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An Update of the Distribution of Selected Radiochemical and Chemical Constituents in Perched Ground Water, Idaho National Laboratory, Idaho, Emphasis 1999-2001

Scientific Investigations Report 2006–5236

U.S. Department of the Interior
U.S. Geological Survey

Cover: Photograph of U.S. Geological Survey well and sampling apparatus at the Idaho National Laboratory, Idaho.
View looking southwest.
(Photograph courtesy of the U.S. Geological Survey Idaho National Laboratory Project Office.)

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Conversion Factors

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
foot squared per day (ft^2/d)	0.09290	meter squared per day
gallon (gal)	3.785	liter
mile (mi)	1.609	kilometer
million gallons (Mgal)	$3{,}785 \times 10^6$	liter
million gallons per year (Mgal/yr)	$3{,}785 \times 10^6$	liter per year
picocurie per liter (pCi/L)	0.037	becquerel per liter
picocurie per milliliter (pCi/mL)	0.037	becquerel per milliliter
pound, avoirdupois (lb)	0.4536	kilogram
pound per year (lb/yr)	0.4536	kilogram per year
square mile (mi^2)	2.590	square kilometer
ton per year (ton/yr)	0.9072	metric ton per year

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

$$°F=(1.8\times°C)+32$$

Conversion Factors, Datums, and Abbreviations, Acronyms, and Symbols—continued

Datums

Vertical coordinate information is referenced to the North American Vertical Datum of 1929 (NAVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

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

Abbreviations, Acronyms, and Symbols

Abbreviations, Acronyms, and Symbols	Definition
Ci	Curie
CFA	Central Facilities Area
DOE	U.S. Department of Energy
INEEL	Idaho National Engineering and Environmental Laboratory (1997-2005)
INEL	Idaho National Engineering Laboratory (1974-97)
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
LRL	laboratory reporting level
LT-MDL	long-term method detection level
mg/L	milligram per liter
MRL	minimum reporting level
NRTS	National Reactor Testing Station (from 1949-74)
NWIS	National Water Information System (USGS)
NWQL	National Water Quality Laboratory
pCi/L	picocurie per liter
pCi/mL	picocurie per milliliter
RESL	Radiological and Environmental Sciences Laboratory
RTC	Reactor Technology Complex
RWMC	Radioactive Waste Management Complex
s	sample standard deviation
SDA	Subsurface Disposal Area
SWP	Sanitary-waste pond
TAN	Test Area North
TRA	Test Reactor Area
µg/L	microgram per liter
USGS	U.S. Geological Survey
VOC	volatile organic compound
<	less than
±	plus or minus

An Update of the Distribution of Selected Radiochemical and Chemical Constituents in Perched Ground Water, Idaho National Laboratory, Idaho, Emphasis 1999–2001

By Linda C. Davis

Abstract

Radiochemical and chemical wastes generated at facilities at the Idaho National Laboratory (INL) were discharged since 1952 to infiltration ponds at the Reactor Technology Complex (RTC) (known as the Test Reactor Area [TRA] until 2005), and the Idaho Nuclear Technology and Engineering Center (INTEC) and buried at the Radioactive Waste Management Complex (RWMC). Disposal of wastewater to infiltration ponds and infiltration of surface water at waste burial sites resulted in formation of perched ground water in basalts and in sedimentary interbeds above the Snake River Plain aquifer. Perched ground water is an integral part of the pathway for waste-constituent migration to the aquifer.

The U.S. Geological Survey (USGS), in cooperation with the U.S. Department of Energy, maintains ground-water monitoring networks at the INL to determine hydrologic trends, and to monitor the movement of radiochemical and chemical constituents in wastewater discharged from facilities to both perched ground water and the aquifer. This report presents an analysis of water-quality and water-level data collected from wells completed in perched ground water at the INL during 1999–2001, and summarizes historical disposal data and water-level-and water-quality trends.

At the RTC, tritium, strontium-90, cesium-137, dissolved chromium, chloride, sodium, and sulfate were monitored in shallow and deep perched ground water. In shallow perched ground water, no tritium was detected above the reporting level. In deep perched ground water, tritium concentrations generally decreased or varied randomly during 1999–2001. During October 2001, tritium concentrations ranged from less than the reporting level to 39.4±1.4 picocuries per milliliter (pCi/mL). Reportable concentrations of tritium during July-October 2001 were smaller than the reported concentrations measured during July–December 1998. Tritium concentrations in water from wells at the RTC were likely affected by: well's distance from the radioactive-waste infiltration ponds (commonly referred to as the warm-waste ponds); water depth below the ponds; the amount of tritium discharged to radioactive-waste infiltration ponds in the past; discontinued use of radioactive-waste infiltration ponds; radioactive decay; and dilution from disposal of nonradioactive water.

During 1999–2001, the strontium-90 concentrations in two wells completed in shallow perched water near the RTC exceeded the reporting level. Strontium-90 concentrations in water from wells completed in deep perched ground water at the RTC varied randomly with time. During October 2001, concentrations in water from five wells exceeded the reporting level and ranged from 2.8±0.7 picocuries per liter (pCi/L) in well USGS 63 to 83.8±2.1 pCi/L in well USGS 54. No reportable concentrations of cesium-137, chromium-51, or cobalt-60 were present in water samples from any of the shallow or deep wells at the RTC during 1999–2001.

Dissolved chromium was not detected in shallow perched ground water at the RTC during 1999–2001. Concentrations of dissolved chromium during July–October 2001 in deep perched ground water near the RTC ranged from 10 micrograms per liter (µg/L) in well USGS 61 to 82 µg/L in well USGS 55. The largest concentrations were in water from wells north and west of the radioactive-waste infiltration ponds. During July–October 2001, dissolved sodium concentrations ranged from 7 milligrams per liter (mg/L) in well USGS 78 to 20 mg/L in all wells except well USGS 68 (413 mg/L). Dissolved chloride concentrations in shallow perched ground water ranged from 10 mg/L in wells CWP 1, 3, and 4 to 53 mg/L in well TRA A 13 during 1999–2001. Dissolved chloride concentrations in deep perched ground water ranged from 5 mg/L in well USGS 78 to 91 mg/L in well USGS 73. The maximum dissolved sulfate concentration in shallow perched ground water was 419 mg/L in well CWP 1 during July 2000. Concentrations of dissolved sulfate in water from wells USGS 54, 60, 63, 69, and PW 8, completed in deep perched ground water near the cold-waste ponds, ranged from 115 to 285 mg/L in July–October 2001. The maximum concentration of dissolved sulfate in water during July–October 2001 was 1,409 mg/L in well USGS 68 west of the chemical-waste pond.

At the INTEC, tritium, strontium-90, cesium-137, dissolved sodium, chloride, sulfate, and nitrite plus nitrate (as nitrogen) were monitored in shallow and deep perched ground water. No reportable concentrations of tritium were measured in shallow perched ground water during 1999–2001. The tritium concentration in water from wells completed in deep perched ground water beneath the infiltration ponds ranged from less than the reporting level in wells PW 1 and PW 5 to 9.7±0.5 pCi/mL in well PW 6 during 1999–2001. The strontium-90 concentration in water from well SWP 8, completed in shallow perched ground water, was 2.1±0.7 pCi/L in July 2001. In October 2001, strontium-90 concentrations in deep perched ground water in wells closest to the ponds were less than the reporting level, not sampled because of access problems, or the wells were dry.

