,400	110	--	--
4/17/2009	1110	E1	52	<1	--	--	--	--	--	--	--
4/17/2009	1111	--	--	--	14	--	5	520	23	--	--
RB1-MN shallow											
8/30/2006	1011	--	--	--	--	--	3	--	1	--	--
11/29/2006	1101	--	--	--	--	--	<1	--	<1	--	--
2/23/2007	1011	--	--	--	--	--	<1	--	<1	--	--
6/4/2007	1016	--	--	--	--	--	<1	--	<1	--	--
8/29/2007	1021	--	--	--	--	--	<1	--	<1	--	--
8/29/2007	1031	--	--	--	--	--	<1	--	<1	--	--
3/5/2008	1026	--	--	--	--	--	<1	--	<1	--	--
3/5/2008	1031	--	--	--	--	--	<1	--	<1	--	--
8/19/2008	1011	--	--	--	--	--	<1	--	<1	--	--
2/9/2009	1020	<1	<1	<1	--	--	--	--	--	--	--
2/9/2009	1021	--	--	--	<1	--	<1	1	<1	--	--
4/1/2009	1110	<1	<1	<1	--	--	--	--	--	--	--
4/1/2009	1111	--	--	--	<1	--	<1	<1	<1	--	--
4/21/2009	0955	<1	<1	<1	--	--	--	--	--	--	--
4/21/2009	0956	--	--	--	<1	--	<1	<1	<1	--	--
6/25/2009	1000	<1	<1	<1	--	--	--	--	--	--	--
6/25/2009	1001	--	--	--	<1	--	<1	<1	<1	--	--
7/14/2009	1025	<1	<1	<1	--	--	--	--	--	--	--
7/14/2009	1026	--	--	--	<1	--	<1	<1	<1	--	--
8/19/2009	0956	--	--	--	<1	--	<1	<1	<1	--	--
11/18/2009	1000	<1	<1	<1	--	<1	<1	--	--	--	--
11/18/2009	1001	--	--	--	<1	--	<1	<1	<1	--	--
3/8/2010	1005	<1	<1	<1	--	<1	<1	--	--	<1	--
3/8/2010	1006	--	--	--	<1	--	<1	<1	<1	--	--

Table 6. Summary of bacterial and viral indicator data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mCP, membrane filtration *Clostridium perfringens* agar; MF, membrane filter; CFU/100 mL, colony forming units per 100 milliliters; *E. coli*, *Escherichia coli*; C13, *E. coli* culture resistant to naladixic acid and used to detect somatic coliphages; PFU/100 milliliters, plaque forming units per 100 milliliters; Famp, *E. coli* culture resistant to ampicillin and streptomycin and used to detect male-specific coliphages; MPN/100 mL, most probable number per 100 milliliters; m-TEC, membrane-thermotolerant *Escherichia coli*; M-FC, membrane method fecal coliform; LES, Lawrence Experiment Station; --, not determined or not applicable; <, less than; E**, estimated; >, greater than]

Date of sample collection (month/day/year)	Sample start time	<i>Clostridium perfringens</i> , mCP MF method (CFU/100 mL)	Coliphage, <i>E. coli</i> , C13 host, MF method (PFU/100 mL)	Coliphage, <i>E. coli</i> , Famp host, MF method (PFU/100 mL)	<i>Escherichia coli</i> , defined substrate technology (MPN/100 mL)	<i>Escherichia coli</i> , modified m-TEC MF method (CFU/100 mL)	Fecal coliform, M-FC MF (0.7 micron) method (CFU/100 mL)	Total coliform, defined substrate technology (MPN/100 mL)	Total coliform, LES Endo method (CFU/100 mL)	Total coliform (CFU/100 mL)	Total coliform, water, m-ColiBlue method (CFU/100 mL)
RB1-MN deep											
8/30/2006	1156	--	--	--	--	--	<1	--	<1	--	--
11/29/2006	0956	--	--	--	--	--	<1	--	<1	--	--
2/23/2007	1206	--	--	--	--	--	<1	--	<1	--	--
6/4/2007	1141	--	--	--	--	--	<1	--	<1	--	--
6/4/2007	1146	--	--	--	--	--	<1	--	<1	--	--
8/29/2007	1231	--	--	--	--	--	<1	--	<1	--	--
3/5/2008	1156	--	--	--	--	--	<1	--	<1	--	--
8/19/2008	1151	--	--	--	--	--	<1	--	<1	--	--
2/9/2009	1150	<1	<1	<1	--	--	--	--	--	--	--
2/9/2009	1151	--	--	--	<1	--	<1	<1	<1	--	--
4/1/2009	1240	<1	<1	<1	--	--	--	--	--	--	--
4/1/2009	1241	--	--	--	<1	--	<1	<1	<1	--	--
4/21/2009	1115	<1	<1	<1	--	--	--	--	--	--	--
4/21/2009	1116	--	--	--	<1	--	<1	<1	<1	--	--
6/25/2009	1200	<1	<1	<1	--	--	--	--	--	--	--
6/25/2009	1201	--	--	--	<1	--	<1	<1	<1	--	--
6/25/2009	1210	<1	<1	<1	--	--	--	--	--	--	--
6/25/2009	1211	--	--	--	<1	--	<1	<1	<1	--	--
7/14/2009	1200	<1	<1	<1	--	--	--	--	--	--	--
7/14/2009	1201	--	--	--	<1	--	<1	<1	<1	--	--
8/19/2009	1125	<1	<1	<1	--	--	--	--	--	--	--
8/19/2009	1126	--	--	--	<1	--	<1	<1	<1	--	--
11/18/2009	1130	<1	<1	<1	--	<1	<1	--	--	--	--
11/18/2009	1131	--	--	--	<1	--	<1	<1	<1	--	--
3/8/2010	1145	<1	<1	<1	--	<1	<1	--	--	<1	--
3/8/2010	1146	--	--	--	<1	--	<1	<1	<1	--	--

Table 6. Summary of bacterial and viral indicator data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—
Continued

[mCP, membrane filtration *Clostridium perfringens* agar; MF, membrane filter; CFU/100 mL, colony forming units per 100 milliliters; *E. coli*, *Escherichia coli*; C13, *E. coli* culture resistant to naladixic acid and used to detect somatic coliphages; PFU/100 milliliters, plaque forming units per 100 milliliters; Famp, *E. coli* culture resistant to ampicillin and streptomycin and used to detect male-specific coliphages; MPN/100 mL, most probable number per 100 milliliters; m-TEC, membrane-thermotolerant *Escherichia coli*; M-FC, membrane method fecal coliform; LES, Lawrence Experiment Station; --, not determined or not applicable; <, less than; E**, estimated; >, greater than]

Date of sample collection (month/day/year)	Sample start time	<i>Clostridium perfringens</i> , mCP MF method (CFU/100 mL)	Coliphage, <i>E. coli</i> , C13 host, MF method (PFU/100 mL)	Coliphage, <i>E. coli</i> , Famp host, MF method (PFU/100 mL)	<i>Escherichia coli</i> , defined substrate technology (MPN/100 mL)	<i>Escherichia coli</i> , modified m-TEC MF method (CFU/100 mL)	Fecal coliform, M-FC MF (0.7 micron) method (CFU/100 mL)	Total coliform, defined substrate technology (MPN/100 mL)	Total coliform, LES Endo method (CFU/100 mL)	Total coliform (CFU/100 mL)	Total coliform, water, m-ColiBlue method (CFU/100 mL)
RB1-MS shallow											
8/30/2006	1031	--	--	--	--	--	6	--	<1	--	--
11/29/2006	1011	--	--	--	--	--	<1	--	<1	--	--
2/23/2007	1031	--	--	--	--	--	<1	--	<1	--	--
6/4/2007	1021	--	--	--	--	--	<1	--	<1	--	--
8/29/2007	1016	--	--	--	--	--	<1	--	<1	--	--
3/4/2008	1015	<1	<1	<1	--	<1	--	--	--	--	--
3/4/2008	1016	--	--	--	--	--	<1	--	<1	--	--
8/18/2008	1031	--	--	--	--	--	<1	--	<1	--	--
2/4/2009	1005	<1	<1	<1	--	--	--	--	--	--	--
2/4/2009	1006	--	--	--	>200	--	<1	<1	<1	--	--
3/24/2009	1135	<1	<1	<1	--	--	--	--	--	--	--
3/24/2009	1136	--	--	--	<1	--	<1	<1	<1	--	--
4/6/2009	1010	<1	<1	<1	--	--	--	--	--	--	--
4/6/2009	1011	--	--	--	<1	--	<1	<1	<1	--	--
4/9/2009	1005	<1	<1	<1	--	--	--	--	--	--	--
4/9/2009	1006	--	--	--	<1	--	<1	<1	<1	--	--
4/16/2009	1015	<1	<1	<1	--	--	--	--	--	--	--
4/16/2009	1016	--	--	--	<1	--	<1	<1	<1	--	--
4/20/2009	1005	<1	<1	<1	--	--	--	--	--	--	--
4/20/2009	1006	--	--	--	<1	--	<1	<1	<1	--	--
5/6/2009	1025	<1	<1	<1	--	--	--	--	--	--	--
5/6/2009	1026	--	--	--	<1	--	<1	12	11	--	--
5/20/2009	1005	<1	<1	<1	--	<1	<1	--	--	E3	--
5/20/2009	1006	--	--	--	<1	--	<1	6	<1	--	--
6/25/2009	1000	<1	<1	<1	--	--	--	--	--	--	--
6/25/2009	1001	--	--	--	<1	--	<1	<1	<1	--	--
7/8/2009	1020	<1	<1	<1	--	--	--	--	--	--	--
7/8/2009	1021	--	--	--	<1	--	<1	<1	<1	--	--
7/13/2009	1015	<1	<1	<1	--	<1	<1	--	--	E6	--
7/13/2009	1016	--	--	--	<1	--	<1	3	<1	--	--

Table 6. Summary of bacterial and viral indicator data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mCP, membrane filtration *Clostridium perfringens* agar; MF, membrane filter; CFU/100 mL, colony forming units per 100 milliliters; *E. coli*, *Escherichia coli*; C13, *E. coli* culture resistant to naladixic acid and used to detect somatic coliphages; PFU/100 milliliters, plaque forming units per 100 milliliters; Famp, *E. coli* culture resistant to ampicillin and streptomycin and used to detect male-specific coliphages; MPN/100 mL, most probable number per 100 milliliters; m-TEC, membrane-thermotolerant *Escherichia coli*; M-FC, membrane method fecal coliform; LES, Lawrence Experiment Station; --, not determined or not applicable; <, less than; E**, estimated; >, greater than]

Date of sample collection (month/day/year)	Sample start time	<i>Clostridium perfringens</i> , mCP MF method (CFU/100 mL)	Coliphage, <i>E. coli</i> , C13 host, MF method (PFU/100 mL)	Coliphage, <i>E. coli</i> , Famp host, MF method (PFU/100 mL)	<i>Escherichia coli</i> , defined substrate technology (MPN/100 mL)	<i>Escherichia coli</i> , modified m-TEC MF method (CFU/100 mL)	Fecal coliform, M-FC MF (0.7 micron) method (CFU/100 mL)	Total coliform, defined substrate technology (MPN/100 mL)	Total coliform, LES Endo method (CFU/100 mL)	Total coliform (CFU/100 mL)	Total coliform, water, m-ColiBlue method (CFU/100 mL)
RB1-MS shallow—Continued											
7/20/2009	1015	<1	<1	<1	--	<1	<1	--	--	--	E17
7/20/2009	1016	--	--	--	<1	--	<1	32	1	--	--
8/18/2009	1010	<1	<1	<1	--	--	--	--	--	--	--
8/18/2009	1011	--	--	--	<1	--	<1	1	1	--	--
11/18/2009	1005	<1	<1	<1	--	<1	<1	--	--	--	<1
11/18/2009	1006	--	--	--	<1	--	<1	<1	<1	--	--
3/1/2010	1130	<1	<1	<1	--	<1	<1	--	--	<1	--
3/1/2010	1131	--	--	--	<1	--	<1	<1	<1	--	--
RB1-MS deep											
8/30/2006	1246	--	--	--	--	--	<1	--	<1	--	--
12/4/2006	1001	--	--	--	--	--	<1	--	<1	--	--
2/23/2007	1146	--	--	--	--	--	<1	--	<1	--	--
6/4/2007	1151	--	--	--	--	--	<1	--	<1	--	--
8/29/2007	1206	--	--	--	--	--	<1	--	<1	--	--
3/4/2008	1200	<1	<1	<1	--	<1	--	--	--	--	--
3/4/2008	1201	--	--	--	--	--	<1	--	<1	--	--
8/18/2008	1231	--	--	--	--	--	<1	--	1	--	--
2/4/2009	1140	<1	<1	<1	--	--	--	--	--	--	--
2/4/2009	1141	--	--	--	<1	--	--	<1	<1	--	--
3/24/2009	1305	<1	<1	<1	--	--	--	--	--	--	--
3/24/2009	1306	--	--	--	<1	--	<1	<1	<1	--	--
4/6/2009	1140	<1	<1	<1	--	--	--	--	--	--	--
4/6/2009	1141	--	--	--	<1	--	<1	<1	<1	--	--
4/9/2009	1135	<1	<1	<1	--	--	--	--	--	--	--
4/9/2009	1136	--	--	--	<1	--	<1	<1	<1	--	--
4/16/2009	1140	<1	<1	<1	--	--	--	--	--	--	--
4/16/2009	1141	--	--	--	<1	--	<1	<1	<1	--	--
4/20/2009	1135	<1	<1	<1	--	--	--	--	--	--	--
4/20/2009	1136	--	--	--	<1	--	<1	<1	<1	--	--
5/6/2009	1150	<1	<1	<1	--	--	--	--	--	--	--

Table 6. Summary of bacterial and viral indicator data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mCP, membrane filtration *Clostridium perfringens* agar; MF, membrane filter; CFU/100 mL, colony forming units per 100 milliliters; *E. coli*, *Escherichia coli*; C13, *E. coli* culture resistant to naladixic acid and used to detect somatic coliphages; PFU/100 milliliters, plaque forming units per 100 milliliters; Famp, *E. coli* culture resistant to ampicillin and streptomycin and used to detect male-specific coliphages; MPN/100 mL, most probable number per 100 milliliters; m-TEC, membrane-thermotolerant *Escherichia coli*; M-FC, membrane method fecal coliform; LES, Lawrence Experiment Station; --, not determined or not applicable; <, less than; E**, estimated; >, greater than]

