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Multilevel Groundwater Monitoring of Hydraulic Head, Water Temperature, and Chemical Constituents in the Eastern Snake River Plain Aquifer, Idaho National Laboratory, Idaho, 2014–18

Scientific Investigations Report 2021–5002

Cover: Photograph showing U.S. Geological Survey drill crew installing multilevel monitoring system and cross section (inset, right) showing components of multi-packer borehole completion and pressure probe used for collecting pressure and temperature measurements , Idaho National Laboratory, Idaho.

Multilevel Groundwater Monitoring of Hydraulic Head, Water Temperature, and Chemical Constituents in the Eastern Snake River Plain Aquifer, Idaho National Laboratory, Idaho, 2014–18

By Brian V. Twining, Roy C. Bartholomay, Jason C. Fisher, and Calvin Anderson

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
Length		
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Area		
square mile (mi ²)	259.0	hectare (ha)
square mile (mi ²)	2.590	square kilometer (km ²)
Pressure		
pound per square inch (lb/in ²)	6.895	kilopascal (kPa)
Density		
pound per cubic foot (lb/ft ³)	16.02	kilogram per cubic meter (kg/m ³)
Radioactivity		
picocurie per liter (pCi/L)	0.037	becquerel per liter (Bq/L)
Hydraulic conductivity		
foot per day (ft/d)	0.3048	meter per day (m/d)
Hydraulic gradient		
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
Transmissivity		
foot squared per day (ft ² /d)	0.09290	meter squared per day (m ² /d)

International System of Units to U.S. customary units

Multiply	By	To obtain
Length		
micrometer (μm)	0.00003.937	inch (in.)
centimeter (cm)	0.3937	inch (in.)
Volume		
liter (L)	1.057	quart (qt)
liter (L)	0.2642	gallon (gal)
Mass		
milligram (mg)	0.00003527	ounce, avoirdupois (oz)
microgram (μg)	0.0000003527	ounce, avoirdupois (oz)

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

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

Datums

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88) or the National Geodetic Vertical Datum of 1929 (NGVD 29), as explicitly noted in the text.

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

Supplemental Information

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius ($\mu\text{S}/\text{cm}$ at 25 °C).

Concentrations of chemical constituents in water are given in either milligrams per liter (mg/L) or micrograms per liter ($\mu\text{g}/\text{L}$).

Activities for radioactive constituents in water are given in picocuries per liter (pCi/L).

The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness $[(\text{ft}^3/\text{d})/(\text{ft}^2)]\text{ft}$. In this report, the mathematically reduced form, foot squared per day (ft^2/d), is used for convenience.

Abbreviations

ATR	Advanced Test Reactor Complex
AVZ	Axial Volcanic Zone
bls	below land surface
BLR	Big Lost River
CFA	Central Facilities Area
Cu	Curie
DOE	Department of Energy
ESRP	eastern Snake River Plain
head	hydraulic head
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
MLMS	multilevel monitoring system
MP	multiport
NRF	Naval Reactors Facility
PCC	Pearson correlation coefficient
PCE	tetrachloroethene
POCs	purgeable organic compounds
NWQL	National Water Quality Laboratory
QA	quality-assurance
QC	quality-control
PCC	Pearson correlation coefficient
RESL	Radiological and Environmental Sciences Laboratory
RPD	relative percent difference
RWMC	Radioactive Waste Management Complex
USGS	U.S. Geological Survey
VOC	volatile organic compound
VRZ	Volcanic Rift Zone

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Abstract

Radiochemical and chemical wastewater discharged to infiltration ponds and disposal wells since the early 1950s at the Idaho National Laboratory (INL), southeastern Idaho, has affected the water quality of the eastern Snake River Plain (ESRP) aquifer. In 2006, the U.S. Geological Survey (USGS), in cooperation with the U.S. Department of Energy, added a multilevel well-monitoring network to their ongoing monitoring program to begin describing the vertical movement and distribution of the chemical constituents in the ESRP aquifer.

The multilevel monitoring system (MLMS) at the INL has been ongoing since 2006, and this report summarizes data collected during 2014–18 from 11 multilevel monitoring wells. Hydraulic head (head) and groundwater temperature data were collected, including 177 measurements from hydraulically isolated depth intervals from 448.0 to 1,377.6 feet below land surface. One port (port 3) within well USGS 134 was not monitored owing to a valve failure.

Vertical head and temperature changes were quantified for each of the 11 multilevel monitoring systems. Fractured basalt zones generally had relatively small vertical head differences and showed a higher occurrence within volcanic rift zones. Poor connectivity between fractures and higher vertical gradients generally were attributed to sediment layers and (or) layers of dense basalt. Hydraulic head ranged from 4,415.5 to 4,462.6 feet above the National Geodetic Vertical Datum of 1929; groundwater temperature ranged from 10.4 to 16.8 degrees Celsius.

Normalized mean head values were analyzed for all 11 multilevel monitoring wells for the period of record (2007–18). The mean head values suggest a moderately positive correlation among all MLMS wells and generally reflect regional fluctuations in water levels in response to seasonal climatic changes. MLMS wells within volcanic rift zones and near the southern boundary indicate a temporal correlation that is strongly positive. MLMS wells in the Big Lost Trough

indicate some variations in temporal correlations that may result from proximity to the mountain front to the northwest and episodic flow in the Big Lost River drainage system.

During 2014–18, water samples were collected from one to four discrete sampling zones, isolated by packers, in the upper 250–750 feet of the aquifer from 11 multilevel monitoring wells and were analyzed for selected radionuclides, inorganic constituents, organic constituents, and nutrients. Some additional samples were collected for volatile organic compounds from wells near the Radioactive Waste Management Complex (RWMC).

Nine quality-control replicate samples, three field blanks, and two equipment blanks were collected during 2014–18 as a measure of quality assurance. Concentrations of major ions and chromium in equipment blank samples were near or less than the reporting levels, suggesting no background contamination from field equipment or source water. About 88 percent of the replicate pairs for radionuclide results were statistically comparable and 100 percent of the replicate pairs for inorganic and organic compounds were statistically comparable.

Concentrations of chloride, chromium, nitrate, sodium, and sulfate in most of the wells showed mostly consistent concentrations with time. Concentrations in well MIDDLE 2050A were markedly lower during 2017 and 2018 than during other sample years and the decrease in concentrations is attributed to flow in the Big Lost River during those years. Chromium concentrations measured in well USGS 133 increased during this time period. Concentrations of most of the chemical constituents were greater than background concentration levels in wells USGS 103, 105, 108, 131A, 132, 137A, and MIDDLE 2051, and were at or less than background concentration levels in wells USGS 133, 134, and 135.

Tritium concentrations in wells USGS 108, 133, 134, 135, 137A, and MIDDLE 2050A mostly were less than reporting levels. Concentrations in wells USGS 105 and 132 mostly were greater than the reporting levels, and concentrations were mostly consistent. Wells USGS 103, USGS 131, and MIDDLE 2051 had concentrations mostly greater than the reporting

level and showed decreasing concentrations. The decreasing concentrations are attributed to discontinued disposal, radioactive decay, and dilution and dispersion in the aquifer.

The volatile organic compound tetrachloromethane was found in all zones sampled in well USGS 132 near the RWMC and was found in two zones in well USGS 137A. Concentrations are attributed to waste disposal at the RWMC. Questionable detections of tetrachloroethene were found in well MIDDLE 2051; the source probably was tubing fluid in the well. Tetrachloroethene was found in the tubing fluid at elevated concentrations in three wells (USGS 137A, MIDDLE 2050A, and MIDDLE 2051), and remedial efforts to remove the elevated concentrations of tetrachloroethene from tubing fluid have been successful in each of the three MLMS wells.

Introduction

The Idaho National Laboratory (INL), encompassing about 890 mi² of the eastern Snake River Plain (ESRP) in southeastern Idaho ([fig. 1](#)), is operated by the U.S. Department of Energy (DOE). The INL was established in 1949 for the development of peacetime atomic energy applications, nuclear safety research, defense programs, environmental research, and advanced energy concepts. Wastewater disposal sites at Test Area North, the Naval Reactors Facility (NRF), the Advanced Test Reactor (ATR) Complex, and the Idaho Nuclear Technology and Engineering Center (INTEC) ([fig. 1](#)) have been principal sources of radioactive- and chemical-waste contaminants in water from the ESRP aquifer. These wastewater disposal sites have included lined evaporation ponds, unlined infiltration ponds and ditches, drain fields, and injection wells. Waste materials buried in shallow pits and trenches within the Subsurface Disposal Area at the Radioactive Waste Management Complex (RWMC) also have contributed contaminants to the groundwater.

Prior to 1984, most of the wastewater generated at the INTEC, which is located in the southwestern part of the INL, was injected directly to the ESRP aquifer through a 598-ft-deep disposal well. In February 1984, routine use of the disposal well was discontinued, and wastewater was then discharged to unlined infiltration ponds south of the INTEC until 2002 (when the ponds were relocated to about 2 mi southwest of the INTEC). The infiltration ponds allowed the wastewater to percolate through about 450 ft of basalt and sediment to the aquifer.

Since 1952, wastewater generated at the ATR Complex has been discharged mostly to ponds. Low-level radioactive wastewater was discharged to infiltration ponds until 1993; since then it has been discharged to evaporation ponds. Nonradioactive wastewater was discharged to the aquifer through a disposal well from 1964 to 1982 and has been discharged to infiltration ponds since 1982 (Bartholomay and others, 2017).

The U.S. Geological Survey (USGS) has maintained a water-quality monitoring program at the INL since 1949 to define (1) the quality and availability of water for human consumption, (2) the usability of the water for supporting construction of facilities and for industrial purposes such as cooling systems and diluting concentrated waste streams, (3) the location and movement of contaminants in the ESRP aquifer, (4) the sources of recharge to the aquifer, (5) an early detection network for contaminants moving past the INL boundaries, and (6) the processes controlling the origin and distribution of contaminants and naturally occurring constituents in the aquifer (Ackerman and others, 2010).

Since the inception of the monitoring program, a network that once numbered almost 200 wells has been sampled for various constituents that may be present in the aquifer from INL waste disposal practices including tritium, strontium-90, cesium-137, plutonium-238, plutonium-239, plutonium-240 (undivided), americium-241, gross alpha- and gross beta-radioactivity, iodine-129, chromium and other trace elements, sodium, chloride, sulfate, nitrate, fluoride, volatile organic compounds (VOCs), and total organic carbon (Bartholomay and others, 2017; Maimor and Bartholomay, 2019). Most of the wells in this network were constructed as open-borehole wells, and many of the wells are open to the aquifer through their entire depth below the water table. This type of construction is good for maximum water-production rates, for identifying the time of arrival of contaminant plumes, and for delineating the horizontal extent of contaminants. However, it is not conducive to identifying either the vertical distribution of contaminants or pressure and temperature gradients in the borehole.

To acquire hydraulic head, water temperature, and water-chemistry data that describe the vertical distribution of constituents in the ESRP aquifer, the USGS collaborated with an INL contractor in 2005 to develop a multilevel monitoring network. The multilevel network allows for sampling of discrete zones of water compared to sampling an open, mixed zone. The multilevel monitoring network was expanded by the USGS during 2006–12. In 2005, 2006, and 2007, wells USGS 103, USGS 132, USGS 133, USGS 134, MIDDLE 2050A, and MIDDLE 2051 ([fig. 1](#), [table 1](#)) were instrumented; in 2009 through 2012, wells USGS 135, USGS 105, USGS 108, USGS 131A and USGS 137A were instrumented with multilevel Westbay™ packer sampling systems to acquire pressure and temperature measurements and water-chemistry data at isolated depths in each of the wells. These isolated depths coincide with the vertical location of groundwater model layers ([table 2](#), at back of report; [fig. 2](#)) in which particles are introduced to simulate groundwater flow paths (Ackerman and others, 2010), and the data collected from the multilevel monitoring system (MLMS) will improve our information for our next groundwater flow model.

Figure 1. Location of selected facilities, multilevel monitoring wells, and volcanic rift zones bounding the Big Lost Trough, Idaho National Laboratory and vicinity, Idaho.

Table 1. Data for multilevel groundwater monitoring wells, Idaho National Laboratory, 2014–18.

[**Local name:** Local well identifier used in this study. USGS, U.S. Geological Survey. **Latitude and Longitude:** In degrees, minutes, seconds and based on the North American Datum of 1983 (NAD 83). **Land-surface altitude:** In feet above National Geodetic Vertical Datum of 1929 (NGVD 29). **Estimated base of aquifer altitude:** In feet above NGVD 29 (Anderson and Liszewski, 1997; Whitehead, 1992). **Hole depth:** In feet below land surface (ft bls). **Site number:** Unique numerical identifier used to access well data (<https://waterdata.usgs.gov/nwis/>)]

Local name	Latitude	Longitude	Land surface altitude (feet)	Estimated base of aquifer altitude (feet)	Hole depth (ft bls)	Site number
USGS 103	43°27'13.24"	112°56'09.51"	5,007.42	2,470	1,307	432714112560701
USGS 105	43°27'03.07"	113°00'20.77"	5,095.12	2,540	1,409	432703113001801
USGS 108	43°26'58.46"	112°58'29.33"	5,031.36	2,495	1,218	432659112582601
USGS 131A	43°30'36.69"	112°58'18.75"	4,976.14	2,475	1,198	433036112581800
USGS 132	43°29'06.34"	113°02'53.93"	5,028.60	2,540	1,238	432906113025000
USGS 133	43°36'05.11"	112°55'46.73"	4,890.12	3,960	818	433605112554300
USGS 134	43°36'10.81"	113°00'01.27"	4,968.84	3,960	949	433611112595800
USGS 135	43°27'53.13"	113°09'38.63"	5,135.94	2,675	1,198	432753113093600
USGS 137A	43°27'02.74"	113°02'58.63"	5,053.81	2,580	1,058	432701113025800
MIDDLE 2050A	43°34'09.14"	112°57'08.37"	4,928.22	3,790	1,427	433409112570500
MIDDLE 2051	43°32'16.59"	113°00'52.37"	4,997.31	3,270	1,179	433217113004900

This report presents hydraulic head, water temperature, and water-chemistry results from data collected between calendar years 2014 to 2018 within 11 separate MLMS wells. MLMS wells are located throughout the INL (fig. 1) and completed in the upper 250–700 ft of the eastern Snake River Plain aquifer at the INL. Normalized mean hydraulic head values were computed, graphed, and analyzed for MLMS data collected for the period of record from each well from all the sample ports. The sample ports were installed in zones of the aquifer that were highly transmissive of groundwater and that represented the water chemistry of the top three to five layers of the USGS INL groundwater model for steady-state and transient groundwater flow (Ackerman and others, 2010).

The list of constituents that were sampled from selected zones during 2014–18 was composed of tritium; gross alpha, beta and gamma radioactivity; and chloride, sodium, chromium, and nutrients (Bartholomay and others, 2014, appendix A, schedule 19). For the entire period of sampling, nine replicate samples and five field equipment blank samples were collected as a measure of quality assurance. Organic samples were collected from three wells near the RWMC to assess whether future sampling should occur and to evaluate tubing fluid contamination. Some water-quality trends of selected constituents were determined to evaluate long-term changes.

Geohydrologic Setting

The INL is located on the west-central part of the ESRP. The ESRP is a northeast-trending structural basin about 200 mi long and 50–70 mi wide (fig. 1). The basin, bounded by faults on the northwest and by downwarping and faulting on the southeast, has been filled with basaltic-lava flows that consist of olivine tholeiitic basaltic lava flows (about 85 percent by volume) with lesser amounts of interbedded fluvial and terrestrial sediments (Kuntz and others, 1992). The basaltic rocks and sedimentary deposits combine to form the ESRP aquifer, which is the primary source of groundwater on the plain. Significant landforms of the ESRP in the vicinity of the INL include (fig. 1) (1) rhyolite domes (Kuntz and others, 1994), (2) Big Lost Trough (Blair, 2002), (3) volcanic rift zones (VRZ), and (4) axial volcanic zone (AVZ). The Big Lost Trough (fig. 1) is bounded to the northwest by mountains and on the other sides by informally named volcanic rift zones—the AVZ extends northeast and southwest and the Arco-Big Southern Butte VRZ extends northwest and southeast. The VRZs, including the Arco-Big Southern Butte VRZ and AVZ, are areas of focused volcanism resulting in high concentrations of volcanic vents and fissures (Anderson and others, 1999, p. 13; Hughes and others, 1999, p. 145), which are the major sources of basaltic rocks on the plain.

Figure 2. Distribution of hydrogeologic units at the water table (A), and cross section showing well depth in relation to model layers and hydrogeologic units along section A–A' (B), Idaho National Laboratory and vicinity, Idaho.

Wells USGS 103, 105, 108, 137A and 135 not projected perpendicular to cross-section trace; well depth based on total depth of well.

Figure 2.—Continued

The Big Lost River (BLR) has been a major source of sediment since late Pliocene time, resulting in a depocenter known as the Big Lost Trough (fig. 1; Geslin and others, 2002). Boreholes drilled in the Big Lost Trough generally encounter greater amounts by volume of interbedded sediment than boreholes drilled in and near the Arco-Big Southern Butte VRZ and AVZ (Anderson and others, 1999, fig. 9, table 2; Hughes and others, 2002; Welhan and others, 2007). Interbedded sediments penetrated by boreholes on the INL range in thickness from equal to or less than 1 ft to equal to or greater than 313 ft and are thickest in the northwestern part of the INL (Anderson and others, 1996; Welhan and others, 2007).

The ESRP aquifer is one of the most productive aquifers in the United States (U.S. Geological Survey, 1985, p. 193). The ESRP aquifer is recharged principally from infiltration of applied irrigation water, infiltration of streamflow, groundwater inflow from adjoining mountain drainage basins, and infiltration of precipitation. Water in the aquifer generally moves from northeast to southwest, and eventually discharges to springs along the Snake River downstream of Twin Falls, Idaho, about 100 mi southwest of the INL. Water moves horizontally through basalt interflow zones and vertically through joints and interfingering edges of interflow zones. Infiltration of surface water, heavy pumpage, geologic conditions, and seasonal fluxes of recharge and discharge locally affect the movement of groundwater (Garabedian, 1986).

At the INL, depth to water in wells completed in the ESRP aquifer ranges from about 200 ft in the northern part of the site to more than 900 ft in its southeastern part (Bartholomay and others, 2020). A substantial proportion of the groundwater moves through the upper 200–800 ft of basaltic rocks (Mann, 1986, p. 21). Ackerman (1991, p. 30), Bartholomay and others (1997, table 3), and Twining and Maimor (2019, table 2) reported a range of transmissivity of basalt in the upper part of the aquifer of 1.1–760,000 ft²/d. The hydraulic gradient at the INL ranges from 2 to 10 ft/mi, with an average of 4 ft/mi (Bartholomay and others, 2020, fig. 9). Horizontal flow velocities of about 2–26 ft/d have been calculated based on the movement of various constituents in different areas of the aquifer at and near the INL (Robertson and others, 1974; Mann and Beasley, 1994; Cecil and others, 2000; Plummer and others, 2000; Busenberg and others, 2001). These flow rates equate to a travel time of 55–700 years for water beneath the INL to travel to springs that discharge at the terminus of the ESRP aquifer. Localized tracer tests at the INL have indicated vertical- and horizontal-transport rates as high as 60–150 ft/d (Nimmo and others, 2002; Duke and others, 2007).

Previous Investigations

Many investigations have evaluated the geology and hydrology of the ESRP aquifer at the INL. A comprehensive listing of publications by the USGS is available at https://www.usgs.gov/centers/id-water/science/publications-idaho-national-laboratory?qt-science_center_objects=0#qt-science_center_objects. Fisher and Twining (2011) documented the use of MLMSs to examine head and temperature for six wells from 2007 to 2008. Additionally, they described the MLMS components and specified the installation process, drilling methods, geology, and geophysical logs for wells USGS 103, USGS 132, USGS 133, USGS 134, MIDDLE 2050A, and MIDDLE 2051. From 2009 to 2010, the MLMS head and temperature monitoring network increased to nine wells (Twining and Fisher, 2012), including construction and monitoring of wells USGS 105, USGS 108, and USGS 135 in addition to the six wells of Fisher and Twining (2011). Twining and Fisher (2012) documented the use of MLMSs to examine head and temperature for these nine wells, revisited methods used to construct head and temperature profiles, summarized data collected from 2009 through 2010, and outlined quality-assurance methods. Twining and Fisher (2015) documented the use of MLMSs to examine head and temperature changes from all 11 MLMS for data collected during 2011–13 and included construction information for wells USGS 131A and USGS 137A in addition to information on the previous nine MLMS wells.

Previous investigations of water chemistry at different depths in the ESRP aquifer at the INL were documented in Peckham (1959), Jones (1961), Olmsted (1962), Mann (1986), Mann and Cecil (1990), Fromm and others (1994), U.S. Department of Energy (2004, 2007, 2008), Bartholomay (2009), Bartholomay and Twining, (2010), Bartholomay (2013), Davis and others (2013), and Bartholomay and others (2013, 2015, 2017). Bartholomay and others (2015) provided a more detailed summary of the water chemistry information presented in all of these reports except for Bartholomay and others (2017). Bartholomay and others (2017) presented water chemistry results from the 11 MLMS wells from 2012 to 2015. A tracer study examining whether drilling fluids could remain in the MLMSs was done by Bartholomay and others (2013) and they found that the tracer moved out of the formation for most of the zones analyzed.

Methods and Quality Assurance

The Westbay™ Multiport (MP) System was selected for multilevel groundwater monitoring at the INL. This system consists of a series of packers, measurement ports, magnetic collars, and variable length sections of casing (fig. 3). The MLMS works to restore the initial pressure and chemical conditions in the well prior to drilling. The MLMS is completely enclosed with a bore plug at the bottom and casing sections, sealed with o-rings, which run the entire length of the well. Each casing joint is leak-proof tested during installation to form a continuous, rigid, sealed system that prevents water from getting in or out. However, if a leak occurs at any joint, hydraulic isolation between the groundwater in the formation and any water inside the casing is maintained because the tubes connect only at the ports (Parker and others, 2006). The modular construction and varying lengths of polyvinyl chloride (PVC) sections allow ports (and, therefore, monitoring intervals) to be placed at almost any desired depth within a hole, provided that the spacing between each interval is great enough to accommodate a sufficient seal.

The methods used to collect depth-discrete measurements of head and temperature were described by Fisher and Twining (2011) and Twining and Fisher (2012) along with methods to calculate pressure probe transducer depths. The methods used for water-sample collection were described in Bartholomay and Twining (2010) and Bartholomay and others (2015). Fisher and Twining (2011) described the modular MLMS components (MP38 compared to MP55), sampling probe, acquisition system, system dimensions, and MLMS installation. All data in this report are available in the U.S. Geological Survey National Water Information System (NWIS) (U.S. Geological Survey, 2020).

Modified from Fisher and Twining, 2011

Figure 3. Components of the Westbay™ Multiport System for multilevel groundwater monitoring.

A general summary and update to the methods for this report are included in the following report sections: (1) “Profiling and Completions,” which describes the methods used to construct head and temperature profiles within a well; (2) “Data Processing,” which describes the customized computer program, “MLMS”; (3) “Sample Collection,” which describes the process for water-sample collection, the analytical methods used for analyses, and some guidelines for interpretation of analytical results; and (4) “Quality Assurance,” which describes the accuracy and precision of head and temperature measurements along with interpretation of reproducibility and bias of the water samples collected.

Profiling and Completions

An individual head or temperature profile represents a set of measurements collected over a relatively short time period. The actual time required for each measurement period varied and was dependent on the quantity and spacing of ports within a MLMS. Profile measurements in this study were completed in less than 2 hours, a period considered nearly instantaneous when contrasted to the slower response times of groundwater systems.