Dissolved sodium, chloride, and sulfate concentrations in shallow and deep perched ground water at the INTEC infiltration ponds during 1999–2001 were similar to or less than the average annual effluent monitoring data.

At the RWMC, tritium, strontium-90, cesium-137, plutonium-238, plutonium-239, -240 (undivided), americium-241, dissolved chloride, and a suite of volatile organic compounds were monitored in deep perched ground water at well USGS 92. Radiochemical constituents in all water samples from well USGS 92 were less than the reporting level with the exception of the April 2000 and October 2001 samples analyzed for tritium. The tritium concentration was at the reporting level at 0.3±.0.1 pCi/mL in April 2000 and slightly above the reporting level at 0.45±0.14 pCi/mL in October 2001. Samples contained concentrations greater than the minimum reporting levels of 15 volatile organic compounds.

Introduction

The Idaho National Laboratory (INL) encompasses about 890 mi^2 of the eastern Snake River Plain in southeastern Idaho (fig. 1). Names formerly used for this site, from earliest to most recent, were National Reactor Testing Station (NRTS, 1949–74), Idaho National Engineering Laboratory (INEL, 1974–97), and Idaho National Engineering and Environmental Laboratory (INEEL, 1997–2005). Facilities at the INL are operated by the U.S. Department of Energy (DOE) and are used in the development of peacetime atomic-energy applications, nuclear-safety research, defense programs, advanced energy concepts, and environmental research. Since 1952, radiochemical and chemical wastes generated at these facilities have been contained in wastewater discharged to infiltration ponds, lined evaporation ponds, disposal wells, or a combination thereof. Liquid and solid radiochemical and chemical wastes also have been buried at the INL. Disposal of wastewater to infiltration ponds and infiltration of surface water at waste-burial sites resulted in formation of perched ground water in basalts and in sedimentary interbeds that overlie the Snake River Plain aquifer. Perched ground water is an integral part of the pathway for waste-constituent migration to the aquifer.

The U.S. Department of Energy (DOE) requires information about the dilute radiochemical- and chemical-waste constituent mobility in perched ground water at the INL to monitor the possible movement of these constituents to the Snake River Plain aquifer. Waste-constituent mobility in part is determined by (1) hydraulic properties of saturated and unsaturated basalts and sedimentary interbeds, (2) location, quantity, and method of waste disposal, (3) waste-constituent chemistry, and (4) geochemical processes taking place in perched ground water. This study was conducted by the U.S. Geological Survey (USGS) in cooperation with the DOE's Idaho Operations Office.

Purpose and Scope

In 1949, the U.S. Atomic Energy Commission, which later became the DOE, requested that the USGS describe the water resources of the area now known as INL. The study's purpose was to characterize the water resources before development of nuclear-reactor testing facilities. Since that time, the USGS has maintained water-level and water-quality monitoring networks at the INL to determine hydrologic trends and to delineate the movement of radiochemical and chemical wastes in ground water and in the Snake River Plain aquifer.

This report presents an analysis of water-level and water-quality data collected from selected wells completed in perched ground water at selected INL facilities during 1999–2001 as part of the continuing hydrogeologic investigations by the USGS at the INL. The report describes the distribution and concentration of selected radiochemical and chemical constituents in perched ground water and the history of waste disposal at the Reactor Technology Complex (RTC) (known as the Test Reactor Area [TRA] until 2005), Idaho Nuclear Technology and Engineering Center (INTEC), and Radioactive Waste Management Complex (RWMC). Perched ground water also has been detected beneath infiltration ponds and ditches at other facilities at the INL, but is not discussed in this report because of the relatively small quantity of wastewater and associated radiochemical and chemical constituents discharged. An analysis of water-quality and water-level data collected from wells completed in the Snake River Plain aquifer during 1999–2001 is described in Davis (2006).

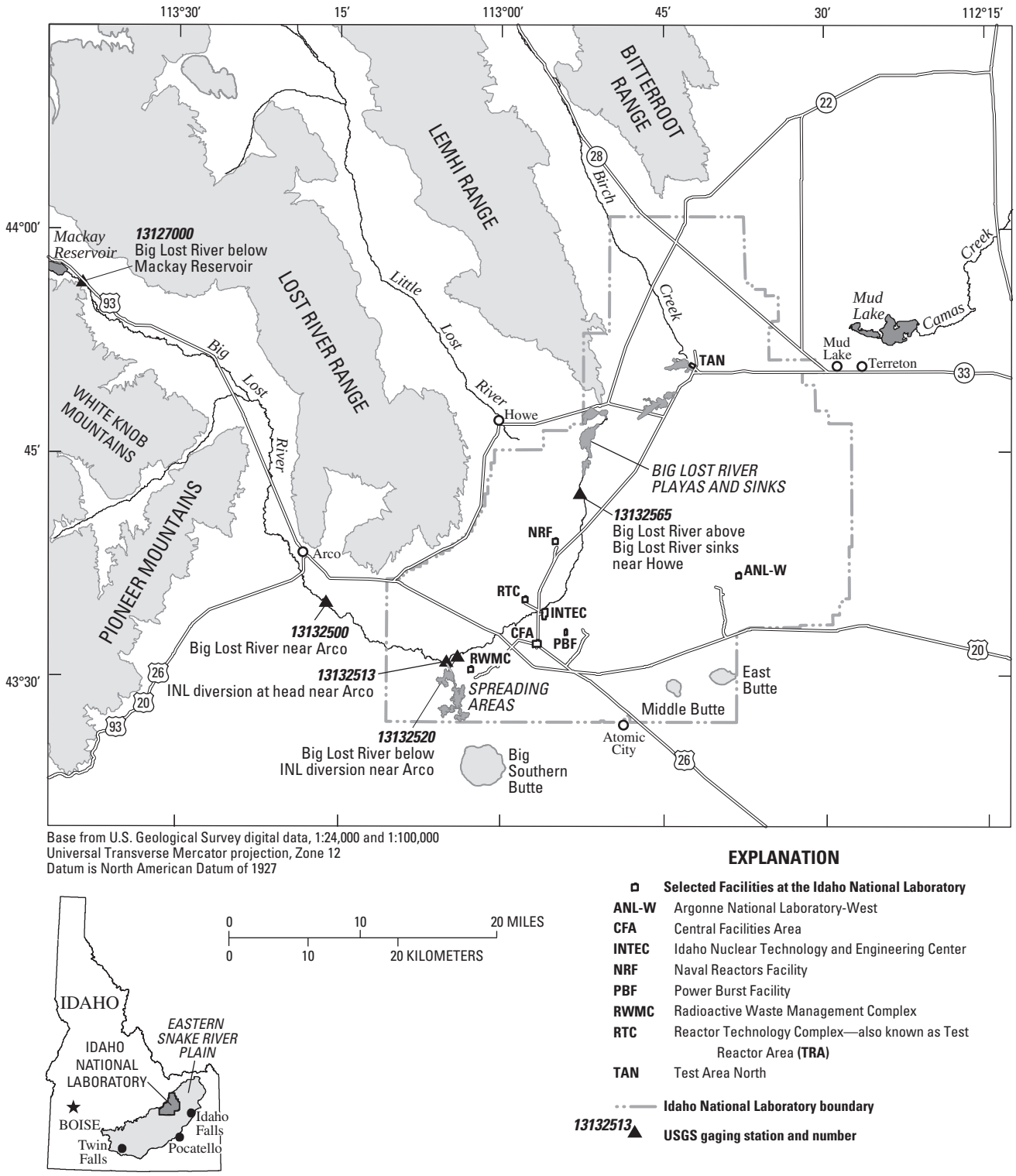

Figure 1. Location of the Idaho National Laboratory, surface-water gaging stations, and selected facilities, Idaho.