Date of sample collection (month/day/year)	Sample start time	<i>Clostridium perfringens</i> , mCP MF method (CFU/100 mL)	Coliphage, <i>E. coli</i> , C13 host, MF method (PFU/100 mL)	Coliphage, <i>E. coli</i> , Famp host, MF method (PFU/100 mL)	<i>Escherichia coli</i> , defined substrate technology (MPN/100 mL)	<i>Escherichia coli</i> , modified m-TEC MF method (CFU/100 mL)	Fecal coliform, M-FC MF (0.7 micron) method (CFU/100 mL)	Total coliform, defined substrate technology (MPN/100 mL)	Total coliform, LES Endo method (CFU/100 mL)	Total coliform (CFU/100 mL)	Total coliform, water, m-ColiBlue method (CFU/100 mL)
RB1-MS deep—Continued											
5/6/2009	1151	--	--	--	<1	--	<1	<1	<1	--	--
5/20/2009	1140	<1	<1	<1	--	<1	<1	--	--	<1	--
5/20/2009	1141	--	--	--	<1	--	<1	<1	<1	--	--
6/25/2009	1145	<1	<1	<1	--	--	--	--	--	--	--
6/25/2009	1146	--	--	--	<1	--	<1	<1	<1	--	--
7/8/2009	1205	<1	<1	<1	--	--	--	--	--	--	--
7/8/2009	1206	--	--	--	<1	--	<1	>200	<1	--	--
7/13/2009	1155	<1	<1	<1	--	--	--	--	--	--	--
7/13/2009	1156	--	--	--	<1	--	<1	37	<1	--	--
7/20/2009	1240	<1	<1	<1	--	<1	<1	--	--	--	E8
7/20/2009	1241	--	--	--	<1	--	<1	15	<1	--	--
8/18/2009	1145	<1	<1	<1	--	--	--	--	--	--	--
8/18/2009	1146	--	--	--	<1	--	<1	2	1	--	--
11/18/2009	1135	<1	<1	<1	--	<1	<1	--	--	--	<1
11/18/2009	1136	--	--	--	<1	--	<1	2	<1	--	--
3/1/2010	1255	<1	<1	<1	--	<1	<1	--	--	<1	--
3/1/2010	1256	--	--	--	<1	--	<1	<1	<1	--	--
RB1-PMS shallow											
2/2/2009	1035	<1	<1	<1	--	--	--	--	--	--	--
2/2/2009	1036	--	--	--	<1	--	<1	<1	<1	--	--
3/26/2009	1115	<1	<1	<1	--	--	--	--	--	--	--
3/26/2009	1116	--	--	--	<1	--	<1	1	<1	--	--
4/4/2009	1005	<1	<1	<1	--	<1	<1	--	--	E23	--
4/8/2009	1005	<1	14	<1	--	--	--	--	--	--	--
4/8/2009	1006	--	--	--	--	--	<1	--	<1	--	--
4/15/2009	1045	<1	9	<1	--	--	--	--	--	--	--
4/15/2009	1046	--	--	--	<1	--	<1	19	1	--	--
4/18/2009	1010	<1	1	<1	--	<1	<1	--	--	E10	--
5/6/2009	1015	<1	2	<1	--	--	--	--	--	--	--
5/6/2009	1016	--	--	--	<1	--	<1	1	18	--	--

Table 6. Summary of bacterial and viral indicator data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mCP, membrane filtration *Clostridium perfringens* agar; MF, membrane filter; CFU/100 mL, colony forming units per 100 milliliters; *E. coli*, *Escherichia coli*; C13, *E. coli* culture resistant to naladixic acid and used to detect somatic coliphages; PFU/100 milliliters, plaque forming units per 100 milliliters; Famp, *E. coli* culture resistant to ampicillin and streptomycin and used to detect male-specific coliphages; MPN/100 mL, most probable number per 100 milliliters; m-TEC, membrane-thermotolerant *Escherichia coli*; M-FC, membrane method fecal coliform; LES, Lawrence Experiment Station; --, not determined or not applicable; <, less than; E**, estimated; >, greater than]

Date of sample collection (month/day/year)	Sample start time	<i>Clostridium perfringens</i> , mCP MF method (CFU/100 mL)	Coliphage, <i>E. coli</i> , C13 host, MF method (PFU/100 mL)	Coliphage, <i>E. coli</i> , Famp host, MF method (PFU/100 mL)	<i>Escherichia coli</i> , defined substrate technology (MPN/100 mL)	<i>Escherichia coli</i> , modified m-TEC MF method (CFU/100 mL)	Fecal coliform, M-FC MF (0.7 micron) method (CFU/100 mL)	Total coliform, defined substrate technology (MPN/100 mL)	Total coliform, LES Endo method (CFU/100 mL)	Total coliform (CFU/100 mL)	Total coliform, water, m-ColiBlue method (CFU/100 mL)
RB1-PMS shallow—Continued											
5/20/2009	1020	<1	<1	<1	--	<1	<1	--	--	<1	--
5/20/2009	1021	--	--	--	<1	--	<1	<1	<1	--	--
7/8/2009	1125	<1	<1	<1	--	--	--	--	--	--	--
7/8/2009	1126	--	--	--	<1	--	<1	>200	100	--	--
7/13/2009	1015	<1	<1	<1	--	<1	E3	--	--	--	--
7/13/2009	1016	--	--	--	<1	--	<1	>2,400	--	--	--
7/20/2009	1025	<1	40	<1	--	E1	<1	--	--	--	E2,000
7/20/2009	1026	--	--	--	<1	--	<1	>200	<1	--	--
8/18/2009	1010	<1	<1	<1	--	--	--	--	--	--	--
8/18/2009	1011	--	--	--	<1	--	<1	1	1	--	--
11/17/2009	0950	<1	<1	<1	--	<1	<1	--	--	--	20
11/17/2009	0951	--	--	--	<1	--	<1	2	4	--	--
3/2/2010	1045	<1	<1	<1	--	<1	<1	--	--	<1	--
3/2/2010	1046	--	--	--	<1	--	<1	<1	<1	--	--
3/2/2010	1050	E1	<1	<1	--	<1	<1	--	--	<1	--
3/2/2010	1051	--	--	--	<1	--	<1	<1	<1	--	--
RB1-PMS deep											
1/22/2009	1300	--	--	--	--	<1	<1	--	--	E1	--
2/2/2009	1205	<1	<1	<1	--	--	--	--	--	--	--
2/2/2009	1206	--	--	--	<1	--	<1	<1	<1	--	--
3/26/2009	1240	<1	<1	<1	--	--	--	--	--	--	--
3/26/2009	1241	--	--	--	<1	--	<1	<1	<1	--	--
4/4/2009	1130	<1	<1	<1	--	<1	<1	--	--	40	--
4/8/2009	1130	<1	11	<1	--	--	--	--	--	--	--
4/8/2009	1131	--	--	--	<1	--	<1	21	<1	--	--
4/15/2009	1215	<1	8	<1	--	--	--	--	--	--	--
4/15/2009	1216	--	--	--	<1	--	<1	8	3	--	--
4/18/2009	1145	<1	1	<1	--	<1	<1	--	--	E9	--
5/6/2009	1140	<1	1	<1	--	--	--	--	--	--	--
5/6/2009	1141	--	--	--	<1	--	<1	1	5	--	--

Table 6. Summary of bacterial and viral indicator data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mCP, membrane filtration *Clostridium perfringens* agar; MF, membrane filter; CFU/100 mL, colony forming units per 100 milliliters; *E. coli*, *Escherichia coli*; C13, *E. coli* culture resistant to naladixic acid and used to detect somatic coliphages; PFU/100 milliliters, plaque forming units per 100 milliliters; Famp, *E. coli* culture resistant to ampicillin and streptomycin and used to detect male-specific coliphages; MPN/100 mL, most probable number per 100 milliliters; m-TEC, membrane-thermotolerant *Escherichia coli*; M-FC, membrane method fecal coliform; LES, Lawrence Experiment Station; --, not determined or not applicable; <, less than; E**, estimated; >, greater than]

Date of sample collection (month/day/year)	Sample start time	<i>Clostridium perfringens</i> , mCP MF method (CFU/100 mL)	Coliphage, <i>E. coli</i> , C13 host, MF method (PFU/100 mL)	Coliphage, <i>E. coli</i> , Famp host, MF method (PFU/100 mL)	<i>Escherichia coli</i> , defined substrate technology (MPN/100 mL)	<i>Escherichia coli</i> , modified m-TEC MF method (CFU/100 mL)	Fecal coliform, M-FC MF (0.7 micron) method (CFU/100 mL)	Total coliform, defined substrate technology (MPN/100 mL)	Total coliform, LES Endo method (CFU/100 mL)	Total coliform (CFU/100 mL)	Total coliform, water, m-ColiBlue method (CFU/100 mL)
RB1-PMS deep—Continued											
5/20/2009	1150	<1	<1	<1	--	<1	<1	--	--	E1	--
5/20/2009	1151	--	--	--	<1	--	<1	<1	1	--	--
7/8/2009	1005	<1	<1	<1	--	--	--	--	--	--	--
7/8/2009	1006	--	--	--	<1	--	<1	>200	12	--	--
7/13/2009	1140	<1	<1	<1	--	<1	<1	--	--	--	--
7/13/2009	1141	--	--	--	<1	--	<1	690	--	--	--
7/20/2009	1200	<1	<1	<1	--	<1	<1	--	--	--	E37
7/20/2009	1201	--	--	--	<1	--	<1	43	<1	--	--
8/18/2009	1145	<1	<1	<1	--	--	--	--	--	--	--
8/18/2009	1146	--	--	--	<1	--	<1	8	2	--	--
11/17/2009	1120	<1	<1	<1	--	<1	E1	--	--	--	E7
11/17/2009	1121	--	--	--	<1	--	<1	6	6	--	--
3/2/2010	1255	<1	<1	<1	--	<1	<1	--	--	E120	--
3/2/2010	1256	--	--	--	<1	--	<1	16	--	--	--
3/22/2010	1025	--	--	--	--	<1	<1	--	--	--	<1
3/22/2010	1026	--	--	--	<1	--	<1	<1	<1	--	--
RB1-P shallow											
1/21/2009	1500	--	--	--	--	<1	<1	--	--	59	--
2/3/2009	1015	E1	<1	<1	--	--	--	--	--	--	--
2/3/2009	1016	--	--	--	29	--	<1	<1	1	--	--
2/3/2009	1020	<1	<1	<1	--	--	--	--	--	--	--
2/3/2009	1021	--	--	--	19	--	<1	<1	1	--	--
3/25/2009	1035	<1	<1	<1	--	--	--	--	--	--	--
3/25/2009	1036	--	--	--	<1	--	<1	<1	<1	--	--
4/4/2009	1310	<1	E46	<1	--	E11	E9	--	--	>120	--
4/4/2009	1315	<1	E63	E1	--	E11	E9	--	--	>120	--
4/7/2009	1155	E1	32	1	--	--	--	--	--	--	--
4/7/2009	1156	--	--	--	<1	--	1	>200	3	--	--
4/15/2009	1040	E1	110	<1	--	--	--	--	--	--	--
4/15/2009	1041	--	--	--	<1	--	<1	>200	5	--	--

Table 6. Summary of bacterial and viral indicator data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mCP, membrane filtration *Clostridium perfringens* agar; MF, membrane filter; CFU/100 mL, colony forming units per 100 milliliters; *E. coli*, *Escherichia coli*; C13, *E. coli* culture resistant to naladixic acid and used to detect somatic coliphages; PFU/100 milliliters, plaque forming units per 100 milliliters; Famp, *E. coli* culture resistant to ampicillin and streptomycin and used to detect male-specific coliphages; MPN/100 mL, most probable number per 100 milliliters; m-TEC, membrane-thermotolerant *Escherichia coli*; M-FC, membrane method fecal coliform; LES, Lawrence Experiment Station; --, not determined or not applicable; <, less than; E**, estimated; >, greater than]

Date of sample collection (month/day/year)	Sample start time	<i>Clostridium perfringens</i> , mCP MF method (CFU/100 mL)	Coliphage, <i>E. coli</i> , C13 host, MF method (PFU/100 mL)	Coliphage, <i>E. coli</i> , Famp host, MF method (PFU/100 mL)	<i>Escherichia coli</i> , defined substrate technology (MPN/100 mL)	<i>Escherichia coli</i> , modified m-TEC MF method (CFU/100 mL)	Fecal coliform, M-FC MF (0.7 micron) method (CFU/100 mL)	Total coliform, defined substrate technology (MPN/100 mL)	Total coliform, LES Endo method (CFU/100 mL)	Total coliform (CFU/100 mL)	Total coliform, water, m-ColiBlue method (CFU/100 mL)
RB1-P shallow—Continued											
4/18/2009	1010	E1	3	<1	--	E4	<1	--	--	E14	--
5/4/2009	1225	<1	<1	<1	--	--	--	--	--	--	--
5/4/2009	1226	--	--	--	<1	--	<1	6	1	--	--
5/19/2009	1145	<1	<1	<1	--	E2	E2	--	--	E4	--
5/19/2009	1146	--	--	--	<1	--	<1	11	1	--	--
8/17/2009	1050	E1	<1	<1	--	--	--	--	--	--	--
8/17/2009	1051	--	--	--	<1	--	<1	>200	10	--	--
11/16/2009	1015	<1	<1	<1	--	<1	<1	--	--	--	<1
11/16/2009	1016	--	--	--	<1	--	<1	<1	<1	--	--
3/3/2010	1020	<1	<1	<1	--	<1	<1	--	--	<1	--
3/3/2010	1021	--	--	--	<1	--	<1	<1	<1	--	--
RB1-P deep											
2/3/2009	1150	<1	<1	<1	--	--	--	--	--	--	--
2/3/2009	1151	--	--	--	22	--	<1	<1	4	--	--
3/25/2009	1205	<1	<1	<1	--	--	--	--	--	--	--
3/25/2009	1206	--	--	--	<1	--	<1	32	<1	--	--
4/4/2009	1440	<1	E59	<1	--	E13	E11	--	--	>120	--
4/7/2009	1320	E1	40	<1	--	--	--	--	--	--	--
4/7/2009	1321	--	--	--	<1	--	2	>200	14	--	--
4/15/2009	1210	E1	100	<1	--	--	--	--	--	--	--
4/15/2009	1211	--	--	--	2	--	1	>200	8	--	--
4/18/2009	1130	E1	1	<1	--	E4	<1	--	--	E12	--
5/4/2009	1335	<1	2	<1	--	--	--	--	--	--	--
5/4/2009	1336	--	--	--	<1	--	<1	5	1	--	--
5/19/2009	1300	<1	<1	<1	--	<1	<1	--	--	E27	--
5/19/2009	1301	--	--	--	<1	--	<1	11	<1	--	--
7/9/2009	1055	<1	<1	<1	--	<1	<1	--	--	17	--
7/9/2009	1056	--	--	--	<1	--	<1	4	<1	--	--
7/13/2009	1235	<1	<1	<1	--	<1	<1	--	--	E10	--
7/13/2009	1236	--	--	--	<1	--	<1	5	<1	--	--