Fluid pressure and temperature measurements were made using a portable sampling probe, a wireline-operated probe that is lowered into the multiport casing from the land surface and positioned at a selected measurement port coupling (fig. 4). The positioned probe was then coupled with the measurement port inlet valve to allow monitoring of groundwater outside the multiport casing and within the monitoring zone, so that groundwater in this zone was vertically isolated between upper and lower packers. Coupling the probe with the measurement port inlet valve was done by extending the backing shoe on the probe to create a hydraulic seal between the probe and the port and to open the port. Fluid pressure and temperature measurements were then transmitted to the land surface through the wireline communication cable, processed using a data acquisition system, and recorded on a datalogger. The head at each measurement port, assuming 100 percent barometric efficiency, was expressed as (Fisher and Twining, 2011):

$$H = \Psi_2 + Z - D = \left(\frac{P_2 - P_{\text{atm}}}{\gamma_w} \right) \times 144 + Z - D, \quad (1)$$

Modified from Fisher and Twining, 2011

Figure 4. Terms used in the calculation of hydraulic head based on the portable probe position when coupled with a measurement port in the multilevel monitoring system.

where

H	is the hydraulic head, in feet;
Ψ_2	is the pressure head outside the multiport casing, in feet;
Z	is the altitude of a referenced land-surface measurement point above the National Geodetic Vertical Datum of 1929 (NVGD 29), in feet;
D	is the depth to the pressure transducer sensor at the measurement port coupling, in feet below land surface;
P_2	is the fluid pressure measured outside the multiport casing in pounds per square inch absolute;
P_{Atm}	is the atmospheric pressure measured at land surface, in pounds per square inch absolute; and
γ_w	is the specific weight of water, in pounds per cubic foot.

Atmospheric pressure was monitored at the land surface using a handheld barometric sensor. The specific weight of water was calculated as a function of temperature only (McCutcheon and others, 1993), assuming negligible salinity and gravitational differences between measurements, and expressed as:

$$\gamma_w = 62.42796 \times \left\{ 1 - \left(\left[\frac{T + 288.9414}{508929.2 \times (T + 68.12963)} \right] \times (T - 3.9863)^2 \right) \right\}, \quad (2)$$

where

γ_w	is in units of pounds per cubic foot, and
T	is water temperature measured inside the multiport casing from the bridge of the pressure transducer in degrees Celsius.

The depth to the pressure transducer sensor at a port coupling was measured once (Fisher and Twining, 2011; Twining and Fisher, 2012, 2015) and calculated as:

$$D = \Psi_1 + L_1 = \left(\frac{P_1 - P_{\text{Atm}}}{\gamma_w} \right) \times 144 + L_1, \quad (3)$$

where

D	is the depth to the pressure transducer, in feet below land surface;
Ψ_1	is the pressure head inside the multiport casing, in feet;
L_1	is the depth to water inside the multiport casing, in feet below land surface; and
P_1	is the fluid pressure measured inside the multiport casing, in pounds per square inch absolute.

The depth to water inside the multiport casing (L_1) was measured using an electronic measuring tape and corrected for borehole deviation (Fisher and Twining, 2011). Simultaneous measurements of P_1 , P_{Atm} , and L_1 were made at each port coupling to account for (1) temporal changes in atmospheric conditions, and (2) depth to water that was dependent on the volume of water displaced by the wireline communication cable.

Multilevel completions included the location of measurement port valves, port couplings, packers, and monitoring zones in the well (where a monitoring zone describes the volumetric space between consecutive packers outside the multiport casing). The location of a multilevel component in a well is based on the measured depth to the pressure transducer at a port coupling (eq. 3) and its position within the MLMS installation log. For example, the length of a monitoring zone is defined as the distance between two consecutive packer seals and calculated by subtracting the depth at the bottom of the upper packer from the depth at the top of the lower packer, or:

$$M_z = (D_{z-1} - a - b - c - d) - (D_z - a - b - c) = D_{z-1} - d - D_z, \quad (4)$$

where

M_z	is the distance between packer seals in monitoring zone z , in feet;
D_z	is the depth to the pressure transducer sensor in the upper port coupling of zone z , in feet below land surface;
D_{z-1}	is the depth to the pressure transducer sensor in the uppermost port coupling of zone $z-1$, the zone located directly beneath zone z , in feet below land surface;
a	is the distance between the pressure transducer sensor and the center of the measurement port inlet valve, in feet, 0.17 feet in both MP systems;
b	is the distance between the center of the measurement port inlet valve and the top of the measurement port coupling, in feet, 0.50 feet in the MP55 system and 0.38 feet in the MP38 system;
c	is the distance between the uppermost measurement port coupling and the bottom of the adjacent packer, in feet, 0.60 feet in both MP systems; and
d	is the length of the inflated packer seal, in feet, 3.00 feet in both MP systems.

Parameters a , b , c , and d were defined using nominal component lengths specified in the MLMS installation log (fig. 4); however, actual parameter lengths may vary because of component deformation in the multiport casing and γ_w port couplings that results from mechanical stretch and thermal expansion during MLMS installation. However, de-stressing

during packer inflation was used to reduce the total strain on the system. Measurement errors associated with component deformation were assumed to be negligible because nominal component lengths were relatively small when compared to the measured depth to a pressure transducer (D).

Standard procedures for collecting profile measurements were first described in Fisher and Twining (2011). The steps are summarized as follows: (1) The sampling probe is lowered to the deepest measurement port in the MLMS; (2) the probe is coupled with the monitoring port to continuously monitor fluid pressure and temperature; (3) measurements of fluid pressure, atmospheric pressure, and water temperature are recorded on a field sheet after temperature readings stabilize with fluctuations of less than 0.1 °C (generally in 30 minutes or less); and (4) after fluid pressure and temperature measurements are recorded, the probe is decoupled from the port and raised to the next highest measurement port. The process is repeated until all ports are measured and final measurements are recorded.

Measurements of hydraulic head are presented in feet above the National Geodetic Vertical Datum of 1929 (NGVD 29) as the reference datum. At the time of this report, the USGS was updating historical vertical datums from NGVD 29 to the current North American Vertical Datum of 1988 (NAVD 88); however, not all MLMS wells had current vertical datums. Furthermore, to keep measurements of hydraulic head consistent with previous reports, the authors determined that using NGVD 29 as the common datum would be the most appropriate course of action. Updates to the latitude and longitude were made to reflect the North American Datum of 1983 (NAD 83); see [table 1](#).

Data Processing

Statistical and graphical analysis of head and temperature data was completed using a customized computer program, “MLMS” (R Development Core Team, 2014). The computer program was used to process field data collected from all 11 MLMS wells to streamline and make data analysis consistent. The program “MLMS” also was used to examine quality-assurance data for head and temperature measurements.

The software program “MLMS” consists of a series of processing functions that include `mlms.export.R`, `mlms.import.R`, `mlms.plotParedPort.R`, `mlms.plotProfile.R`, and `mlms.process.R`. In addition, the software program “MLMS” requires a separate file (`Completions.mps`) that contains well information for graphing and analysis. This file (`Completions.mps`) includes borehole identifier, units of measure, borehole location (latitude, longitude, and land-surface altitude), casing length, measurement point, borehole drilled depth, completion depth, drilled date, installation date, number of zones, zone number, zone top, zone bottom, measurement port number, and port depth.

Field measurements were collected electronically and recorded on paper forms using a standardized field sheet (Bartholomay and others, 2014, fig. 10). The electronically stored measurements for each well were copied to text file templates and processed using the customized software program “MLMS.”

Sample Collection

Sample collection by the USGS at the INL generally followed guidelines established by the USGS that are documented in the USGS National Field Manual (U.S. Geological Survey, variously dated) and Bartholomay and others (2014). Water samples were collected from 11 wells each equipped with a dedicated MLMS. A list of sample port depths from sampling zones from the aquifer are shown in [table 2](#), at back of report.

Samples were collected using precleaned, stainless-steel thief sampling bottles that were lowered to the zone to be sampled, connected to the sampling port, and filled with formation water. The stainless-steel bottles were then raised to the surface and emptied into a precleaned container; the water was then processed to fill appropriate bottles for analyses. Field measurements also were taken from the precleaned container for pH, specific conductance, water temperature, and dissolved oxygen ([table 3](#), at back of report). The field measurements were consistent with other measurements taken at the INL with pH ranging from 7.5 to 8.2 pH units; specific conductance ranging from 276 to 428 microsiemens per centimeter at 25 degrees Celsius (°C); water temperature ranging from 10.9 to 16.4 °C, and dissolved oxygen concentration ranging from 6.34 to 11.0 mg/L ([table 3](#), at back of report). Sample bottles were cleaned between uses in each sample zone by washing them in a Liquinox® solution and rinsing them with deionized water.

Field processing of samples differed depending on the constituents for which analyses were requested. Samples analyzed by the USGS National Water Quality Laboratory (NWQL) were placed in containers and preserved in accordance with laboratory requirements specified by Timme (1995) and Bartholomay and others (2014, appendix A). Containers and preservatives used for this study were supplied by the NWQL and had undergone a rigorous quality-control procedure (Pritt, 1989, p. 75) to minimize sample contamination. Water samples requiring filtration were filtered through a disposable 0.45-μm filter cartridge that had been pre-rinsed with at least 1 L of deionized water. Constituent concentrations obtained from analysis of the 0.45-μm filtrate are referred to as “dissolved” concentrations in this report. Samples analyzed by the Radiological and Environmental Sciences Laboratory (RESL) at the INL were placed in containers and preserved in accordance with laboratory requirements specified by Bodnar and Percival (1982) and Bartholomay and others (2014, appendix A).

Analytical methods used by the USGS NWQL for selected organic, inorganic, and radionuclide constituents are described by Goerlitz and Brown (1972), Thatcher and others (1977), Wershaw and others (1987), Fishman and Friedman (1989), Faires (1993), Fishman (1993), Rose and Schroeder (1995), and McCurdy and others (2008). A discussion of procedures used by the DOE RESL for the analysis of radionuclides in water is provided by Bodnar and Percival (1982), Sill and Sill (1994), and U.S. Department of Energy (1995).

Concentrations of radionuclides are reported with an estimated sample standard deviation, s , which is obtained by propagating sources of analytical uncertainty in measurements. McCurdy and others (2008) provided details on interpreting radiological data used by the USGS. The guidelines for interpreting analytical results are based on an extension of a method proposed by Currie (1984) and discussed in Bartholomay and others (2017). In this report, radionuclide concentrations less than $3s$ are considered to be less than a “reporting level.” The reporting level should not be confused with the analytical method detection limit, which is based on laboratory procedures.

Concentrations of inorganic and organic constituents are reported with reference to long term method detection levels, laboratory reporting levels, interim reporting levels or with reference to minimum reporting levels. A description of the various criteria used to report inorganic and organic constituents is found in Bartholomay and others (2017, p. 28).

Statistical methods used to produce trend graphs follow methods described in Davis and others (2015).

Quality Assurance and Quality Control

The accuracy and precision of MLMS head measurements within the ESRP aquifer were first quantified using methods documented in Fisher and Twining (2011) by accounting for the cumulative error of five variables in the hydraulic head equation (eq. 1). In summary, the cumulative error for all five variables for independent head readings is ± 2.3 ft; a value determined by summing measurement accuracies for fluid pressure head (± 1.15 ft), atmospheric pressure head (± 0.01 ft), land-surface altitude (± 0.01 ft), and pressure transducer sensor depth (± 1.17 ft) (Fisher and Twining, 2011). Many of the sources of measurement error are minimized when considering the differences between two closely spaced readings of head, where head values are monitored using the same pressure probe, at similar depths, and at similar water densities. Under these conditions, vertical head differences have much less error than the error associated with any single head measurement because some sources of error subtract and are equal to or nearly equal for adjacent port readings. Therefore, a ± 0.1 -ft measurement accuracy was assumed for vertical head differences (and gradients) calculated between adjacent monitoring zones (Fisher and Twining, 2011).

Calibration of the fluid pressure sensor was done by the probe manufacturer. Calibration corrections were not applied to fluid pressure measurements because of the relatively high specified accuracy of the reference pressure sensor at ± 0.100 lb/in² (or ± 0.23 ft at 13 °C), which is the average ambient temperature in these wells (Fisher and Twining, 2011). Discussion and results from previous calibration testing are available in Twining and Fisher (2015).

Measurement precision was examined for 9 of 11 MLMSs by comparing head values between paired-ports, with two measurement ports located in the same monitoring zone (figs. 4 and 5). The method describing this technique was first noted in Fisher and Twining (2011). Theoretically, the distribution of head within a monitoring zone should be uniform; therefore, any substantial head difference between paired-port measurements may indicate a malfunctioning measurement port, a well construction anomaly, or groundwater density variations because of differences in total dissolved solids. For 34 of 40 monitoring zones, paired-port mean head differences were small (<0.10 ft) for head measurements taken from 2014 to 2018 (fig. 5; appendix 1). Five MLMS zones had paired-port mean head differences that exceeded ± 0.2 ft: (1) USGS 103 (zone 9) head measurements ranged from 0.30 to 0.44 ft; (2) USGS 108 (zone 4) head measurements ranged from -0.01 to 0.67 ft; (3) USGS 108 (zone 11) head measurements ranged from 0.90 to 1.04 ft; (4) USGS 131A (zone 12) head measurements ranged from 1.83 to 2.44 ft; and (5) USGS 134 (zone 15) head measurements ranged from 0.42 to 0.79 ft (appendix 1).

Paired-point data from USGS 108 (zones 4 and 11) represent data from the only two zones inconsistent with previous analyses (Twining and Fisher 2012, 2015). USGS 108 (zone 4) has a suspected erroneous measurement taken on June 24, 2014; whereas the remainder of the measurements taken from 2015 to 2018 show minor paired-port head difference (<0.1 ft). Compared to previous investigations, the paired-port data range for USGS 108 (zone 11) was markedly higher. However, USGS 108 (zone 11) falls within a cased section of the borehole that shows slotted perforations (Twining and Fisher, 2012). The paired-port head difference, reported for zone 11 in USGS 108, suggests that the perforated section is becoming partially plugged or that potential debris surrounds port 16 (table 2, at back of report).

Quality-assurance (QA) protocol applied to water samples were first described by Bartholomay and Twining (2010). The overall QA and detailed descriptions of internal quality-control (QC) practices used by the NWQL are provided by Friedman and Erdmann (1982), Jones (1987), and Pritt and Raese (1995). The overall QA and detailed descriptions of internal QC practices used by the RESL are provided in Bodnar and Percival (1982) and U.S. Department of Energy (1995). Water samples were collected in accordance with a QA plan for quality-of-water activities conducted by personnel assigned to the USGS INL project office (Bartholomay and others, 2014). Additional QA was assessed with QC replicates and blanks. Nine QC replicate samples were collected

Figure 5. Hydraulic head differences between paired-ports and measurement ports in the same monitoring zone in wells U.S. Geological Survey (USGS) 103, USGS 105, USGS 108, USGS 131A, USGS 132, USGS 133, USGS 134, USGS 135, and USGS 137A, Idaho National Laboratory, Idaho, 2014–18.

during 2014–18; three field blanks were collected at wells MIDDLE 2050A and USGS 137A and consisted of distilled water from the USGS Idaho Falls Field Office. Two equipment blanks were collected at wells USGS 133 and MIDDLE 2051. Concentrations of major ions, nutrients, and chromium in blank samples were near or less than the reporting levels, suggesting no background contamination from field equipment or source water, except for one sample from USGS 137A for nutrient data. QAW-54 contained concentrations of nitrite plus nitrate and orthophosphate as phosphorus that seem to represent actual sample water from well USGS 137A; it is uncertain if the results were caused by field error or laboratory error.

If the uncertainty of the result is not readily available, which is often the case for most of the inorganic and organic constituents, the relative percent difference (RPD) can be used to compare equivalency of replicate pairs. The RPD is calculated based on the formula:

$$RPD = ((ABS(X1-X2))/((X1+X2)/2)) \times 100, \quad (5)$$

where

RPD is the relative percent difference,
ABS is the absolute value,
X1 is the result for the primary environmental sample, and
X2 is the result for the field-replicate sample.

Figure 5.—Continued

A typical data-quality objective for field-replicate samples is a maximum RPD of 20 percent (Taylor, 1987). RPDs were less than 20 percent using equation 6 for 58 out of the 58 samples (100 percent) and can be considered statistically equivalent using this statistical test. Results of replicate samples generally indicated that the sample collection and laboratory procedures used were appropriate for the data obtained.

The statistical equivalency of radiochemical-constituent concentrations in sample replicate pairs was determined following a method defined by Volk (1969) and described in more detail by Williams (1996). In this method, statistical equivalence is determined within a specified confidence level. A value for the standard deviate, Z, is calculated, and then the level of significance of the result is evaluated (evaluation of the level of significance assumes that the sample population is distributed normally). For this report, concentrations of individual constituents in sample pairs (constituent pairs) were considered to be equivalent when the results were within

two standard deviations of each other. At this confidence level (95-percent), the level of significance, determined from a standard normal probability curve, was 0.05 for a two-tailed test, and it corresponded to a Z-value of 1.96.

The equation used to determine Z was adapted from Volk (1969)

$$Z = \frac{|x - y|}{\sqrt{(S_x)^2 + (S_y)^2}}, \tag{6}$$

where

- x is the concentration of a constituent in the routine sample,
- y is the concentration of the same constituent in the sequential replicate sample,
- S_x is the standard deviation of x, and
- S_y is the standard deviation of y.

When the population is not distributed normally, which is often the case with radiochemical results (L. DeWayne Cecil, U.S. Geological Survey, written commun., January 4, 2009), or an approximation of the standard deviation is used, a Z-value less than 1.96 must be considered as a guide when testing for equivalence. Constituent concentrations in sample pairs were considered to be statistically equivalent when the calculated Z-value was less than or equal to 1.96.

The use of [equation 5](#), therefore, is considered to be a guide in determining if the results of radionuclide analyses of a replicate pair of samples were equivalent. The results and reported standard deviations for the analyses of replicate pairs and the Z-values are provided in the concentration tables that are given later in this report. Z-values were less than 1.96 for 21 of the 24 replicate pairs (88 percent) and can be considered statistically equivalent. One replicate pair for gross alpha (QAW-44), and two replicate pairs for gross beta (QAW-44 and QAW-45) were not considered equivalent with this statistical test.

Hydraulic Head and Temperature Measurements

Head and temperature measurements were reported for the 11 MLMS wells for 2014–18 ([fig. 1](#), [table 1](#)). Head and temperature measurements were recorded in 137 hydraulically isolated monitoring zones located 448.0–1,377.6 ft below land surface (bls) ([table 2](#), at back of report). Detailed descriptions of geophysical logs, lithology logs, and completion logs for MLMS wells (USGS 103, USGS 105, USGS 108, USGS 131A, USGS 132, USGS 133, USGS 134, USGS 135, USGS 137A, MIDDLE 2050A, and MIDDLE 2051) are provided by Fisher and Twining (2011), Twining and Fisher (2012), and Twining and Fisher (2015).

MLMS Measurements

During the 2014–18 multilevel monitoring period, 105 profiles were collected and analyzed; these profiles represent individual annual and quarterly measurements of head and temperature from 11 MLMS wells ([fig. 6](#); [appendix 2](#)). The MLMS profile schedule varied as follows: (1) Annual measurements were taken for MLMS wells USGS 103, USGS 105, USGS 108, USGS 132, USGS 133, USGS 134, and USGS 135; (2) quarterly measurements were taken for MLMS well USGS 131A during 2014 and into the third quarter of 2015 (September 2015), switching to annual measurements starting in 2016; and (3) quarterly measurements were taken for MLMS wells USGS 137A, MIDDLE 2050A, and MIDDLE 2051. Changes to the MLMS measurement schedule were based on profile consistency reported in Fisher and Twining (2011), Twining and Fisher (2012, 2015), and program changes.

Throughout the five-year monitoring period, the hydraulic head at all MLMS wells ranged from 4,415.5 to 4,462.6 ft at wells USGS 135 and USGS 133, respectively ([fig. 1](#); [appendix 2](#)). The lowest head values were measured in the farthest downgradient wells USGS 103, USGS 105, USGS 108, USGS 132, USGS 135, and USGS 137A (near the southern boundary); the highest head values were in the farthest upgradient wells USGS 133 and USGS 134 ([fig. 1](#)). Water temperature ranged from 10.4 to 16.8 °C at wells MIDDLE 2051 and MIDDLE 2050A, respectively ([fig. 6](#); [appendix 2](#)), which is within the reported range for temperatures measured in the ESRP aquifer at or near the INL—9.0–19.1 °C (Davis and others, 2013).

To quantify temporal variability in MLMS head and temperature between profile periods from 2014 to 2018, a Pearson correlation coefficient (PCC) was computed for each profile; methods used to compute PCCs are described in Fisher and Twining (2011). Computed PCCs ranged from –1 to 1; however, the closer the PCC is to either –1 or 1, the stronger the correlation. To evaluate the correlation among all head or temperature profiles in a well requires the calculation of PCC for all permutations of profiles taken two at a time for each port, and the minimum of these values reflects the poorest correlation between profiles in a well. During the examination of individual head measurements and computation of PCC, seven suspected erroneous head measurements were identified and noted in the comment field in [table 4](#) and are shown in [figure 7](#). Erroneous measurements can occur if there is an inadequate face seal between the measurement probe and measurement port or if the port is blocked, resulting in an artificially lower PCC. Attempts were made to identify erroneous measurements; however, the suspected erroneous data were not removed from the PCC computation.

Profile data, plotted as individual measurements, reflect variability in head and temperature for all 11 MLMS wells ([fig. 6](#)). Profile data variability for individual MLMS measurements collected from 2014 to 2018 reflected variability similar to that of profile data collected during previous investigations (Fisher and Twining [2011], Twining and Fisher [2012, 2015]). Head and temperature data suggest that the general shape and variability reported for each MLMS profile have remained consistent year after year; however, some seasonal variability was measured in wells near the BLR. The BLR surface water was present in 2 of 5 years (2017–18) for data considered as part of this investigation ([fig. 8](#)). Increased head was measured in discrete zones representing the top 100 ft of the aquifer starting in May 2017 in USGS wells MIDDLE 2050A and MIDDLE 2051 and was reflected in lowered PCC estimates as compared to years previously reported ([table 4](#)). For example, PCC estimates for hydraulic head reported for 2011–13 (Twining and Fisher, 2015) in MLMS wells MIDDLE 2050A and MIDDLE 2051 were 0.95 and 0.98 respectively. As expected, surface water from the BLR contributes to recharging the ESRP aquifer and MLMS well data suggest some localized mounding of water in wells near the BLR.

Figure 6. Hydraulic head differences between paired-ports and measurement ports in the same monitoring zone in wells U.S. Geological Survey (USGS) 103, USGS 105, USGS 108, USGS 131A, USGS 132, USGS 133, USGS 134, USGS 135, USGS 137A, MIDDLE 2050A, and MIDDLE 2051, Idaho National Laboratory, Idaho, 2014–18.

Figure 6.—Continued

Figure 6.—Continued

Figure 6.—Continued

Table 4. Minimum Pearson correlation coefficients for hydraulic head and temperature profiles at selected wells, Idaho National Laboratory, Idaho, 2014–18.