Previous Investigations

The extent of perched ground water at the RTC and the distribution of selected wastewater constituents in perched ground water are discussed in a series of reports describing the hydrology of the INL. This series includes reports by Barraclough, Teasdale, and Jensen (1967), Barraclough, Teasdale, and others (1967), and Barraclough and Jensen (1976). An analysis of perched ground water at the RTC is presented in a comprehensive discussion of conditions related to the disposal of wastewater to the subsurface at the INL (Robertson and others, 1974). Later reports present data on perched ground water at the RTC, INTEC, and RWMC: hydrologic conditions during 1974–78 were described by Barraclough and others (1981); during 1979–81 by Lewis and Jensen (1985); and during 1982–85 by Pittman and others (1988). Cecil and others (1991) discussed mechanisms responsible for formation of perched ground water and described the distribution of chemical and radiochemical constituents in perched ground water at the RTC, INTEC, and RWMC during 1986–88. Distribution of selected radiochemical and chemical constituents in perched ground water during 1989–91 was described by Tucker and Orr (1998); during 1992–95 by Bartholomay (1998); and during 1996–98 by Bartholomay and Tucker (2000).

Robertson (1977) used a three-segment numerical model to simulate flow and transport of chemical and radionuclide constituents through perched ground water at the RTC. The model included effects of convection, hydrodynamic dispersion, radioactive decay, and adsorption. Hull (1989) developed a conceptual model that described migration pathways for wastewater and constituents from the radioactive-waste infiltration ponds (commonly referred to as the warm-waste ponds) at the RTC. Orr (1999) described the development of a transient numerical simulation used to evaluate a conceptual model of flow through perched ground water beneath wastewater infiltration ponds at the RTC. Anderson and Lewis (1989) and Anderson (1991) correlated drill cores and geophysical logs to describe a complex sequence of basalt flows and sedimentary interbeds in the unsaturated zone underlying the RWMC, RTC, and INTEC. This stratigraphic sequence provides the geologic framework where perched ground water formed. Ackerman (1991) analyzed data from 43 aquifer tests conducted in 22 wells to estimate transmissivity of basalts and sedimentary interbeds containing perched ground water beneath the RTC and INTEC.

Ground-Water Monitoring Networks

Ground-water monitoring networks at the INL are maintained by the USGS to characterize the occurrence, movement, and quality of perched ground water beneath INL facilities. Periodic water–level and –quality data are obtained from these networks. Data from these monitoring networks are on file at the USGS INL Project Office and are available on the USGS National Water Information System (NWIS) Web site at http://waterdata.usgs.gov/id/nwis/nwis.

Water-Level Monitoring Network

The USGS perched water-level monitoring network was designed to estimate the extent of perched ground water and the volume of perched water in storage. Water levels in 42 wells (fig. 2) were monitored during 1999–2001. At the RTC, the network included 22 wells to monitor deep perched ground-water levels and 11 wells to monitor shallow perched ground-water levels. Shallow perched ground water is considered water perched in surficial sediment deposits, and deep perched ground water is water perched at greater depths. Perching mechanisms are attributed to contrasting hydraulic properties between sedimentary interbeds and basalts or between low-permeability basalt-flow interiors and overlying fractured basalt. At the INTEC, the network included seven wells to monitor perched ground-water levels around the INTEC infiltration ponds and one well to monitor the water-level changes in deep perched ground water beneath the INTEC. Perched ground water at the RWMC was monitored in one well. Well locations and frequency of water-level measurements as of December 2001 are shown in figure 2.

Water-Quality Monitoring Network

The radiochemical and chemical character of perched ground water beneath INL facilities was determined from analyses of water samples collected as part of the USGS water-quality monitoring network to identify contaminant concentrations and define the pattern of waste migration in perched ground water and in the Snake River Plain aquifer.

Type, frequency, and depth of ground-water sampling generally depend on the information needed in a specific area. Water samples routinely are collected from selected wells and analyzed for concentrations of tritium, strontium-90, cesium-137, cobalt-60, plutonium-238, plutonium-239 and plutonium-240 (undivided), americium-241, dissolved chromium, sodium, chloride, sulfate, nitrate, volatile organic compounds (VOCs), and measurements of specific conductance, pH, and water temperature. Water samples were analyzed for concentrations of radiochemical constituents at the Radiological and Environmental Sciences Laboratory (RESL) and for chemical constituents at the National Water Quality Laboratory (NWQL) in Lakewood, Colo. Well locations in the USGS water-quality monitoring network for perched ground water beneath INL facilities during 1999–2001 and the frequency of sample collection are shown in figure 3 and table 1. A sample schedule that lists constituents analyzed at each site is available in a report by Mann (1996, attachment 1).