Table 6. Summary of bacterial and viral indicator data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mCP, membrane filtration *Clostridium perfringens* agar; MF, membrane filter; CFU/100 mL, colony forming units per 100 milliliters; *E. coli*, *Escherichia coli*; C13, *E. coli* culture resistant to naladixic acid and used to detect somatic coliphages; PFU/100 milliliters, plaque forming units per 100 milliliters; Famp, *E. coli* culture resistant to ampicillin and streptomycin and used to detect male-specific coliphages; MPN/100 mL, most probable number per 100 milliliters; m-TEC, membrane-thermotolerant *Escherichia coli*; M-FC, membrane method fecal coliform; LES, Lawrence Experiment Station; --, not determined or not applicable; <, less than; E**, estimated; >, greater than]

Date of sample collection (month/day/year)	Sample start time	<i>Clostridium perfringens</i> , mCP MF method (CFU/100 mL)	Coliphage, <i>E. coli</i> , C13 host, MF method (PFU/100 mL)	Coliphage, <i>E. coli</i> , Famp host, MF method (PFU/100 mL)	<i>Escherichia coli</i> , defined substrate technology (MPN/100 mL)	<i>Escherichia coli</i> , modified m-TEC MF method (CFU/100 mL)	Fecal coliform, M-FC MF (0.7 micron) method (CFU/100 mL)	Total coliform, defined substrate technology (MPN/100 mL)	Total coliform, LES Endo method (CFU/100 mL)	Total coliform (CFU/100 mL)	Total coliform, water, m-ColiBlue method (CFU/100 mL)
RB1-P deep—Continued											
7/20/2009	1000	<1	<1	<1	--	<1	<1	--	--	--	E6
7/20/2009	1001	--	--	--	<1	--	1	3	1	--	--
8/12/2009	1020	<1	<1	<1	--	<1	<1	--	--	--	E4
8/12/2009	1021	--	--	--	<1	--	<1	<1	1	--	--
8/17/2009	1210	<1	<1	<1	--	--	--	--	--	--	--
8/17/2009	1211	--	--	--	<1	--	<1	74	6	--	--
11/16/2009	1125	<1	<1	<1	--	<1	<1	--	--	--	<1
11/16/2009	1126	--	--	--	<1	--	<1	<1	<1	--	--
3/3/2010	1135	<1	<1	<1	--	<1	<1	--	--	<1	--
3/3/2010	1136	--	--	--	<1	--	<1	<1	<1	--	--
RB1-TR											
3/26/2009	1020	<1	<1	<1	--	--	--	--	--	--	--
3/26/2009	1021	--	--	--	<1	--	<1	6	<1	--	--
4/3/2009	1350	<1	1	<1	--	--	--	--	--	--	--
4/3/2009	1351	--	--	--	5	--	1	>200	7	--	--
4/7/2009	1000	<1	36	2	--	--	--	--	--	--	--
4/7/2009	1001	--	--	--	1	--	2	370	4	--	--
4/7/2009	1005	1	42	<1	--	--	--	--	--	--	--
4/7/2009	1006	--	--	--	<1	--	4	390	6	--	--
4/14/2009	1131	--	--	--	2	--	7	1,600	14	--	--
4/14/2009	1330	E1	100	<1	--	--	--	--	--	--	--
4/17/2009	1250	<1	1	<1	--	--	--	--	--	--	--
4/17/2009	1251	--	--	--	1	--	<1	16	17	--	--
4/23/2009	1121	--	--	--	1	--	4	32	16	--	--
4/23/2009	1220	E1	1	<1	--	E1	E2	--	--	120	--
4/27/2009	1140	E1	3	<1	--	--	--	--	--	--	--
4/27/2009	1141	--	--	--	1	--	4	200	24	--	--
5/4/2009	1055	<1	<1	<1	--	--	--	--	--	--	--
5/4/2009	1056	--	--	--	<1	--	<1	3	1	--	--
5/19/2009	1020	<1	<1	<1	--	<1	<1	--	--	50	--
5/19/2009	1021	--	--	--	<1	--	<1	34	<1	--	--

Table 6. Summary of bacterial and viral indicator data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mCP, membrane filtration *Clostridium perfringens* agar; MF, membrane filter; CFU/100 mL, colony forming units per 100 milliliters; *E. coli*, *Escherichia coli*; C13, *E. coli* culture resistant to naladixic acid and used to detect somatic coliphages; PFU/100 milliliters, plaque forming units per 100 milliliters; Famp, *E. coli* culture resistant to ampicillin and streptomycin and used to detect male-specific coliphages; MPN/100 mL, most probable number per 100 milliliters; m-TEC, membrane-thermotolerant *Escherichia coli*; M-FC, membrane method fecal coliform; LES, Lawrence Experiment Station; --, not determined or not applicable; <, less than; E**, estimated; >, greater than]

Date of sample collection (month/day/year)	Sample start time	<i>Clostridium perfringens</i> , mCP MF method (CFU/100 mL)	Coliphage, <i>E. coli</i> , C13 host, MF method (PFU/100 mL)	Coliphage, <i>E. coli</i> , Famp host, MF method (PFU/100 mL)	<i>Escherichia coli</i> , defined substrate technology (MPN/100 mL)	<i>Escherichia coli</i> , modified m-TEC MF method (CFU/100 mL)	Fecal coliform, M-FC MF (0.7 micron) method (CFU/100 mL)	Total coliform, defined substrate technology (MPN/100 mL)	Total coliform, LES Endo method (CFU/100 mL)	Total coliform (CFU/100 mL)	Total coliform, water, m-ColiBlue method (CFU/100 mL)
Diverted SW, PAC building											
4/3/2009	1010	130	1,300	14	--	--	--	--	--	--	--
4/3/2009	1011	--	--	--	906	--	2,700	24,196	2,300	--	--
4/14/2009	1010	8	5,500	<1	--	--	--	--	--	--	--
4/14/2009	1011	--	--	--	1,600	--	5,000	72,700	8,000	--	--
4/17/2009	0950	92	2,800	2	--	--	42	--	--	--	--
4/17/2009	0951	--	--	--	473	--	--	6,867	1,100	--	--

** Values may be reported as estimated (E) if values are out of instrument calibration range, data quantification was not performed according to method specific criteria, or deviation for the standard operating procedure was required. Values are considered detections. (Childress and others, 1999).

Table 7. Summary of iron-related bacteria data and sulfate-reducing bacteria data from biotester analysis of water samples collected as part of the *Equus* Beds Passive Recharge Project at RB1, 2009–2010.

[IRB, iron-related bacteria; CFU/mL, colony forming units per 100 milliliters; SRB, sulfate-reducing bacteria; BR, brown ring; <, less than; N/A, non-aggressive; FO, foam; RC, red cloudy; BA, blackened top and base; BC, brown cloudy; BT, blackened top; BB, blackened base; GC, green cloudy; BL, black liquid; --, not determined or not applicable]

Date of sample collection (month/day/year)	Sample start time	IRB Biotester (CFU/mL)	IRB Biotester Reaction Pattern Signature	SRB Biotester (CFU/mL)	SRB Biotester Reaction Pattern Signature
IW-09 shallow					
2/10/2009	0955	150	BR	<200	N/A
4/2/2009	1055	35,000	FO-BR	<200	N/A
4/22/2009	1020	25	RC	<200	N/A
6/10/2009	0955	2,300	FO	<200	N/A
7/14/2009	1020	<25	N/A	<200	N/A
8/19/2009	1000	25	BR	200	BA
11/17/2009	1005	9,000	FO-BR	<200	N/A
3/9/2010	1010	9,000	FO-BR	<200	N/A
IW-09 deep					
2/10/2009	1125	150	BR	<200	N/A
4/2/2009	1215	500	FO-BC, BR	5,000	BT-BA
4/22/2009	1200	150	FO	<200	N/A
8/19/2009	1150	25	FO	200	BB
11/17/2009	1145	500	FO	<200	N/A
3/9/2010	1155	150	FO-BR	<200	N/A
RB1 source water					
4/3/2009	1215	35,000	FO-GC, BL	100,000	BT-BA
4/14/2009	1140	35,000	FO-BC-BR/BL	100,000	BT-BA
4/17/2009	1110	35,000	FO-BL-BR	100,000	BT-BA
RB1-MN shallow					
2/9/2009	1020	9,000	FO	200	BB
4/1/2009	1110	9,000	FO	5,000	BB-BA
4/21/2009	0955	9,000	FO	18,000	BT-BA
6/25/2009	1000	35,000	FO-BR	5,000	BT-BA
7/14/2009	1025	<25	N/A	<200	N/A
8/19/2009	0955	35,000	FO	18,000	BT-BA
11/18/2009	1005	35,000	FO-BR	18,000	BT-BA
3/8/2010	1010	9,000	FO-BR	<200	NA
RB1-MN deep					
2/9/2009	1150	9,000	BR	18,000	BB-BA
4/1/2009	1240	150	FO	<200	N/A
4/21/2009	1115	500	FO-GC	18,000	BT-BA
6/25/2009	1200	500	FO-BR	<200	N/A
7/14/2009	1200	25	FO	200	BB
8/19/2009	1125	2,300	FO	<200	N/A
11/24/2009	1130	500	FO-BR	<200	N/A
3/8/2010	1145	25	BR	<200	N/A
RB1-MS shallow					
2/4/2009	1005	25	--	100,000	BT-BA
3/4/2009	1015	2,300	FO	200	BB
3/24/2009	1135	2,300	FO	18,000	BT-BA
4/6/2009	1010	9,000	FO	18,000	BT-BA
4/9/2009	1005	9,000	FO	1,200	BT-BA
4/16/2009	1015	9,000	FO	18,000	BT-BA
4/20/2009	1005	35,000	FO	100,000	BT-BA
5/6/2009	1025	35,000	FO-GC	5,000	BT-BA
5/20/2009	1005	<25	N/A	100,000	BT
6/25/2009	1000	2,300	BR-FO	100,000	BT-BA
7/8/2009	1020	35,000	FO-GC	100,000	BT-BA
7/13/2009	1015	140,000	FO-GC	100,000	BT-BA

Table 7. Summary of iron-related bacteria data and sulfate-reducing bacteria data from biotester analysis of water samples collected as part of the *Equus* Beds Passive Recharge Project at RB1, 2009–2010.—Continued

[IRB, iron-related bacteria; CFU/mL, colony forming units per 100 milliliters; SRB, sulfate-reducing bacteria; BR, brown ring; <, less than; N/A, non-aggressive; FO, foam; RC, red cloudy; BA, blackened top and base; BC, brown cloudy; BT, blackened top; BB, blackened base; GC, green cloudy; BL, black liquid; --, not determined or not applicable]

Date of sample collection (month/day/year)	Sample start time	IRB Biotester (CFU/mL)	IRB Biotester Reaction Pattern Signature	SRB Biotester (CFU/mL)	SRB Biotester Reaction Pattern Signature
RB1-MS shallow—Continued					
7/20/2009	1015	140,000	FO-BC-BG	100,000	BT-BA
8/18/2009	1010	140,000	FO-BG, BR	100,000	BT-BA
11/18/2009	1005	35,000	FO-BR-GC	1,200	BT
3/1/2010	1130	150	FO	<200	N/A
RB1-MS deep					
2/4/2009	1140	9,000	FO	5,000	BT-BA
3/4/2009	1200	<25	N/A	500	BB-BA
3/24/2009	1305	2,300	FO-BR	18,000	BT-BA
4/6/2009	1140	35,000	FO-BR	18,000	BT-BA
4/9/2009	1135	35,000	FO-BR	100,000	BT-BA
4/16/2009	1140	35,000	FO-CL-BR	100,000	BB-BA
4/20/2009	1135	35,000	FO	100,000	BT-BA
5/6/2009	1150	35,000	FO	5,000	BT-BA
5/20/2009	1140	35,000	FO	<200	N/A
6/25/2009	1145	35,000	FO-BR-BC, BG-GC	100,000	BT-BA
7/8/2009	1205	35,000	FO-RC	100,000	BT-BA
7/13/2009	1155	35,000	FO-RC	100,000	BT-BA
7/20/2009	1240	35,000	FO-BG, BR-GC	100,000	BT-BA
8/18/2009	1145	35,000	FO-BG-BR	<200	N/A
11/18/2009	1135	35,000	FO-RC	<200	N/A
3/1/2010	1255	<25	FO	<200	N/A
RB1-PMS shallow					
1/22/2009	1415	500	FO, BR, BC	18,000	BT-BA
2/2/2009	1035	500	FO	<200	N/A
3/26/2009	1115	35,000	FO-CL	100,000	BT-BA
4/4/2009	1005	35,000	FO-BR, GC-BL	700,000	BT-BA
4/8/2009	1005	35,000	FO-BR	700,000	BT-BA
4/15/2009	1045	9,000	FO, BC-GC, BR	5,000	BT
5/6/2009	1015	35,000	FO-GC	100,000	BT-BA
5/20/2009	1020	9,000	FO-GC, B R	5,000	BT-BA
7/8/2009	1125	9,000	FO-RC	100,000	BT-BA
7/13/2009	1015	9,000	FO-RC-BL	700,000	BT-BA
7/20/2009	1025	9,000	FO-GC-BL	100,000	BT-BA
8/18/2009	1010	2,300	FO-BC, BG-BR	200	BA
11/17/2009	0950	9,000	FO-GC	1,200	BT-BA
3/2/2010	--	35,000	FO-GC	18,000	BT-BA
RB1-PMS deep					
1/22/2009	1300	500	FO, BR, BC	1,200	BA
2/2/2009	1205	2,300	FO, BR, BC	18,000	BA
3/26/2009	1240	35,000	FO-GC-BL	700,000	BT-BA
4/4/2009	1130	35,000	FO-GC, BR	100,000	BT
4/8/2009	1130	35,000	FO-GC-BL	5,000	BT-BA
4/15/2009	1215	35,000	FO-BC-BR	<200	N/A
4/18/2009	1145	35,000	FO-RC	<200	N/A
5/6/2009	1140	35,000	FO-RC-BL	18,000	BT
5/20/2009	1150	35,000	FO	<200	N/A
7/8/2009	1005	35,000	FO-RC-BL	5,000	BT-BA
7/13/2009	1140	35,000	FO-RC-BL	100,000	BT-BA
7/20/2009	1200	35,000	FO-BR, BC, BG-BL	100,000	BT-BA
8/18/2009	1145	35,000	FO-BG-BC	1,200	BA

Table 7. Summary of iron-related bacteria data and sulfate-reducing bacteria data from biotester analysis of water samples collected as part of the *Equus* Beds Passive Recharge Project at RB1, 2009–2010.—Continued

[IRB, iron-related bacteria; CFU/mL, colony forming units per 100 milliliters; SRB, sulfate-reducing bacteria; BR, brown ring; <, less than; N/A, non-aggressive; FO, foam; RC, red cloudy; BA, blackened top and base; BC, brown cloudy; BT, blackened top; BB, blackened base; GC, green cloudy; BL, black liquid; --, not determined or not applicable]