[**Local name:** Local well identifier used in this study and shown in [fig. 1](#). USGS, U.S. Geological Survey. **Suspected erroneous data:** Identified in [fig. 7](#); measurements represent abnormal pressure readings that do not seem to reflect ambient pressure]

Local name	Minimum Pearson correlation coefficient		Suspected erroneous data
	Hydraulic head	Temperature	
USGS 103	−0.13	0.92	None
USGS 105	0.97	0.99	None
USGS 108	0.73	0.86	Head data taken on 06-24-14 (port 5)
USGS 131A	0.90	1.00	None
USGS 132	0.21	0.97	Head data taken on 06-20-18 (port 4)
USGS 133	1.00	0.99	None
USGS 134	0.56	0.99	None
USGS 135	0.99	0.85	None
USGS 137A	−0.86	0.17	None
MIDDLE 2050A	0.68	0.99	Head data taken on 12-21-15 and 12-01-16 (port 13), and 12-18-18 (port 11)
MIDDLE 2051	0.91	0.99	Head data taken on 09-24-14 (port 3) and 03-17-15 (port 8)

Minimum PCC values for head profiles ranged from −0.86 at well USGS 137A to 1.00 at well USGS 133 ([table 4](#)). In four wells (USGS 103, USGS 108, USGS 132, and USGS 137A), the minimum PCC was less than 0.90 and is attributed to small vertical head differences and a relative uncertainty for head differences between adjacent zones of ± 0.1 ft. Under these circumstances, measurement error can produce a lower PCC even though a strong correlation exists (Twining and Fisher, 2015). MLMS well USGS 134 showed a minimum PCC of 0.56, partly because of the head difference variation between ports in monitoring zones 14 and 15 and supported pressure response changes related to mountain front recharge events, as previously described in Fisher and Twining (2011), Twining and Fisher (2012), and Twining and Fisher (2015). MLMS well MIDDLE 2050A had a minimum PCC value of 0.68, partly because of head difference related to seasonal variability between ports in upper monitoring zones (12–15), in addition to suspected erroneous readings ([table 4](#), [fig. 7](#)). All other minimum PCC values were greater than or equal to 0.90 and suggest a strong positive correlation among head profiles.

Minimum PCC values for the temperature profiles ranged from 0.17 in MLMS well USGS 137A to 1.00 in MLMS well USGS 131A ([table 4](#)). The computed PCCs for most temperature profiles equaled or exceeded 0.92 and suggest a strong positive correlation among temperature profiles. However, three MLMS wells (USGS 108, USGS 135, and USGS 137A) had computed PCCs of less than 0.90 ([table 4](#)). The PCC computed for MLMS well USGS 108 suggests that the measured aquifer temperature was not allowed to fully equilibrate during certain profile periods, most visible during 2016, producing a lower PCC ([fig. 6](#)). For MLMS wells USGS 135 and USGS

137A, the temperature range was about 0.2 and 0.3 °C, respectively. Under these circumstances a slight measurement error can produce a low PCC where a strong correlation exists.

Well Profile Comparisons

The methods used to describe the shape of individual head and temperature profiles along with major head inflections were first examined in Fisher and Twining (2011). Review of the MLMS data from 2014 to 2018 suggest that the general shape of individual head and temperature profiles has remained consistent between measurement events. This report does not present major head inflection data, where the general profile shape of MLMS head and temperature data remained mostly consistent from year to year; however, this report does consider measured ranges in data collected as part of this investigation and the last 10 years of normalized hydraulic head measurements and regional effects to the ESRP groundwater system.

The range in head and temperature data was examined between MLMS wells to better understand groundwater flow below the INL for aquifer intervals that ranged from 234 to 913 ft ([table 5](#)). Head for a single profile event, considering all MLMS wells in this study, ranged from 0.1 to 16.3 ft for MLMS wells USGS 137A and MIDDLE 2051, respectively; temperature for all MLMS wells ranged from 0.9 to 5.9 °C for MLMS wells USGS 135 and MIDDLE 2050A, respectively ([table 5](#); [appendix 2](#)). Previously reported head ranged from 0.1 to 9.8 ft for MLMS wells USGS 137A and MIDDLE 2051, respectively; previously reported temperature ranged from 0.2 to 5.3 °C for MLMS wells USGS 135 and MIDDLE 2050A, respectively (Twining and Fisher, 2012).

Figure 7. Individual hydraulic head measurements and suspected erroneous data taken at wells U.S. Geological Survey (USGS) 103, USGS 105, USGS 108, USGS 131A, USGS 132, USGS 133, USGS 134, USGS 135, USGS 137A, MIDDLE 2050A, and MIDDLE 2051, Idaho National Laboratory, Idaho, 2014–18.

Figure 7.—Continued

Figure 8. Big Lost River surface water flow measured at U.S. Geological Survey (USGS) streamgage 13132535, Big Lost River at Lincoln Boulevard Bridge, near Atomic City, Idaho National Laboratory, Idaho, January 2014–December 2018.

The temporal correlation among MLMSs was analyzed for new head data collected from 2014 to 2018, but also includes those previously reported going back to 2007 (Fisher and Twining 2011; Twining and Fisher, 2012, 2015), using the normalized mean head, $\hat{H}$; these values of head were calculated for each MLMS and are expressed as follows (Fisher and Twining, 2011):

$$\hat{H}_t = \frac{H_t - \bar{H}}{s} \quad \text{for } t = 1, \dots, n; \quad (7)$$

where

$\bar{H}_t$ is the profile mean head for measurement event t , in feet, and defined as

$$\bar{H}_t = \frac{1}{n} \sum_{i=1}^n H_i; \quad (8)$$

where

n is the total number of port head measurements in the MLMS borehole;
 H_i is the head measurement at port i , in feet; and
 $\bar{H}$ is the mean of the profiles mean head values for all measurement events, in feet, and defined as

$$\bar{H} = \frac{1}{n} \sum_{i=1}^n \bar{H}_i; \quad (9)$$

and

s is the standard deviation of the profile mean head values for all measurement events, in feet, and defined as

$$s = \sqrt{\frac{1}{n} \sum_{i=1}^n (\bar{H}_i - \bar{H})^2}. \quad (10)$$

Table 5. Summary of depth range, hydraulic head statistics, fluid temperature statistics, average water-level depth, and saturated thickness of the aquifer at each borehole, Idaho National Laboratory, Idaho, 2014–18.

[**Local name:** Local well identifier used in this study. USGS, U.S. Geological Survey. **Depth range:** Measured from the top of the uppermost monitoring zone to the bottom of the lowest zone in feet. **Hydraulic head statistics:** Include the mean, minimum and maximum in feet above National Geodetic Vertical Datum of 1929 (NGVD 29) in feet from values presented in appendix 3. Standard deviation (SD) represents the amount of variation in values presented in appendix 3 and shown in ft. **Fluid temperature statistics:** Include: the mean, minimum, maximum, and SD, and are computed from the values presented in appendix 3 and indicated in degrees Celsius (°C). **Water-level depth:** Reported in feet below land surface (ft bls) and refers to (land surface altitude, in ft) – (mean hydraulic head, in ft), as reported in table 1. **Saturated aquifer thickness:** Taken from Twining and Fisher, 2015]

Local name	Depth range (feet)	Hydraulic head statistics				Fluid temperature statistics				Water-level depth (ft bls)	Saturated aquifer thickness (feet)
		Mean (feet)	Minimum (feet)	Maximum (feet)	SD (feet)	Mean (°C)	Minimum (°C)	Maximum (°C)	SD (°C)		
USGS 103	610	4,419.4	4,418.2	4,421.9	1.2	12.7	12.3	13.7	2.6	591.42	1,950
USGS 105	583	4,419.0	4,417.4	4,421.6	1.3	12.9	12.2	13.6	0.4	679.58	1,950
USGS 108	550	4,419.3	4,417.7	4,421.7	1.2	12.6	12.1	13.2	0.3	615.49	1,950
USGS 131A	627	4,429.4	4,427.7	4,434.2	1.3	12.7	11.1	13.9	0.8	550.21	1,950
USGS 132	590	4,419.5	4,418.0	4,426.0	1.7	12.2	10.7	13.2	0.7	612.58	1,880
USGS 133	318	4,458.6	4,454.3	4,462.6	2.9	11.7	10.9	12.7	0.5	435.02	500
USGS 134	333	4,451.8	4,450.8	4,453.6	0.8	13.9	12.6	15.5	0.8	520.58	500
USGS 135	410	4,416.9	4,415.5	4,420.0	1.2	11.7	11.3	12.2	0.3	722.48	1,870
USGS 137A	234	4,425.7	4,424.1	4,427.8	0.9	12.8	12.3	13.3	0.3	631.58	1,845
MIDDLE 2050A	913	4,444.7	4,442.7	4,446.6	0.8	13.4	10.9	16.8	1.8	487.01	660
MIDDLE 2051	615	4,428.1	4,424.1	4,440.4	3.0	13.6	10.4	15.5	1.5	572.70	1,160

The values of $\hat{H}$ for each of the 11 MLMS wells (fig. 9; appendix 3) suggest a moderate positive correlation among all MLMS wells, which reflects regional fluctuations in water levels in response to seasonality and location. For example, flow in the BLR that occurred during 2017 and 2018 (fig. 8) correlates to increased normalized mean total head for all MLMS wells (fig. 9).

Normalized mean head was examined for all 11 MLMS wells by location. Graphs of normalized mean total head include five MLMS wells that are located within the Big Lost Trough and six MLMS wells that are located within the AVZ and Arco-Big Southern Butte VRZ (figs. 1 and 9). Normalized mean head temporal correlations are stronger when the borehole locations are considered. For example, MLMS wells within the AVZ and Arco-Big Southern Butte VRZ (USGS 103, USGS 105, USGS 108, USGS 132, USGS 135, and USGS 137A, fig. 1) are completed in an area of highly permeable media and relatively large saturated thickness and show a positive temporal correlation (fig. 9A). Temporal correlation between MLMS wells completed in the Big Lost Trough generally is positive (fig. 9B). Subtle differences in temporal correlation can be attributed to frequency of measurements but also recharge from snowmelt or surface water flow in the BLR, or both (figs. 1, 8, and 9).

Groundwater temperature profiles for MLMS wells located along AVZ and Arco-Big Southern Butte VRZ (USGS 103, USGS 105, USGS 108, USGS 132, USGS 135, USGS 137A) mostly are dominated by convective heat transfer (fig. 1). Except for borehole USGS 132, MLMS temperature data vary between 0.9 to 1.4 °C, suggesting a narrow temperature range over several hundred feet (table 5). As previously reported, interconnected fractures over several hundred feet of aquifer result in the vertical movement of groundwater as the aquifer thickens and as transmissivity increases along the southern boundary of the INL (Twining and Fisher, 2015).

Groundwater temperature profiles for MLMS wells located within the Big Lost Trough (USGS 131A, USGS 133, USGS 134, MIDDLE 2050A, MIDDLE 2051) mostly were dominated by conductive heat transfer and MLMS temperature data vary within a broader range (1.8–5.9°C) compared to southern boundary MLMS wells (table 5). MLMS wells located within the Big Lost Trough generally were completed within a section of the ESRP aquifer that contain high percentages of fine-grained sediment (Twining and Fisher, 2015). Temperature trends in MLMS wells for 2014–18 were similar to those reported in Fisher and Twining (2011), Twining and Fisher (2012), and Twining and Fisher (2015), and suggest that groundwater temperature vertical profiles have remained stable.

Figure 9. Quarterly values of the normalized mean hydraulic head at MLMS wells in (A) the Axial Volcanic Zone and Arco-Big Southern Butte Volcanic Rift Zone (wells U.S. Geological Survey [USGS] 103, USGS 105, USGS 108, USGS 131A, and USGS 132), and (B) the Big Lost Trough (wells USGS 133, USGS 134, USGS 135, USGS 137A, MIDDLE 2050A, and MIDDLE 2051), Idaho National Laboratory, Idaho, 2007–18.

Chemical Constituents in the Eastern Snake River Plain Aquifer

Water samples were analyzed for concentrations of chloride, chromium, sodium, sulfate, and nutrients by the NWQL from 22 select zones in 11 MLMS wells (tables 6 and 7, at back of report). Concentrations of gross alpha, gross beta, tritium, and cesium-137 were analyzed by the RESL (table 8, at back of report). Well MIDDLE 2051 (port 1) was sampled for a suite of water chemistry constituents in 2016 to determine whether the chemistry of water in the aquifer was changing (table 9, at back of report). Additionally, because of unexpected findings of tetrachloroethene from VOC sampling of well MIDDLE 2051 by the INL contractor Fluor (Forbes and Lawrence, 2018), the USGS collected additional samples from 15 zones from three MLMS wells (USGS 132, USGS 137A, and MIDDLE 2051) in 2016 and 2017, along with collecting VOC concentrations from tubing fluid from four MLMS wells (table 10, at back of report).

Chloride

Chloride has been discharged in wastewater at several facilities in the western part of the INL since 1952 and is still being discharged near the INTEC, ATR Complex, and NRF in infiltration ponds and ditches (fig. 1). The background chloride concentration in the water in the western part of the ESRP aquifer at the INL is about 12 mg/L (Bartholomay and Hall, 2016). For comparison to health criteria, the secondary maximum contaminant level (MCL) for drinking water is 250 mg/L (U.S. Environmental Protection Agency, 2019a). During 2014–18, concentrations of chloride for selected zones in all MLMS wells ranged from 4.2 mg/L in well MIDDLE 2050A (port 15) to 26.4 mg/L in well USGS 131A (port 10) (table 6, at back of report).

Chloride concentrations from water-quality samples collected from selected ports in well USGS 103 (ports 1, 3, 7, and 11) ranged from the background concentration of about 12.0 mg/L in port 11 to 14.6 mg/L in ports 1 and 7 and concentrations remain mostly consistent within discrete zones (table 6, at back of report). Chloride concentrations for well USGS 105 (ports 6, 10, and 14) showed similar concentrations with depth, ranging from 11.7 to 12.8 mg/L (table 6, at back of report). Chloride concentrations for well USGS 108 (ports 1 and 12) have remained consistent for the period of sample record, with discrete zones having concentrations greater than the background concentration ranging from 16.1 (port 12) to 17.2 mg/L (port 1) (table 6, at back of report). Chloride concentrations for well USGS 131A (ports 3, 6, 10,

and 15) ranged from 13.0 (port 6) to 26.4 mg/L (port 10), and chloride concentrations were much more elevated (by about 10 mg/L) at port 10 when compared to other ports in well USGS 131A (table 6, at back of report). Chloride concentrations in well USGS 132 (port 18) have remained mostly consistent, with concentrations less than background levels, but one sample collected during 2018 was slightly greater than background at 12.3 mg/L (table 6, at back of report). Wells USGS 133 (port 12), USGS 134 (port 19) and USGS 135 (port 9) had consistent chloride concentrations that were less than background levels, ranging from 6.7 to 11.9 mg/L (table 6, at back of report). Chloride concentrations for well USGS 137A ranged from 11.1 to 14.2 mg/L and decreased with increasing aquifer depth at this location (Bartholomay and others, 2015). Chloride concentrations in well USGS 137A were near the background concentration in the deeper ports (port 1, 3, and 5), and were slightly greater than the background concentration in the port near the top of the aquifer (port 7) (table 6, at back of report). Chloride concentrations in well MIDDLE 2050A (port 15) were variable, ranging from 4.2 to 12.5 mg/L, and showed a statistically significant decreasing trend (fig. 10). Concentrations decreased substantially during years 2006, 2012, 2017, and 2018 (fig. 10), which suggests that chloride concentrations may be diluted during years in which flow occurred in the BLR (Bartholomay and others, 2020, fig. 8). Well MIDDLE 2051 (ports 1, 3, 6, and 9) had consistent chloride concentrations, ranging from 10.5 to 11.7 mg/L (table 6, at back of report). Wells MIDDLE 2050A and MIDDLE 2051 are both adjacent to the BLR (fig. 1), but well MIDDLE 2050A only has samples from near the top of the aquifer and samples from well MIDDLE 2051 are only from ports deeper in the aquifer (table 6, at back of report). Based on the chloride data, surface water recharges mainly the upper unit of the aquifer and does not seem to affect deeper zones to the same extent.

Chromium

Chromium has been discharged in wastewater primarily at the ATR Complex in the past and was also discharged to the disposal well at the ATR Complex. Minor amounts of chromium also were discharged at the INTEC and the Power Burst Facility. The background chromium concentration in water in the western part of the ESRP aquifer at the INL is about 3 µg/L (Bartholomay and Hall, 2016). For comparison to health criteria, the MCL for drinking water is 100 µg/L (U.S. Environmental Protection Agency, 2019b). Concentrations of chromium for selected zones in all MLMS wells ranged from 0.86 µg/L in well MIDDLE 2050A (port 15) to 10.9 µg/L in well USGS 131A (port 10) (table 6, at back of report).

Figure 10. Survival regression model graphs showing (A) chloride, (B) nitrate, (C) sodium, (D) sulfate, and (E) chromium measured in water samples collected from well MIDDLE 2050A (Site No. 433409112570515), Idaho National Laboratory, Idaho, 2005–18.

Figure 10.—Continued

Chromium concentrations in several of the MLMS wells (USGS 103, 105, 108, 131A, 132, 133, 134, 137A, MIDDLE 2050A, and MIDDLE 2051) are greater than background levels and have remained mostly consistent through time (table 6, at back of report). Chromium concentrations for well USGS 133 have increased from 6.35 µg/L in 2014 to 8.91 µg/L in 2018 (table 6, at back of report). This well is downgradient from the NRF, where some wastewater disposal has affected chromium concentrations in the aquifer, so the increasing concentrations may be from the movement of water from the NRF area. Well USGS 135 has had consistent concentrations less than background levels for the ESRP aquifer. Well MIDDLE 2050A had lower concentrations during 2006, 2012, 2017, and 2018 than during the other sample years that are attributed to surface water recharge from the BLR (figs. 8 and 10).

Sodium

Sodium has been discharged in wastewater at several facilities in the western part of the INL since 1952 and is still being discharged near the INTEC, ATR Complex, and NRF into infiltration ponds and ditches. The background sodium

concentration in groundwater in the western part of the ESRP aquifer at the INL is about 8 mg/L (Bartholomay and Hall, 2016). Concentrations of sodium for selected zones in all MLMS wells ranged from 6.1 mg/L in well USGS 135 (port 9) to 12.9 mg/L in well USGS 132 (port 18) (table 6, at back of report).

Sodium concentrations in well USGS 103 (ports 1, 3, 7, and 11) also have remained consistent for the period of sample record, with all concentrations near background levels for the ESRP aquifer (table 6, at back of report). Sodium concentrations in well USGS 105 (ports 6, 10, and 14) have remained consistent for the period of sample record, with all three zones having concentrations greater than background levels. Sodium concentrations in well USGS 108 (ports 1 and 12) have remained consistent for the period of sample record with both zones having concentrations near background levels. Sodium concentrations in well USGS 131A (ports 3, 6, 10, and 15) have increased slightly in the past four years and ranged from 7.4 mg/L in port 15 to 9.9 mg/L in port 10 (table 6, at back of report). Sodium concentrations in well USGS 132 (port 18) have remained consistent and were slightly greater than background levels. Sodium concentrations in well(s) USGS

133, 134, and 135 have shown consistent concentrations that were at or less than background levels in the ESRP aquifer. Well USGS 137A (ports 1, 3, 5, and 7) has sodium concentrations that ranged from 9.6 to 12.1 mg/L, with sodium slightly elevated in the upper part of the aquifer at this location and concentrations decreasing deeper in the aquifer (table 6, at back of report; Bartholomay and others, 2015, fig. 14). Well Middle 2050A (port 15) sodium concentrations were lowest during the years 2006, 2012, 2017, and 2018, which were attributed to dilution from BLR recharge (Bartholomay and others, 2020, figs. 8 and 10). Well MIDDLE 2051 (ports 1, 3, 6, and 9) sodium concentrations generally were near the background level and have remained consistent throughout their period of record.

Sulfate

Sulfate has been discharged in wastewater at several facilities in the western part of the INL since 1952 and is still being discharged near the INTEC, ATR Complex, and NRF into infiltration ponds and ditches. The background sulfate concentration in groundwater in the western part of the ESRP aquifer at the INL is about 21 mg/L (Bartholomay and Hall, 2016). For comparison to health standards, the secondary MCL for drinking water is 250 mg/L (U.S. Environmental Protection Agency, 2019a). Concentrations of sulfate for selected zones in all MLMS wells ranged from 18.4 mg/L in well MIDDLE 2050A (port 15) to 28.3 mg/L in well USGS 131A (port 10) (table 6, at back of report).

During 2014–18, sulfate concentrations in well USGS 103 (ports 1, 3, 7, and 11) have remained consistent with all concentrations near background levels for the ESRP aquifer (table 6, at back of report). Sulfate concentrations in well USGS 105 (ports 6, 11, and 14) have remained consistent for the period of sample record or slightly decreased, with all three zones having concentrations greater than background levels (table 6, at back of report). Sulfate concentrations in well USGS 108 (ports 1 and 12) have remained consistent or slightly decreased for the period of sample record, with both zones having concentrations greater than background levels (table 6, at back of report).

Sulfate concentrations in the upper two zones (ports 15 and 10) from USGS 131A have remained relatively consistent in the past 5 years; the upper zone (port 15) has concentrations slightly greater than background levels and the deeper zone (port 10) has concentrations greater than background levels (table 6, at back of report). Sulfate concentrations for MLMS well USGS 132 (port 18) have remained consistent and are greater than background levels (table 6, at back of report). Sulfate concentrations for well(s) USGS 133, 134, and 135 have shown consistent concentrations that were below background levels in the aquifer (table 6, at back of report). Sulfate concentrations in well USGS 137A (ports 5 and 7) were greater than background levels. Sulfate concentrations in MLMS well MIDDLE 2050A (port 15) ranged

from 18.4 to 23.2 mg/L (table 6, at back of report); concentrations decreased substantially during 2006, 2012, 2017, 2018, probably because of flow in the BLR (figs. 8 and 10). Well MIDDLE 2051 (ports 1, 3, 6, and 9) had sulfate concentrations ranging from 22.6 to 26.6 mg/L (table 6, at back of report); however, concentrations were slightly higher in ports 6 and 9 than in ports 1 and 3, which are deeper in the ESRP aquifer.

Nitrate

Nitrate has been discharged in wastewater at the INTEC into the disposal well and infiltration ponds and was leaked at the INTEC tank farm during a transfer from one tank to another (Cahn and others, 2006). The background nitrate concentration in the water in the western part of the ESRP aquifer at the INL is about 0.66 mg/L (Bartholomay and Hall, 2016). For comparison to health standards, the MCL for drinking water is 10 mg/L (U.S. Environmental Protection Agency, 2019b). Nitrite plus nitrate (hereinafter referred to as nitrate because nitrite is negligible) concentrations from 2014 to 2018 are given in table 7, at back of report.

During 2014–18, nitrate concentrations for well USGS 103 (ports 1, 3, 7, and 11) have remained consistent, ranging from 0.643 to 0.820 mg/L. Nitrate concentrations in well USGS 105 (ports 6, 10, 14) have remained consistent, with concentrations slightly greater than background levels, ranging from 0.689 to 0.956 mg/L. Nitrate concentrations for well USGS 108 (ports 1 and 12) have remained consistently greater than background levels, ranging from 0.881 to 1.03 mg/L. Nitrate concentrations for well USGS 131A (ports 3, 6, 10, and 15) have remained consistently greater than background levels, ranging from 0.859 to 1.31 mg/L. Nitrate concentrations for well USGS 132 (port 18) have remained consistent at levels slightly greater than background concentrations, ranging from 0.717 to 0.886 mg/L. Nitrate concentrations in MLMS well USGS 133 (port 12) have remained consistent at levels slightly greater than background levels, ranging from 0.779 to 0.827 mg/L. Nitrate concentrations in well USGS 134 (port 19) have remained consistent near background levels, ranging from 0.612 to 0.706 mg/L. Nitrate concentrations in well USGS 135 (port 9) have remained consistently less than background concentrations, ranging from 0.564 to 0.619 mg/L. Nitrate concentrations in well USGS 137A (ports 1, 3, 5, and 7) have remained consistently near background levels, ranging from 0.602 to 0.802 mg/L. Nitrate concentrations in well MIDDLE 2050A (port 15) showed a statistically significant decreasing trend (fig. 10) and were slightly above background concentrations, except during years when there was flow in the BLR (2006, 2012, 2017, and 2018) (Bartholomay and others, 2020; figs. 8 and 10), when concentrations were well below background levels. Nitrate concentrations in well MIDDLE 2051 (ports 1, 3, 6, and 9) remained consistent at levels slightly greater than background levels, ranging from 0.817 to 0.941 mg/L.