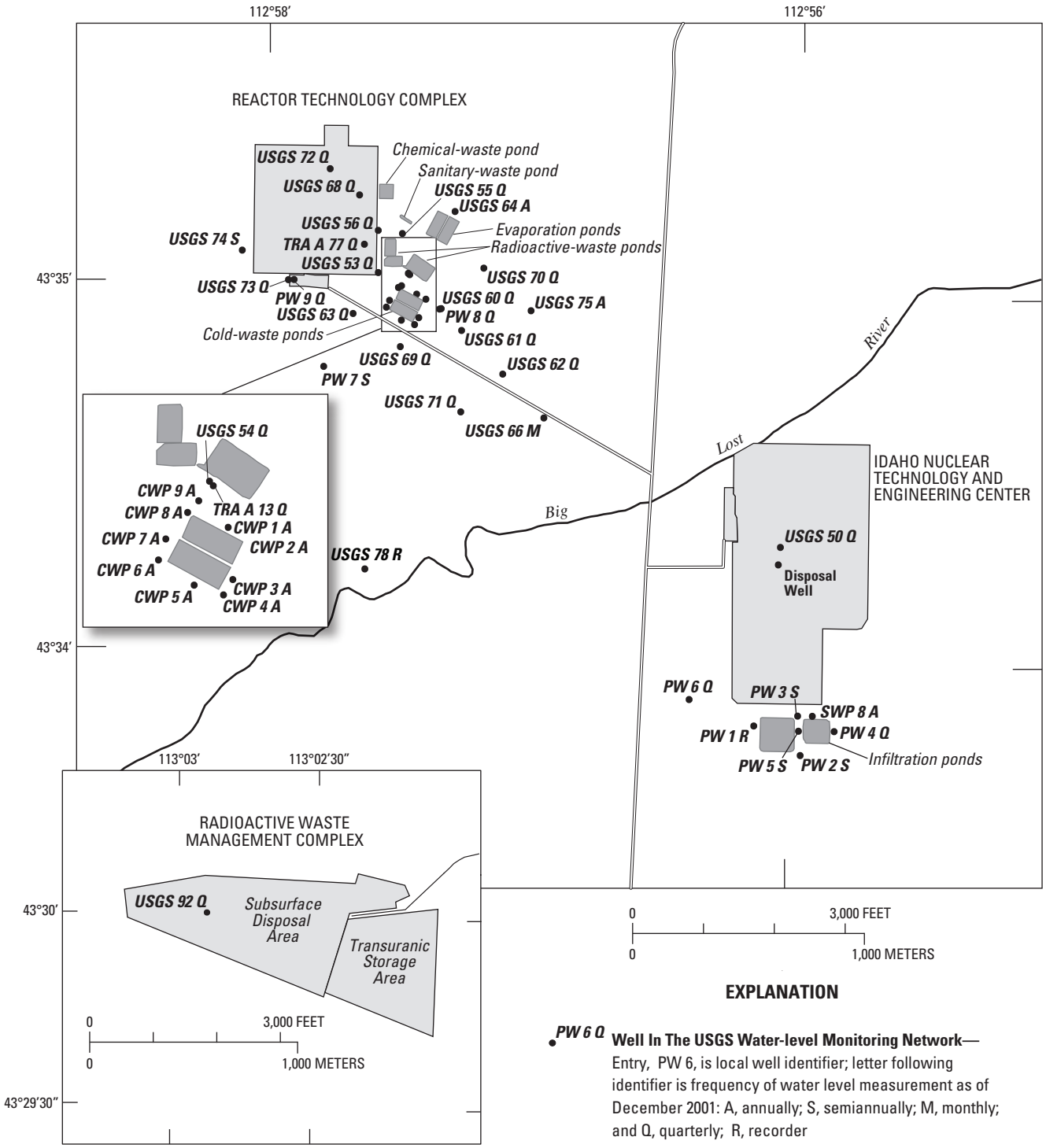

Figure 2. Location of wells in the U.S. Geological Survey water-level monitoring network at the Reactor Technology Complex, Idaho Nuclear Technology and Engineering Center, and Radioactive Waste Management Complex, Idaho National Laboratory, Idaho, and frequency of water-level measurements, as of December 2001.

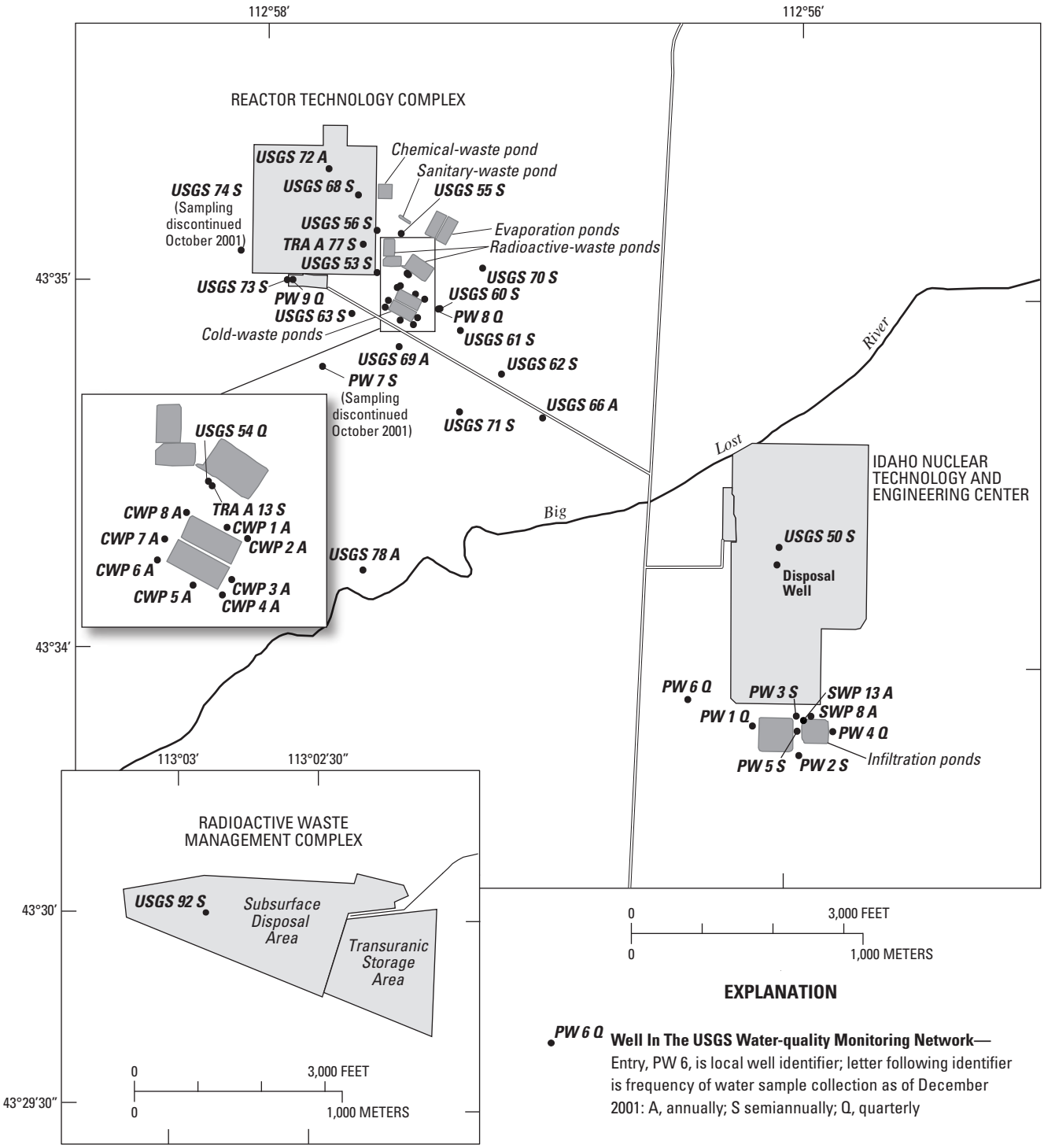

Figure 3. Location of wells in the U.S. Geological Survey water-quality monitoring network at the Reactor Technology Complex, Idaho Nuclear Technology and Engineering Center, and Radioactive Waste Management Complex, Idaho National Laboratory, Idaho, and frequency of water-sample collections, as of December 2001.

Table 1. Location and construction of wells in the U.S. Geological Survey perched ground water-quality monitoring network and sample-collection method and frequency, Idaho National Laboratory, Idaho, as of December 2001.

[**Well No.:** Locations of wells are shown in figure 3. **Sample-collection method:** Pump, sample collected with a pump (pumping rate in gallons per minute); Bail, sample collected with a bailer (sample collection depth in feet below land surface). **Sample-collection frequency:** A, annually, S, semiannually; Q, quarterly. **Abbreviation:** USGS, U.S. Geological Survey. **Symbol:** <, less than]