Date of sample collection (month/day/year)	Sample start time	IRB Biotester (CFU/mL)	IRB Biotester Reaction Pattern Signature	SRB Biotester (CFU/mL)	SRB Biotester Reaction Pattern Signature
RB1-PMS deep—Continued					
11/17/2009	1120	500	FO-GC	18,000	BT-BA
3/2/2010	--	35,000	FO-GC	100,000	BT-BA
3/22/2010	1025	<25	N/A	200	BB
RB1-P shallow					
1/21/2009	1500	2,300	FO-BC, BR	5,000	BB-BA
2/3/2009	1015	2,300	FO-BR, BC	100,000	BA
3/25/2009	1035	35,000	FO-GC-BL	700,000	BT-BA
4/4/2009	1310	35,000	FO-BC-RC-BR, BL	700,000	BT-BA
4/7/2009	1155	35,000	FO-BG-BR	18,000	BT-BA
4/15/2009	1040	35,000	FO-BR-BG	500	BB
4/18/2009	1010	35,000	FO-GC	500	BA
5/4/2009	1225	35,000	FO	18,000	BB-BA
5/19/2009	1145	35,000	FO-RC-BR-BL	100,000	BT-BA
8/17/2009	1050	140,000	FO-BG-BC-GC-BL	<200	N/A
11/16/2009	1015	35,000	FO-BR-GC	5,000	BB-BA
3/3/2010	--	35,000	FO	200	BB
RB1-P deep					
2/3/2009	1150	9,000	FO-BR, BG	100,000	BT-BA
3/25/2009	1205	35,000	FO-GC-BL	100,000	BT-BA
4/4/2009	1440	35,000	FO-BC-BL	700,000	BT-BA
4/18/2009	1130	35,000	FO-RC	<200	N/A
5/4/2009	1035	35,000	FO	100,000	BT-BA
5/19/2009	1300	35,000	FO-RC, BR	100,000	BT-BA
7/9/2009	1055	35,000	FO-GC	<200	N/A
7/13/2009	1235	35,000	FO-GC	200	BB-BA
7/20/2009	1000	35,000	FO-RC-BL	700,000	BT-BA
8/12/2009	1020	35,000	FO-BR-BG-BC	<200	N/A
8/17/2009	1210	140,000	FO-BG-BC-BR	200	BA
11/16/2009	1125	35,000	FO-GC	1,200	BB-BA
3/3/2010	--	35,000	FO	200	BB
RB1-P TR					
3/26/2009	1020	35,000	FO-BR-BC	700,000	BT-BA
4/3/2009	1350	35,000	FO-GC-BL	18,000	BT-BA
4/7/2009	1000	35,000	FO-BC-GC-BL	18,000	BT-BA
4/14/2009	1330	35,000	FO-BC-BR	1,200	BT-BA
4/17/2009	1250	35,000	FO-BR, BC	200	BB
4/23/2009	1220	140,000	FO-GC-RC	700,000	BT-BA
4/27/2009	1140	35,000	FG-GC	100,000	BT-BA
5/4/2009	1055	35,000	FO	18,000	BT-BA
5/19/2009	1020	35,000	FO-RC-BR	<200	N/A
Diverted SW, PAC building					
4/3/2009	1010	35,000	FO-BC-BL	700,000	BT-BA
4/14/2009	1010	35,000	FO-GC, BG-BL	100,000	BT-BA
4/17/2009	0950	35,000	FO-BL-BR	100,000	BA

Table 8. Summary of major ion data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.

[mg/L, milligrams per liter; --, not determined or not applicable; <, less than; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Bicarbonate, inflection-point titration method (mg/L)	Bromide (mg/L)	Carbonate, inflection-point titration method (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Ammonia (mg/L)	Nitrate plus nitrite (mg/L)	Nitrate (mg/L)	Ortho-phosphate (mg/L)	Phosphorus (mg/L)	Organic carbon (mg/L)
IW-09 shallow																
3/19/2002	1101	65.5	12.5	3.53	45.1	170	0.1	0	16	86	0.06	10.8	10.8	0.215	0.1	--
6/20/2002	0936	63.5	12.7	3.47	42.4	180	0.2	0	16	95	0.05	13.3	13.2	0.215	0.1	1.3
2/14/2003	1036	64.9	12.2	3.75	41.3	160	0.1	0	16	79	<0.03	--	<0.01	0.276	0.15	--
6/25/2003	0856	69.9	12.9	3.71	32	150	0.1	0	19	139	<0.03	6.35	6.29	0.552	0.211	0.6
6/25/2003	0905	70.1	12.8	3.51	31.3	--	--	--	10.4	130	<0.04	6.12	6.01	0.595	0.21	0.6
2/10/2004	1031	65	12.1	3.55	34.2	150	0.1	0	16	104	<0.03	9	9	--	0.23	--
6/25/2004	0926	68.4	12.5	3.45	30.8	140	0.1	0	15	136	<0.03	6.96	6.96	0.276	0.244	0.8
7/11/2005	1201	69.4	12.4	3.82	31.3	130	0.1	0	10.5	127	<0.03	5.06	5.06	0.736	0.247	--
6/14/2006	1046	62.5	12.2	3.44	39.3	160	<0.03	0	20.6	82.7	<0.03	11.4	11.4	0.491	0.091	--
6/14/2006	1050	62.4	11.8	3.22	37.8	--	--	--	19	84.1	E0.006	12.4	12.3	0.519	0.16	0.8
6/20/2007	1021	61.2	11.9	4	28.3	140	0.1	0	11	110	0.05	5.62	5.62	0.705	0.227	0.71
6/12/2008	0941	57.6	10.8	3	27.6	140	0.1	0	<5	87	0.08	8.46	8.42	0.552	0.22	--
2/10/2009	0956	58.6	10.8	3	30	130	0.1	0	16	83	0.04	6.57	6.53	0.675	0.23	0.69
4/2/2009	1056	55.4	10	3	31.1	120	0.1	0	18	77	0.2	5.36	5.34	0.644	0.21	0.67
4/22/2009	1021	56.5	10.4	3	30.1	130	0.1	0	18	81	0.06	5.39	5.36	0.644	0.2	0.7
6/10/2009	0956	59.6	10.7	3	25.2	130	0.1	0	11	100	<0.03	3.9	3.83	0.736	0.24	--
6/10/2009	1000	56.5	10.5	3.14	24.4	--	--	--	13.4	104	<0.02	4.01	3.95	0.855	0.26	1.1
7/14/2009	1021	60.4	10.8	3	25.8	120	0.1	0	12	100	<0.03	3.81	3.74	0.705	0.36	0.71
8/19/2009	1001	59	10.8	3	26.9	120	0.1	0	14	98	<0.03	4.62	4.55	0.736	0.26	0.63
11/17/2009	1006	57.9	10.5	3	30.5	130	0.1	0	21	86	<0.03	4.44	4.36	0.736	0.22	0.75
3/9/2010	1011	55.7	9.9	3	32.2	140	0.1	0	19	80	<0.03	5.42	5.34	0.644	0.19	0.68

Table 8. Summary of major ion data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; --, not determined or not applicable; <, less than; E**, estimated]

Date of sample collection (month/day/ year)	Sample start time	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Bicarbonate, inflection- point titration method (mg/L)	Bromide (mg/L)	Carbonate, inflection- point titration method (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Ammonia (mg/L)	Nitrate plus nitrite (mg/L)	Nitrate (mg/L)	Ortho- phosphate (mg/L)	Phosphorus (mg/L)	Organic carbon (mg/L)
IW-09 deep																
3/19/2002	1306	57.9	8.71	2.45	38.8	240	0.1	0	22	25	0.26	0.02	0.02	0.429	0.21	--
6/24/2002	1046	59.7	9.17	2.67	37.9	240	0.1	0	31	22	0.24	0.41	0.41	0.46	0.26	0.7
2/14/2003	1336	62.0	9.34	2.66	39.3	240	0.1	0	29	23	0.2	0.31	0.31	0.46	0.22	--
6/25/2003	1136	58.2	8.94	2.5	38.1	240	0.1	0	30	25	0.2	0.03	0.03	0.552	0.212	0.5
6/25/2003	1145	57.4	8.66	2.33	36.3	--	--	--	30.5	26.2	0.21	<0.06	--	0.552	0.19	0.5
2/10/2004	1226	67.2	10.2	2.61	39.8	240	0.1	0	49	27	0.17	<0.02	<0.01	--	0.21	--
6/25/2004	1131	66.9	10	2.56	40.1	230	0.1	0	51	31	0.22	0.13	0.13	0.46	0.226	0.6
7/11/2005	1031	68.1	10.1	2.74	41.9	230	0.2	0	47.5	31.1	0.18	0.36	0.36	0.521	0.203	--
6/14/2006	1236	66.7	10.2	2.59	39.3	230	0.2	0	49.8	27.1	0.2	0.3	0.3	0.521	0.142	--
6/20/2007	1221	62.3	9.57	2	38.1	240	0.2	0	42	22	0.32	<0.02	<0.01	0.552	0.208	0.6
6/12/2008	1111	66.2	9.84	2	38.6	240	0.1	0	55	23	0.18	0.06	0.06	0.429	0.19	--
2/10/2009	1126	71.8	10.7	3	41.8	230	0.2	0	58	24	0.24	0.17	0.17	0.491	0.222	0.64
4/2/2009	1216	74.2	11	3	44.5	230	0.2	0	56	24	0.29	0.18	0.18	0.705	0.19	0.56
4/22/2009	1201	71.5	10.6	2	40.9	230	0.2	0	58	24	0.23	<0.02	<0.01	0.675	0.18	0.62
6/10/2009	1121	71.3	10.5	2	42.2	230	0.1	0	57	23	0.22	<0.02	<0.01	0.521	0.18	--
6/10/2009	1125	66.3	10	2.33	39.5	--	--	--	59.2	27.7	0.223	E.02	E.02	0.586	0.18	0.8
7/14/2009	1151	73.2	10.8	3	41.1	230	0.2	0	58	24	0.22	<0.02	<0.01	0.46	0.28	0.62
8/19/2009	1151	72.6	11.1	3	44.1	230	0.1	0	67	25	0.24	<0.02	<0.01	0.552	0.2	0.52
11/17/2009	1146	73.5	10.7	3	41	230	0.2	0	56	22	0.23	0.16	0.16	0.46	0.21	0.6
3/9/2010	1156	77.5	11.2	3	41.6	140	0.3	0	74	24	0.25	0.01	0.01	0.521	0.18	0.57
RB1 source water																
8/3/2007	1106	23.6	4.12	12	47	110	0.1	0	21	86	0.05	0.79	0.76	--	0.08	5.53
8/3/2007	1116	23.6	4.14	12	46.7	78	0.1	0	21	86	0.04	0.79	0.76	--	0.105	5.49
4/3/2009	1216	49.5	9.87	11	39.1	44	0.1	0	62	100	0.54	2.68	2.58	--	<0.03	6.62
4/14/2009	1141	43.4	9.5	9	77.9	120	0.2	0	65	110	0.15	2.29	2.19	--	0.03	11.9
4/17/2009	1111	67.9	13.8	10	86.5	140	0.2	0	94	130	0.03	1.3	1.26	--	<0.03	8.16

Table 8. Summary of major ion data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; --, not determined or not applicable; <, less than; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Bicarbonate, inflection-point titration method (mg/L)	Bromide (mg/L)	Carbonate, inflection-point titration method (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Ammonia (mg/L)	Nitrate plus nitrite (mg/L)	Nitrate (mg/L)	Ortho-phosphate (mg/L)	Phosphorus (mg/L)	Organic carbon (mg/L)
RB1-MN shallow																
8/30/2006	1011	107.0	23.3	4.36	82.1	250	0.4	0	170	77.9	0.08	<0.02	<0.01	0.368	0.169	0.8
11/29/2006	1101	107.0	22.4	4.07	77.6	250	0.5	0	150	65.1	--	<0.02	<0.01	0.307	0.257	--
2/23/2007	1011	105.0	22.5	3.92	71.6	250	0.6	0	162	69.7	--	<0.02	<0.01	0.368	0.275	--
6/4/2007	1016	105.0	22.2	4	71	250	0.6	0	170	68	--	0.19	0.19	--	0.265	--
8/29/2007	1021	97.6	20.3	4	70.5	240	0.4	0	150	78	0.08	<0.02	<0.01	--	0.286	0.67
8/29/2007	1031	98.4	20.4	4	70.6	250	0.3	0	150	78	0.06	<0.02	<0.01	--	0.319	0.64
3/5/2008	1026	111.0	22.8	4	69.8	240	0.7	0	160	74	--	<0.02	<0.01	--	0.267	--
3/5/2008	1031	113.0	23.1	4	71.4	240	0.7	0	160	74	--	<0.02	<0.01	--	0.271	--
8/19/2008	1011	107.0	22.2	4	70.9	250	0.7	0	150	84	0.06	<0.02	<0.01	--	0.24	0.96
2/9/2009	1021	114.0	23.7	4	73.1	250	0.6	0	160	81	0.08	0.18	0.18	--	0.269	0.65
4/1/2009	1111	114.0	23.1	4	71	240	0.7	0	160	78	0.08	0.2	0.2	--	0.22	0.66
4/21/2009	0956	115.0	23.3	4	68.7	240	0.7	0	160	79	0.07	0.22	0.22	--	0.28	0.76
6/25/2009	1001	114.0	23.1	4	71.7	240	0.4	0	160	79	0.06	0.24	0.24	--	0.24	1.03
7/14/2009	1026	107.0	21.9	4	70.2	250	0.3	0	150	84	0.06	<0.02	<0.01	0.184	0.38	0.82
8/19/2009	0956	107.0	22.3	4	71.6	250	0.3	0	150	89	0.09	<0.02	<0.01	--	0.28	0.64
11/18/2009	1001	118.0	23.8	4	72.4	250	0.7	0	170	79	0.08	0.2	0.2	--	0.25	0.72
3/8/2010	1006	112.0	22.5	4	72.1	260	0.6	0	160	84	0.07	<0.02	<0.01	--	0.22	0.83
RB1-MN deep																
8/30/2006	1156	65.8	11	3.06	49.2	250	0.1	0	47.8	28.8	0.22	0.23	0.23	0.521	0.243	1
11/29/2006	956	69.7	10.8	2.9	48.4	250	0.1	0	63.4	28.7	--	0.1	0.1	0.429	0.261	--
2/23/2007	1206	62.9	9.59	2.64	44.1	250	0.2	0	49.9	26.7	--	<0.02	<0.01	0.491	0.287	--
6/4/2007	1141	62.3	9.34	3	42.9	250	0.2	0	42	21	--	0.16	0.16	0.245	0.273	--
6/4/2007	1146	62.4	9.34	3	43	250	0.2	0	42	21	--	0.16	0.16	0.276	0.273	--
8/29/2007	1231	65.8	9.95	3	43.9	240	0.2	0	53	22	0.2	<0.02	<0.01	0.184	0.336	0.57
3/5/2008	1156	73.0	10.7	3	47.2	240	0.3	0	63	22	--	<0.02	<0.01	0.153	0.266	--
8/19/2008	1151	74.1	11.2	3	47.3	250	0.3	0	66	22	0.22	<0.02	<0.01	0.276	0.27	0.81
2/9/2009	1151	75.3	11.2	3	48.6	240	0.3	0	64	22	0.26	0.17	0.17	0.184	0.247	0.67
4/1/2009	1241	74.0	10.8	3	46.4	240	0.2	0	59	21	0.27	0.2	0.2	0.245	0.23	0.62
4/21/2009	1116	69.3	10.1	3	44.1	250	0.2	0	49	22	0.22	<0.02	<0.01	0.399	0.24	0.66
6/25/2009	1201	69.4	10.0	3	45.3	240	0.1	0	52	21	0.18	0.19	0.19	0.245	0.26	0.64
6/25/2009	1211	69.8	10.1	3	45.6	240	0.1	0	51	21	0.18	0.19	0.19	0.245	0.252	0.79
7/14/2009	1201	76.3	11.2	3	47	250	0.1	0	66	21	0.22	<0.02	<0.01	0.184	0.37	0.7
8/19/2009	1126	70.9	10.5	3	46.3	240	0.1	0	58	22	0.28	<0.02	<0.01	0.307	0.26	0.55
11/18/2009	1131	77.4	11.4	3	47.2	240	0.3	0	73	22	0.22	0.19	0.19	0.307	0.23	0.64
3/8/2010	1146	71.8	10.3	3	45.8	250	0.3	0	64	22	0.25	0.01	0.01	0.307	0.23	0.62