Gross Alpha- and Beta-Particle Radioactivity

Gross alpha- and beta-particle radioactivity is a measure of the total radioactivity emitted as alpha and beta particles during the radioactive decay process. The radioactivity usually is reported as if it occurred as 1 radionuclide. Gross alpha and beta measurements are used to screen for radioactivity in the aquifer as a possible indicator of groundwater contamination. Water samples collected during 2014–18 were analyzed for gross alpha- and gross beta-particle radioactivity by the RESL. In 2008, the RESL increased the sensitivity of the gross alpha- and gross beta-particle radioactivity and changed the radionuclide reported for gross alpha-particle radioactivity from plutonium-239 to thorium-230, and for gross beta-particle radioactivity from cesium-137 to strontium-90/yttrium-90. The minimum detectable activity decreased from about 1.6 to 1.5 picocuries per liter (pCi/L) for gross alpha-particle radioactivity and from about 6.4 to 3.4 pCi/L for gross beta-particle radioactivity, allowing for increased detectable concentrations (Bartholomay and Twining, 2010).

During 2014–18, water from 22 zones from 11 MLMS wells was sampled and analyzed for gross alpha-particle radioactivity. Two MLMS wells had one sample each that equaled or exceeded the reporting level, with well USGS 105 (port 14) having a concentration of 9 ± 3 pCi/L and MLMS well USGS 108 (port 12) having a concentration of 15 ± 4 pCi/L (table 8, at back of report). Alpha-particle radioactivity concentrations in all other water samples were less than the reporting level. The lack of consistent concentrations of gross alpha-activity may indicate that the detections are false positives.

During 2014–18, concentrations of gross-beta particle radioactivity in water from several of the wells equaled or exceeded the reporting level in at least one of the sampling periods, and concentrations ranged from 2.1 ± 0.7 pCi/L to 4.8 ± 0.9 pCi/L in well USGS 108 (port 1) and well USGS 131A (port 15), respectively (table 8, at back of report). Concentrations in all samples from wells USGS 134, 135 and MIDDLE 2050A were less than the reporting level. The upper two zones in well USGS 131A (port 10 and 15), 7 of the 10 samples collected exceeded the reporting level (table 8, at back of report). Tritium, a beta emitter, is present in these wells and probably explains why gross-beta particle radioactivity also is present.

Tritium

Tritium was discharged in wastewater to a disposal well at the INTEC and into infiltration ponds at the INTEC and the ATR Complex from 1952 until the early 1990s (Bartholomay and others, 2020). The background tritium concentration in the water in the western part of the ESRP aquifer at the INL is about 34 pCi/L (Bartholomay and Hall, 2016). For comparison to the health standard, the MCL for drinking water is 20,000 pCi/L (U.S. Environmental Protection Agency, 2019a), and tritium has a half-life of 12.3 years (Walker and others, 1989, p. 20). Concentrations for tritium for all samples collected during 2014–18 are given in table 8, at back of report.

Wells USGS 108, 133, 134, 135, 137A, and MIDDLE 2050A have tritium concentrations mostly less than the reporting levels. Most concentrations of tritium in wells USGS 105 and 132 are greater than the reporting levels, and concentrations were mostly consistent during 2014–18 (table 8, at back of report; fig. 11). Wells USGS 103, 131A, MIDDLE 2051 have concentrations mostly greater than the reporting levels and show statistically significant decreasing concentrations through time in USGS 103 (zone 1), USGS 131A (zone 12), and Middle 2051 (zone 9) (fig. 11). Decreases in tritium concentrations are attributed to discontinued disposal, radioactive decay, and dilution and dispersion in the aquifer.

Cesium-137

Cesium-137 was discharged to the radioactive-waste infiltration ponds at the ATR Complex from 1952 until the ponds closed in 1993. Additionally, cesium-137 was discharged at the INTEC facility into its disposal well and infiltration ponds and an estimated 19,100 curies was reported leaked at the INTEC Tank farm in 1972 (Cahn and others, 2006). The half-life of cesium-137 is 30.17 years (Walker and others, 1989, p. 34).

During 2014–15, groundwater was sampled and analyzed for cesium-137 using gamma spectrometry for all MLMS wells (table 8, at back of report). All MLMS samples collected during 2014–15 had concentrations at or less than the reporting level. Because cesium-137 mostly was not detected in the wells, sampling was discontinued starting in 2016.

Figure 11. Survival regression model graphs showing tritium measured in water samples collected from wells (A) U.S. Geological Survey (USGS) 103 (Site No. 432714112560702), (B) USGS 103 (Site No. 432714112560704), (C) USGS 103 (Site No. 432714112560708), (D) USGS 103 (Site No. 432714112560712), (E) USGS 105 (Site No. 432703113001807), (F) USGS 105 (Site No. 432703113001811), (G) USGS 105 (Site No. 432703113001815), (H) USGS 131A (Site No. 433036112581810), (I) USGS 131A (Site No. 433036112581815), (J) USGS 132 (Site No. 432906113025018), (K) MIDDLE 2051 (Site No. 433217113004903), and (L) MIDDLE 2051 (Site No. 433217113004909), Idaho National Laboratory Idaho, 2005–18. Delta symbol (Δ) represents the percent change shown by the trend line based on the survival regression model.

Figure 11.—Continued

Figure 11.—Continued

Figure 11.—Continued

Purgeable Organic Compounds

In 2015, the INL contractor Fluor detected purgeable organic compounds (POCs) in well MIDDLE 2051, mainly tetrachloroethene (PCE); previous sampling did not detect any POCs (Forbes and Lawrence, 2018). Because of the questionable detections, the USGS was asked to sample the well with Fluor and the Idaho Department of Environmental Quality INL oversight program in 2016. Initial sampling of MLMS well MIDDLE 2051 on June 8, 2016, showed a large concentration (744 $\mu\text{g/L}$) of PCE and a small concentration of trichloroethene (table 10, at back of report). The concentration of PCE was greater than anticipated levels and resulted in an extensive research study to try to find the source of the PCE (Forbes and Lawrence, 2018). To verify data previously reported, an entire suite of chemical constituents were collected and analyzed for well MIDDLE 2051 (port 1) on June 30, 2016 (table 9, at back of report). Results indicated that the 2016 chemical concentrations reported for well MIDDLE 2051 (port 1) were similar to concentration levels previously reported (Bartholomay and Twining, 2010), so it was concluded that the aquifer was not undergoing any extreme chemical change indicated by the POC results. The resample in well MIDDLE 2051 (port 1) for POCs indicated that PCE was still present but at a much lower concentration of 0.774 $\mu\text{g/L}$ (tables 9 and 10, at back of report). Upon further investigation, we determined that the initial sample collected on June 8, 2016, probably was contaminated with tubing fluid (Forbes and Lawrence, 2018). Tubing fluid is water that was added during the installation of the MLMS. Fluor MLMS installation records indicated that the tubing fluid in wells MIDDLE 2050A and MIDDLE 2051 was well water from Firestation #2 and that well water was sampled by Fluor and PCE was not detected (Forbes, and Lawrence, 2018); however, all USGS MLMS wells are filled with deionized bottled water.

To determine if the tubing contained elevated concentrations of PCE the tubing fluid was sampled on July 19, 2016 at well MIDDLE 2051. The tubing fluid sampled at well MIDDLE 2051 had a PCE concentration of 662 $\mu\text{g/L}$ (table 10, at back of report). Because of the large concentration found in the tubing fluid in well MIDDLE 2051, we decided to sample the tubing fluid in all the MLMS wells. Results from three other MLMS wells (USGS 132, USGS 137A, and MIDDLE 2050A) sampled by the USGS are given in table 10, at back of report; results from Fluor sampling are given in Forbes and Lawrence (2018). Results indicated that three of the MLMS wells USGS 137A, MIDDLE 2050A, and MIDDLE 2051 had PCE above acceptable levels and cleanup, as described by Forbes and Lawrence (2018), was done to decrease PCE contamination in the tubing fluid to acceptable levels.

In addition to POC sampling at well MIDDLE 2051, POCs in wells USGS 132 and USGS 137A were sampled because these wells are downgradient from the RWMC and known concentrations of several POCs originate from waste disposal at the RWMC (Bartholomay and others, 2017). Results indicate that the aquifer has detectable concentrations

of tetrachloromethane (carbon tetrachloride) for all MLMS zones for well USGS 132 (ports 1, 6, 10, 14, 18, and 22) and in two zones for well USGS 137A (ports 1 and 7) (table 10, at back of report). Tetrachloromethane has been found in several of the wells around the RWMC, so these detections and concentration levels seem reasonable for the well locations. Because of the concentrations found in well USGS 132, POC analyses were added to the sample schedule for the zone routinely sampled from well USGS 132 starting in 2017. PCE was not detected in well USGS 137A (ports 1, 3, 5, and 7) and only a trace amount was detected in one zone in well USGS 132 (port 14) (table 10, at back of report).

Summary

Radiochemical and chemical wastewater discharged to infiltration ponds and disposal wells since the early 1950s at the Idaho National Laboratory (INL), southeastern Idaho, has affected the water quality of the eastern Snake River Plain aquifer. In 2005, the U.S. Geological Survey (USGS), in cooperation with the U.S. Department of Energy, added a multilevel well-monitoring network to their ongoing monitoring program to begin describing the vertical movement and distribution of the chemical constituents in the eastern Snake River Plain aquifer.

Vertical head and temperature change were quantified for each of the 11 multilevel monitoring systems. Fractured basalt zones generally had relatively small vertical head differences and showed a higher occurrence within volcanic rift zones. Poor connectivity between fractures and higher vertical gradients generally was attributed to sediment layers and (or) layers of dense basalt. Hydraulic head ranged from 4,415.5 to 4,462.6 feet above the National Geodetic Vertical Datum of 1929 in wells U.S. Geological Survey (USGS) 135 and USGS 133, respectively; groundwater temperature ranged from 10.4 to 16.8 degrees Celsius in wells MIDDLE 2051 and MIDDLE 2050A, respectively.

Normalized mean head values were analyzed for all 11 multilevel monitoring wells for the period of record (2007–18). The mean head values suggest a moderately positive correlation among all multilevel monitoring system (MLMS) wells and generally reflect regional fluctuations in water levels in response to seasonal climatic changes. MLMS wells within volcanic rift zones and near the southern boundary (USGS 103, USGS 105, USGS 108, USGS 132, USGS 135, USGS 137A) indicated a temporal correlation that is strongly positive. MLMS wells in the Big Lost Trough indicate some variations in temporal correlations that may result from proximity to the mountain front to the northwest and episodic flow in the Big Lost River drainage system.

During 2014–18, water samples were collected from one to four discrete sampling zones in the upper 250–750 feet of the aquifer from 11 wells and were analyzed for selected radionuclides, inorganic constituents, organic constituents, and

nutrients. Some additional samples were collected for volatile organic compounds near the Radioactive Waste Management Complex (RWMC).

Nine quality-control replicate samples were collected during 2014–18 as a measure of quality assurance; three field blanks and two equipment blanks also were collected using deionized water from the USGS Idaho Falls Field Office. Concentrations of major ions and chromium in equipment blank samples were near or less than the reporting levels, suggesting no background contamination from field equipment or source water. About 88 percent of the replicate pairs for radionuclide results were statistically comparable and 100 percent of the replicate pairs for inorganic and organic compounds were statistically comparable. The sample results for most of the quality assurance samples indicate that sample collection and laboratory procedures used were appropriate for the data collected.

Concentrations of chloride, chromium, nitrate, sodium, and sulfate in most of the wells showed mostly consistent concentrations with time. Concentrations in well Middle 2050A were markedly lower during 2017 and 2018 than during other sample years and the decrease in concentrations is attributed to flow in the Big Lost River during those years. Chromium showed increasing concentrations in USGS 133. Concentrations of most of the chemical constituents were greater than background concentration levels in wells USGS 103, 105, 108, 131A, 132, 137A, and MIDDLE 2051, and were at or less than background levels in wells USGS 133, 134, and 135.

Tritium concentrations in wells USGS 108, 133, 134, 135, 137A, and MIDDLE 2050A, mostly were less than reporting levels. Most well USGS 105 and 132 concentrations were greater than the reporting levels and concentrations were mostly consistent. Wells USGS 103, USGS 131A, and MIDDLE 2051 had concentrations mostly greater than the reporting level and showed decreasing concentrations. The decreasing concentrations are attributed to discontinued disposal, radioactive decay, and dilution and dispersion in the aquifer.

The volatile organic compound tetrachloromethane was found in all zones sampled in well USGS 132 near RWMC and was found in two zones in well USGS 137A. Concentrations are attributed to waste disposal at the RWMC. Questionable detections of tetrachloroethene were found in well MIDDLE 2051; the source probably was tubing fluid in the well. Tetrachloroethene was found in the tubing fluid at elevated concentrations in three wells (USGS 137A, MIDDLE 2050A, and MIDDLE 2051), and this compound is being removed from the tubing fluid.

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Table 2. Completion data for multilevel wells and associated groundwater model layer information, boreholes U.S. Geological Survey (USGS) 103, USGS 105, USGS 108, USGS 131A, USGS 132, USGS 133, USGS 134, USGS 135, USGS 137A, MIDDLE 2050A, and MIDDLE 2051, Idaho National Laboratory, Idaho, 2014–18.

[**Bold** port values indicate sample ports used to collect water chemistry. **Local name:** Local well identifier used in this study. USGS, U.S. Geological Survey. **Zone number:** Identifier used to locate monitoring zones. **Zone depth interval:** Limits in feet below land surface (ft bls) and length in feet (ft). **Port number:** Identifier used to locate port couplings. **Port coupling depth:** Depth to the top of the measurement port coupling in ft bls. **Groundwater sample port:** Port where groundwater sample data is collected in addition to pressure and temperature data. “Yes” denotes that samples are collected and “No” denotes that the port is not used to collect water samples. **Model layer:** Identified and described in Ackerman and others (2010) and established as layers 1–5 for zones where groundwater samples were collected. Layer 1 represents the upper 100 ft of the aquifer; layer 2 represents water from 100 to 200 ft below the top of the aquifer; layer 3 represents water from 200 to 300 ft below the top of the aquifer; layer 4 represents water from 300 to 500 ft below the top of the aquifer; layer 5 represents water from 500 to 800 ft below the top of the aquifer; and layer 6 represents water from more than 800 ft below the top of the aquifer. None of the wells reach model layer 6. “–” indicates zones not sampled from. **Site number:** Unique numerical identifier used to access port data (<https://waterdata.usgs.gov/nwis/>)]

Local name	Zone number	Zone depth interval		Port number	Port coupling depth (ft bls)	Groundwater sample port	Model layer	Site number
		Bottom (ft bls)	Top (ft bls)					
USGS 103	1	1,279.4	1,257.4	1	1,258.0	Yes	5	432714112560702
	2	1,254.4	1,242.9	2	1,243.5	No	–	432714112560703
	3	1,239.9	1,184.4	3	1,209.7	Yes	5	432714112560704
				4	1,185.0	No	–	432714112560705
	4	1,181.4	1,115.2	5	1,115.8	No	–	432714112560706
	5	1,112.2	1,100.6	6	1,101.2	No	–	432714112560707
	6	1,097.6	1,063.2	7	1,086.8	Yes	4 and 5	432714112560708
				8	1,063.8	No	–	432714112560709
	7	1,060.2	1,045.5	9	1,046.1	No	–	432714112560710
	8	1,042.5	1,016.5	10	1,017.1	No	–	432714112560711
	9	1,013.5	958.0	11	992.9	Yes	4	432714112560712
				12	958.6	No	–	432714112560713
	10	955.0	948.4	13	949.0	No	–	432714112560714
	11	945.4	922.6	14	923.2	No	–	432714112560715
	12	919.6	891.6	15	908.7	Yes	4	432714112560716
				16	892.2	No	–	432714112560717
	13	888.6	862.6	17	863.2	No	–	432714112560718
	14	859.6	835.1	18	835.7	No	–	432714112560719
	15	832.1	766.9	19	801.9	Yes	2 and 3	432714112560720
				20	767.5	No	–	432714112560721
	16	763.9	694.3	21	694.9	No	–	432714112560722
	17	691.3	669.6	22	680.3	Yes	1 and 2	432714112560723
				23	670.2	No	–	432714112560724

Table 2. Completion data for multilevel wells and associated groundwater model layer information, boreholes U.S. Geological Survey (USGS) 103, USGS 105, USGS 108, USGS 131A, USGS 132, USGS 133, USGS 134, USGS 135, USGS 137A, MIDDLE 2050A, and MIDDLE 2051, Idaho National Laboratory, Idaho, 2014–18.—Continued

[**Bold** port values indicate sample ports used to collect water chemistry. **Local name:** Local well identifier used in this study. USGS, U.S. Geological Survey. **Zone number:** Identifier used to locate monitoring zones. **Zone depth interval:** Limits in feet below land surface (ft bls) and length in feet (ft). **Port number:** Identifier used to locate port couplings. **Port coupling depth:** Depth to the top of the measurement port coupling in ft bls. **Groundwater sample port:** Port where groundwater sample data is collected in addition to pressure and temperature data. “Yes” denotes that samples are collected and “No” denotes that the port is not used to collect water samples. **Model layer:** Identified and described in Ackerman and others (2010) and established as layers 1–5 for zones where groundwater samples were collected. Layer 1 represents the upper 100 ft of the aquifer; layer 2 represents water from 100 to 200 ft below the top of the aquifer; layer 3 represents water from 200 to 300 ft below the top of the aquifer; layer 4 represents water from 300 to 500 ft below the top of the aquifer; layer 5 represents water from 500 to 800 ft below the top of the aquifer; and layer 6 represents water from more than 800 ft below the top of the aquifer. None of the wells reach model layer 6. “—” indicates zones not sampled from. **Site number:** Unique numerical identifier used to access port data (<https://waterdata.usgs.gov/nwis/>)]

Local name	Zone number	Zone depth interval		Port number	Port coupling depth (ft bls)	Groundwater sample port	Model layer	Site number
		Bottom (ft bls)	Top (ft bls)					
USGS 105	1	1,290.1	1,279.2	1	1,279.8	No	—	432703113001802
	2	1,276.2	1,224.8	2	1,242.2	Yes	5	432703113001803
	3	1,221.8	1,165.9	3	1,225.4	No	—	432703113001804
	4	1,162.9	1,105.4	4	1,166.5	No	—	432703113001805
	5	1,102.4	1,034.6	5	1,106.0	No	—	432703113001806
				6	1,071.6	Yes	4	432703113001807
	6	1,031.6	1,005.1	7	1,035.2	No	—	432703113001808
	7	1,002.1	985.4	8	1,005.7	No	—	432703113001809
	8	982.4	929.3	9	986.0	No	—	432703113001810
				10	951.6	Yes	3 and 4	432703113001811
	9	926.3	909.6	11	929.9	No	—	432703113001812
	10	906.6	865.3	12	910.2	No	—	432703113001813
	11	862.3	830.4	13	865.9	No	—	432703113001814
				14	851.2	Yes	2	432703113001815
	12	827.4	754.9	15	831.0	No	—	432703113001816
	13	751.9	706.9	16	755.5	No	—	432703113001817
				17	727.6	Yes	1	432703113001818
				18	707.4	No	—	432703113001819

Table 2. Completion data for multilevel wells and associated groundwater model layer information, boreholes U.S. Geological Survey (USGS) 103, USGS 105, USGS 108, USGS 131A, USGS 132, USGS 133, USGS 134, USGS 135, USGS 137A, MIDDLE 2050A, and MIDDLE 2051, Idaho National Laboratory, Idaho, 2014–18.—Continued

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Local name	Zone number	Zone depth interval		Port number	Port coupling depth (ft bls)	Groundwater sample port	Model layer	Site number
		Bottom (ft bls)	Top (ft bls)					
USGS 108	1	1,191.9	1160.9	1	1,171.8	Yes	5	432659112582602
				2	1,161.5	No	—	432659112582603
	2	1,157.9	1,121.6	3	1,122.2	No	—	432659112582604
	3	1,118.6	1,062.6	4	1,063.2	No	—	432659112582605
	4	1,059.6	1,018.0	5	1,028.8	Yes	5	432659112582606
				6	1,018.6	No	—	432659112582607
	5	1,015.0	980.4	7	981.0	No	—	432659112582608
	6	977.4	906.7	8	907.3	No	—	432659112582609
	7	903.7	872.0	9	887.7	Yes	3	432659112582610
				10	872.6	No	—	432659112582611
	8	869.0	832.7	11	833.3	No	—	432659112582612
	9	829.7	791.4	12	808.8	Yes	2 and 3	432659112582613
				13	792.0	No	—	432659112582614
	10	788.4	681.8	14	682.4	No	—	432659112582615
	11	678.8	642.1	15	661.1	Yes	1	432659112582616
				16	642.7	No	—	432659112582617

Table 2. Completion data for multilevel wells and associated groundwater model layer information, boreholes U.S. Geological Survey (USGS) 103, USGS 105, USGS 108, USGS 131A, USGS 132, USGS 133, USGS 134, USGS 135, USGS 137A, MIDDLE 2050A, and MIDDLE 2051, Idaho National Laboratory, Idaho, 2014–18.—Continued

[**Bold** port values indicate sample ports used to collect water chemistry. **Local name:** Local well identifier used in this study. USGS, U.S. Geological Survey. **Zone number:** Identifier used to locate monitoring zones. **Zone depth interval:** Limits in feet below land surface (ft bls) and length in feet (ft). **Port number:** Identifier used to locate port couplings. **Port coupling depth:** Depth to the top of the measurement port coupling in ft bls. **Groundwater sample port:** Port where groundwater sample data is collected in addition to pressure and temperature data. “Yes” denotes that samples are collected and “No” denotes that the port is not used to collect water samples. **Model layer:** Identified and described in Ackerman and others (2010) and established as layers 1–5 for zones where groundwater samples were collected. Layer 1 represents the upper 100 ft of the aquifer; layer 2 represents water from 100 to 200 ft below the top of the aquifer; layer 3 represents water from 200 to 300 ft below the top of the aquifer; layer 4 represents water from 300 to 500 ft below the top of the aquifer; layer 5 represents water from 500 to 800 ft below the top of the aquifer; and layer 6 represents water from more than 800 ft below the top of the aquifer. None of the wells reach model layer 6. “—” indicates zones not sampled from. **Site number:** Unique numerical identifier used to access port data (<https://waterdata.usgs.gov/nwis/>)]

Local name	Zone number	Zone depth interval		Port number	Port coupling depth (ft bls)	Groundwater sample port	Model layer	Site number
		Bottom (ft bls)	Top (ft bls)					
USGS 131A	1	1,188.8	1,176.6	1	1,177.2	No	—	433036112581801
	2	1,173.6	1,160.1	2	1,160.7	No	—	433036112581802
	3	1,157.1	1,120.4	3	1,136.1	Yes	5	433036112581803
				4	1,121.0	No	—	433036112581804
	4	1,117.4	1,061.4	5	1,062.0	No	—	433036112581805
	5	1,058.4	956.3	6	980.3	Yes	4	433036112581806
				7	956.9	No	—	433036112581807
	6	953.3	928.4	8	929.0	No	—	433036112581808
	7	925.4	844.9	9	845.5	No	—	433036112581809
	8	841.9	795.4	10	811.2	Yes	3	433036112581810
				11	796.0	No	—	433036112581811
	9	792.4	733.0	12	733.6	No	—	433036112581812
	10	730.0	693.7	13	694.3	No	—	433036112581813
	11	690.7	634.6	14	635.2	No	—	433036112581814
	12	631.6	562.0	15	615.6	Yes	1	433036112581815
				16	562.6	No	—	433036112581816

Table 2. Completion data for multilevel wells and associated groundwater model layer information, boreholes U.S. Geological Survey (USGS) 103, USGS 105, USGS 108, USGS 131A, USGS 132, USGS 133, USGS 134, USGS 135, USGS 137A, MIDDLE 2050A, and MIDDLE 2051, Idaho National Laboratory, Idaho, 2014–18.—Continued