Well No.	USGS site No.	Well construction		Sample collection		
		Diameter (inches)	Depth (feet)	Method		Frequency
CWP 1	433459112572601	10	66.0	Bail	(65)	A
CWP 2	433458112572401	10	52.5	Bail	(52)	A
CWP 3	433455112572501	10	60.5	Bail	(60)	A
CWP 4	433454112572601	10	61.0	Bail	(60)	A
CWP 5	433455112572901	10	53.5	Bail	(53)	A
CWP 6	433456112573301	10	52.5	Bail	(52)	A
CWP 7	433458112573201	10	53.5	Bail	(53)	A
CWP 8	433500112573001	10	66.0	Bail	(65)	A
PW 1	433349112560701	10	117	Pump	(3)	Q
PW 2	433344112555601	10	131	Bail	(115)	S
PW 3	433351112555701	10	125	Bail	(121)	S
PW 4	433348112554901	10	136	Pump	(6)	Q
PW 5	433348112555701	10	124	Pump	(8)	S
PW 6	433353112562201	10	125	Bail	(125)	Q
PW 8	433456112572001	10	166	Pump	(8)	Q
PW 9	433500112575401	10	200	Pump	(5)	Q
SWP 8	433351112555401	2	26	Bail	(26)	A
SWP 13	433349112555702	2	32	Bail	(32)	A
TRA A 13	433502112572802	2	59	Bail	(59)	S
TRA A 77	433507112573801	2	33	Bail	(33)	S
USGS 50	433419112560201	6	405	Pump	(<1)	S
USGS 53	433503112573401	6	90	Bail	(75)	S
USGS 54	433503112572801	6	91	Pump	(4)	Q
USGS 55	433508112573001	6	79	Pump	(1)	S
USGS 56	433509112573501	6	80	Pump	(1)	S
USGS 60	433456112571901	6	117	Pump	(6)	S
USGS 61	433453112571601	10	123	Pump	(6)	S
USGS 62	433446112570701	8	165	Pump	(5)	S
USGS 63	433455112574001	10	97	Pump	(5)	S
USGS 66	433436112564801	6	475	Bail	(214)	A
USGS 68	433516112573901	10	128	Pump	(1)	S
USGS 69	433450112573001	10	115	Pump	(5)	A
USGS 70	433504112571001	8	100	Pump	(6)	S
USGS 71	433439112571501	8	184	Bail	(175)	S
USGS 72	433519112574601	6	177	Pump	(1)	A
USGS 73	433502112575401	6	127	Pump	(1.5)	S
USGS 78	433413112573501	7	204	Bail	(160)	A
USGS 92	433000113025301	6	214	Bail	(213)	S

Water-Quality Sampling Methods and Quality Assurance

Methods used to sample and analyze for selected constituents generally followed guidelines established by the USGS (Goerlitz and Brown, 1972; Stevens and others, 1975; Wood, 1981; Claassen, 1982; W.L. Bradford, USGS, written commun., 1985; Wershaw and others, 1987; Fishman and Friedman, 1989; and Wilde and others, 1998).

Water samples were collected according to a quality-assurance plan for water-quality activities conducted by personnel at the INL Project Office (Mann, 1996). Water samples collected for dissolved constituent analysis are filtered through a 0.45-micron membrane filter. About 10 percent of samples collected generally are for quality assurance. Quality-assurance samples collected by the USGS INL Project Office include equipment blanks, splits, and replicates. Nine quality-assurance replicates were collected for wells sampled for this study; results are included in the tables in this report. Comparative studies to determine agreement between analytical results for individual water-sample pairs by laboratories involved in the INL Project Office quality-assurance program were summarized by Wegner (1989), and Williams (1996, 1997). Additional quality-assurance studies by personnel at the INL Project Office included:

1. An evaluation of field sampling and preservation methods for strontium-90 (Cecil and others, 1989);
2. A study comparing pump types used for sampling VOCs (Knobel and Mann, 1993);
3. An analysis of tritium and strontium-90 concentrations in water from wells after purging different borehole volumes (Bartholomay, 1993);
4. An analysis of effects of various preservation types on nutrient concentrations (Bartholomay and Williams, 1996); and
5. An analysis of two analytical methods to determine gross alpha- and beta-particle activity (Bartholomay and others, 1999).

Geohydrologic Setting

The eastern Snake River Plain is a northeast oriented structural basin about 200-mi long and 50- to 70-mi wide. The plain consists of surficial alluvial and eolian sediments and basalt outcrops underlain by a layered sequence of basalt flows and sedimentary interbeds. Individual basalt flows are from 10- to 50-ft thick, although the average thickness is from 20 to 25 ft (Mundorff and others, 1964, p. 143). Surficial sediments and sedimentary interbeds consist of sand, silt, clay, and lesser amounts of gravel. Locally, rhyolitic flows and tuffs are exposed at land surface or are present at depth.

The top of the Snake River Plain aquifer is about 450 ft below land surface at the RTC and INTEC and about 600 ft below land surface at the RWMC. The unsaturated zone beneath these facilities consists of alluvial and eolian surficial sediments, basalt flows, and sedimentary interbeds and is typical of the stratigraphy at the INL. Anderson and Lewis (1989), Anderson (1991), Anderson and Bowers (1995), and Anderson and Liszewski (1997) described the stratigraphic sequence of the unsaturated zone and uppermost part of the Snake River Plain aquifer at selected INL facilities and at and near the INL. This sequence was formed by extrusion and cooling of basaltic lava followed by periods of volcanic quiescence and sedimentary deposition (Nace and others, 1975, p. 16; Anderson and others, 1997). Vertical and horizontal fractures developed as lava flows cooled. These fractures and interflow rubble zones are primary conduits through which water is transmitted.

Locally, perched ground water formed in the basalt and in sedimentary interbeds in response to recharge from wastewater infiltration ponds and localized infiltration of snowmelt and rain. Perched ground water also formed from streamflow infiltration of the Big Lost River (fig. 1). Transmissivity estimates from 22 wells completed in perched ground water ranged from 1.0 to 15,000 ft^2/d.(Ackerman, 1991, p. 10). Differences in the vertical hydraulic conductivity of basalt layers and sedimentary interbeds in the unsaturated zone provide mechanisms for development of perched ground water (Cecil and others, 1991, p. 17). The vertical hydraulic conductivity of a sedimentary interbed typically is smaller than an overlying fractured basalt layer. Perched ground water is closely associated with sedimentary interbeds beneath the RTC, INTEC, and RWMC. Several perched water zones exist below each facility. A more detailed description of the perched zones is available in Cecil and others (1991). Alterations in the baked zones between two basalt layers may contribute to decreased vertical hydraulic conductivity. Dense, unfractured basalt or sediment and chemical filling of fractures near the upper contact of a basalt layer limit the capability of the basalt to transmit water.

Guidelines for Interpreting Results of Radiochemical Analyses

Radionuclide concentrations are reported with an estimated sample standard deviation, **s**, which is obtained by propagating sources of analytical uncertainty in measurements. Guidelines for interpreting analytical results are based on an extension of a method proposed by Currie (1984).

During analysis for a particular radionuclide, laboratory measurements are made on a target sample and a prepared blank. Instrument signals for the sample and the blank vary randomly. Therefore, it is essential to distinguish between two key aspects of the problem of detection: (1) the instrument signal for the sample must be larger than the signal observed

for the blank before the decision can be made that a radionuclide was detected; and (2) an estimate must be made of the minimum radionuclide concentration that will yield a sufficiently large observed signal before the correct decision can be made for detection or non-detection of a radionuclide. The first aspect of the problem is a qualitative decision based on an observed signal and a definite detection criterion. The second aspect of the problem is an estimation of detection capabilities of a given measurement process.

In the laboratory, instrument signals must exceed a critical level of 1.6**s** before the qualitative decision can be made regarding whether a radionuclide was detected. At 1.6**s**, the correct conclusion—not detected—is about a 95-percent probability. Given a large number of samples, as many as 5 percent of the samples with measured concentrations greater than or equal to 1.6**s**, which were determined as detected, might not contain the radionuclide. These measurements are referred to as false positives and are errors of the first kind in hypothesis testing.

Once the critical level of 1.6**s** is defined, the minimum detectable concentration may be determined. Concentrations that equal 3**s** represent measurements at the minimum detectable concentration. For true concentrations equal to or greater than 3**s,** the probability is 95 percent or higher that the radionuclide was detected in a sample. In a large number of samples, the conclusion—not detected—will be made in 5 percent of samples that contain true concentrations at the minimum detectable concentration of 3**s**. These measurements are referred to as false negatives and are errors of the second kind in hypothesis testing.