Table 8. Summary of major ion data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; --, not determined or not applicable; <, less than; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Bicarbonate, inflection-point titration method (mg/L)	Bromide (mg/L)	Carbonate, inflection-point titration method (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Ammonia (mg/L)	Nitrate plus nitrite (mg/L)	Nitrate (mg/L)	Ortho-phosphate (mg/L)	Phosphorus (mg/L)	Organic carbon (mg/L)
RB1-MS shallow																
8/30/2006	1031	53.7	11.2	3.12	64	220	<0.03	0	29.7	78	0.06	0.37	0.37	0.337	0.184	1
11/29/2006	1011	56.1	10.8	3.02	51.3	220	0.1	0	48.2	67.1	--	0.16	0.16	0.399	0.224	--
2/23/2007	1031	55	10.9	2.94	48	220	0.1	0	29.3	66.1	--	0.19	0.19	0.368	0.231	--
6/4/2007	1021	54.1	10.5	3	47.6	220	0.2	0	26	62	--	0.32	0.32	0.061	0.215	--
8/29/2007	1016	53.2	10.2	3	46.8	220	0.1	0	19	66	0.05	<0.02	<0.01	0.031	0.252	0.89
3/4/2008	1016	54.4	10.3	3	48.4	220	0.1	0	15	62	0.04	<0.02	<0.01	0.307	0.219	--
8/18/2008	1031	53.7	10.4	3	49.4	220	0.1	0	14	64	0.05	<0.02	<0.01	0.123	0.22	0.95
2/4/2009	1006	56	10.7	3	50.1	230	0.1	0	13	65	<0.03	0.15	0.15	0.061	0.23	0.82
3/24/2009	1136	57.4	10.8	3	49	220	0.1	0	12	66	0.04	0.17	0.17	0.245	0.23	0.81
4/6/2009	1011	57.3	11	3	51.2	220	0.1	0	13	66	0.05	0.14	0.14	0.337	0.25	0.86
4/9/2009	1006	57.4	11	3	50.3	230	0.1	0	14	68	0.04	<0.02	<0.01	0.153	0.2	0.87
4/16/2009	1016	56	10.8	3	49.6	220	0.1	0	14	68	<0.03	<0.02	<0.01	0.153	0.25	0.89
4/20/2009	1006	57.3	11.3	3	52.6	220	0.1	0	14	67	0.04	<0.02	<0.01	0.245	0.2	0.89
5/6/2009	1026	55.9	10.8	3	49	220	0.1	0	14	64	0.032	0.04	0.04	0.061	0.25	0.87
5/20/2009	1006	56.2	10.8	3	50.3	220	0.1	0	15	64	0.03	0.02	0.02	0.061	0.252	0.95
6/25/2009	1001	55.1	10.5	3	49.4	220	0.2	0	16	66	0.04	0.02	0.02	0.123	0.215	0.85
7/8/2009	1021	56.8	10.7	3	49	220	0.1	0	15	69	0.05	<0.02	<0.01	--	0.22	0.89
7/13/2009	1016	57.5	11	3	49.5	220	0.1	0	14	71	0.04	<0.02	<0.01	--	0.35	0.85
7/20/2009	1016	57.5	11.1	3	49.7	230	0.4	0	13	73	0.03	<0.02	<0.01	0.061	0.18	0.91
8/18/2009	1011	59.4	11.3	3	51.1	220	0.1	0	14	75	0.06	<0.02	<0.01	0.184	0.24	0.72
11/18/2009	1006	55.3	10.5	3	48.2	210	0.1	0	15	68	0.09	<0.02	<0.01	0.184	0.24	0.87
3/1/2010	1131	53.3	10.1	3	46.6	210	0.1	0	20	69	0.06	0.01	0.01	0.215	0.19	0.84

Table 8. Summary of major ion data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; --, not determined or not applicable; <, less than; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Bicarbonate, inflection-point titration method (mg/L)	Bromide (mg/L)	Carbonate, inflection-point titration method (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Ammonia (mg/L)	Nitrate plus nitrite (mg/L)	Nitrate (mg/L)	Ortho-phosphate (mg/L)	Phosphorus (mg/L)	Organic carbon (mg/L)
RB1-MS deep																
8/30/2006	1246	64.9	10.2	2.75	44.9	240	0.1	0	45.1	27.6	0.24	0.05	0.05	0.613	0.214	0.8
12/4/2006	1001	64.2	9.41	2.52	41.8	240	0.1	0	44.7	26.6	--	0.07	0.07	0.583	0.238	--
2/23/2007	1146	62.2	9.43	2.43	40.1	240	0.3	0	43.9	31.8	--	0.02	0.02	0.429	0.235	--
6/4/2007	1151	62	9.28	2	39.2	240	0.2	0	41	22	--	<0.02	<0.01	0.491	0.231	--
8/29/2007	1206	61.4	9.01	2	38.6	230	0.2	0	40	24	0.22	<0.02	<0.01	0.429	0.258	0.68
3/4/2008	1201	64.2	9.27	2	40.2	230	0.2	0	37	23	0.2	<0.02	<0.01	0.491	0.212	--
8/18/2008	1231	67.3	9.83	3	42.1	240	0.2	0	44	24	0.27	<0.02	<0.01	0.521	0.21	0.84
2/4/2009	1141	59.9	8.66	2	39	230	0.1	0	26	25	0.2	0.17	0.17	0.491	0.24	0.66
3/24/2009	1306	64.6	9.2	2	39.2	230	0.1	0	35	23	0.24	0.17	0.17	0.583	0.23	0.6
4/6/2009	1141	64.4	9.4	3	41.5	230	0.1	0	30	24	0.28	0.17	0.17	0.613	0.21	0.68
4/9/2009	1136	64.8	9.46	2	41.8	240	0.1	0	30	24	0.21	<0.02	<0.01	0.644	0.2	0.66
4/16/2009	1141	63	9.24	2	40.2	230	0.1	0	31	24	0.16	<0.02	<0.01	0.675	0.21	0.74
4/20/2009	1136	65.1	9.66	3	42	230	0.1	0	33	24	0.23	<0.02	<0.01	0.613	0.21	0.69
5/6/2009	1151	64	9.35	2	39.4	230	0.1	0	31	24	0.262	<0.02	<0.01	0.46	0.22	0.62
5/20/2009	1141	63.2	9.16	2	39.8	230	0.1	0	29	24	0.2	<0.02	<0.01	0.491	0.221	0.73
6/25/2009	1146	63.2	9.14	2	40	230	0.1	0	31	24	0.18	<0.02	<0.01	0.46	0.237	0.65
7/8/2009	1206	62.7	8.95	2	38.8	240	0.1	0	30	25	0.22	<0.02	<0.01	0.46	0.21	0.67
7/13/2009	1156	62.3	8.98	2	38.9	230	0.1	0	30	25	0.22	<0.02	<0.01	0.491	0.24	0.68
7/20/2009	1241	62.8	9.08	2	39.4	240	0.1	0	29	25	0.22	<0.02	<0.01	0.613	0.24	0.63
8/18/2009	1146	59.5	8.7	2	38.3	230	0.1	0	25	26	0.24	<0.02	<0.01	0.552	0.24	0.55
11/18/2009	1136	58.6	8.36	2	37.2	230	0.1	0	22	26	0.21	0.15	0.15	0.583	0.24	0.75
3/1/2010	1256	57	8.09	2	36.7	230	0.1	0	24	26	0.26	<0.02	<0.01	0.552	0.21	0.6

Table 8. Summary of major ion data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; --, not determined or not applicable; <, less than; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Bicarbonate, inflection-point titration method (mg/L)	Bromide (mg/L)	Carbonate, inflection-point titration method (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Ammonia (mg/L)	Nitrate plus nitrite (mg/L)	Nitrate (mg/L)	Ortho-phosphate (mg/L)	Phosphorus (mg/L)	Organic carbon (mg/L)
RB1-PMS shallow																
1/22/2009	1416	56.5	11.3	3	48.1	180	0.2	0	39	67	<0.03	1.8	1.79	0.307	0.09	0.79
2/2/2009	1036	56.2	11.4	3	48.3	180	0.2	0	42	67	<0.03	1.91	1.91	0.184	0.07	0.73
3/26/2009	1116	46.7	9.3	3	39.4	170	0.1	0	21	41	<0.03	1.42	1.4	0.307	0.11	0.64
4/4/2009	1006	48.7	9.94	3	42.7	150	0.1	0	25	54	<0.03	1.82	1.78	0.307	0.1	0.94
4/8/2009	1006	56.5	11.3	3	59.1	130	0.2	0	57	92	<0.03	2.23	2.2	0.307	0.09	4.44
4/15/2009	1046	51	9.76	4	51.7	130	0.1	0	48	74	<0.03	2.08	2.08	0.276	0.09	2.82
4/18/2009	1011	56.1	10.6	6	69.7	130	0.2	0	66	98	<0.03	1.9	1.9	0.337	0.12	4.67
5/6/2009	1016	42.2	8.4	4	43	120	0.1	0	34	62	<0.03	1.59	1.59	0.46	0.16	2.27
5/20/2009	1021	51.6	10.2	5	47.6	150	0.2	0	39	64	<0.03	1.47	1.47	0.337	0.127	1.36
7/8/2009	1126	55.2	10.9	3	44.6	170	0.3	0	81	58	<0.03	0.98	0.96	0.644	0.1	0.84
7/13/2009	1016	68.1	13.4	4	54.4	190	0.4	0	78	50	0.08	0.73	0.71	0.429	0.13	0.91
7/20/2009	1026	73.4	14.5	4	57.7	200	0.4	0	98	46	<0.03	0.74	0.73	0.429	0.16	0.82
8/18/2009	1011	52.7	10.9	3	43.9	150	0.2	0	40	68	<0.03	0.82	0.81	0.215	0.09	0.83
11/17/2009	0951	58.8	11.8	3	46.3	160	0.2	0	44	78	<0.03	1.2	1.16	0.245	0.07	0.99
3/2/2010	1046	57.2	11.5	3	45.6	160	0.2	0	46	83	0.04	1.18	1.14	0.245	0.08	0.77
3/2/2010	1051	57.9	11.5	3	45.6	160	0.2	0	46	83	<0.03	1.17	1.13	0.245	0.08	0.76
RB1-PMS deep																
1/22/2009	1301	68.1	13.3	3	56.4	200	0.4	0	75	58	0.05	1.13	1.09	--	0.15	0.85
2/2/2009	1206	56.1	11.5	3	51.1	180	0.2	0	38	72	<0.03	1.77	1.77	0.583	0.2	0.83
3/26/2009	1241	47.2	9.6	3	41	180	0.1	0	17	42	0.03	1.39	1.38	0.613	0.21	0.82
4/4/2009	1131	50.4	10.3	3	46.1	160	0.1	0	25	59	0.04	1.95	1.9	0.644	0.21	1.19
4/8/2009	1131	58.4	11.5	3	66.1	140	0.2	0	59	94	0.04	2.51	2.47	0.644	0.2	3.95
4/15/2009	1216	53.5	10	5	57.6	150	0.2	0	52	75	<0.03	2.09	2.09	0.675	0.23	2.93
4/18/2009	1146	56.6	10.9	6	73.1	140	0.2	0	64	99	<0.03	2.15	2.15	0.644	0.23	4.7
5/6/2009	1141	41.9	8.72	5	43.4	120	0.1	0	30	65	<0.03	1.72	1.72	0.675	0.23	2.19
5/20/2009	1151	46.5	9.48	5	45.8	150	0.1	0	28	58	0.03	1.86	1.86	0.675	0.212	1.66
7/8/2009	1006	73.4	14.4	5	57	200	0.2	0	40	59	<0.03	1.5	1.48	0.307	0.19	1.06
7/13/2009	1141	83.2	16	5	63	220	0.2	0	110	47	0.04	0.93	0.92	0.705	0.18	1.06
7/20/2009	1201	95	18.1	6	70	230	0.3	0	150	41	<0.03	0.8	0.8	0.491	0.2	0.95
8/18/2009	1146	61.1	13	4	50.8	180	0.2	0	50	77	<0.03	1.02	1.01	0.613	0.2	1
11/17/2009	1121	56.2	11.7	3	48.4	160	0.2	0	44	79	<0.03	1.21	1.17	0.613	0.18	1.09
3/2/2010	1256	58.8	11.9	3	49	170	0.2	0	47	88	<0.03	0.92	0.88	0.521	0.15	0.95
3/22/2010	1026	60	12.4	3	51.2	170	0.2	0	48	90	<0.03	0.89	0.86	0.521	0.17	0.97