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Local name	Zone number	Zone depth interval		Port number	Port coupling depth (ft bls)	Groundwater sample port	Model layer	Site number
		Bottom (ft bls)	Top (ft bls)					
USGS 132	1	1,213.6	1,152.3	1	1,173.0	Yes	5	432906113025001
				2	1,152.9	No	—	432906113025002
	2	1,149.3	1,144.1	3	1,144.7	No	—	432906113025003
	3	1,141.1	1,134.3	4	1,134.9	No	—	432906113025004
	4	1,131.3	1,046.1	5	1,046.7	No	—	432906113025005
	5	1,043.1	984.3	6	1,011.6	Yes	4	432906113025006
				7	984.9	No	—	432906113025007
	6	981.3	953.2	8	953.8	No	—	432906113025008
	7	950.2	938.4	9	939.0	No	—	432906113025009
	8	935.4	911.1	10	918.7	No	—	432906113025010
				11	911.7	Yes	4	432906113025011
	9	908.1	876.7	12	877.3	No	—	432906113025012
	10	873.7	866.8	13	867.4	No	—	432906113025013
	11	863.8	811.5	14	827.3	Yes	3	432906113025014
				15	812.1	No	—	432906113025015
	12	808.5	801.6	16	802.2	No	—	432906113025016
	13	798.6	790.1	17	790.7	No	—	432906113025017
	14	787.1	726.6	18	765.4	Yes	2	432906113025018
				19	727.2	No	—	432906113025019
	15	723.6	672.5	20	673.1	No	—	432906113025020
	16	669.5	662.6	21	663.2	No	—	432906113025021
	17	659.6	623.6	22	637.9	Yes	1	432906113025022
				23	624.2	No	—	432906113025023

Table 2. Completion data for multilevel wells and associated groundwater model layer information, boreholes U.S. Geological Survey (USGS) 103, USGS 105, USGS 108, USGS 131A, USGS 132, USGS 133, USGS 134, USGS 135, USGS 137A, MIDDLE 2050A, and MIDDLE 2051, Idaho National Laboratory, Idaho, 2014–18.—Continued

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Local name	Zone number	Zone depth interval		Port number	Port coupling depth (ft bls)	Groundwater sample port	Model layer	Site number
		Bottom (ft bls)	Top (ft bls)					
USGS 133	1	766.4	724.8	1	745.5	Yes	4	433605112554301
				2	725.4	No	—	433605112554302
	2	721.8	715.0	3	715.6	No	—	433605112554303
	3	712.0	698.6	4	699.2	No	—	433605112554304
	4	695.6	685.5	5	686.1	Yes	3	433605112554305
	5	682.5	618.2	6	618.8	No	—	433605112554306
	6	615.2	593.7	7	594.3	No	—	433605112554307
	7	590.7	555.5	8	569.6	Yes	2	433605112554308
				9	556.1	No	—	433605112554309
	8	552.5	539.1	10	539.7	No	—	433605112554310
	9	536.1	483.2	11	483.8	No	—	433605112554311
	10	480.2	448.0	12	469.1	Yes	1	433605112554312
				13	448.6	No	—	433605112554313

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Local name	Zone number	Zone depth interval		Port number	Port coupling depth (ft bls)	Groundwater sample port	Model layer	Site number
		Bottom (ft bls)	Top (ft bls)					
USGS 134	1	886.8	881.0	1	881.6	No	—	433611112595801
	2	878.0	871.0	2	871.6	No	—	433611112595802
	3	868.0	846.0	13	856.1	Yes*	4	433611112595803
				4	846.6	Yes	4	433611112595804
	4	843.0	831.0	5	831.6	No	—	433611112595805
	5	828.0	821.0	6	821.6	No	—	433611112595806
	6	818.0	782.0	7	806.6	No	—	433611112595807
				8	782.6	Yes	3 and 4	433611112595808
	7	779.0	747.0	9	747.6	No	—	433611112595809
	8	744.0	723.0	10	723.6	No	—	433611112595810
	9	720.0	690.9	11	706.5	Yes	2 and 3	433611112595811
				12	691.5	No	—	433611112595812
	10	687.9	664.9	13	665.5	No	—	433611112595813
	11	661.9	654.9	14	655.5	No	—	433611112595814
	12	651.9	638.9	15	645.5	Yes	2	433611112595815
				16	639.5	No	—	433611112595816
	13	635.9	604.8	17	605.4	No	—	433611112595817
	14	601.8	592.8	18	593.4	No	—	433611112595818
	15	589.8	553.8	19	578.5	Yes	1	433611112595819
				20	554.4	No	—	433611112595820

Table 2. Completion data for multilevel wells and associated groundwater model layer information, boreholes U.S. Geological Survey (USGS) 103, USGS 105, USGS 108, USGS 131A, USGS 132, USGS 133, USGS 134, USGS 135, USGS 137A, MIDDLE 2050A, and MIDDLE 2051, Idaho National Laboratory, Idaho, 2014–18.—Continued

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Local name	Zone number	Zone depth interval		Port number	Port coupling depth (ft bls)	Groundwater sample port	Model layer	Site number
		Bottom (ft bls)	Top (ft bls)					
USGS 135	1	1,136.6	1,105.6	1	1,116.4	Yes	4	432753113093601
				2	1,106.1	No	—	432753113093602
	2	1,102.6	1,054.8	3	1,055.3	No	—	432753113093603
	3	1,051.8	1,010.6	4	1,011.1	No	—	432753113093604
	4	1,007.6	967.5	5	988.1	Yes	3	432753113093605
				6	968.0	No	—	432753113093606
	5	964.5	923.3	7	923.7	No	—	432753113093607
	6	920.3	864.2	8	864.7	No	—	432753113093608
	7	861.2	822.6	9	836.7	Yes	2	432753113093609
				10	823.1	No	—	432753113093610
	8	819.6	790.0	11	790.4	No	—	432753113093611
	9	787.0	765.3	12	765.8	No	—	432753113093612
	10	762.3	727.0	13	737.9	Yes	1	432753113093613
				14	727.5	No	—	432753113093614
USGS 137A	1	894.7	874.5	1	875.1	Yes	3	432701113025801
	2	871.5	864.7	2	865.3	No	—	432701113025802
	3	861.7	787.2	3	840.7	Yes	2 and 3	432701113025803
				4	787.8	No	—	432701113025804
	4	784.2	746.2	5	746.8	Yes	2	432701113025805
				6	721.7	No	—	432701113025806
	5	718.1	640.1	7	660.9	Yes	1	432701113025807
				8	640.7	No	—	432701113025808

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Local name	Zone number	Zone depth interval		Port number	Port coupling depth (ft bls)	Groundwater sample port	Model layer	Site number
		Bottom (ft bls)	Top (ft bls)					
MIDDLE 2050A	1	1,377.6	1,267.5	1	1,268.1	No	—	433409112570501
	2	1,264.5	1,229.7	2	1,230.3	No	—	433409112570502
	3	1,226.7	1,179.7	3	1,180.3	Yes	5	433409112570503
	4	1,176.7	1,081.3	4	1,081.9	No	—	433409112570504
	5	1,078.3	1,043.6	5	1,044.2	No	—	433409112570505
	6	1,040.6	998.7	6	999.3	Yes	5	433409112570506
	7	995.7	843.1	7	843.7	No	—	433409112570507
	8	840.1	810.4	8	811.0	No	—	433409112570508
	9	807.4	790.0	9	790.6	Yes	4	433409112570509
	10	787.0	719.5	10	720.1	No	—	433409112570510
	11	716.5	706.4	11	707.0	No	—	433409112570511
	12	703.4	643.3	12	643.9	Yes	2 and 3	433409112570512
	13	640.3	623.7	13	624.3	No	—	433409112570513
	14	620.7	541.6	14	542.2	No	—	433409112570514
	15	538.6	464.9	15	516.8	Yes	1	433409112570515

Table 2. Completion data for multilevel wells and associated groundwater model layer information, boreholes U.S. Geological Survey (USGS) 103, USGS 105, USGS 108, USGS 131A, USGS 132, USGS 133, USGS 134, USGS 135, USGS 137A, MIDDLE 2050A, and MIDDLE 2051, Idaho National Laboratory, Idaho, 2014–18.—Continued

[**Bold** port values indicate sample ports used to collect water chemistry. **Local name:** Local well identifier used in this study. USGS, U.S. Geological Survey. **Zone number:** Identifier used to locate monitoring zones. **Zone depth interval:** Limits in feet below land surface (ft bls) and length in feet (ft). **Port number:** Identifier used to locate port couplings. **Port coupling depth:** Depth to the top of the measurement port coupling in ft bls. **Groundwater sample port:** Port where groundwater sample data is collected in addition to pressure and temperature data. “Yes” denotes that samples are collected and “No” denotes that the port is not used to collect water samples. **Model layer:** Identified and described in Ackerman and others (2010) and established as layers 1–5 for zones where groundwater samples were collected. Layer 1 represents the upper 100 ft of the aquifer; layer 2 represents water from 100 to 200 ft below the top of the aquifer; layer 3 represents water from 200 to 300 ft below the top of the aquifer; layer 4 represents water from 300 to 500 ft below the top of the aquifer; layer 5 represents water from 500 to 800 ft below the top of the aquifer; and layer 6 represents water from more than 800 ft below the top of the aquifer. None of the wells reach model layer 6. “—” indicates zones not sampled from. **Site number:** Unique numerical identifier used to access port data (<https://waterdata.usgs.gov/nwis/>)]

Local name	Zone number	Zone depth interval		Port number	Port coupling depth (ft bls)	Groundwater sample port	Model layer	Site number
		Bottom (ft bls)	Top (ft bls)					
MIDDLE 2051	1	1,176.5	1,140.3	1	1,140.9	Yes	5	433217113004901
	2	1,137.3	1,130.5	2	1,131.1	No	—	433217113004902
	3	1,127.5	1,090.5	3	1,091.1	Yes	5	433217113004903
	4	1,087.5	1,002.2	4	1,002.8	No	—	433217113004904
	5	999.2	879.4	5	880.0	No	—	433217113004905
	6	876.4	826.2	6	826.8	Yes	3 and 4	433217113004906
	7	823.2	791.9	7	792.5	No	—	433217113004907
	8	788.9	773.8	8	774.4	No	—	433217113004908
	9	770.8	748.4	9	749.0	Yes	2 and 3	433217113004909
	10	745.4	646.7	10	647.3	No	—	433217113004910
	11	643.7	612.2	11	612.8	No	—	433217113004911
	12	609.2	561.8	12	602.9	Yes	1	433217113004912

¹Port no longer functioning.

Table 3. Field measurements of pH, specific conductance, water temperature, and dissolved oxygen in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.

[**Local name:** Local well identifier used in this study. USGS, U.S. Geological Survey. **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port as shown in table 2, in feet below land surface (ft bls). **Date:** Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **Time:** Sample collection time in 24-hour military time. **pH:** Negative base-10 logarithm of hydrogen ion activity in moles per liter. **Specific conductance:** Microsiemens per centimeter (µS/cm) at 25 degrees Celsius. **Temperature:** °C, degrees Celsius. **Dissolved oxygen:** In milligrams per liter (mg/L). **Remarks:** QAW, quality assurance Westbay™ sample. Values for replicates are the same measurement as the primary sample]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Time	pH	Specific conductance (µS/cm)	Water temperature (°C)	Dissolved oxygen (mg/L)	Remarks
USGS 103	11	992.9	06-09-2014	1115	7.8	349	12.3	9.43	
	11	992.9	06-16-2015	1645	8.0	346	12.5	9.81	
	11	992.9	06-15-2016	0934	8.0	339	12.5	9.61	
	11	992.9	06-26-2017	1635	8.1	345	14.5	9.52	
	11	992.9	06-26-2018	1530	8.0	351	13.7	9.80	
	7	1,086.8	06-09-2014	1018	7.8	356	12.3	9.96	
	7	1,086.8	06-16-2015	1546	8.0	366	12.4	9.76	
	7	1,086.8	06-14-2016	1720	8.1	355	12.7	9.51	
	7	1,086.8	06-26-2017	1535	8.1	355	14.0	8.06	
	7	1,086.8	06-26-2018	1430	8.0	364	13.5	9.62	
	3	1,209.7	06-09-2014	0917	7.9	361	12.4	9.38	
	3	1,209.7	06-16-2015	1240	8.0	362	12.5	9.27	
	3	1,209.7	06-14-2016	1415	7.9	360	12.8	10.3	
	3	1,209.7	06-26-2017	1435	8.1	361	13.9	8.78	
	3	1,209.7	06-26-2018	1330	8.0	360	13.4	9.55	
	1	1,258.0	06-08-2014	1600	8.0	357	12.6	9.64	QAW-43 replicate
	1	1,258.0	06-08-2014	1605	8.0	357	12.6	9.64	
	1	1,258.0	06-16-2015	1407	8.0	366	12.6	10.2	
	1	1,258.0	06-14-2016	1535	8.1	360	12.7	9.47	
	1	1,258.0	06-26-2017	1325	8.1	360	13.4	8.67	
	1	1,258.0	06-26-2018	1145	8.0	355	13.3	8.75	

Table 3. Field measurements of pH, specific conductance, water temperature, and dissolved oxygen in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

[**Local name:** Local well identifier used in this study. **USGS,** U.S. Geological Survey. **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port as shown in table 2, in feet below land surface (ft bls). **Date:** Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **Time:** Sample collection time in 24-hour military time. **pH:** Negative base-10 logarithm of hydrogen ion activity in moles per liter. **Specific conductance:** Microsiemens per centimeter ($\mu\text{S}/\text{cm}$) at 25 degrees Celsius. **Temperature:** °C, degrees Celsius. **Dissolved oxygen:** In milligrams per liter (mg/L). **Remarks:** QAW, quality assurance Westbay™ sample. Values for replicates are the same measurement as the primary sample]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Time	pH	Specific conductance ($\mu\text{S}/\text{cm}$)	Water temperature (°C)	Dissolved oxygen (mg/L)	Remarks
USGS 105	14	851.2	06-25-2014	1648	8.0	358	12.5	8.42	
	14	851.2	06-17-2015	1232	8.1	361	12.7	8.55	
	14	851.2	06-16-2016	1138	8.1	359	12.8	9.20	
	14	851.2	06-14-2017	1420	8.1	358	14.0	8.90	
	14	851.2	06-27-2018	1605	8.1	354	13.8	6.97	
	10	951.6	06-26-2014	1109	8.0	355	12.8	9.09	
	10	951.6	06-17-2015	1538	8.0	365	13.0	7.74	
	10	951.6	06-16-2016	1246	8.1	358	13.2	9.56	
	10	951.6	06-14-2017	1320	8.0	365	14.0	8.34	
	10	951.6	06-27-2018	1435	8.0	365	13.9	9.33	
	6	1,071.6	06-25-2014	1457	8.0	359	12.8	9.57	
	6	1,071.6	06-17-2015	1344	8.0	362	12.9	8.80	
	6	1,071.6	06-16-2016	1441	7.8	362	13.1	8.66	
	6	1,071.6	06-14-2017	1215	7.9	363	13.8	9.00	
	6	1,071.6	06-27-2018	1300	8.0	358	13.8	8.45	

Table 3. Field measurements of pH, specific conductance, water temperature, and dissolved oxygen in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

[**Local name:** Local well identifier used in this study. **USGS,** U.S. Geological Survey. **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port as shown in table 2, in feet below land surface (ft bls). **Date:** Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **Time:** Sample collection time in 24-hour military time. **pH:** Negative base-10 logarithm of hydrogen ion activity in moles per liter. **Specific conductance:** Microsiemens per centimeter ($\mu\text{S}/\text{cm}$) at 25 degrees Celsius. **Temperature:** $^{\circ}\text{C}$, degrees Celsius. **Dissolved oxygen:** In milligrams per liter (mg/L). **Remarks:** QAW, quality assurance Westbay™ sample. Values for replicates are the same measurement as the primary sample]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Time	pH	Specific conductance ($\mu\text{S}/\text{cm}$)	Water temperature ($^{\circ}\text{C}$)	Dissolved oxygen (mg/L)	Remarks
USGS 108	12	808.8	06-25-2014	1010	7.8	379	12.2	8.35	
	12	808.8	06-25-2014	1015	7.8	379	12.2	8.35	QAW-44 replicate
	12	808.8	06-18-2015	1150	7.8	385	12.4	8.13	
	12	808.8	06-15-2016	1638	7.9	382	12.6	7.68	
	12	808.8	06-20-2017	1410	8.0	383	13.9	9.05	
	12	808.8	06-20-2017	1415	8.0	383	13.9	9.05	QAW-51 replicate
	12	808.8	06-25-2018	1350	7.9	380	13.6	9.76	
	12	808.8	06-25-2018	1355	7.9	380	13.6	9.76	QAW-55 replicate
	1	1,171.8	06-24-2014	1635	7.6	400	12.6	9.63	
	1	1,171.8	06-18-2015	1305	7.6	408	12.7	9.54	
	1	1,171.8	06-15-2016	1450	7.8	397	12.7	10.4	
	1	1,171.8	06-15-2016	1455	7.8	397	12.7	10.4	QAW-49 replicate
	1	1,171.8	06-20-2017	1255	7.8	399	16.4	10.2	
	1	1,171.8	06-25-2018	1135	7.9	397	13.3	10.1	

Table 3. Field measurements of pH, specific conductance, water temperature, and dissolved oxygen in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

[**Local name:** Local well identifier used in this study. **USGS:** U.S. Geological Survey. **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port as shown in table 2, in feet below land surface (ft bls). **Date:** Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **Time:** Sample collection time in 24-hour military time. **pH:** Negative base-10 logarithm of hydrogen ion activity in moles per liter. **Specific conductance:** Microsiemens per centimeter ($\mu\text{S}/\text{cm}$) at 25 degrees Celsius. **Temperature:** °C, degrees Celsius. **Dissolved oxygen:** In milligrams per liter (mg/L). **Remarks:** QAW, quality assurance Westbay™ sample. Values for replicates are the same measurement as the primary sample]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Time	pH	Specific conductance ($\mu\text{S}/\text{cm}$)	Water temperature (°C)	Dissolved oxygen (mg/L)	Remarks
USGS 131A	15	615.6	06-19-2014	1453	7.9	356	11.3	7.81	
	15	615.6	06-15-2015	1540	8.1	365	11.5	8.83	
	15	615.6	06-29-2016	1145	8.0	365	12.0	9.35	
	15	615.6	06-22-2017	1225	7.9	357	13.7	9.16	
	15	615.6	06-19-2018	1315	8.1	362	12.5	8.35	
	10	811.2	06-19-2014	1359	7.8	421	12.2	9.41	
	10	811.2	06-15-2015	1411	7.9	425	12.3	7.96	
	10	811.2	06-29-2016	0940	7.8	428	12.6	9.51	
	10	811.2	06-22-2017	1130	7.7	425	13.4	9.37	
	10	811.2	06-19-2018	1200	7.9	420	13.0	9.51	
	6	980.3	06-19-2014	1307	7.9	392	13.2	10.1	
	6	980.3	06-15-2015	1705	8.0	393	13.3	9.87	
	3	1,136.1	06-19-2014	1209	7.9	389	13.2	8.82	
	3	1,136.1	06-15-2015	1255	8.0	394	13.4	9.01	
	22	637.9	06-13-2017	1535	8.1	392	12.4	6.60	
USGS 132	18	765.4	06-17-2014	1431	8.0	353	12.3	8.22	
	18	765.4	06-09-2015	1109	8.2	368	12.6	7.71	
	18	765.4	06-07-2016	1247	8.2	356	13.0	8.85	
	18	765.4	06-13-2017	1515	8.0	358	13.0	9.57	
	18	765.4	06-20-2018	1240	8.1	365	13.6	8.41	
	14	827.3	06-13-2017	1410	8.0	351	13.1	9.85	
	10	918.7	06-13-2017	1335	8.0	355	12.9	9.95	
	6	1,011.6	06-13-2017	1300	8.0	357	12.6	8.12	
	1	1,173.0	06-13-2017	1225	7.8	363	11.5	9.24	

Table 3. Field measurements of pH, specific conductance, water temperature, and dissolved oxygen in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

[**Local name:** Local well identifier used in this study. **USGS,** U.S. Geological Survey. **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port as shown in table 2, in feet below land surface (ft bls). **Date:** Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **Time:** Sample collection time in 24-hour military time. **pH:** Negative base-10 logarithm of hydrogen ion activity in moles per liter. **Specific conductance:** Microsiemens per centimeter ($\mu\text{S}/\text{cm}$) at 25 degrees Celsius. **Temperature:** °C, degrees Celsius. **Dissolved oxygen:** In milligrams per liter (mg/L). **Remarks:** QAW, quality assurance Westbay™ sample. Values for replicates are the same measurement as the primary sample]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Time	pH	Specific conductance ($\mu\text{S}/\text{cm}$)	Water temperature (°C)	Dissolved oxygen (mg/L)	Remarks
USGS 137A	7	660.9	07-10-2014	1020	7.9	366	12.6	7.29	
	7	660.9	06-22-2015	1525	8.1	370	12.8	7.61	
	7	660.9	06-13-2016	1230	8.0	360	13.1	7.61	
	7	660.9	06-19-2017	1100	8.0	363	13.6	7.30	
	7	660.9	06-18-2018	1330	8.1	363	14.1	7.30	
	5	746.8	07-10-2014	0918	7.8	362	12.5	8.47	
	5	746.8	06-22-2015	1222	8.0	365	12.7	8.72	
	5	746.8	06-13-2016	1050	7.9	353	12.9	8.08	
	5	746.8	06-19-2017	1000	7.9	356	13.6	8.27	
	5	746.8	06-18-2018	1145	8.0	356	13.4	8.40	
	5	746.8	06-18-2018	1150	8.1	6	13.7	6.48	QAW-54 field blank
	3	840.7	07-09-2014	1501	8.0	360	12.4	8.64	
	3	840.7	06-22-2015	1405	8.1	360	12.6	9.06	
	3	840.7	06-19-2017	0905	8.0	354	13.4	7.64	
	1	875.1	07-09-2014	1405	8.0	359	12.7	8.70	
MIDDLE 2050A	1	875.1	06-22-2015	1115	8.0	358	12.6	10.1	
	1	875.1	06-19-2017	0840	7.8	355	13.9	8.55	
	15	516.8	06-26-2014	1315	8.1	378	10.9	8.00	
	15	516.8	06-23-2015	0900	8.2	2	22.4	6.72	QAW-46 field blank
	15	516.8	06-23-2015	1200	7.9	382	11.1	7.82	
	15	516.8	06-20-2016	1201	8.1	379	11.5	7.21	
	15	516.8	06-21-2017	1235	8.2	9	24.6	6.34	QAW-52 field blank
	15	516.8	06-21-2017	1455	7.8	328	12.0	7.80	
	15	516.8	06-12-2018	1410	8.0	316	11.4	6.83	

Table 3. Field measurements of pH, specific conductance, water temperature, and dissolved oxygen in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

[**Local name:** Local well identifier used in this study. **USGS, U.S. Geological Survey.** **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port as shown in table 2, in feet below land surface (ft bls). **Date:** Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **Time:** Sample collection time in 24-hour military time. **pH:** Negative base-10 logarithm of hydrogen ion activity in moles per liter. **Specific conductance:** Microsiemens per centimeter ($\mu\text{S}/\text{cm}$) at 25 degrees Celsius. **Temperature:** $^{\circ}\text{C}$, degrees Celsius. **Dissolved oxygen:** In milligrams per liter (mg/L). **Remarks:** QAW, quality assurance Westbay™ sample. Values for replicates are the same measurement as the primary sample]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Time	pH	Specific conductance ($\mu\text{S}/\text{cm}$)	Water temperature ($^{\circ}\text{C}$)	Dissolved oxygen (mg/L)	Remarks
MIDDLE 2051	12	602.9	06-8-2016	1415	7.9	352	12.0	7.82	
	9	749.0	06-10-2015	1321	8.1	384	13.2	7.61	
	9	749.0	06-08-2016	1100	8.0	380	13.1	9.89	
	9	749.0	06-08-2016	1105	8.0	380	13.1	9.89	QAW-48 replicate
	9	749.0	06-28-2017	1425	8.0	374	13.3	8.10	
	9	749.0	06-13-2018	1340	7.9	367	14.4	9.56	
	6	826.8	06-18-2014	1500	7.9	382	13.4	10.0	
	6	826.8	06-08-2016	1153	8.1	388	14.6	7.67	
	3	1,091.1	06-18-2014	1326	7.9	360	14.8	10.3	
	3	1,091.1	06-10-2015	1149	8.1	370	15.0	8.56	
	3	1,091.1	06-10-2015	1154	8.1	370	15.0	8.56	QAW-45 replicate
	3	1,091.1	06-08-2016	0910	8.0	368	14.8	10.0	
	3	1,091.1	06-08-2016	1010	8.4	13	21.9	7.40	QAW-47 equipment blank
	3	1,091.1	06-28-2017	1205	7.9	363	15.6	10.3	
	3	1,091.1	06-28-2017	1210	7.9	363	15.6	10.3	QAW-53 replicate
	3	1,091.1	06-13-2018	1130	7.9	360	15.4	9.24	
	1	1,140.9	06-30-16	1230	7.9	367	15.1	10.6	
	1	1,140.9	06-30-2016	1235	7.9	367	15.1	10.6	QAW-50 replicate

Table 6. Concentrations of dissolved chloride, chromium, sodium, and sulfate in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.