True radionuclide concentrations between 1.6**s** and 3**s** have larger errors of the second kind. That is, there is a larger-than-5-percent probability of false negative results for samples with true concentrations between 1.6**s** and 3**s**. Although the radionuclide might have been detected, such detection may not be considered reliable; at 1.6**s**, the probability of a false negative is about 50 percent.

The critical level and minimum detectable concentration are based on counting statistics alone and do not include systematic or random errors inherent in laboratory procedures. The values 1.6**s** and 3**s** vary slightly with background or blank counts, with the number of gross counts for individual analyses, and for different radionuclides.

In this report, radionuclide concentrations less than 3**s** are considered to be below a "reporting level." The critical level, minimum detectable concentration, and reporting level help the reader interpret analytical results and do not represent absolute radioactivity concentrations, which may or may not have been detected.

Many analytical results of environmental radioactivity measurements are at or near zero. If the true concentration for a given radionuclide is zero, a given set of analytical results for that radionuclide should be distributed about zero, with an equal number of negative and positive measurements. Negative analytical results occur if the radioactivity of a water sample is less than background radioactivity or the radioactivity of the prepared blank sample in the laboratory (American Society for Testing and Materials, 1992, p. 126; Knobel and others, 1992, p. 51).

Guidelines for Interpreting Results of Chemical Analyses

Historically, the NWQL used a minimum reporting level (MRL) to report nondetected concentrations or concentrations less than the MRL. The MRL for chemical constituents is the lowest measured constituent concentration that may be reliably reported using a given analytical method (Timme, 1995). This was the "less than" value reported by the NWQL. However, the NWQL determined that establishment of MRLs often was inconsistent, undefined, undocumented, and subjective (Childress and others, 1999). In 1998, the NWQL began implementing new reporting procedures for some analytical methods based on long-term method detection levels. Childress and others (1999, p. 16) explained the new reporting procedures used by the NWQL:

"The USGS National Water Quality Laboratory collects quality-control data on a continuing basis to evaluate selected analytical methods to determine long-term method detection levels (LT–MDLs) and laboratory reporting levels (LRLs). These values are re-evaluated each year on the basis of the most recent quality control data and, consequently, may change from year to year.

This reporting procedure limits the occurrence of false positive error. The chance of falsely reporting a concentration greater than the LT–MDL for a sample in which the analyte is not present is 1 percent or less. Application of the LRL limits the occurrence of false negative error. The chance of falsely reporting a non-detection for a sample in which the analyte is present at a concentration equal to or greater than the LRL is 1 percent or less.

Accordingly, concentrations are reported as <LRL for samples in which the analyte was either not detected or did not pass identification. Analytes detected at concentrations between the LT-MDL and LRL and that pass identification criteria are estimated. Estimated concentrations will be noted with a remark code of "E." These data should be used with the understanding that their uncertainty is greater than that of data reported without the "E" remark code."

New LRLs were established for some analytical methods during 1999–2001. In this report, concentrations determined using these methods are reported as greater than the LRL; concentrations determined using other methods are reported as greater than the MRL. Estimated concentrations less than the LRLs are treated as nondetected concentrations for consistency with treatment in previous publications, and because an estimated concentration is considered a "qualitatively detected analyte" (Childress and others, 1999, p. 7).

Distribution of Selected Radiochemical and Chemical Constituents in Perched Ground Water

Wastewater-disposal sites at INL facilities are the principal sources of radiochemical and chemical constituents in the Snake River Plain aquifer. These sites included infiltration ponds and ditches, lined evaporation ponds, drain fields, pits, and disposal wells. During 1999–2001, wastewater was discharged to infiltration and lined-evaporation ponds. Liquid and solid waste materials buried at the RWMC (fig. 1) also are sources of some constituents in ground water.

Radiochemical and chemical constituents in wastewater migrate to the Snake River Plain aquifer through perched ground water beneath wastewater infiltration ponds at the RTC and INTEC. Perched ground water beneath the RWMC formed from infiltration of snowmelt and rain and recharge from the Big Lost River and INL spreading areas. This perched water contains constituents leached from buried radioactive and organic-chemical wastes. The extent of this perched ground water is affected by the waste-disposal practices.

Contractors at each INL facility collect radioactive- and chemical-waste-disposal data. Historical radioactive-waste-disposal data presented in this report were obtained from a series of radioactive-waste-management information reports (French and others, 1997b; French and Taylor, 1998, and French and others, 1999b). Chemical-waste-disposal data were obtained from a series of nonradiological-waste-management information reports (French and others, 1997a; 1998; 1999a). Since 1999, no formal program has been in place to compile annual amounts of constituents discharged at each facility (Richard Kauffman, U.S. Department of Energy, oral commun., 2005); however, the INEEL Site Environmental Reports (Stoller Corp., 2002a, b, and c) provide some radioactive waste disposal data for 1999–2001. Effluent monitoring and wastewater discharge raw data for some INL facilities were provided by DOE contractor personnel (Teresa Meachum, CH2M-WG Idaho, LLC, written commun., 2005), however compilation of those data was beyond the scope of this report. Therefore, this report does not present amounts and types of most radioactive and chemical wastes discharged at the various facilities for 1999–2001. Davis (2006) presents a more detailed description of the waste-disposal history at selected facilities.

Reactor Technology Complex

Shallow and deep perched ground water formed at the RTC in response to wastewater disposal to radioactive-, chemical-, cold-, and sanitary-waste ponds (fig. 2). During 2001, about 293 Mgal/yr of wastewater was discharged to infiltration and lined evaporation ponds at the RTC. Selected radiochemical and inorganic chemical constituents in wastewater have been monitored in the shallow and deep perched ground water since the early 1960s.

Water samples from seven wells (CWP 1, 2, 3, 4, 5, 8, TRA A 13) (fig. 3) completed in shallow perched ground water near the RTC routinely were collected and analyzed for selected radiochemical and chemical constituents during 1999–2001. No water was present in wells CWP 6, 7, and TRA A 77 during this period. Water samples also were collected from 16 wells (PW 8 and 9, USGS 54, 55, 60 through 63, 66, 68 through 73, 78) (fig. 3) completed in deep perched ground water beneath the RTC. No samples were collected from wells USGS 53, 56, 74, and PW 7 because either the well was dry or water was below the level of the pump intake. Selection of radiochemical and chemical constituents for analyses was based on waste-disposal history at the RTC. Selected radiochemical constituents were tritium, strontium-90, cesium-137, and gamma analyses; chemical constituents were dissolved chromium, sodium, chloride, and sulfate.

Tritium

Tritium has a half-life of 12.3 years (Walker and others, 1989, p. 20). During 1952–93, about 10,500 Curies (Ci) of tritium was contained in wastewater discharged to the radioactive-waste infiltration ponds at the RTC. Since August 1993, tritium in wastewater has been discharged to two lined evaporation ponds, replacing the radioactive-waste infiltration ponds (fig. 3) (Orr, 1999), which probably prevents radioactive wastewater from entering the ground. Before 1980, tritium generally accounted for less than 20 percent of the total radioactivity discharged to the ponds; most of the rest consisted of radionuclides with half-lives on the order of several weeks, as well as small amounts of strontium-90, cesium-137, and cobalt-60 (Barraclough and others, 1981). After 1980, tritium generally accounted for more than 90 percent of the total radioactivity. About 191 Ci of tritium was released in wastewater to the RTC lined evaporation ponds

during 1999–2000 (Stoller Corp., 2002a, 2002b). Data are not available for the total amount of tritium in wastewater discharged in 2001. Figure 4 shows annual wastewater and tritium discharged to the radioactive-waste infiltration and lined evaporation ponds during 1962–2001.