Table 8. Summary of major ion data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; --, not determined or not applicable; <, less than; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Bicarbonate, inflection-point titration method (mg/L)	Bromide (mg/L)	Carbonate, inflection-point titration method (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Ammonia (mg/L)	Nitrate plus nitrite (mg/L)	Nitrate (mg/L)	Ortho-phosphate (mg/L)	Phosphorus (mg/L)	Organic carbon (mg/L)
RB1-P shallow																
1/21/2009	1501	56	11.7	3	52.6	170	0.2	0	40	84	0.05	1.36	1.36	0.307	0.08	0.96
2/3/2009	1016	62.9	13.6	3	70.6	210	0.2	0	38	110	<0.03	2.36	2.36	0.307	0.11	1.36
2/3/2009	1021	62.3	13.3	3	68.8	210	0.1	0	38	110	<0.03	2.37	2.37	0.307	0.12	1.32
3/25/2009	1036	58.1	10.7	3	52.7	180	0.1	0	19	90	<0.03	1.5	1.5	0.429	0.11	1.04
4/4/2009	1311	61.6	8.23	5	58.1	82	0.1	0	64	110	0.2	2.75	2.66	0.245	0.06	5.59
4/4/2009	1316	60.3	8.02	5	56.6	79	0.1	0	64	110	0.2	2.78	2.7	0.245	0.06	5.72
4/7/2009	1156	57.9	11.1	11	83.4	120	0.2	0	80	120	0.17	2.73	2.66	0.153	0.06	7.29
4/15/2009	1041	54.4	10.6	9	80.5	130	0.2	0	80	110	0.04	2.32	2.32	0.184	0.06	7.68
4/18/2009	1011	56.5	11.7	10	85.9	120	0.2	0	84	120	<0.03	1.77	1.77	0.153	0.06	7.2
5/4/2009	1226	32.3	6.51	7	38.4	73	0.1	0	24	86	<0.03	0.6	0.6	0.123	0.04	3.18
5/19/2009	1146	54.2	11	7	61.4	190	0.1	0	34	80	0.03	1.99	1.99	0.276	0.111	2.27
8/17/2009	1051	68.3	13.9	4	55.6	160	0.2	0	54	110	<0.03	0.19	0.19	0.215	0.07	1.01
11/16/2009	1016	62.2	12.9	3	52	160	0.2	0	47	100	<0.03	0.52	0.49	0.215	0.06	1.11
3/3/2010	1021	59.4	12	3	50.9	160	0.2	0	43	110	0.05	0.36	0.32	0.307	0.1	1.19
RB1-P deep																
2/3/2009	1151	62.9	13.5	3	69.1	220	0.1	0	38	120	<0.03	2.46	2.46	0.399	0.11	1.33
3/25/2009	1206	57.6	10.6	3	51.9	180	0.1	0	19	89	<0.03	1.52	1.52	0.429	0.11	1.04
4/4/2009	1441	61.3	8.2	5	58	83	0.1	0	64	110	0.17	2.76	2.68	0.245	0.06	5.71
4/7/2009	1321	56.9	10.9	11	81.9	120	0.2	0	80	120	0.2	2.72	2.65	0.153	0.07	7.2
4/15/2009	1211	55.1	10.7	9	80.9	140	0.2	0	80	110	0.03	2.31	2.31	0.184	0.06	7.51
4/18/2009	1131	57.1	11.7	10	85.8	120	0.2	0	84	120	<0.03	1.78	1.78	0.153	0.06	7.43
5/4/2009	1336	32.4	6.56	7	38.8	68	0.1	0	24	86	<0.03	0.6	0.6	0.092	0.04	3.2
5/19/2009	1301	54.5	11.1	7	61.3	190	0.1	0	33	79	<0.03	2.04	2.04	0.276	0.102	2.24
7/9/2009	1056	67.5	12.1	5	56.8	200	0.3	0	73	62	0.05	0.4	0.39	0.184	0.06	1.41
7/13/2009	1236	71.8	12.9	4	56.6	200	0.3	0	74	61	0.12	0.16	0.16	0.184	0.07	1.13
7/20/2009	1001	75.7	13.9	4	58	200	0.3	0	81	63	0.09	0.12	0.12	0.153	0.07	1.07
8/12/2009	1021	81.70	15.1	4	60.6	210	0.2	0	95	69	0.078	0.15	0.15	0.245	0.07	0.84
8/17/2009	1211	69.30	14.1	4	55.7	160	0.2	0	56	110	0.04	0.16	0.16	0.215	0.08	0.99
11/16/2009	1126	67.70	13.8	3	54	160	0.2	0	53	110	0.05	0.39	0.36	0.215	0.06	1
3/3/2010	1136	65.00	13	3	52.4	160	0.2	0	50	110	<0.03	0.28	0.22	0.215	0.08	0.97

Table 8. Summary of major ion data from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[mg/L, milligrams per liter; --, not determined or not applicable; <, less than; E**, estimated]

Date of sample collection (month/day/year)	Sample start time	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Bicarbonate, inflection-point titration method (mg/L)	Bromide (mg/L)	Carbonate, inflection-point titration method (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Ammonia (mg/L)	Nitrate plus nitrite (mg/L)	Nitrate (mg/L)	Ortho-phosphate (mg/L)	Phosphorus (mg/L)	Organic carbon (mg/L)
RB1-P TR																
3/26/2009	1021	57.40	11.00	3.00	54.40	180	0.10	0	20.0	90.0	<0.030	1.70	1.69	0.491	0.130	1.15
4/3/2009	1351	59.50	8.26	3.00	36.10	85	0.10	0	43.0	89.0	0.090	2.66	2.60	0.276	0.080	3.78
4/7/2009	1001	57.40	10.90	11.00	82.40	120	0.20	0	80.0	120.0	0.260	2.73	2.66	0.153	0.070	7.17
4/7/2009	1006	58.30	11.10	11.00	83.60	120	0.20	0	80.0	120.0	0.220	2.72	2.65	0.153	0.080	7.24
4/14/2009	1131	58.90	11.60	10.00	79.60	140	0.20	0	88.0	110.0	0.060	2.25	2.25	0.276	0.060	6.73
4/17/2009	1251	58.80	12.00	11.00	86.10	140	0.20	0	84.0	120.0	0.030	1.87	1.87	0.153	0.060	7.51
4/23/2009	1121	40.00	8.00	8.00	67.80	90	0.20	0	68.0	98.0	0.040	1.01	1.01	0.184	0.080	5.28
4/27/2009	1141	26.40	5.37	6.00	40.50	85	0.10	0	27.0	47.0	0.040	1.38	1.38	0.245	0.100	3.20
5/4/2009	1056	32.60	6.56	7.00	38.20	71	0.10	0	24.0	86.0	0.030	0.62	0.62	0.123	0.050	3.23
5/19/2009	1021	46.70	9.38	7.00	51.20	160	0.10	0	29.0	68.0	0.030	1.76	1.76	0.245	0.081	2.16
Diverted SW, PAC building																
4/3/2009	1011	50.53	10.50	11.03	39.89	117	0.14	0	69.2	31.0	0.580	2.83	2.74	1.104	0.360	19.00
4/14/2009	1011	45.21	9.84	9.28	36.13	129	0.16	0	63.3	27.3	0.170	1.84	1.78	0.889	0.300	26.30
4/17/2009	0951	73.87	14.77	9.91	59.90	188	0.26	0	104.2	38.6	0.060	1.35	1.30	0.797	0.230	24.20

** Values may be reported as estimated (E) if values are out of instrument calibration range, data quantification was not performed according to method specific criteria, or deviation for the standard operating procedure was required. Values are considered detections. (Childress and others, 1999).

Table 9. Summary of trace element and atrazine concentrations from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.

[µg/L, micrograms per liter; --, not determined or not applicable; M*, presence of material verified, but not quantified; E**, estimated; <, less than; >, greater than]

Date of sample collection (month/day/year)	Sample start time	Iron (µg/L)	Manganese (µg/L)	Arsenic (µg/L)	Atrazine, recoverable (µg/L)	Triazine screen, enzyme link immuno sorbent assay, recoverable (µg/L)
IW-09 shallow						
3/19/2002	1100	--	--	--	--	<0.10
3/19/2002	1101	<5	100	<1.00	--	--
6/20/2002	0935	--	--	--	0.011	<0.10
6/20/2002	0936	<5	120	<1.00	--	--
2/14/2003	1035	--	--	--	--	<0.10
2/14/2003	1036	M	250	<1.00	--	--
2/14/2003	1037	--	--	--	--	<0.10
6/25/2003	0855	--	--	--	0.009	<0.10
6/25/2003	0856	<5	360	<1.00	--	--
6/25/2003	0905	<8	362	--	--	--
2/10/2004	1030	--	--	--	--	<0.10
2/10/2004	1031	<5	300	<1.00	--	--
6/25/2004	0925	--	--	--	--	<0.10
6/25/2004	0926	<5	330	1.20	--	--
7/11/2005	1200	--	--	--	--	<0.10
7/11/2005	1201	<5	360	<1.00	--	--
6/14/2006	1045	--	--	--	--	<0.10
6/14/2006	1046	<50	170	<1.00	--	--
6/14/2006	1050	E5	159	0.65	--	--
6/20/2007	1020	--	--	--	0.014	<0.10
6/20/2007	1021	<100	26	<1.00	--	--
6/12/2008	0940	--	--	--	--	<0.10
6/12/2008	0941	<100	426	<1.00	--	--
2/10/2009	0955	--	--	--	--	<0.10
2/10/2009	0956	<100	339	<1.00	--	--
4/2/2009	1055	--	--	--	--	<0.10
4/2/2009	1056	<100	259	<1.00	--	--
4/22/2009	1020	--	--	--	--	<0.10
4/22/2009	1021	<100	255	<1.00	--	--
6/10/2009	0955	--	--	--	--	<0.10
6/10/2009	0956	<100	376	<1.00	--	--
6/10/2009	1000	<4	337	1.00	--	--
7/14/2009	1020	--	--	--	--	<0.10
7/14/2009	1021	<100	345	<1.00	--	--
8/19/2009	1000	--	--	--	--	<0.10
8/19/2009	1001	<100	321	<1.00	--	--
11/17/2009	1005	--	--	--	--	<0.10
11/17/2009	1006	<100	295	<1.00	--	--
3/9/2010	1010	--	--	--	--	<0.10
3/9/2010	1011	<100	229	2.70	--	--
IW-09 deep						
3/19/2002	1305	--	--	--	--	<0.10
3/19/2002	1306	80	400	16.90	--	--
6/24/2002	1045	--	--	--	--	<0.10
6/24/2002	1046	100	410	17.00	--	--
2/14/2003	1335	--	--	--	--	<0.10
2/14/2003	1336	120	440	16.60	--	--
6/25/2003	1135	--	--	--	<0.007	<0.10
6/25/2003	1136	70	380	16.20	--	--
6/25/2003	1145	70	380	--	--	--

Table 9. Summary of trace element and atrazine concentrations from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[µg/L, micrograms per liter; --, not determined or not applicable; M*, presence of material verified, but not quantified; E**, estimated; <, less than; >, greater than]

Date of sample collection (month/day/year)	Sample start time	Iron (µg/L)	Manganese (µg/L)	Arsenic (µg/L)	Atrazine, recoverable (µg/L)	Triazine screen, enzyme link immuno sorbent assay, recoverable (µg/L)
IW-09 deep—Continued						
2/10/2004	1225	--	--	--	--	<0.10
2/10/2004	1226	100	430	19.50	--	--
2/10/2004	1227	--	--	--	--	<0.10
6/25/2004	1130	--	--	--	--	<0.10
6/25/2004	1131	100	430	21.00	--	--
6/25/2004	1132	--	--	--	--	<0.10
7/11/2005	1030	--	--	--	--	<0.10
7/11/2005	1031	80	420	14.00	--	--
6/14/2006	1235	--	--	--	--	<0.10
6/14/2006	1236	100	450	18.30	--	--
6/20/2007	1220	--	--	--	<0.007	<0.10
6/20/2007	1221	<100	421	19.00	--	--
6/12/2008	1110	--	--	--	--	<0.10
6/12/2008	1111	<100	469	21.00	--	--
2/10/2009	1125	--	--	--	--	<0.10
2/10/2009	1126	110	469	14.00	--	--
4/2/2009	1215	--	--	--	--	<0.10
4/2/2009	1216	110	486	13.00	--	--
4/22/2009	1200	--	--	--	--	<0.10
4/22/2009	1201	<100	472	17.00	--	--
6/10/2009	1120	--	--	--	--	<0.10
6/10/2009	1121	<100	459	16.00	--	--
6/10/2009	1125	82	424	17.50	--	--
7/14/2009	1150	--	--	--	--	<0.10
7/14/2009	1151	110	473	18.00	--	--
8/19/2009	1150	--	--	--	--	<0.10
8/19/2009	1151	<100	473	16.00	--	--
11/17/2009	1145	--	--	--	--	<0.10
11/17/2009	1146	100	485	17.00	--	--
3/9/2010	1155	--	--	--	--	<0.10
3/9/2010	1156	120	517	19.20	--	--
RB1 source water						
8/3/2007	1105	--	--	--	0.114	0.10
8/3/2007	1106	<100	<5	<1.00	--	--
8/3/2007	1107	--	--	--	--	0.13
8/3/2007	1115	--	--	--	0.114	<0.10
8/3/2007	1116	<100	<5	<1.00	--	--
4/3/2009	1215	--	--	--	--	0.42
4/3/2009	1216	<100	61	<1.00	--	--
4/14/2009	1140	--	--	--	0.050	0.66
4/14/2009	1141	<100	<5	<1.00	--	--
4/17/2009	1110	--	--	--	--	0.27
4/17/2009	1111	<100	7	<1.00	--	--
RB1-MN shallow						
8/30/2006	1010	--	--	--	<0.007	<0.10
8/30/2006	1011	2,910	360	9.10	--	--
8/30/2006	1015	--	--	--	--	--
11/29/2006	1100	--	--	--	--	<0.10
11/29/2006	1101	3,910	290	9.10	--	--
2/23/2007	1010	--	--	--	--	<0.10
2/23/2007	1011	4,300	290	7.80	--	--

Table 9. Summary of trace element and atrazine concentrations from water samples collected as part of the Equus Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[µg/L, micrograms per liter; --, not determined or not applicable; M*, presence of material verified, but not quantified; E**, estimated; <, less than; >, greater than]