[**Local name:** Local well identifier used in this study (see figure 1 for locations). **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port value as estimated in table 2, shown as feet below land surface (ft bls). **Date** refers to date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy) **RPD:** Relative percent difference in percent. **Remarks:** QAW, quality assurance Westbay™ sample. **Abbreviations and symbol:** NA, Not applicable; NS, Not sampled; µg/L, micrograms per liter; mg/L, milligrams per liter; <, less than]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Chloride (mg/L)	RPD	Chromium (µg/L)	RPD	Sodium (mg/L)	RPD	Sulfate (mg/L)	RPD	Remarks
USGS 103	11	992.9	07-08-2014	12.8	NA	5.81	NA	8.3	NA	21.2	NA	
	11	992.9	06-16-2015	12.5	NA	5.48	NA	8.5	NA	21.2	NA	
	11	992.9	06-14-2016	12.0	NA	5.99	NA	9.0	NA	20.2	NA	
	11	992.9	06-26-2017	12.1	NA	6.57	NA	8.8	NA	20.7	NA	
	11	992.9	06-26-2018	13.6	NA	5.99	NA	9.3	NA	22.0	NA	
	7	1,086.8	07-08-2014	14.3	NA	5.75	NA	8.9	NA	22.3	NA	
	7	1,086.8	06-16-2015	14.4	NA	5.59	NA	8.8	NA	22.9	NA	
	7	1,086.8	06-14-2016	14.0	NA	5.69	NA	9.0	NA	22.1	NA	
	7	1,086.8	06-26-2017	13.5	NA	6.37	NA	8.7	NA	21.7	NA	
	7	1,086.8	06-26-2018	14.6	NA	5.55	NA	9.5	NA	22.9	NA	
	3	1,209.7	07-09-2014	14.2	NA	5.47	NA	8.7	NA	22.4	NA	
	3	1,209.7	06-16-2015	14.4	NA	5.39	NA	8.7	NA	22.9	NA	
	3	1,209.7	06-14-2016	14.2	NA	5.61	NA	9.1	NA	22.3	NA	
	3	1,209.7	06-26-2017	14.1	NA	6.12	NA	8.9	NA	22.1	NA	
	3	1,209.7	06-26-2018	14.4	NA	5.66	NA	9.4	NA	22.8	NA	
	1	1,258.0	07-08-2014	14.3	NA	5.34	NA	9.0	NA	22.5	NA	
	1	1,258.0	07-08-2014	14.2	0.3	5.95	10.8	8.9	1.0	22.6	0.1	QAW-43 replicate
	1	1,258.0	06-16-2015	14.6	NA	5.27	NA	9.1	NA	23.1	NA	
	1	1,258.0	06-14-2016	14.2	NA	5.48	NA	9.3	NA	22.4	NA	
	1	1,258.0	06-26-2017	14.0	NA	5.99	NA	8.7	NA	21.9	NA	
	1	1,258.0	06-26-2018	14.5	NA	5.05	NA	9.6	NA	22.9	NA	

Table 6. Concentrations of dissolved chloride, chromium, sodium, and sulfate in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

[**Local name:** Local well identifier used in this study (see figure 1 for locations). **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port value as estimated in table 2, shown as feet below land surface (ft bls). **Date** refers to date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **RPD:** Relative percent difference in percent. **Remarks:** QAW, quality assurance Westbay™ sample. **Abbreviations and symbol:** NA, Not applicable; NS, Not sampled; µg/L, micrograms per liter; mg/L, milligrams per liter; <, less than]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Chloride (mg/L)	RPD	Chromium (µg/L)	RPD	Sodium (mg/L)	RPD	Sulfate (mg/L)	RPD	Remarks
USGS 105	14	851.2	06-25-2014	11.9	NA	7.10	NA	11.0	NA	25.4	NA	
	14	851.2	06-17-2015	12.0	NA	7.70	NA	11.4	NA	24.9	NA	
	14	851.2	06-16-2016	11.9	NA	7.57	NA	11.5	NA	24.4	NA	
	14	851.2	06-14-2017	12.1	NA	7.57	NA	11.0	NA	24.3	NA	
	14	851.2	06-27-2018	11.7	NA	7.46	NA	11.7	NA	24.3	NA	
	10	951.6	06-26-2014	12.6	NA	6.64	NA	10.1	NA	24.1	NA	
	10	951.6	06-17-2015	12.7	NA	7.13	NA	10.7	NA	24.1	NA	
	10	951.6	06-16-2016	12.4	NA	7.05	NA	10.0	NA	23.1	NA	
	10	951.6	06-14-2017	12.6	NA	6.98	NA	9.9	NA	23.3	NA	
	10	951.6	06-27-2018	12.4	NA	7.40	NA	11.0	NA	23.8	NA	
	6	1,071.6	06-25-2014	12.6	NA	7.26	NA	10.6	NA	25.4	NA	
	6	1,071.6	06-17-2015	12.7	NA	7.30	NA	10.8	NA	24.9	NA	
	6	1,071.6	06-16-2016	12.6	NA	7.38	NA	10.9	NA	24.4	NA	
	6	1,071.6	06-14-2017	12.8	NA	7.28	NA	9.9	NA	24.3	NA	
	6	1,071.6	06-27-2018	12.7	NA	8.44	NA	11.6	NA	24.3	NA	

Table 6. Concentrations of dissolved chloride, chromium, sodium, and sulfate in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

[**Local name:** Local well identifier used in this study (see figure 1 for locations). **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port value as estimated in table 2, shown as feet below land surface (ft bls). **Date** refers to date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **RPD:** Relative percent difference in percent. **Remarks:** QAW, quality assurance Westbay™ sample. **Abbreviations and symbol:** NA, Not applicable; NS, Not sampled; µg/L, micrograms per liter; mg/L, milligrams per liter; <, less than]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Chloride (mg/L)	RPD	Chromium (µg/L)	RPD	Sodium (mg/L)	RPD	Sulfate (mg/L)	RPD	Remarks
USGS 108	12	808.8	06-25-2014	16.2	NA	5.65	NA	8.4	NA	24.8	NA	
	12	808.8	06-25-2014	16.2	0.1	5.92	4.6	8.3	1.1	24.8	0.1	QAW-44 replicate
	12	808.8	06-18-2015	16.2	NA	6.20	NA	8.8	NA	24.5	NA	
	12	808.8	06-15-2016	16.0	NA	5.93	NA	8.7	NA	24.1	NA	
	12	808.8	06-20-2017	16.1	NA	5.99	NA	8.4	NA	24.1	NA	
	12	808.8	06-20-2017	16.1	0.0	6.06	1.3	8.7	2.7	24.1	0.0	QAW-51 replicate
	12	808.8	06-25-2018	16.2	NA	5.25	NA	9.0	NA	24.3	NA	
	12	808.8	06-25-2018	16.2	0.0	5.95	12.4	9.1	1.3	24.3	0.1	QAW-55 replicate
	1	1,171.8	06-24-2014	17.2	NA	5.15	NA	7.8	NA	25.4	NA	
	1	1,171.8	06-18-2015	17.1	NA	5.38	NA	8.3	NA	25.0	NA	
	1	1,171.8	06-15-2016	17.0	NA	5.50	NA	8.1	NA	24.7	NA	
	1	1,171.8	06-15-2016	17.0	0.0	NS	NA	8.6	6.5	24.6	0.0	QAW-49 replicate
USGS 131A	1	1,171.8	06-20-2017	17.2	NA	5.86	NA	8.1	NA	24.9	NA	
	1	1,171.8	06-25-2018	16.6	NA	5.46	NA	8.2	NA	24.5	NA	
	15	615.6	06-19-2014	16.5	NA	9.52	NA	7.4	NA	23.1	NA	
	15	615.6	06-15-2015	17.1	NA	9.16	NA	7.9	NA	24.0	NA	
	15	615.6	06-29-2016	17.0	NA	10.6	NA	8.0	NA	23.3	NA	
	15	615.6	06-22-2017	16.4	NA	10.7	NA	7.8	NA	22.9	NA	
	15	615.6	06-19-2018	16.4	NA	9.11	NA	8.2	NA	22.9	NA	
	10	811.2	06-19-2014	26.2	NA	9.52	NA	8.8	NA	27.5	NA	
	10	811.2	06-15-2015	26.4	NA	8.98	NA	9.4	NA	28.3	NA	
	10	811.2	06-29-2016	25.4	NA	9.58	NA	9.6	NA	27.4	NA	
	10	811.2	06-22-2017	25.0	NA	10.6	NA	9.7	NA	27.1	NA	
	10	811.2	06-19-2018	24.6	NA	10.9	NA	9.9	NA	27.1	NA	
	6	980.3	06-19-2014	13.0	NA	4.65	NA	7.7	NA	22.9	NA	
	6	980.3	06-15-2015	13.3	NA	4.72	NA	8.2	NA	23.7	NA	
	3	1,136.1	06-19-2014	13.3	NA	4.51	NA	7.5	NA	23.0	NA	
	3	1,136.1	06-15-2015	13.6	NA	4.75	NA	8.0	NA	23.6	NA	

Table 6. Concentrations of dissolved chloride, chromium, sodium, and sulfate in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

[**Local name:** Local well identifier used in this study (see figure 1 for locations). **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port value as estimated in table 2, shown as feet below land surface (ft bls). **Date** refers to date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **RPD:** Relative percent difference in percent. **Remarks:** QAW, quality assurance Westbay™ sample. **Abbreviations and symbol:** NA, Not applicable; NS, Not sampled; µg/L, micrograms per liter; mg/L, milligrams per liter; <, less than]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Chloride (mg/L)	RPD	Chromium (µg/L)	RPD	Sodium (mg/L)	RPD	Sulfate (mg/L)	RPD	Remarks
USGS 132	18	765.4	06-17-2014	10.9	NA	6.85	NA	9.3	NA	25.1	NA	
	18	765.4	06-09-2015	10.8	NA	7.67	NA	10.1	NA	24.7	NA	
	18	765.4	06-07-2016	10.9	NA	8.08	NA	9.6	NA	25.2	NA	
	18	765.4	06-13-2017	10.9	NA	7.82	NA	9.3	NA	24.9	NA	
	18	765.4	06-20-2018	12.3	NA	7.90	NA	12.9	NA	27.6	NA	
USGS 133	12	469.1	06-17-2014	11.9	NA	6.35	NA	8.2	NA	19.0	NA	
	12	469.1	06-17-2014	<0.02	NA	<0.6	NA	<0.06	NA	<0.02	NA	QAW-42 equipment blank
	12	469.1	06-09-2015	11.7	NA	7.81	NA	8.8	NA	18.7	NA	
	12	469.1	06-13-2016	11.6	NA	8.75	NA	8.6	NA	19.0	NA	
	12	469.1	06-21-2017	11.5	NA	9.52	NA	8.4	NA	18.8	NA	
	12	469.1	06-12-2018	11.2	NA	8.91	NA	8.2	NA	18.6	NA	
USGS 134	19	645.5	06-16-2014	9.6	NA	5.53	NA	7.6	NA	19.9	NA	
	19	645.5	06-08-2015	9.5	NA	6.35	NA	8.4	NA	19.6	NA	
	19	645.5	06-06-2016	9.6	NA	6.29	NA	7.7	NA	20.0	NA	
	19	645.5	06-12-2017	9.6	NA	6.47	NA	7.7	NA	19.9	NA	
	19	645.5	06-11-2018	9.5	NA	5.95	NA	8.1	NA	20.0	NA	
USGS 135	9	836.7	06-23-2014	6.7	NA	2.30	NA	6.1	NA	19.5	NA	
	9	836.7	06-11-2015	6.7	NA	2.73	NA	6.6	NA	19.3	NA	
	9	836.7	06-09-2016	6.8	NA	2.78	NA	6.3	NA	19.7	NA	
	9	836.7	06-15-2017	6.8	NA	2.71	NA	6.2	NA	19.8	NA	
	9	836.7	06-14-2018	6.8	NA	2.59	NA	6.6	NA	19.6	NA	

Table 6. Concentrations of dissolved chloride, chromium, sodium, and sulfate in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

[**Local name:** Local well identifier used in this study (see figure 1 for locations). **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port value as estimated in table 2, shown as feet below land surface (ft bls). **Date** refers to date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **RPD:** Relative percent difference in percent. **Remarks:** QAW, quality assurance Westbay™ sample. **Abbreviations and symbol:** NA, Not applicable; NS, Not sampled; µg/L, micrograms per liter; mg/L, milligrams per liter; <, less than]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Chloride (mg/L)	RPD	Chromium (µg/L)	RPD	Sodium (mg/L)	RPD	Sulfate (mg/L)	RPD	Remarks
USGS 137A	7	660.9	07-10-2014	14.2	NA	6.14	NA	11.8	NA	26.8	NA	
	7	660.9	06-22-2015	13.7	NA	6.36	NA	12.0	NA	26.3	NA	
	7	660.9	06-13-2016	13.7	NA	6.80	NA	12.0	NA	26.0	NA	
	7	660.9	06-19-2017	13.7	NA	6.94	NA	11.8	NA	25.8	NA	
	7	660.9	06-18-2018	13.4	NA	7.98	NA	12.1	NA	25.5	NA	
	5	746.8	07-10-2014	12.4	NA	5.92	NA	10.5	NA	25.7	NA	
	5	746.8	06-22-2015	12.1	NA	5.54	NA	11.1	NA	25.5	NA	
	5	746.8	06-13-2016	12.0	NA	6.60	NA	11.4	NA	24.9	NA	
	5	746.8	06-19-2017	12.0	NA	6.48	NA	10.8	NA	24.8	NA	
	5	746.8	06-18-2018	12.1	NA	5.94	NA	11.6	NA	24.9	NA	
MIDDLE 2050A	5	746.8	06-18-2018	0.10	NA	<0.6	NA	<0.4	NA	0.03	NA	QAW-54 field blank
	3	840.7	07-09-2014	11.1	NA	5.59	NA	9.6	NA	24.8	NA	
	3	840.7	06-22-2015	11.1	NA	6.01	NA	10.6	NA	24.9	NA	
	1	875.1	07-09-2014	11.1	NA	5.75	NA	10.1	NA	24.9	NA	
	1	875.1	06-22-2015	11.1	NA	5.28	NA	10.6	NA	24.9	NA	
	15	516.8	06-26-2014	12.5	NA	7.06	NA	7.6	NA	23.0	NA	
	15	516.8	06-23-2015	<0.02	NA	<0.6	NA	<0.06	NA	<0.02	NA	QAW-46 field blank
	15	516.8	06-23-2015	12.3	NA	7.22	NA	8.3	NA	23.2	NA	
	15	516.8	06-20-2016	11.9	NA	8.42	NA	8.3	NA	22.7	NA	
	15	516.8	06-21-2017	<0.02	NA	<0.6	NA	<0.1	NA	<0.02	NA	QAW-52 field blank
	15	516.8	06-21-2017	5.2	NA	2.22	NA	6.9	NA	19.2	NA	
	15	516.8	06-12-2018	4.2	NA	0.86	NA	7.0	NA	18.4	NA	

Table 6. Concentrations of dissolved chloride, chromium, sodium, and sulfate in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

[**Local name:** Local well identifier used in this study (see figure 1 for locations). **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port value as estimated in table 2, shown as feet below land surface (ft bls). **Date** refers to date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **RPD:** Relative percent difference in percent. **Remarks:** QAW, quality assurance Westbay™ sample. **Abbreviations and symbol:** NA, Not applicable; NS, Not sampled; µg/L, micrograms per liter; mg/L, milligrams per liter; <, less than]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Chloride (mg/L)	RPD	Chromium (µg/L)	RPD	Sodium (mg/L)	RPD	Sulfate (mg/L)	RPD	Remarks
MIDDLE 2051	9	749.0	06-10-2015	10.5	NA	6.68	NA	9.0	NA	25.1	NA	
	9	749.0	06-08-2016	10.7	NA	6.58	NA	8.2	NA	25.6	NA	
	9	749.0	06-28-2017	10.7	NA	6.69	NA	8.5	NA	25.3	NA	
	9	749.0	06-13-2018	10.5	NA	6.61	NA	9.0	NA	25.0	NA	
	6	826.8	06-18-2014	11.0	NA	6.17	NA	8.2	NA	26.5	NA	
	3	1,091.1	06-18-2014	11.7	NA	5.64	NA	7.3	NA	22.8	NA	
	3	1,091.1	06-10-2015	11.5	NA	6.64	NA	8.4	NA	22.6	NA	
	3	1,091.1	06-10-2015	11.5	0.1	6.72	1.3	8.3	1.7	22.6	0.1	QAW-45 replicate
	3	1,091.1	06-08-2016	11.6	NA	6.26	NA	7.9	NA	23.0	NA	
	3	1,091.1	06-08-2016	0.03	NA	<0.6	NA	<0.06	NA	0.02	NA	QAW-47 equipment blank
	3	1,091.1	06-28-2017	11.6	NA	6.69	NA	7.8	NA	22.8	NA	
	3	1,091.1	06-28-2017	11.6	0.3	6.64	0.7	7.9	0.9	22.9	0.2	QAW-53 replicate
	3	1,091.1	06-13-2018	11.6	NA	6.68	NA	8.5	NA	22.8	NA	
	1	1,140.9	06-30-2016	11.7	NA	6.70	NA	8.6	NA	23.0	NA	

Table 7. Concentrations of dissolved nutrients in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.

[**Local name:** Local well identifier used in this study (see [figure 1](#) for locations). **Port number:** Identifier used to locate port couplings (see [table 2](#)). **Port depth:** Depth to the port value as estimated in [table 2](#), shown as feet below land surface (ft bis). **Date:** Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **RPD:** Relative percent difference in percent. NA, Not applicable. **Remarks:** QAW, quality assurance Westbay™ sample. **Abbreviation and symbol:** mg/L, milligrams per liter; <, less than]

Local name	Port number	Port depth (ft bis)	Date (mm-dd-yyyy)	Ammonia (as nitrogen) (mg/L)		Nitrite (as nitrogen) (mg/L)		Nitrite plus nitrate (as nitrogen) (mg/L)		Ortho-phosphate (as phosphorus) (mg/L)		Remarks
				RPD		RPD		RPD		RPD		
USGS 103	11	992.9	07-09-2014	<0.01	NA	<0.001	NA	0.702	NA	0.016	NA	
	11	992.9	06-16-2015	<0.01	NA	<0.001	NA	0.643	NA	0.018	NA	
	11	992.9	06-15-2016	<0.01	NA	<0.001	NA	0.675	NA	0.015	NA	
	11	992.9	06-26-2017	<0.01	NA	<0.001	NA	0.680	NA	0.017	NA	
	11	992.9	06-26-2018	<0.01	NA	<0.001	NA	0.743	NA	0.017	NA	
	7	1,086.8	07-09-2014	<0.01	NA	<0.001	NA	0.820	NA	0.018	NA	
	7	1,086.8	06-16-2015	<0.01	NA	<0.001	NA	0.713	NA	0.019	NA	
	7	1,086.8	06-14-2016	<0.01	NA	<0.001	NA	0.792	NA	0.019	NA	
	7	1,086.8	06-26-2017	<0.01	NA	<0.001	NA	0.774	NA	0.018	NA	
	7	1,086.8	06-26-2018	<0.01	NA	<0.001	NA	0.801	NA	0.015	NA	
	3	1,209.7	07-09-2014	<0.01	NA	<0.001	NA	0.777	NA	0.017	NA	
	3	1,209.7	06-16-2015	<0.01	NA	<0.001	NA	0.700	NA	0.019	NA	
	3	1,209.7	06-14-2016	0.014	NA	<0.001	NA	0.807	NA	0.019	NA	
	3	1,209.7	06-26-2017	<0.01	NA	<0.001	NA	0.815	NA	0.019	NA	
	3	1,209.7	06-26-2018	<0.01	NA	<0.001	NA	0.763	NA	0.021	NA	
	1	1,258.0	07-08-2014	<0.01	NA	<0.001	NA	0.807	NA	0.019	NA	
	1	1,258.0	07-08-2014	<0.01	0.0	<0.001	0.0	0.807	0.0	0.017	7.6	QAW-43 replicate
	1	1,258.0	06-16-2015	<0.01	NA	<0.001	NA	0.718	NA	0.019	NA	
	1	1,258.0	06-14-2016	<0.01	NA	<0.001	NA	0.815	NA	0.019	NA	
	1	1,258.0	06-26-2017	<0.01	NA	<0.001	NA	0.796	NA	0.017	NA	
	1	1,258.0	06-26-2018	0.022	NA	<0.001	NA	0.764	NA	0.020	NA	

Table 7. Concentrations of dissolved nutrients in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

[**Local name:** Local well identifier used in this study (see figure 1 for locations). **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port value as estimated in table 2, shown as feet below land surface (ft bls). **Date:** Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **RPD:** Relative percent difference in percent. NA, Not applicable. **Remarks:** QAW, quality assurance Westbay™ sample. **Abbreviation and symbol:** mg/L, milligrams per liter; <, less than]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Ammonia (as nitrogen) (mg/L)		Nitrite (as nitrogen) (mg/L)		Nitrite plus nitrate (as nitrogen) (mg/L)		Ortho-phosphate (as phosphorus) (mg/L)		Remarks
				RPD	NA	RPD	NA	RPD	NA	RPD	NA	
USGS 105	14	851.2	06-25-2014	<0.01	NA	<0.001	NA	0.721	NA	0.019	NA	
	14	851.2	06-17-2015	<0.01	NA	<0.001	NA	0.689	NA	0.020	NA	
	14	851.2	06-16-2016	<0.01	NA	<0.001	NA	0.736	NA	0.011	NA	
	14	851.2	06-14-2017	<0.01	NA	<0.001	NA	0.735	NA	0.018	NA	
	14	851.2	06-27-2018	<0.01	NA	0.0011	NA	0.711	NA	0.019	NA	
	10	951.6	06-26-2014	<0.01	NA	<0.001	NA	0.774	NA	0.049	NA	
	10	951.6	06-17-2015	<0.01	NA	<0.001	NA	0.778	NA	0.020	NA	
	10	951.6	06-16-2016	<0.01	NA	<0.001	NA	0.812	NA	0.017	NA	
	10	951.6	06-14-2017	<0.01	NA	<0.001	NA	0.826	NA	0.018	NA	
	10	951.6	06-27-2018	<0.01	NA	<0.001	NA	0.781	NA	0.020	NA	
	6	1,071.6	06-25-2014	<0.01	NA	<0.001	NA	0.754	NA	0.018	NA	
	6	1,071.6	06-17-2015	<0.01	NA	<0.001	NA	0.754	NA	0.019	NA	
	6	1,071.6	06-16-2016	<0.01	NA	<0.001	NA	0.956	NA	0.017	NA	
	6	1,071.6	06-14-2017	<0.01	NA	<0.001	NA	0.838	NA	0.019	NA	
	6	1,071.6	06-27-2018	<0.01	NA	<0.001	NA	0.728	NA	0.020	NA	