Well TRA A 77 (fig. 3) is completed in shallow perched ground water in alluvium near the RTC retention basin (fig. 5), where radioactive wastewater flowed before it was discharged to the radioactive-waste infiltration ponds (figs. 3 and 5). Some wastewater reportedly leaked to the subsurface through cracks in the retention basin (U.S. Department of Energy, 1991, p. 29). To prevent discharge of radioactive wastewater to the retention basin, the retention basin was isolated in 1993 when discharge to the lined evaporation ponds began (Bartholomay and Tucker, 2000). The largest tritium concentration in water from well TRA A 77 during 1989–91 was 3,790±50 pCi/mL (Tucker and Orr, 1998, p. 15). In 1992, the largest tritium concentration increased slightly to 3,940±60 pCi/mL (Bartholomay, 1998, p. 41). In October 1995, the tritium concentration in water from well TRA A 77 had decreased to 22.4±0.9 pCi/mL (Bartholomay, 1998, p. 41) and by April 1997 to 1.0±0.15 pCi/mL (Bartholomay, 1998, table 2). Historically, tritium concentrations were variable in water from well TRA A 77. Because of the shallow depth of well TRA A 77 and its proximity to the leaking retention basin, the variability in tritium concentrations in this well could have been the result of changes in tritium disposal rates (Bartholomay, 1998, p. 10). No samples were collected from this well since April 1997 because no water was present in the well during scheduled sampling dates. The lack of water in this well may be the result of discontinued use of the retention basin for transfer of radioactive wastewater.

Maximum concentrations of tritium in water from well TRA A 13 decreased from 158±2 pCi/mL during 1982-85 to 1.1±0.3 pCi/mL during 1986–88 (Cecil and others, 1991, p. 33); during 1989–2001, tritium concentrations in water from this well were less than the reporting level. The decrease in tritium concentrations in well TRA A 13, between the radioactive-waste infiltration ponds and the cold-waste ponds (fig. 3), likely is attributed to the large quantity of nonradioactive water discharged to the cold-waste ponds (Bartholomay and Tucker, 2000).

Wells CWP 1 through CWP 9 monitor shallow perched ground water around the cold-waste ponds at the RTC. During 1982–2001, tritium was less than the reporting level in water from wells CWP 1 through CWP 7. A tritium concentration of 0.8±0.2 pCi/mL was measured in water from well CWP 8 in November 1988, and since then, concentrations have been less than the reporting level. Tritium concentrations in water from well CWP 9 (fig. 2) decreased from 6.3±0.2 pCi/mL during 1982–85 to 1.1±0.2 pCi/mL during 1986–88 (Cecil and others, 1991, p. 35). No samples have been collected at CWP 9 since 1988. Discharge of cooling-tower wastewater to the TRA disposal well ceased in 1982 and this water subsequently was discharged to the cold-waste ponds. The absence of detectable tritium concentrations in most CWP wells was attributed to the large quantity of nonradioactive wastewater discharged to the cold-waste ponds since 1982, which has diluted any residual radioactive-waste infiltration pond water (Bartholomay and Tucker, 2000).

Tritium concentrations in water from nine wells completed in deep perched ground water (PW 8, PW 9, USGS 54, 55, 61, 66, 70, 71, and 73) generally were greater than the reporting levels during 1999–2001. Concentrations decreased in some wells and varied randomly in other wells (table 2), and all reportable concentrations were less than the 1998 concentrations. Tritium concentrations in water from four wells (USGS 60, 68, 69, and 78) were less than the reporting level during 1999–2001 (table 2). Tritium concentrations varied between reportable and nonreportable concentrations in water from two wells, USGS 62 and 63, during 1999-2001. Tritium concentrations in water from well USGS 62 were greater than the reporting level in October 1999 and April 2000, but the concentration decreased to less than the reporting level by October 2001. Concentrations in water from well USGS 63 were greater than the reporting level in October 2000, however, the concentration decreased to less than the reporting level by October 2001 (table 2). An obstruction in well USGS 53 in 1996 prevented water-level measurement or water-quality sampling. The water level in well USGS 56 decreased below the pump intake in 1997 and no samples have been collected at this well since January 1997 due to lack of water. No samples were collected at wells USGS 74 and PW 7 because they have been dry since 1993 and 1994, respectively. The decreases in concentration and lack of water in wells USGS 53 and 56 may be attributed to discontinuing wastewater disposal to the radioactive-waste infiltration ponds. Variations in tritium concentrations in water from these wells likely are attributed to fluctuations in disposal rates and to mixing of water from the radioactive- and cold-waste ponds (Bartholomay and Tucker, 2000).