Date of sample collection (month/day/year)	Sample start time	Iron (µg/L)	Manganese (µg/L)	Arsenic (µg/L)	Atrazine, recoverable (µg/L)	Triazine screen, enzyme link immuno sorbent assay, recoverable (µg/L)
RB1-MN shallow—Continued						
6/4/2007	1015	--	--	--	--	<0.10
6/4/2007	1016	4,150	277	9.00	--	--
6/4/2007	1017	--	--	--	--	<0.10
8/29/2007	1020	--	--	--	<0.007	<0.10
8/29/2007	1021	4,040	262	7.00	--	--
8/29/2007	1030	--	--	--	<0.007	<0.10
8/29/2007	1031	4,070	263	8.00	--	--
3/5/2008	1025	--	--	--	--	<0.10
3/5/2008	1026	4,570	290	7.00	--	--
3/5/2008	1030	--	--	--	--	<0.10
3/5/2008	1031	4,570	290	8.00	--	--
8/19/2008	1010	--	--	--	<0.007	<0.10
8/19/2008	1011	4,260	271	8.00	--	--
2/9/2009	1020	--	--	--	--	<0.10
2/9/2009	1021	4,670	300	7.00	--	--
4/1/2009	1110	--	--	--	--	<0.10
4/1/2009	1111	4,730	306	7.00	--	--
4/21/2009	0955	--	--	--	--	<0.10
4/21/2009	0956	4,760	310	8.00	--	--
6/25/2009	1000	--	--	--	<0.007	<0.10
6/25/2009	1001	4,740	311	7.00	--	--
7/14/2009	1025	--	--	--	--	<0.10
7/14/2009	1026	4,370	281	8.00	--	--
8/19/2009	0955	--	--	--	--	<0.10
8/19/2009	0956	4,270	271	7.00	--	--
8/19/2009	0957	--	--	--	--	<0.10
11/18/2009	1000	--	--	--	--	<0.10
11/18/2009	1001	4,700	306	8.00	--	--
3/8/2010	1005	--	--	--	--	<0.10
3/8/2010	1006	4,590	299	10.60	--	--
RB1-MN deep						
8/30/2006	1155	--	--	--	<0.007	<0.10
8/30/2006	1156	640	420	16.60	--	--
11/29/2006	0955	--	--	--	--	<0.10
11/29/2006	0956	770	420	16.00	--	--
2/23/2007	1205	--	--	--	--	<0.10
2/23/2007	1206	750	390	14.00	--	--
6/4/2007	1140	--	--	--	--	<0.10
6/4/2007	1141	720	368	15.00	--	--
6/4/2007	1145	--	--	--	--	<0.10
6/4/2007	1146	730	370	16.00	--	--
8/29/2007	1230	--	--	--	<0.007	<0.10
8/29/2007	1231	800	407	12.00	--	--
3/5/2008	1155	--	--	--	--	<0.10
3/5/2008	1156	880	418	14.00	--	--
8/19/2008	1150	--	--	--	<0.007	<0.10
8/19/2008	1151	1,050	435	14.00	--	--
2/9/2009	1150	--	--	--	--	<0.10
2/9/2009	1151	920	433	13.00	--	--
4/1/2009	1240	--	--	--	--	<0.10
4/1/2009	1241	850	432	13.00	--	--

Table 9. Summary of trace element and atrazine concentrations from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[µg/L, micrograms per liter; --, not determined or not applicable; M*, presence of material verified, but not quantified; E**, estimated; <, less than; >, greater than]

Date of sample collection (month/day/year)	Sample start time	Iron (µg/L)	Manganese (µg/L)	Arsenic (µg/L)	Atrazine, recoverable (µg/L)	Triazine screen, enzyme link immuno sorbent assay, recoverable (µg/L)
RB1-MN deep—Continued						
4/1/2009	1242	--	--	--	--	<0.10
4/21/2009	1115	--	--	--	--	<0.10
4/21/2009	1116	840	398	14.0	--	--
6/25/2009	1200	--	--	--	<0.007	<0.10
6/25/2009	1201	840	400	14.0	--	--
6/25/2009	1210	--	--	--	<0.007	<0.10
6/25/2009	1211	840	403	14.0	--	--
7/14/2009	1200	--	--	--	--	<0.10
7/14/2009	1201	920	435	14.0	--	--
8/19/2009	1125	--	--	--	--	<0.10
8/19/2009	1126	850	408	14.0	--	--
11/18/2009	1130	--	--	--	--	<0.10
11/18/2009	1131	960	452	14.0	--	--
3/8/2010	1145	--	--	--	--	<0.10
3/8/2010	1146	870	407	16.7	--	--
RB1-MS shallow						
8/30/2006	1030	--	--	--	E0.002	<0.10
8/30/2006	1031	800	170	7.10	--	--
8/30/2006	1035	--	--	--	--	--
11/29/2006	1010	--	--	--	--	<0.10
11/29/2006	1011	1,000	150	6.20	--	--
2/23/2007	1030	--	--	--	--	<0.10
2/23/2007	1031	1,140	160	5.00	--	--
2/23/2007	1032	--	--	--	--	<0.10
6/4/2007	1020	--	--	--	--	<0.10
6/4/2007	1021	970	140	5.00	--	--
8/29/2007	1015	--	--	--	<0.007	<0.10
8/29/2007	1016	970	131	5.00	--	--
3/4/2008	1015	--	--	--	E0.004	<0.10
3/4/2008	1016	1,020	125	5.00	--	--
8/18/2008	1030	--	--	--	E0.003	<0.10
8/18/2008	1031	1,050	124	6.00	--	--
8/18/2008	1032	--	--	--	--	<0.10
2/4/2009	1005	--	--	--	--	<0.10
2/4/2009	1006	1,170	120	5.00	--	--
3/24/2009	1135	--	--	--	--	<0.10
3/24/2009	1136	1,150	116	4.00	--	--
4/6/2009	1010	--	--	--	--	<0.10
4/6/2009	1011	1,180	120	5.00	--	--
4/9/2009	1005	--	--	--	<0.050	<0.10
4/9/2009	1006	1,180	118	4.00	--	--
4/16/2009	1015	--	--	--	--	<0.10
4/16/2009	1016	1,160	117	5.00	--	--
4/20/2009	1005	--	--	--	--	<0.10
4/20/2009	1006	1,130	114	5.00	--	--
5/6/2009	1025	--	--	--	<0.050	<0.10
5/6/2009	1026	1,150	115	5.00	--	--
5/20/2009	1005	--	--	--	--	<0.10
5/20/2009	1006	1,110	117	5.00	--	--
6/25/2009	1000	--	--	--	E0.006	<0.10
6/25/2009	1001	1,150	116	4.00	--	--

Table 9. Summary of trace element and atrazine concentrations from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[µg/L, micrograms per liter; --, not determined or not applicable; M*, presence of material verified, but not quantified; E**, estimated; <, less than; >, greater than]

Date of sample collection (month/day/year)	Sample start time	Iron (µg/L)	Manganese (µg/L)	Arsenic (µg/L)	Atrazine, recoverable (µg/L)	Triazine screen, enzyme link immuno sorbent assay, recoverable (µg/L)
RB1-MS shallow—Continued						
7/8/2009	1020	--	--	--	--	<0.10
7/8/2009	1021	1,210	115	4.00	--	--
7/13/2009	1015	--	--	--	--	<0.10
7/13/2009	1016	1,150	110	5.00	--	--
7/20/2009	1015	--	--	--	--	<0.10
7/20/2009	1016	1,040	105	4.00	--	--
8/18/2009	1010	--	--	--	--	<0.10
8/18/2009	1011	1,180	113	4.00	--	--
11/18/2009	1005	--	--	--	--	<0.10
11/18/2009	1006	1,140	111	5.00	--	--
3/1/2010	1130	--	--	--	--	<0.10
3/1/2010	1131	1,120	109	5.50	--	--
RB1-MS deep						
8/30/2006	1245	--	--	--	<0.007	<0.10
8/30/2006	1246	180	420	20.3	--	--
12/4/2006	1000	--	--	--	--	<0.10
12/4/2006	1001	200	410	17.9	--	--
2/23/2007	1145	--	--	--	--	<0.10
2/23/2007	1146	230	430	15.0	--	--
6/4/2007	1150	--	--	--	--	<0.10
6/4/2007	1151	220	412	17.0	--	--
8/29/2007	1205	--	--	--	<0.007	<0.10
8/29/2007	1206	230	425	13.0	--	--
3/4/2008	1200	--	--	--	<0.007	<0.10
3/4/2008	1201	250	414	16.0	--	--
8/18/2008	1230	--	--	--	<0.007	<0.10
8/18/2008	1231	250	440	17.0	--	--
2/4/2009	1140	--	--	--	--	<0.10
2/4/2009	1141	220	389	14.0	--	--
3/24/2009	1305	--	--	--	--	<0.10
3/24/2009	1306	240	418	16.0	--	--
4/6/2009	1140	--	--	--	--	<0.10
4/6/2009	1141	240	413	15.0	--	--
4/9/2009	1135	--	--	--	<0.050	<0.10
4/9/2009	1136	230	410	15.0	--	--
4/16/2009	1140	--	--	--	--	<0.10
4/16/2009	1141	230	408	16.0	--	--
4/20/2009	1135	--	--	--	--	<0.10
4/20/2009	1136	230	414	16.0	--	--
5/6/2009	1150	--	--	--	<0.050	<0.10
5/6/2009	1151	240	413	15.0	--	--
5/20/2009	1140	--	--	--	--	<0.10
5/20/2009	1141	230	405	15.0	--	--
6/25/2009	1145	--	--	--	<0.007	<0.10
6/25/2009	1146	240	416	15.0	--	--
7/8/2009	1205	--	--	--	--	<0.10
7/8/2009	1206	230	410	14.0	--	--
7/13/2009	1155	--	--	--	--	<0.10
7/13/2009	1156	220	400	16.0	--	--
7/20/2009	1240	--	--	--	--	<0.10
7/20/2009	1241	230	400	17.0	--	--

Table 9. Summary of trace element and atrazine concentrations from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[µg/L, micrograms per liter; --, not determined or not applicable; M*, presence of material verified, but not quantified; E**, estimated; <, less than; >, greater than]

Date of sample collection (month/day/year)	Sample start time	Iron (µg/L)	Manganese (µg/L)	Arsenic (µg/L)	Atrazine, recoverable (µg/L)	Triazine screen, enzyme link immuno sorbent assay, recoverable (µg/L)
RB1-MS deep—Continued						
8/18/2009	1145	--	--	--	--	<0.10
8/18/2009	1146	210	386	15.0	--	--
11/18/2009	1135	--	--	--	--	<0.10
11/18/2009	1136	210	373	15.0	--	--
3/1/2010	1255	--	--	--	--	<0.10
3/1/2010	1256	210	372	16.4	--	--
RB1-PMS shallow						
1/22/2009	1415	--	--	--	--	<0.10
1/22/2009	1416	<100	20	<1.00	--	--
2/2/2009	1035	--	--	--	--	<0.10
2/2/2009	1036	<100	12	<1.00	--	--
3/26/2009	1115	--	--	--	--	<0.10
3/26/2009	1116	<100	17	<1.00	--	--
4/4/2009	1005	--	--	--	--	<0.10
4/4/2009	1006	<100	14	<1.00	--	--
4/8/2009	1005	--	--	--	0.310	0.50
4/8/2009	1006	<100	16	<1.00	--	--
4/8/2009	1010	--	--	--	--	--
4/15/2009	1045	--	--	--	--	0.18
4/15/2009	1046	<100	15	<1.00	--	--
4/18/2009	1010	--	--	--	--	0.85
4/18/2009	1011	<100	15	<1.00	--	--
5/6/2009	1015	--	--	--	0.300	0.29
5/6/2009	1016	<100	17	<1.00	--	--
5/20/2009	1020	--	--	--	--	<0.10
5/20/2009	1021	<100	14	<1.0	--	--
7/8/2009	1125	--	--	--	--	<0.10
7/8/2009	1126	<100	20	<1.00	--	--
7/13/2009	1015	--	--	--	--	<0.10
7/13/2009	1016	<100	18	1.00	--	--
7/20/2009	1025	--	--	--	--	<0.10
7/20/2009	1026	<100	20	1.00	--	--
8/18/2009	1010	--	--	--	--	<0.10
8/18/2009	1011	<100	14	<1.00	--	--
11/17/2009	0950	--	--	--	--	<0.10
11/17/2009	0951	<100	16	<1.00	--	--
3/2/2010	1045	--	--	--	--	<0.10
3/2/2010	1046	<100	13	1.90	--	--
3/2/2010	1050	--	--	--	--	<0.10
3/2/2010	1051	<100	13	1.90	--	--
RB1-PMS deep						
1/22/2009	1300	--	--	--	--	<0.10
1/22/2009	1301	1170	195	4.00	--	--
2/2/2009	1205	--	--	--	--	<0.10
2/2/2009	1206	<100	50	<1.00	--	--
3/26/2009	1240	--	--	--	--	<0.10
3/26/2009	1241	100	34	<1.00	--	--
4/4/2009	1130	--	--	--	--	<0.10
4/4/2009	1131	<100	40	<1.00	--	--
4/8/2009	1130	--	--	--	0.310	0.22
4/8/2009	1131	<100	54	<1.00	--	--

Table 9. Summary of trace element and atrazine concentrations from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[µg/L, micrograms per liter; --, not determined or not applicable; M*, presence of material verified, but not quantified; E**, estimated; <, less than; >, greater than]

Date of sample collection (month/day/year)	Sample start time	Iron (µg/L)	Manganese (µg/L)	Arsenic (µg/L)	Atrazine, recoverable (µg/L)	Triazine screen, enzyme link immuno sorbent assay, recoverable (µg/L)
RB1-PMS deep—Continued						
4/15/2009	1215	--	--	--	--	0.44
4/15/2009	1216	<100	46	1.00	--	--
4/15/2009	1217	--	--	--	--	0.30
4/18/2009	1145	--	--	--	--	0.44
4/18/2009	1146	<100	41	<1.00	--	--
5/6/2009	1140	--	--	--	0.430	0.46
5/6/2009	1141	<100	33	<1.00	--	--
5/20/2009	1150	--	--	--	--	<0.10
5/20/2009	1151	<100	30	<1.00	--	--
7/8/2009	1005	--	--	--	--	<0.10
7/8/2009	1006	<100	6	<1.00	--	--
7/13/2009	1140	--	--	--	--	<0.10
7/13/2009	1141	<100	18	1.00	--	--
7/20/2009	1200	--	--	--	--	<0.10
7/20/2009	1201	<100	71	<1.00	--	--
8/18/2009	1145	--	--	--	--	<0.10
8/18/2009	1146	<100	21	<1.00	--	--
11/17/2009	1120	--	--	--	--	<0.10
11/17/2009	1121	<100	30	<1.00	--	--
3/2/2010	1255	--	--	--	--	<0.10
3/2/2010	1256	<100	36	1.70	--	--
3/22/2010	1025	--	--	--	--	<0.10
3/22/2010	1026	<100	36	1.80	--	--
RB1-P shallow						
1/21/2009	1500	--	--	--	--	<0.10
1/21/2009	1501	<100	23	<1.00	--	--
2/3/2009	1015	--	--	--	--	<0.10
2/3/2009	1016	<100	40	<1.00	--	--
2/3/2009	1017	--	--	--	--	<0.10
2/3/2009	1020	--	--	--	--	<0.10
2/3/2009	1021	<100	40	<1.00	--	--
3/25/2009	1035	--	--	--	--	<0.10
3/25/2009	1036	<100	30	1.00	--	--
4/4/2009	1310	--	--	--	--	0.59
4/4/2009	1311	<100	17	<1.00	--	--
4/4/2009	1315	--	--	--	0.730	0.34
4/4/2009	1316	<100	17	<1.00	--	--
4/7/2009	1155	--	--	--	0.530	0.45
4/7/2009	1156	<100	21	1.00	--	--
4/7/2009	1200	--	--	--	--	--
4/15/2009	1040	--	--	--	--	0.82
4/15/2009	1041	<100	8	1.00	--	--
4/18/2009	1010	--	--	--	--	0.53
4/18/2009	1011	<100	<5	1.00	--	--
5/4/2009	1225	--	--	--	1.650	1.90
5/4/2009	1226	<100	<5	<1.00	--	--
5/19/2009	1145	--	--	--	--	<0.10
5/19/2009	1146	<100	<5	2.00	--	--
8/17/2009	1050	--	--	--	--	<0.10
8/17/2009	1051	<100	25	<1.00	--	--
11/16/2009	1015	--	--	--	--	<0.10