Table 7. Concentrations of dissolved nutrients in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

[**Local name:** Local well identifier used in this study (see figure 1 for locations). **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port value as estimated in table 2, shown as feet below land surface (ft bls). **Date:** Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **RPD:** Relative percent difference in percent. NA, Not applicable. **Remarks:** QAW, quality assurance Westbay™ sample. **Abbreviation and symbol:** mg/L, milligrams per liter; <, less than]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Ammonia (as nitrogen) (mg/L)	RPD	Nitrite (as nitrogen) (mg/L)	RPD	Nitrite plus nitrate (as nitrogen) (mg/L)	RPD	Ortho-phosphate (as phosphorus) (mg/L)	RPD	Remarks
USGS 108	12	808.8	06-25-2014	<0.01	NA	<0.001	NA	0.927	NA	0.019	NA	
	12	808.8	06-25-2014	<0.01	NA	<0.001	0.0	0.924	0.2	0.019	1.1	QAW-44 replicate
	12	808.8	06-18-2015	<0.01	NA	<0.001	NA	0.881	NA	0.020	NA	
	12	808.8	06-15-2016	<0.01	NA	<0.001	NA	0.919	NA	0.018	NA	
	12	808.8	06-20-2017	<0.01	NA	<0.001	NA	0.896	NA	0.018	NA	
	12	808.8	06-20-2017	<0.01	NA	<0.001	NA	0.897	0.1	0.018	1.3	QAW-51 replicate
	12	808.8	06-25-2018	<0.01	NA	<0.001	NA	0.881	NA	0.020	NA	
	12	808.8	06-25-2018	<0.01	NA	<0.001	NA	0.895	1.6	0.019	9.2	QAW-55 replicate
	1	1,171.8	06-24-2014	0.014	NA	0.003	NA	1.02	NA	0.025	NA	
	1	1,171.8	06-18-2015	<0.01	NA	0.010	NA	0.984	NA	0.027	NA	
	1	1,171.8	06-15-2016	<0.01	NA	0.002	NA	1.02	NA	0.026	NA	
	1	1,171.8	06-15-2016	<0.01	NA	<0.001	NA	1.03	0.1	0.026	1.2	QAW-49 replicate
	1	1,171.8	06-20-2017	<0.01	NA	<0.001	NA	1.00	NA	0.026	NA	
	1	1,171.8	06-25-2018	<0.01	NA	<0.001	NA	1.02	NA	0.021	NA	

Table 7. Concentrations of dissolved nutrients in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

[**Local name:** Local well identifier used in this study (see figure 1 for locations). **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port value as estimated in table 2, shown as feet below land surface (ft bls). **Date:** Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **RPD:** Relative percent difference in percent. NA, Not applicable. **Remarks:** QAW, quality assurance Westbay™ sample. **Abbreviation and symbol:** mg/L, milligrams per liter; <, less than]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Ammonia (as nitrogen) (mg/L)		Nitrite (as nitrogen) (mg/L)		Nitrite plus nitrate (as nitrogen) (mg/L)		Ortho-phosphate (as phosphorus) (mg/L)		Remarks
				RPD	NA	RPD	NA	RPD	NA	RPD	NA	
USGS 131A	15	615.6	06-19-2014	<0.01	NA	<0.001	NA	0.902	NA	0.019	NA	QAW-42 equipment blank
	15	615.6	06-15-2015	<0.01	NA	<0.001	NA	0.872	NA	0.022	NA	
	15	615.6	06-29-2016	<0.01	NA	<0.001	NA	0.859	NA	0.021	NA	
	15	615.6	06-22-2017	<0.01	NA	<0.001	NA	0.893	NA	0.022	NA	
	15	615.6	06-19-2018	<0.01	NA	<0.001	NA	0.870	NA	0.023	NA	
	10	811.2	06-19-2014	<0.01	NA	<0.001	NA	1.31	NA	0.017	NA	
	10	811.2	06-15-2015	<0.01	NA	<0.001	NA	1.23	NA	0.018	NA	
	10	811.2	06-29-2016	<0.01	NA	<0.001	NA	1.22	NA	0.018	NA	
	10	811.2	06-22-2017	<0.01	NA	<0.001	NA	1.29	NA	0.018	NA	
	10	811.2	06-19-2018	<0.01	NA	<0.001	NA	1.27	NA	0.018	NA	
	6	980.3	06-19-2014	<0.01	NA	<0.001	NA	1.04	NA	0.017	NA	
	6	980.3	06-15-2015	<0.01	NA	<0.001	NA	0.982	NA	0.020	NA	
USGS 132	3	1,136.1	06-19-2014	<0.01	NA	<0.001	NA	1.05	NA	0.017	NA	
	3	1,136.1	06-15-2015	<0.01	NA	<0.001	NA	0.990	NA	0.019	NA	
	18	765.4	06-17-2014	<0.01	NA	<0.001	NA	0.765	NA	0.020	NA	
	18	765.4	06-09-2015	<0.01	NA	<0.001	NA	0.717	NA	0.021	NA	
	18	765.4	06-07-2016	<0.01	NA	<0.001	NA	0.719	NA	0.023	NA	
USGS 133	18	765.4	06-13-2017	<0.01	NA	<0.001	NA	0.737	NA	0.021	NA	
	18	765.4	06-20-2018	<0.01	NA	<0.001	NA	0.886	NA	0.021	NA	
	12	469.1	06-17-2014	<0.01	NA	<0.001	NA	0.818	NA	0.020	NA	
	12	469.1	06-17-2014	0.014	NA	<0.001	NA	<0.04	NA	<0.004	NA	
	12	469.1	06-09-2015	<0.01	NA	<0.001	NA	0.779	NA	0.022	NA	
	12	469.1	06-13-2016	<0.01	NA	<0.001	NA	0.808	NA	0.023	NA	
	12	469.1	06-21-2017	<0.01	NA	<0.001	NA	0.789	NA	0.023	NA	
	12	469.1	06-12-2018	<0.01	NA	<0.001	NA	0.827	NA	0.024	NA	

Table 7. Concentrations of dissolved nutrients in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

[**Local name:** Local well identifier used in this study (see figure 1 for locations). **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port value as estimated in table 2, shown as feet below land surface (ft bls). **Date:** Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **RPD:** Relative percent difference in percent. NA, Not applicable. **Remarks:** QAW, quality assurance Westbay™ sample. **Abbreviation and symbol:** mg/L, milligrams per liter; <, less than]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Ammonia (as nitrogen) (mg/L)	RPD	Nitrite (as nitrogen) (mg/L)	RPD	Nitrite plus nitrate (as nitrogen) (mg/L)	RPD	Ortho-phosphate (as phosphorus) (mg/L)	RPD	Remarks
USGS 134	19	645.5	06-16-2014	<0.01	NA	<0.001	NA	0.646	NA	0.078	NA	
	19	645.5	06-08-2015	<0.01	NA	<0.001	NA	0.622	NA	0.099	NA	
	19	645.5	06-06-2016	<0.01	NA	<0.001	NA	0.612	NA	0.083	NA	
	19	645.5	06-12-2017	<0.01	NA	<0.001	NA	0.636	NA	0.077	NA	
	19	645.5	06-11-2018	0.011	NA	<0.001	NA	0.706	NA	0.071	NA	
USGS 135	9	836.7	06-23-2014	<0.01	NA	<0.001	NA	0.578	NA	0.017	NA	
	9	836.7	06-11-2015	<0.01	NA	<0.001	NA	0.564	NA	0.018	NA	
	9	836.7	06-09-2016	<0.01	NA	<0.001	NA	0.603	NA	0.020	NA	
	9	836.7	06-15-2017	<0.01	NA	<0.001	NA	0.609	NA	0.019	NA	
	9	836.7	06-14-2018	<0.01	NA	<0.001	NA	0.619	NA	0.020	NA	
USGS 137A	7	660.9	07-10-2014	<0.01	NA	<0.001	NA	0.707	NA	0.016	NA	
	7	660.9	06-22-2015	<0.01	NA	<0.001	NA	0.670	NA	0.018	NA	
	7	660.9	06-13-2016	<0.01	NA	<0.001	NA	0.729	NA	0.019	NA	
	7	660.9	06-19-2017	<0.01	NA	<0.001	NA	0.719	NA	0.017	NA	
	7	660.9	06-18-2018	<0.01	NA	<0.001	NA	0.740	NA	0.017	NA	
	5	746.8	07-10-2014	<0.01	NA	<0.001	NA	0.663	NA	0.017	NA	
	5	746.8	06-22-2015	<0.01	NA	<0.001	NA	0.663	NA	0.017	NA	
	5	746.8	06-13-2016	<0.01	NA	<0.001	NA	0.623	NA	0.019	NA	
	5	746.8	06-19-2017	<0.01	NA	<0.001	NA	0.683	NA	0.020	NA	
	5	746.8	06-18-2018	<0.01	NA	<0.001	NA	0.665	NA	0.016	NA	
	5	746.8	06-18-2018	<0.01	NA	<0.001	NA	0.802	18.6	0.020	23.9	QAW-54 field blank
	3	840.7	07-09-2014	0.013	NA	<0.001	NA	0.632	NA	0.016	NA	
	3	840.7	06-22-2015	<0.01	NA	<0.001	NA	0.602	NA	0.020	NA	
	1	875.1	07-09-2014	0.016	NA	<0.001	NA	0.637	NA	0.016	NA	
	1	875.1	06-22-2015	<0.01	NA	<0.001	NA	0.612	NA	0.021	NA	

Table 7. Concentrations of dissolved nutrients in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

[**Local name:** Local well identifier used in this study (see figure 1 for locations). **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port value as estimated in table 2, shown as feet below land surface (ft bls). **Date:** Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **RPD:** Relative percent difference in percent. NA, Not applicable. **Remarks:** QAW, quality assurance Westbay™ sample. **Abbreviation and symbol:** mg/L, milligrams per liter; <, less than]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Ammonia (as nitrogen) (mg/L)	Nitrite (as nitrogen) (mg/L)	RPD	Nitrite plus nitrate (as nitrogen) (mg/L)	RPD	Ortho-phosphate (as phosphorus) (mg/L)	RPD	Remarks
MIDDLE 2050A	15	516.8	06-26-2014	0.012	<0.001	NA	0.729	NA	0.039	NA	
	15	516.8	06-23-2015	<0.01	<0.001	NA	<0.04	NA	<0.004	NA	QAW-46 field blank
	15	516.8	06-23-2015	<0.01	<0.001	NA	0.689	NA	0.031	NA	
	15	516.8	06-20-2016	<0.01	<0.001	NA	0.731	NA	0.028	NA	
	15	516.8	06-21-2017	<0.01	<0.001	NA	<0.04	NA	<0.004	NA	QAW-52 field blank
	15	516.8	06-21-2017	<0.01	<0.001	NA	0.547	NA	0.028	NA	
	15	516.8	06-12-2018	<0.01	<0.001	NA	0.451	NA	0.028	NA	
MIDDLE 2051	9	749.0	06-10-2015	<0.01	<0.001	NA	0.817	NA	0.024	NA	
	9	749.0	06-08-2016	<0.01	<0.001	NA	0.847	NA	0.024	NA	
	9	749.0	06-28-2017	<0.01	<0.001	NA	0.845	NA	0.023	NA	
	9	749.0	06-13-2018	<0.01	<0.001	NA	0.830	NA	0.023	NA	
	6	826.8	06-18-2014	<0.01	<0.001	NA	0.903	NA	0.024	NA	
	3	1,091.1	06-18-2014	<0.01	<0.001	NA	0.917	NA	0.018	NA	
	3	1,091.1	06-10-2015	0.011	<0.001	NA	0.876	NA	0.018	NA	QAW-45 replicate
	3	1,091.1	06-10-2015	0.010	<0.001	4.3	0.871	0.5	0.018	0.6	
	3	1,091.1	06-08-2016	<0.01	<0.001	NA	0.908	NA	0.019	NA	
	3	1,091.1	06-08-2016	<0.01	<0.001	NA	<0.04	NA	<0.004	NA	QAW-47 equipment blank
	3	1,091.1	06-28-2017	<0.01	<0.001	NA	0.907	NA	0.017	NA	
	3	1,091.1	06-28-2017	<0.01	<0.001	NA	0.900	0.8	0.016	2.5	QAW-53 replicate
	3	1,091.1	06-13-2018	<0.01	<0.001	NA	0.941	NA	0.020	NA	
	1	1,140.9	06-30-2016	<0.01	<0.001	NA	0.842	NA	0.018	NA	

Table 8. Concentrations of gross alpha-particle radioactivity, gross-beta particle radioactivity, tritium, and cesium-137 in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.

Analytical uncertainties are reported as 1 sample standard deviation (s). Concentrations that meet or exceed the reporting level of 3 times the 1s value are shown in **boldface** type. Z-values associated with quality-assurance replicates were calculated using [equation 1](#). Samples were analyzed at the Radiological and Environmental Sciences Laboratory. **Local name:** Local well identifier used in this study (see [figure 1](#) for locations). USGS, U.S. Geological Survey. **Port number:** Identifier used to locate port couplings (see [table 2](#)). **Port depth:** Depth to the port as shown in [table 2](#), in feet below land surface (ft bls). **Date:** Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **Remarks:** QAW, quality assurance Westbay™ sample. **Abbreviations:** NA, Not applicable; NS, Not sampled; pCi/L, picocuries per liter

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Gross alpha particle activity (pCi/L)	Z-value	Gross beta-particle radioactivity (pCi/L)	Z-value	Tritium (pCi/L)	Z-value	Cesium-137 (pCi/L)	Z-value	Remarks
USGS 103	11	992.9	07-09-2014	0±2	NA	1.7±0.8	NA	130±50	NA	6±6	NA	
	11	992.9	06-16-2015	0±2	NA	0±1.2	NA	100±50	NA	14±7	NA	
	11	992.9	06-15-2016	-2.6±1.5	NA	0.8±1	NA	140±50	NA	NS	NA	
	11	992.9	06-26-2017	-2±2	NA	2.2±0.9	NA	90±50	NA	NS	NA	
	11	992.9	06-26-2018	2±2	NA	3.7±0.9	NA	100±50	NA	NS	NA	
	7	1,086.8	07-09-2014	4±2	NA	1±0.7	NA	200±50	NA	5±9	NA	
	7	1,086.8	06-16-2015	-1±2	NA	1±0.8	NA	150±50	NA	18±8	NA	
	7	1,086.8	06-14-2016	1±1.6	NA	1.5±0.8	NA	210±50	NA	NS	NA	
	7	1,086.8	06-26-2017	-2±2	NA	3±0.9	NA	130±50	NA	NS	NA	
	7	1,086.8	06-26-2018	1.65±1.76	NA	2.6±0.8	NA	240±50	NA	NS	NA	
	3	1,209.7	07-09-2014	7±3	NA	2.9±0.8	NA	230±60	NA	NS	NA	
	3	1,209.7	06-16-2015	1.09±2.32	NA	0.3±0.7	NA	150±50	NA	16±9	NA	
	3	1,209.7	06-14-2016	0.6±1.6	NA	0.6±0.8	NA	220±50	NA	19±8	NA	
	3	1,209.7	06-26-2017	1±1.79	NA	3.2±0.8	NA	220±50	NA	NS	NA	
	3	1,209.7	06-26-2018	3±2	NA	3.6±0.8	NA	180±50	NA	NS	NA	
	1	1,258.0	07-08-2014	2±2	NA	1.9±0.8	NA	310±60	NA	10±6	NA	
	1	1,258.0	07-08-2014	0±4	0.45	2.5±0.9	0.50	190±50	1.54	23±9	1.2	QAW-43 replicate
	1	1,258.0	06-16-2015	-6±2	NA	2.1±1	NA	160±50	NA	8±7	NA	
	1	1,258.0	06-14-2016	-0.7±1.6	NA	1±0.9	NA	250±50	NA	NS	NA	
	1	1,258.0	06-26-2017	1.24±1.87	NA	1±0.7	NA	110±50	NA	NS	NA	
	1	1,258.0	06-26-2018	3±2	NA	3±0.8	NA	160±50	NA	NS	NA	

Table 8. Concentrations of gross alpha-particle radioactivity, gross-beta particle radioactivity, tritium, and cesium-137 in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

Analytical uncertainties are reported as 1 sample standard deviation (s). Concentrations that meet or exceed the reporting level of 3 times the 1s value are shown in **boldface** type. Z-values associated with quality-assurance replicates were calculated using equation 1. Samples were analyzed at the Radiological and Environmental Sciences Laboratory. **Local name:** Local well identifier used in this study (see figure 1 for locations). USGS, U.S. Geological Survey. **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port as shown in table 2, in feet below land surface (ft bls). **Date:** Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **Remarks:** QAW, quality assurance Westbay™ sample. **Abbreviations:** NA, Not applicable; NS, Not sampled; pCi/L, picocuries per liter]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Gross alpha particle activity (pCi/L)	Z-value	Gross beta-particle radioactivity (pCi/L)	Z-value	Tritium (pCi/L)	Z-value	Cesium-137 (pCi/L)	Z-value	Remarks
USGS 105	14	851.2	06-25-2014	1.54±1.91	NA	2.4±0.8	NA	90±50	NA	1.39±5.69	NA	
	14	851.2	06-17-2015	9±3	NA	1.7±0.7	NA	110±50	NA	23±8	NA	
	14	851.2	06-16-2016	-0.7±1.7	NA	2.3±0.9	NA	210±50	NA	NS	NA	
	14	851.2	06-14-2017	0±2	NA	2±0.8	NA	230±50	NA	NS	NA	
	14	851.2	06-27-2018	5±2	NA	2.5±0.8	NA	100±50	NA	NS	NA	
	10	951.6	06-26-2014	0±4	NA	2.9±0.9	NA	460±60	NA	31±12	NA	
	10	951.6	06-17-2015	-4±2	NA	1.7±1	NA	150±50	NA	18±7	NA	
	10	951.6	06-16-2016	-1.6±1.6	NA	1.3±0.9	NA	210±50	NA	NS	NA	
	10	951.6	06-14-2017	0±2	NA	3.2±0.9	NA	140±50	NA	NS	NA	
	10	951.6	06-27-2018	1.66±1.77	NA	2.1±0.8	NA	170±50	NA	NS	NA	
	6	1,071.6	06-25-2014	0±2	NA	2±0.8	NA	200±50	NA	24±10	NA	
	6	1,071.6	06-17-2015	-2±2	NA	0.8±0.9	NA	180±50	NA	7±6	NA	
	6	1,071.6	06-16-2016	-0.5±1.7	NA	2.1±0.9	NA	190±50	NA	NS	NA	
	6	1,071.6	06-14-2017	1±2	NA	2.4±0.8	NA	220±50	NA	NS	NA	
	6	1,071.6	06-27-2018	2±2	NA	1.6±0.8	NA	270±50	NA	NS	NA	

Table 8. Concentrations of gross alpha-particle radioactivity, gross-beta particle radioactivity, tritium, and cesium-137 in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

Analytical uncertainties are reported as 1 sample standard deviation (s). Concentrations that meet or exceed the reporting level of 3 times the 1s value are shown in **boldface** type. Z-values associated with quality-assurance replicates were calculated using equation 1. Samples were analyzed at the Radiological and Environmental Sciences Laboratory. **Local name:** Local well identifier used in this study (see figure 1 for locations). USGS, U.S. Geological Survey. **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port as shown in table 2, in feet below land surface (ft bis). **Date:** Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **Remarks:** QAW, quality assurance Westbay™ sample. **Abbreviations:** NA, Not applicable; NS, Not sampled; pCi/L, picocuries per liter

Local name	Port number	Port depth (ft bis)	Date (mm-dd-yyyy)	Gross alpha particle activity (pCi/L)	Z-value	Gross beta-particle radioactivity (pCi/L)	Z-value	Tritium (pCi/L)	Z-value	Cesium-137 (pCi/L)	Z-value	Remarks
USGS 108	12	808.8	06-25-2014	15±4	NA	4.7±0.8	NA	30±50	NA	20±9	NA	
	12	808.8	06-25-2014	0±2	3.35	0.7±0.8	3.54	10±50	0.28	10±6	0.92	QAW-44 replicate
	12	808.8	06-18-2015	-4±2	NA	0.8±1.1	NA	30±50	NA	16±9	NA	
	12	808.8	06-15-2016	2±2	NA	2.5±0.8	NA	110±50	NA	NS	NA	
	12	808.8	06-20-2017	-1±2	NA	3.1±0.9	NA	60±50	NA	NS	NA	
	12	808.8	06-20-2017	-2±2	0.35	2.6±0.9	0.39	70±50	0.14	NS	NA	QAW-51 replicate
	12	808.8	06-25-2018	4±2	NA	2.6±0.8	NA	80±50	NA	NS	NA	
	12	808.8	06-25-2018	4±2	0	1.8±0.7	0.85	80±50	0	NS	NA	QAW-55 replicate
	1	1,171.8	06-24-2014	1.03±1.9	NA	2±0.8	NA	70±50	NA	7±6	NA	
	1	1,171.8	06-18-2015	-0.02±7.11	NA	1.1±0.8	0.44	-10±50	NA	21±7	NA	
	1	1,171.8	06-15-2016	0.6±1.6	NA	0.8±0.8	NA	110±50	NA	NS	NA	
	1	1,171.8	06-15-2016	-2.7±1.6	1.46	2±0.9	1.00	100±50	0.14	NS	NA	QAW-49 replicate
	1	1,171.8	06-20-2017	2±2	NA	2.9±0.8	NA	14.5±46.2	NA	NS	NA	
	1	1,171.8	06-25-2018	5±2	NA	2.1±0.7	NA	110±50	NA	NS	NA	

Table 8. Concentrations of gross alpha-particle radioactivity, gross-beta particle radioactivity, tritium, and cesium-137 in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

Analytical uncertainties are reported as 1 sample standard deviation (s). Concentrations that meet or exceed the reporting level of 3 times the 1s value are shown in **boldface** type. Z-values associated with quality-assurance replicates were calculated using equation 1. Samples were analyzed at the Radiological and Environmental Sciences Laboratory. **Local name:** Local well identifier used in this study (see figure 1 for locations). USGS, U.S. Geological Survey. **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port as shown in table 2, in feet below land surface (ft bis). **Date:** Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **Remarks:** QAW, quality assurance Westbay™ sample. **Abbreviations:** NA, Not applicable; NS, Not sampled; pCi/L, picocuries per liter