Table 9. Summary of trace element and atrazine concentrations from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[µg/L, micrograms per liter; --, not determined or not applicable; M*, presence of material verified, but not quantified; E**, estimated; <, less than; >, greater than]

Date of sample collection (month/day/year)	Sample start time	Iron (µg/L)	Manganese (µg/L)	Arsenic (µg/L)	Atrazine, recoverable (µg/L)	Triazine screen, enzyme link immuno sorbent assay, recoverable (µg/L)
RB1-P shallow—Continued						
11/16/2009	1016	<100	46	<1.00	--	--
11/16/2009	1017	--	--	--	--	0.11
3/3/2010	1020	--	--	--	--	<0.10
3/3/2010	1021	<100	63	1.40	--	--
RB1-P deep						
2/3/2009	1150	--	--	--	--	<0.10
2/3/2009	1151	<100	41	<1.00	--	--
3/25/2009	1205	--	--	--	--	<0.10
3/25/2009	1206	<100	31	1.00	--	--
4/4/2009	1440	--	--	--	--	0.60
4/4/2009	1441	<100	17	<1.00	--	--
4/7/2009	1320	--	--	--	0.470	0.71
4/7/2009	1321	<100	20	1.00	--	--
4/7/2009	1325	--	--	--	--	--
4/15/2009	1210	--	--	--	--	0.75
4/15/2009	1211	<100	8	<1.00	--	--
4/18/2009	1130	--	--	--	--	0.36
4/18/2009	1131	<100	<5	<1.00	--	--
4/18/2009	1132	--	--	--	--	0.46
5/4/2009	1335	--	--	--	1.710	1.10
5/4/2009	1336	<100	<5	<1.00	--	--
5/19/2009	1300	--	--	--	--	<0.10
5/19/2009	1301	<100	<5	1.00	--	--
5/19/2009	1302	--	--	--	--	<0.10
7/9/2009	1055	--	--	--	0.100	0.34
7/9/2009	1056	<100	49	<1.00	--	--
7/13/2009	1235	--	--	--	--	<0.10
7/13/2009	1236	<100	121	3.00	--	--
7/20/2009	1000	--	--	--	<0.050	0.11
7/20/2009	1001	<100	199	4.00	--	--
8/12/2009	1020	--	--	--	--	<0.10
8/12/2009	1021	130	219	4.00	--	--
8/17/2009	1210	--	--	--	--	<0.10
8/17/2009	1211	<100	30	<1.00	--	--
11/16/2009	1125	--	--	--	--	--
3/3/2010	1135	--	--	--	--	<0.10
3/3/2010	1136	<100	56	1.40	--	--
RB1-P TR						
3/26/2009	1020	--	--	--	--	<0.10
3/26/2009	1021	<100	28	<1.00	--	--
4/3/2009	1350	--	--	--	--	0.37
4/3/2009	1351	<100	10	<1.00	--	--
4/3/2009	1352	--	--	--	--	0.44
4/7/2009	1000	--	--	--	0.490	0.54
4/7/2009	1001	<100	21	1.00	--	--
4/7/2009	1002	--	--	--	0.440	--
4/7/2009	1005	--	--	--	--	0.44
4/7/2009	1006	<100	21	1.00	--	--
4/14/2009	1131	<100	9	<1.00	--	--
4/14/2009	1330	--	--	--	--	0.71

Table 9. Summary of trace element and atrazine concentrations from water samples collected as part of the *Equus* Beds Experimental Passive Recharge Project at RB1, 2009–2010.—Continued

[µg/L, micrograms per liter; --, not determined or not applicable; M*, presence of material verified, but not quantified; E**, estimated; <, less than; >, greater than]

Date of sample collection (month/day/year)	Sample start time	Iron (µg/L)	Manganese (µg/L)	Arsenic (µg/L)	Atrazine, recoverable (µg/L)	Triazine screen, enzyme link immuno sorbent assay, recoverable (µg/L)
RB1-P TR—Continued						
4/17/2009	1250	--	--	--	--	0.61
4/17/2009	1251	<100	5	1.00	--	--
4/23/2009	1121	<100	<5	2.00	--	--
4/23/2009	1220	--	--	--	--	0.48
4/23/2009	1222	--	--	--	--	0.44
4/27/2009	1140	--	--	--	--	0.69
4/27/2009	1141	<100	<5	2.00	--	--
5/4/2009	1055	--	--	--	1.760	1.40
5/4/2009	1056	<100	<5	<1.00	--	--
5/4/2009	1057	--	--	--	--	1.80
5/19/2009	1020	--	--	--	--	<0.10
5/19/2009	1021	<100	<5	1.00	--	--
Diverted SW, PAC building						
4/3/2009	1010	--	--	--	--	3.02
4/3/2009	1011	<100	33	2.30	--	--
4/14/2009	1010	--	--	--	3.370	2.85
4/14/2009	1011	<100	24	2.00	--	--
4/14/2009	1012	--	--	--	3.130	--
4/17/2009	0950	--	--	--	--	4.05
4/17/2009	0951	<100	10	2.90	--	--

* National Water Information System: Web Interface Help System, accessed March 17, 2011, at http://nwis.waterdata.usgs.gov/nwis/help/help?codes_help#remark_cd.

** Values may be reported as estimated (E) if values are out of instrument calibration range, data quantification was not performed according to method specific criteria, or deviation for the standard operating procedure was required. Values are considered detections. (Childress and others, 1999).

Table 10. Saturation indices calculated for groundwater samples collected from RB1 sites, January 2009–March 2010.

Date of sample (month/day/year)	Mineral (chemical formula) saturation indices			
	Calcite (CaCO ₃)	Iron hydroxide Fe ₃ (OH) ₈	Manganite (MnOOH)	Scorodite (FeAsO ₄ ·2H ₂ O)
IW-09 shallow				
2/10/2009	-1.02	-2.31	-1.46	-6.59
4/2/2009	-1.07	-2.34	-1.43	-6.57
4/22/2009	-0.83	-1.96	-1.18	-6.74
6/10/2009	-1.03	-2.15	-1.69	-6.62
7/14/2009	-0.63	-1.38	-0.93	-6.93
8/19/2009	-0.65	-1.37	-0.89	-6.91
11/17/2009	-0.63	-1.33	-0.84	-6.91
3/9/2010	-0.63	-1.45	-1.08	-6.48
IW-09 deep				
2/10/2009	-0.28		-1.08	-5.74
4/2/2009	-0.37	-1.14	-1.24	-5.67
4/22/2009	-0.19	-0.39	-1.51	-5.82
6/10/2009	-0.28	-0.58	-1.73	-5.75
7/14/2009	-0.08	-0.16	-1.33	-5.88
8/19/2009	-0.08	-0.31	-1.34	-5.98
11/17/2009	0.13	-0.69	-0.34	-6.22
3/9/2010	-0.23	-0.03	-1.18	-5.85
RB1-MN deep				
2/9/2009	-0.34	1.62	-1.31	-4.76
4/1/2009	-0.45	1.32	-1.46	-4.70
4/21/2009	-0.17	2.42	-1.57	-4.96
6/25/2009	-0.27	1.52	-1.18	-4.89
7/14/2009	-0.42	1.94	-2.17	-4.68
8/19/2009	-0.26	2.23	-1.79	-4.87
11/18/2009	0.06	2.13	-0.53	-5.18
3/8/2010	-0.04	2.59	-1.35	-5.03
RB1-MN shallow				
2/9/2009	-0.52	3.18	-2.06	-4.10
4/1/2009	-0.63	2.97	-2.21	-4.04
4/21/2009	-0.43	3.36	-1.81	-4.11
6/25/2009	-0.51	2.96	-2.07	-4.15
7/14/2009	-0.73	3.06	-3.20	-4.04
8/19/2009	-0.44	3.79	-2.58	-4.24
11/18/2009	-0.21	3.72	-1.46	-4.28
3/8/2010	-0.30	4.21	-2.27	-4.09
RB1-MS deep				
2/4/2009	-0.45	-0.21	-1.33	-5.33
3/24/2009	-0.32	0.01	-1.13	-5.35
4/6/2009	-0.43	-0.10	-1.31	-5.26
4/9/2009	-0.31	0.57	-1.76	-5.39
4/16/2009	-0.13	0.83	-1.37	-5.59
4/20/2009	-0.31	0.57	-1.75	-5.37
5/6/2009	-0.02	0.96	-1.19	-5.74
5/20/2009	-0.32	0.54	-1.77	-5.40
6/25/2009	0.08	1.02	-1.01	-5.89
7/8/2009	-0.21	0.60	-1.61	-5.56
7/13/2009	-0.22	0.54	-1.62	-5.53
7/20/2009	-0.41	0.30	-2.01	-5.27
8/18/2009	-0.35	0.38	-1.81	-5.45
11/18/2009	-0.06	0.25	-0.63	-5.78
3/1/2010	-0.03	0.92	-1.11	-5.80

Table 10. Saturation indices calculated for groundwater samples collected from RB1 sites, January 2009–March 2010.—Continued

Date of sample (month/day/year)	Mineral (chemical formula) saturation indices			
	Calcite (CaCO ₃)	Iron hydroxide Fe ₃ (OH) ₈	Manganite (MnOOH)	Scorodite (FeAsO ₄ ·2H ₂ O)
RB1-MS shallow				
2/4/2009	-0.90	1.24	-2.64	-4.76
3/24/2009	-0.80	1.33	-2.47	-4.94
4/6/2009	-0.82	1.47	-2.46	-4.82
4/9/2009	-0.79	1.95	-3.09	-4.94
4/16/2009	-0.52	2.50	-2.50	-5.08
4/20/2009	-0.70	2.11	-2.90	-4.93
5/6/2009	-0.41	2.32	-2.03	-5.18
5/20/2009	-0.71	1.89	-2.76	-4.95
6/25/2009	-0.31	2.54	-2.01	-5.41
7/8/2009	-0.59	2.24	-2.77	-5.12
7/13/2009	-0.58	2.02	-2.64	-5.04
7/20/2009	-0.69	1.74	-2.84	-5.09
8/18/2009	-0.68	1.90	-2.81	-5.04
11/18/2009	-0.45	2.49	-2.18	-5.18
3/1/2010	-0.45	2.72	-2.27	-5.12
RB1-P deep				
2/3/2009	-1.01	-1.89	-2.17	-6.32
3/25/2009	-0.94	-1.95	-2.37	-6.49
4/4/2009	-1.16	-1.43	-2.74	-6.56
4/7/2009	-0.53	0.05	-1.26	-6.98
4/15/2009	-0.59	-1.21	-1.92	-6.94
4/18/2009	-0.58	-1.56	-2.36	-7.07
5/4/2009	-1.32	-1.86	-3.15	-6.77
5/19/2009	-0.78	-2.36	-3.17	-6.73
7/9/2009	-0.20	-1.02	-1.49	-7.16
7/13/2009	-0.26	-0.98	-1.50	-6.57
7/20/2009	0.25	-0.38	-0.37	-7.13
8/12/2009	-0.11	-0.51	-1.07	-6.46
8/17/2009	-0.68	-1.45	-2.67	-6.76
11/16/2009	-0.72	-1.22	-2.50	-6.70
RB1-P shallow				
1/21/2009	-1.08	-2.29	-2.78	-6.48
2/3/2009	-1.05	-1.66	-2.07	-6.25
3/25/2009	-0.94	-1.93	-2.38	-6.48
4/4/2009	-1.17	-1.36	-2.74	-6.54
4/7/2009	-0.53	0.20	-1.18	-6.93
4/15/2009	-0.63	-1.14	-1.89	-6.91
4/18/2009	-0.52	-1.53	-2.36	-7.06
5/4/2009	-1.29	-1.90	-3.17	-6.79
5/19/2009	-0.78	-2.39	-3.20	-6.44
8/17/2009	-0.69	-1.50	-2.72	-6.76
11/16/2009	-0.75	-1.31	-2.41	-6.71
RB1-P TR				
3/26/2009	-0.85	-1.67	-2.16	-6.52
4/3/2009	-0.80	-0.23	-1.88	-6.73
4/7/2009	-0.55	0.27	-1.14	-6.91
4/17/2009	-0.63	-1.75	-2.57	-6.98
4/23/2009	-0.74	-1.41	-2.29	-6.91
4/27/2009	-0.98	-1.63	-2.39	-6.77
5/4/2009	-1.21	-1.64	-2.93	-6.84
5/19/2009	-0.81	-2.05	-2.95	-6.77

Table 10. Saturation indices calculated for groundwater samples collected from RB1 sites, January 2009–March 2010.—Continued

Date of sample (month/day/year)	Mineral (chemical formula) saturation indices			
	Calcite (CaCO ₃)	Iron hydroxide Fe ₃ (OH) ₈	Manganite (MnOOH)	Scorodite (FeAsO ₄ ·2H ₂ O)
RB1-PMS deep				
1/22/2009	-0.58	1.61	-1.76	-5.09
2/2/2009	-0.91	-2.28	-2.28	-6.58
3/26/2009	-0.88	-1.88	-2.22	-6.59
4/4/2009	-0.90	-1.60	-2.43	-6.60
4/8/2009	-0.95	-1.58	-2.14	-6.57
4/15/2009	-0.76	-1.46	-1.55	-6.72
4/18/2009	-0.66	-1.36	-1.43	-6.83
5/6/2009	-1.19	-2.27	-2.42	-6.57
5/20/2009	-0.95	-2.13	-2.29	-6.65
7/8/2009	-0.44	-1.63	-2.86	-6.85
7/13/2009	-0.46	-1.87	-2.55	-6.78
7/20/2009	-0.29	-1.68	-1.81	-6.87
8/18/2009	-0.77	-2.09	-2.64	-6.69
11/17/2009	-0.76	-1.50	-2.49	-6.72
3/2/2010	-0.63	-1.26	-2.29	-6.57
RB1-PMS shallow				
4/8/2009		-1.66	-2.64	-6.58
4/15/2009	-0.90	-1.72	-2.26	-6.66
4/18/2009	-0.68	-1.41	-1.92	-6.86
5/6/2009	-1.18	-2.28	-2.74	-6.58
5/20/2009	-0.80	-1.92	-2.49	-6.74
7/8/2009	-0.63	-1.62	-2.45	-6.87
7/13/2009	-0.50	-1.48	-2.54	-6.85
7/20/2009	-0.45	-1.64	-2.35	-6.86
8/18/2009	-0.69	-1.67	-2.45	-6.84
11/17/2009	-0.66	-1.29	-2.56	-6.80
3/2/2010	-0.62	-1.28	-2.61	-6.57
RB1 source water				
4/3/2009	-2.46	-3.33	-3.81	-6.16
4/14/2009	-0.29	0.25	-1.49	-7.47
4/17/2009	-0.79	-1.46	-3.10	-6.72

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