Local name	Port number	Port depth (ft bis)	Date (mm-dd-yyyy)	Gross alpha particle radioactivity (pCi/L)	Z-value	Gross beta-particle radioactivity (pCi/L)	Z-value	Tritium (pCi/L)	Z-value	Cesium-137 (pCi/L)	Z-value	Remarks
USGS 131A	15	615.6	06-19-2014	4±2	NA	1.5±0.7	NA	860±70	NA	15±8	NA	
	15	615.6	06-15-2015	-3±2	NA	1.6±0.9	NA	850±60	NA	10±7	NA	
	15	615.6	06-29-2016	6±2	NA	2.3±0.7	NA	980±60	NA	NS	NA	
	15	615.6	06-22-2017	1±2	NA	3.2±0.8	NA	800±60	NA	NS	NA	
	15	615.6	06-19-2018	6±2	NA	4.8±0.9	NA	640±60	NA	NS	NA	
	10	811.2	06-19-2014	0±4	NA	2.5±0.9	NA	1290±70	NA	2±6	NA	
USGS 132	10	811.2	06-15-2015	-2±2	NA	3.2±0.9	NA	1160±70	NA	12±7	NA	
	10	811.2	06-29-2016	6±2	NA	4.3±0.8	NA	1040±60	NA	NS	NA	
	10	811.2	06-22-2017	2±2	NA	4.4±0.9	NA	1100±70	NA	NS	NA	
	10	811.2	06-19-2018	1.44±1.73	NA	5±0.9	NA	1020±60	NA	NS	NA	
	6	980.3	06-19-2014	0±3	NA	2±0.8	NA	150±50	NA	2±5	NA	
	6	980.3	06-15-2015	5±3	NA	1.2±0.7	NA	110±50	NA	29±10	NA	
	3	1,136.1	06-19-2014	3±2	NA	2.9±0.8	NA	40±50	NA	19±8	NA	
	3	1,136.1	06-15-2015	-1±3	NA	2.8±0.9	NA	50±50	NA	17±7	NA	
	18	765.4	06-17-2014	1.55±1.92	NA	2.1±0.8	NA	360±60	NA	19±8	NA	
	18	765.4	06-09-2015	-1±2	NA	2±0.9	NA	150±50	NA	29±12	NA	
USGS 133	18	765.4	06-07-2016	-0.7±1.73	NA	3.5±0.9	NA	210±50	NA	NS	NA	
	18	765.4	06-13-2017	-1±2	NA	1.5±0.8	NA	160±50	NA	NS	NA	
	18	765.4	06-20-2018	1.2±1.7	NA	2.9±0.8	NA	160±50	NA	NS	NA	
	12	469.1	06-17-2014	2±2	NA	2.5±0.8	NA	30±60	NA	27±10	NA	
	12	469.1	06-17-2014	-2.2±1.4	NA	-2±0.7	NA	-20±50	NA	20±8	NA	QAW-42 equipment blank
	12	469.1	06-09-2015	1.58±2.28	NA	1.9±0.8	NA	-12.3±48.1	NA	9±6	NA	
	12	469.1	06-13-2016	0.3±1.4	NA	3±0.9	NA	10.2±44.2	NA	NS	NA	
	12	469.1	06-21-2017	0±2	NA	2.9±0.9	NA	40±50	NA	NS	NA	
	12	469.1	06-12-2018	2±2	NA	2.8±0.8	NA	20±50	NA	NS	NA	

Table 8. Concentrations of gross alpha-particle radioactivity, gross-beta particle radioactivity, tritium, and cesium-137 in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

Analytical uncertainties are reported as 1 sample standard deviation (s). Concentrations that meet or exceed the reporting level of 3 times the 1s value are shown in **boldface** type. Z-values associated with quality-assurance replicates were calculated using [equation 1](#). Samples were analyzed at the Radiological and Environmental Sciences Laboratory. **Local name:** Local well identifier used in this study (see [figure 1](#) for locations). USGS, U.S. Geological Survey. **Port number:** Identifier used to locate port couplings (see [table 2](#)). **Port depth:** Depth to the port as shown in [table 2](#), in feet below land surface (ft bls). **Date:** Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **Remarks:** QAW, quality assurance Westbay™ sample. **Abbreviations:** NA, Not applicable; NS, Not sampled; pCi/L, picocuries per liter]

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Gross alpha particle activity (pCi/L)	Z-value	Gross beta-particle radioactivity (pCi/L)	Z-value	Tritium (pCi/L)	Z-value	Cesium-137 (pCi/L)	Z-value	Remarks
USGS 134	19	645.5	06-16-2014	1.53±1.89	NA	2.2±0.8	NA	-70±50	NA	17±10	NA	
	19	645.5	06-08-2015	-1.08±2.18	NA	0.6±0.9	NA	-80±50	NA	3±5	NA	
	19	645.5	06-06-2016	3±2	NA	1.4±0.7	NA	10±40	NA	NS	NA	
	19	645.5	06-12-2017	-1±2	NA	1.5±0.8	NA	-30±50	NA	NS	NA	
	19	645.5	06-11-2018	0.8±1.6	NA	2±0.8	NA	30±50	NA	NS	NA	
USGS 135	9	836.7	06-23-2014	3±2	NA	1.4±0.8	NA	-11.4±50.4	NA	19±9	NA	
	9	836.7	06-23-2014	NS	NA	NS	NA	4.13±1.81	NA	NS	NA	
	9	836.7	06-11-2015	-3±2	NA	-0.1±0.3	NA	-60±50	NA	32±11	NA	
	9	836.7	06-09-2016	1.4±1.6	NA	0±130	NA	-10±403	NA	NS	NA	
	9	836.7	06-15-2017	1.38±1.79	NA	2.2±0.8	NA	-20±50	NA	NS	NA	
	9	836.7	06-14-2018	3±2	NA	1.5±0.7	NA	20±40	NA	NS	NA	

Table 8. Concentrations of gross alpha-particle radioactivity, gross-beta particle radioactivity, tritium, and cesium-137 in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

Analytical uncertainties are reported as 1 sample standard deviation (s). Concentrations that meet or exceed the reporting level of 3 times the 1s value are shown in boldface type. Z-values associated with quality-assurance replicates were calculated using equation 1 . Samples were analyzed at the Radiological and Environmental Sciences Laboratory. Local name: Local well identifier used in this study (see figure 1 for locations). USGS, U.S. Geological Survey. Port number: Identifier used to locate port couplings (see table 2). Port depth: Depth to the port as shown in table 2 , in feet below land surface (ft bls). Date: Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). Remarks: QAW, quality assurance Westbay™ sample. Abbreviations: NA, Not applicable; NS, Not sampled; pCi/L, picocuries per liter]												
Local name	Port Num-ber	Port depth (ft bls)	Date (mm-dd-yyyy)	Gross alpha particle radio-activity (pCi/L)	Z-value	Gross beta-particle radioactivity (pCi/L)	Z-value	Tritium (pCi/L)	Z-value	Cesium-137 (pCi/L)	Z-value	Remarks
USGS 137A	7	660.9	07-10-2014	-2.9±1.7	NA	1.7±0.9	NA	10±50	NA	28±11	NA	
	7	660.9	06-22-2015	-1.15±2.32	NA	2.2±0.9	NA	20±50	NA	24±10	NA	
	7	660.9	06-13-2016	0.4±1.5	NA	1.9±0.8	NA	150±50	NA	NS	NA	
	7	660.9	06-19-2017	1±2	NA	2.6±0.8	NA	50±50	NA	NS	NA	
	7	660.9	06-18-2018	2±2	NA	3.6±0.9	NA	30±50	NA	NS	NA	
	5	746.8	07-10-2014	3±2	NA	1.2±0.7	NA	40±50	NA	23±10	NA	
	5	746.8	06-22-2015	-1.65±2.18	NA	0.2±1.6	NA	10±50	NA	12±6	NA	
	5	746.8	06-13-2016	0.8±1.6	NA	2.6±0.8	NA	80±50	NA	NS	NA	
	5	746.8	06-19-2017	0.4±1.6	NA	3.9±0.9	NA	100±50	NA	NS	NA	
MIDDLE 2050A	5	746.8	06-18-2018	1.23±1.71	NA	1.7±0.8	NA	100±50	NA	NS	NA	
	5	746.8	06-18-2018	0.7±1.4	NA	0.5±0.7	NA	-12.6±44.3	NA	NS	NA	QAW-54 field blank
	3	840.7	07-09-2014	4±2	NA	0.7±0.6	NA	130±50	NA	7±7	NA	
	3	840.7	06-22-2015	-3±2	NA	0.9±1	NA	-50±50	NA	3±5	NA	
	1	875.1	07-9-2014	1.01±1.86	NA	1.9±0.8	NA	60±50	NA	9±6	NA	
	1	875.1	06-22-2015	-0.03±10.93	NA	1.5±0.8	NA	-40±50	NA	19±10	NA	
	15	516.8	06-26-2014	2±2	NA	1.7±0.8	NA	40±50	NA	23±8	NA	
	15	516.8	06-23-2015	-2±2	NA	-0.8±0.7	NA	-30±50	NA	21±9	NA	QAW-46 field blank
	15	516.8	06-23-2015	3±3	NA	0.4±0.6	NA	-20±50	NA	18±8	NA	
	15	516.8	06-20-2016	0.8±1.6	NA	2.6±0.8	NA	90±50	NA	NS	NA	
	15	516.8	06-21-2017	-0.7±1.4	NA	-0.2±0.6	NA	-50±40	NA	NS	NA	QAW-52 field blank
	15	516.8	06-21-2017	0±2	NA	2.5±0.8	NA	40±50	NA	NS	NA	
	15	516.8	06-12-2018	4±2	NA	0.8±0.6	NA	16.8±44.9	NA	NS	NA	

Table 8. Concentrations of gross alpha-particle radioactivity, gross-beta particle radioactivity, tritium, and cesium-137 in water from multiple levels in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2014–18.—Continued

Analytical uncertainties are reported as 1 sample standard deviation (s). Concentrations that meet or exceed the reporting level of 3 times the 1s value are shown in **boldface** type. Z-values associated with quality-assurance replicates were calculated using equation 1. Samples were analyzed at the Radiological and Environmental Sciences Laboratory. **Local name:** Local well identifier used in this study (see figure 1 for locations). USGS, U.S. Geological Survey. **Port number:** Identifier used to locate port couplings (see table 2). **Port depth:** Depth to the port as shown in table 2, in feet below land surface (ft bls). **Date:** Date sample collected in calendar month (mm), calendar day (dd), and calendar year (yyyy). **Remarks:** QAW, quality assurance Westbay™ sample. **Abbreviations:** NA, Not applicable; NS, Not sampled; pCi/L, picocuries per liter

Local name	Port number	Port depth (ft bls)	Date (mm-dd-yyyy)	Gross alpha particle radioactivity (pCi/L)	Z-value	Gross beta-particle radioactivity (pCi/L)	Z-value	Tritium (pCi/L)	Z-value	Cesium-137 (pCi/L)	Z-value	Remarks
MIDDLE 2051	9	749.0	06-10-2015	-1.14±2.3	NA	1.4±0.9	NA	200±50	NA	18±9	NA	
	9	749.0	06-08-2016	1.66±1.73	NA	1.8±0.8	NA	240±50	NA	NS	NA	
	9	749.0	06-28-2017	0±2	NA	1.8±0.8	NA	210±50	NA	NS	NA	
	9	749.0	06-13-2018	4±2	NA	2.7±0.8	NA	230±50	NA	NS	NA	
	6	826.8	06-18-2014	5±2	NA	2.1±0.8	NA	590±60	NA	9±6	NA	
	3	1,091.1	06-18-2014	1.05±1.92	NA	0.7±0.8	NA	250±60	NA	6±6	NA	
	3	1,091.1	06-10-2015	-2±2	NA	2.6±0.9	NA	200±50	NA	13±6	NA	
	3	1,091.1	06-10-2015	2±2	1.4	-0.4±1.1	2.1	130±50	0.99	29±12	1.2	QAW-45 replicate
	3	1,091.1	06-08-2016	0.4±1.5	NA	1.4±0.8	NA	150±50	NA	NS	NA	
	3	1,091.1	06-08-2016	1.4±1.4	NA	-1.2±0.8	NA	-20±40	NA	NS	NA	QAW-47 equipment blank
	3	1,091.1	06-28-2017	0±2	NA	2.7±0.9	NA	140±50	NA	NS	NA	
	3	1,091.1	06-28-2017	2±2	0.71	1.8±0.8	0.75	160±50	0.28	NS	NA	QAW-53 replicate
	3	1,091.1	06-13-2018	2±2	NA	±0.8	NA	180±50	NA	NS	NA	
	1	1,140.9	06-30-2016	0.3±1.6	NA	0±0.2	NA	180±50	NA	5±4	NA	

Table 9. Concentrations of selected chemical and radiochemical constituents in water from well MIDDLE 2051, Idaho National Laboratory, Idaho.

[See figure 1 for well location. Uncertainty of radiochemical constituents is 1 sample standard deviation (*s*). Concentrations that meet or exceed the reporting level of 3 times the 1*s* value are shown in **boldface** type. Analytical results are in micrograms per liter unless noted otherwise. Samples were analyzed at the U.S. Geological Survey (USGS) National Water Quality Laboratory in Lakewood, Colorado, unless otherwise indicated. **Constituent or measurement:** Sample date mm/dd/yy indicates month/day/year. **Abbreviations and symbols:** CaCO₃, calcium carbonate; N, nitrogen; P, phosphorus; RESL, Radiological and Environmental Sciences Laboratory; RSIL, USGS Reston Stable Isotope Laboratory in Reston, Virginia; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; pCi/L, picocuries per liter; <, less than; ±, plus or minus; NA, Not analyzed]

Constituent or measurement	Multilevel well name— MIDDLE 2051	Constituent or measurement	Multilevel well name— MIDDLE 2051
Port depth (feet below land surface)	1,141	Manganese	<0.4
Port number for multilevel well	1	Mercury	<0.005
Sample date	06-30-2016	Molybdenum	1.22
Time	1230	Nickel	0.61
Water temperature (°C)	15.1	Selenium	1.16
Air Temperature (°C)	29.3	Silver	0.115
pH (field)	7.9	Strontium	234
pH (laboratory)	8.2	Thallium	<0.03
Specific conductance (µS/cm) (field)	367	Tungsten	NA
Dissolved oxygen (mg/L)	10.6	Uranium	1.48
Alkalinity (mg/L as CaCO ₃)	145	Vanadium	5.9
Total dissolved solids (mg/L)	194	Zinc	5.51
Calcium (mg/L)	43	Tritium (pCi/L) (RESL)	180±50
Magnesium (mg/L)	20.9	Strontium-90 (pCi/L) (RESL)	0.1±0.7
Potassium (mg/L)	2.54	Cesium-137 (pCi/L) (RESL)	5+/4
Silica (mg/L)	27.8	Gross alpha (pCi/L) (RESL)	0.3±1.6
Sodium (mg/L)	8.57	Gross beta (pCi/L) (RESL)	0±0.2
Bromide (mg/L)	0.027	Americium-241 (pCi/L) (RESL)	0.01±0.013
Chloride (mg/L)	11.7	Plutonium-238 (pCi/L) (RESL)	0.003±0.006
Fluoride (mg/L)	0.164	Plutonium-239,240 (pCi/L) (RESL)	–0.003±0.006
Sulfate (mg/L)	23	Uranium-234 (pCi/L)	1.47±0.15
Ammonia as N (mg/L)	<0.01	Uranium-235 (pCi/L)	0.041±0.017
Nitrite as N (mg/L)	<0.001	Uranium-238 (pCi/L)	0.556±0.073
Nitrate plus nitrite as N (mg/L)	0.842	Deuterium (per mil) (RSIL)	–133.36
Orthophosphate as P (mg/L)	0.018	Oxygen-18 (per mil) (RSIL)	–17.06
Aluminum	8.21	Volatile organic compounds	
Antimony	0.184	Acrylonitrile	<2.5
Arsenic	1.4	Benzene	<0.1
Barium	32.1	Bromobenzene	<0.2
Beryllium	<0.19	Bromochloromethane	<0.2
Boron	18	Bromomethane	<0.4
Cadmium	<0.03	CFC-11	<0.2
Chromium	6.7	CFC-12	<0.2
Cobalt	0.12	CFC-113	<0.1
Copper	<0.8	CHBrC12	<0.1
Iron	<4	Chlorobenzene	<0.1
Lead	<0.04	Chloroethane	<0.2
Lithium	2.6	Chloromethane	<0.2

Table 9. Concentrations of selected chemical and radiochemical constituents in water from well MIDDLE 2051, Idaho National Laboratory, Idaho.—Continued

[See figure 1 for well location. Uncertainty of radiochemical constituents is 1 sample standard deviation (*s*). Concentrations that meet or exceed the reporting level of 3 times the 1*s* value are shown in **boldface** type. Analytical results are in micrograms per liter unless noted otherwise. Samples were analyzed at the U.S. Geological Survey (USGS) National Water Quality Laboratory in Lakewood, Colorado, unless otherwise indicated. **Constituent or measurement:** Sample date mm/dd/yy indicates month/day/year. **Abbreviations and symbols:** CaCO₃, calcium carbonate; N, nitrogen; P, phosphorus; RESL, Radiological and Environmental Sciences Laboratory; RSIL, USGS Reston Stable Isotope Laboratory in Reston, Virginia; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; pCi/L, picocuries per liter; <, less than; ±, plus or minus; NA, Not analyzed]

Constituent or measurement	Multilevel well name— MIDDLE 2051	Constituent or measurement	Multilevel well name— MIDDLE 2051
cis-1,2-dichloroethene	<0.1	Xylene	<0.2
cis-1,3-dichloropropene	<0.2	1,1,1-trichloroethane	<0.1
Dibromochloropropane	<0.5	1,1,1,2-tetrachloroethane	<0.2
Dibromochloromethane	<0.2	1,1,2,2-tetrachloroethane	<0.2
Dibromomethane	<0.2	1,1,2-trichloroethane	<0.2
Dichloromethane	<0.2	1,1-dichloroethane	<0.1
Ethylbenzene	<0.1	1,1-dichloroethene	<0.1
Hexachlorobutadiene	<0.2	1,1-dichloropropene	<0.2
Isopropylbenzene	<0.2	1,2,3-trichloropropane	<0.2
MTBE	<0.2	1,2,3-trichlorobenzene	<0.2
Naphthalene	<0.5	1,2,4-trichlorobenzene	<0.2
n-butylbenzene	<0.2	1,2,4-trimethylbenzene	<0.2
n-propylbenzene	<0.2	1,2-dibromoethane	<0.2
sec-butylbenzene	<0.2	1,2-dichlorobenzene	<0.1
Styrene	<0.1	1,2-dichloroethane	<0.2
tert-butylbenzene	<0.2	1,2-dichloropropane	<0.1
Tetrachloroethene	0.774	1,3-dichlorobenzene	<0.1
Tetrachloromethane	<0.2	1,3-dichloropropane	<0.2
Toluene	<0.1	1,3,5-trimethylbenzene	<0.2
trans-1,2-dichloroethene	<0.1	1,4-dichlorobenzene	<0.1
trans-1,3-dichloropropene	<0.2	2-chlorotoluene	<0.2
Tribromomethane	<0.2	2,2-dichloropropane	<0.2
Trichloroethene	<0.1	4-chlorotoluene	<0.2
Trichloromethane	<0.1	4-isopropyltoluene	<0.2
Vinyl chloride	<0.2		

Table 10. Concentrations of selected purgeable organic compounds in water from multiple levels of selected wells, Idaho National Laboratory, Idaho.

[Tubing fluid samples were taken without accessing a port at depths near the bottom of the well. Samples were analyzed at the USGS National Water Quality Laboratory in Lakewood, Colorado, for 61 organic compounds. **Local name:** Local well identifier used in this study; see [figure 1](#) for location. **Port number:** Identifier used to locate port coupling depth at discrete zones; see [table 2](#). **Date:** Date sample collected on calendar month (mm), day (dd), and calendar year (yyyy). **Time:** Sample collection time in 24-hour military time. **Other:** Notes on particular samples collected. **Abbreviations and symbol:** NA, Not applicable; QA, quality assurance; RPD, relative percent difference (only calculated for tetrachloroethene); <, less than]

Local name	Port number	Date	Time	Tetrachloro-methane (ug/L)	Tetrachloro-ethene (ug/L)	Other
USGS 132	NA	09-20-2016	1150	<0.02	0.521	Tubing fluid
USGS 132	1	06-13-2017	1225	0.273	<0.01	
USGS 132	6	06-13-2017	1300	0.216	<0.01	
USGS 132	10	06-13-2017	1335	0.222	<0.01	
USGS 132	14	06-13-2017	1410	0.219	0.117	
USGS 132	18	06-13-2017	1515	0.295	<0.01	
USGS 132	18	06-20-2018	1240	0.412	<0.01	
USGS 132	22	06-13-2017	1535	0.370	<0.01	
USGS 137A	NA	09-20-2016	1315	<0.02	0.200	Tubing fluid
USGS 137A	1	06-19-2017	0840	0.201	<0.01	
USGS 137A	3	06-19-2017	0905	<0.02	<0.01	
USGS 137A	5	06-19-2017	1000	<0.02	<0.01	
USGS 137A	7	06-19-2017	1100	0.202	<0.01	
MIDDLE 2051	NA	07-19-2016	0935	<0.02	662	Tubing fluid
MIDDLE 2051	1	06-08-2016	1240	<0.02	744	Trichloroethene, 0.137
MIDDLE 2051	1	06-28-2017	1100	<0.02	1.33	
MIDDLE 2051	1	06-30-2016	1230	<0.02	0.774	
MIDDLE 2051	1	06-30-2016	1235	<0.02	0.682	Replicate, RPD=12.6
MIDDLE 2051	3	06-08-2016	0910	<0.02	0.642	
MIDDLE 2051	3	06-08-2016	1010	<0.02	<0.01	QA blank
MIDDLE 2051	3	06-28-2017	1205	<0.02	0.736	
MIDDLE 2051	3	06-28-2017	1210	<0.02	0.694	Replicate, RPD=5.9
MIDDLE 2051	6	06-08-2016	1325	<0.02	0.367	
MIDDLE 2051	6	06-28-2017	1330	<0.02	3.87	
MIDDLE 2051	9	06-08-2016	1100	<0.02	0.184	

Table 10. Concentrations of selected purgeable organic compounds in water from multiple levels of selected wells, Idaho National Laboratory, Idaho.—Continued

[Tubing fluid samples were taken without accessing a port at depths near the bottom of the well. Samples were analyzed at the USGS National Water Quality Laboratory in Lakewood, Colorado, for 61 organic compounds. **Local name:** Local well identifier used in this study; see [figure 1](#) for location. **Port number:** Identifier used to locate port coupling depth at discrete zones; see [table 2](#). **Date:** Date sample collected on calendar month (mm), day (dd), and calendar year (yyyy). **Time:** Sample collection time in 24-hour military time. **Other:** Notes on particular samples collected. **Abbreviations and symbol:** NA, Not applicable; QA, quality assurance; RPD, relative percent difference (only calculated for tetrachloroethene); <, less than]

Local name	Port number	Date	Time	Tetrachloro-methane (ug/L)	Tetrachloro-ethene (ug/L)	Other
MIDDLE 2051	9	06-08-2016	1105	<0.02	0.179	Replicate, RPD=2.8
MIDDLE 2051	9	06-28-2017	1425	<0.02	0.573	
MIDDLE 2051	12	06-08-2016	1415	<0.02	0.128	
MIDDLE 2051	12	06-28-2017	1445	<0.02	0.115	
MIDDLE 2050A	NA	09-20-2016	0945	<0.02	830	Tubing fluid; toluene, 0.112; vinyl chloride, 0.233; trichloroethene, 0.551

Appendix 1. Paired Port Statistics for Boreholes U.S. Geological Survey (USGS) 103, USGS 105, USGS 108, USGS 131A, USGS 132, USGS 133, USGS 134, USGS 135, and USGS 137A, Idaho National Laboratory, Idaho, 2014–18

Appendix 1 is a Microsoft Excel® table available for download at <https://doi.org/10.3133/sir20215002>.

Appendix 2. Atmospheric Pressure, Water Temperature, Fluid Pressure, and Hydraulic Head Data from Port Measurements for Boreholes U.S. Geological Survey (USGS) 103, USGS 105, USGS 108, USGS 131A, USGS 132, USGS 133, USGS 134, USGS 135, USGS 137A, MIDDLE 2050A, and MIDDLE 2051, Idaho National Laboratory, Idaho, 2014–18

Appendix 2 is a Microsoft Excel® table available for download at <https://doi.org/10.3133/sir20215002>.

Appendix 3. Mean and Normalized Mean Hydraulic Head Values for Boreholes U.S. Geological Survey (USGS) 103, USGS 105, USGS 108, USGS 131A, USGS 132, USGS 133, USGS 134, USGS 135, USGS 137A, MIDDLE 2050A, and MIDDLE 2051, Idaho National Laboratory, Idaho, 2007–18

Appendix 3 is a Microsoft Excel® table available for download at <https://doi.org/10.3133/sir20215002>.

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For more information concerning the research in this report, contact the
Director, Idaho Water Science Center
U.S. Geological Survey
230 Collins Road
Boise, Idaho 83702-4520
<https://www.usgs.gov/centers/id-water>