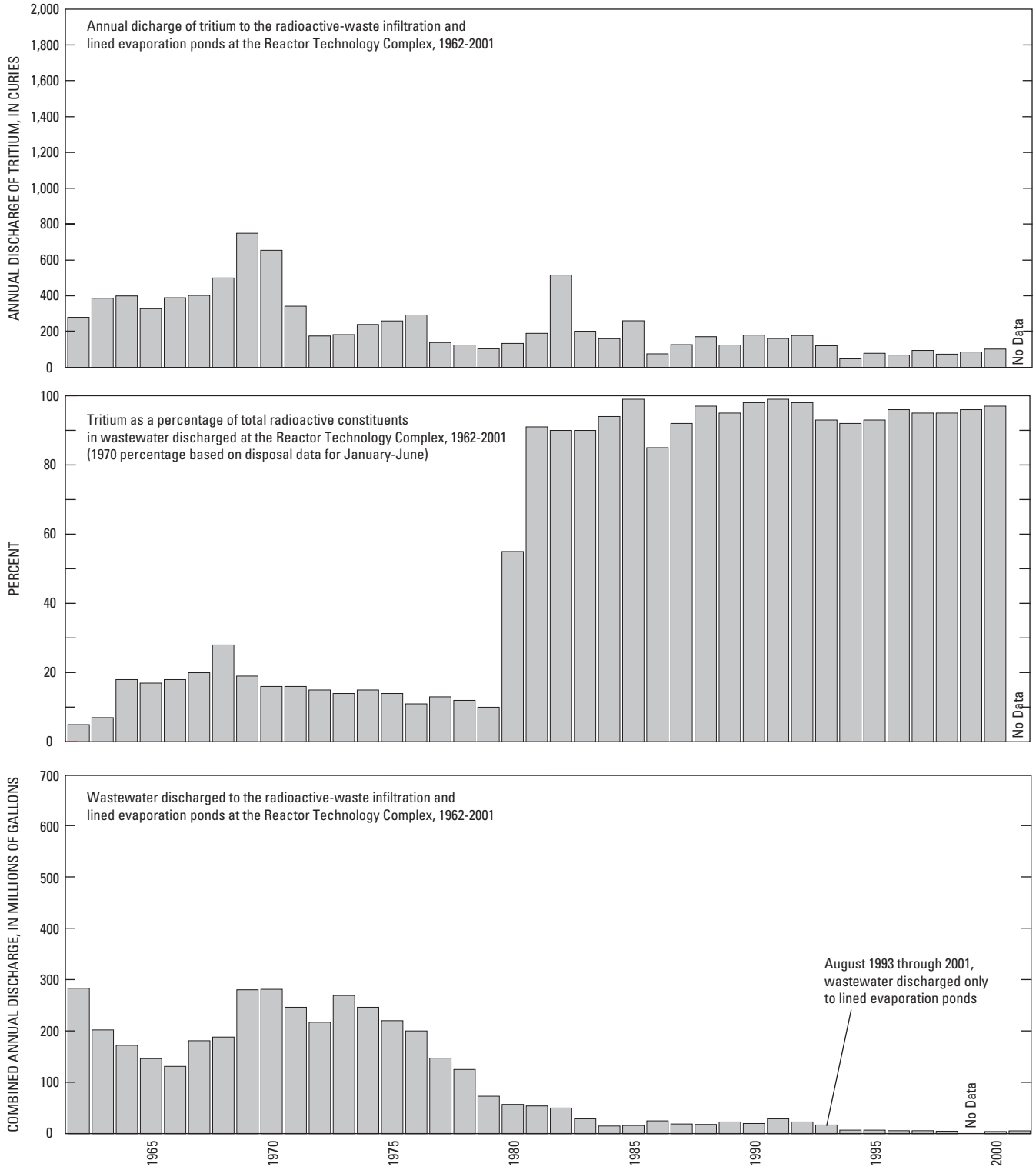

Figure 4. Amount of tritium discharged, tritium as a percentage of total radioactive constituents in wastewater discharged, and volume of wastewater discharged to the radioactive-waste infiltration and lined evaporation ponds at the Reactor Technology Complex, Idaho National Laboratory, Idaho, 1962–2001.

During July–October 2001, the most recent tritium concentrations in water from eight wells completed in deep perched ground water at the RTC exceeded the reporting levels (fig. 5; table 2). Tritium concentrations ranged from 0.49±0.14 pCi/mL (well PW 8) to 39.4±1.4 pCi/mL (well PW 9). During July–October 2001, reportable tritium concentrations in water from wells completed in deep perched ground water (fig. 5) were less than concentrations measured during July–December 1998 (Bartholomay and Tucker, 2000, fig. 5).

Water samples collected in October 2001 from wells USGS 73 and PW 9 contained tritium concentrations of 9.3±0.5 and 39.4±1.4 pCi/mL, respectively. These concentrations represent generally steady decreases since 1993 when the radioactive-waste infiltration ponds were taken out of service. Water in well USGS 74 contained 93.1±1.7 pCi/mL in April 1992; however, no samples have been collected since 1992 because the well has been dry.

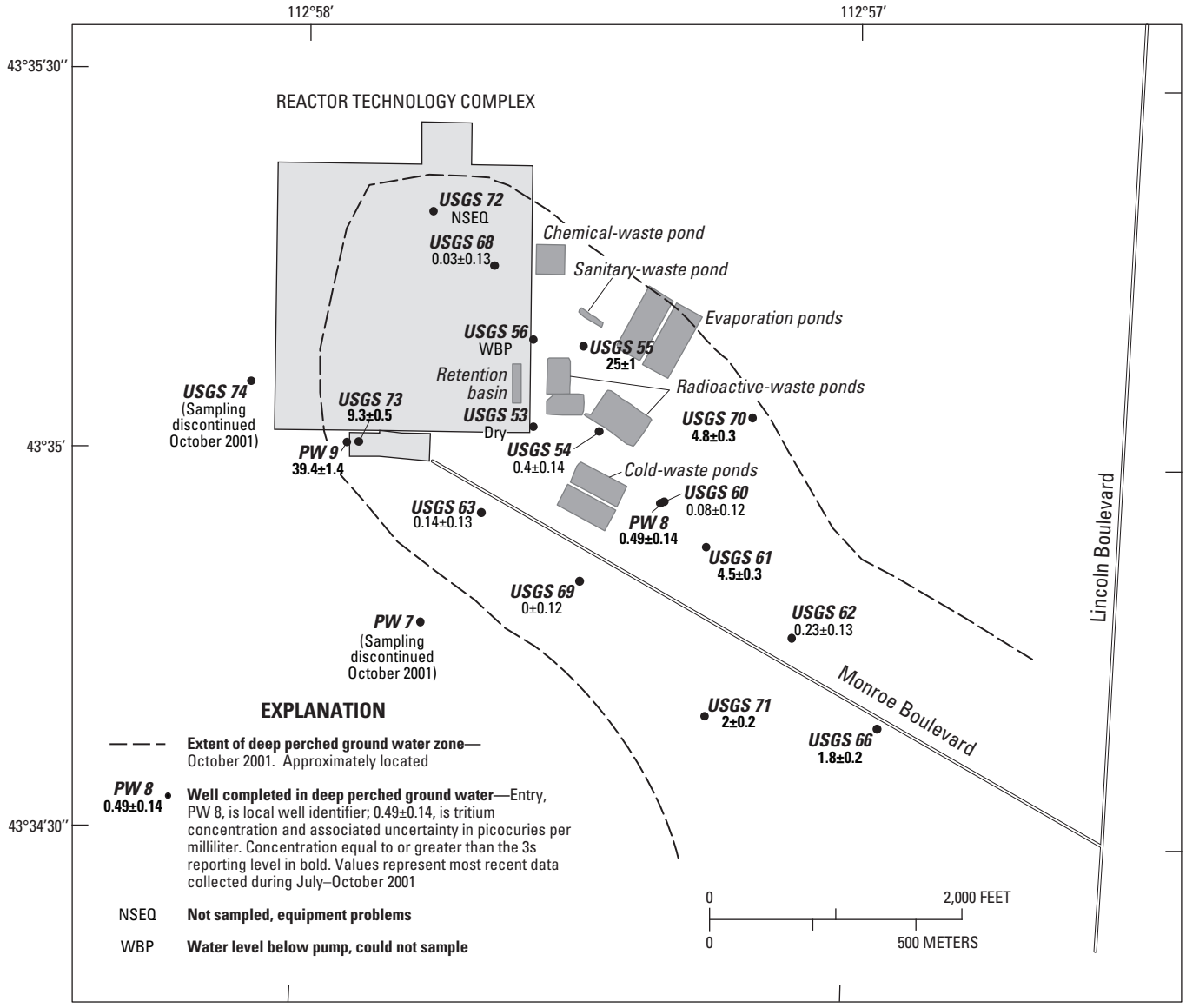

Figure 5. Concentrations of tritium in water from wells completed in deep perched ground water, Reactor Technology Complex, Idaho National Laboratory, Idaho, July–October 2001.

Table 2. Concentrations of tritium, strontium-90, and cesium-137 in perched ground water from selected wells, Reactor Technology Complex, Idaho National Laboratory, Idaho, 1999–2001.

[**Well No.:** Locations of wells are shown in figure 3. Analyses completed by the Radiological and Environmental Sciences Laboratory. Analytical uncertainties are reported as 1 times the sample standard deviation. Concentrations equal to or greater than 3 times the sample standard deviation are considered to be greater than the reporting level and are bold. **Abbreviations:** DP, well completed in deep perched water; QA-3, quality assurance replicate sample, number indicates the replicate sequence number during a sampling event; SP, well completed in shallow perched water; NR, analysis not requested; NS, not sampled due to lack of water or because water level was below pump intake; NSO, not sampled because of obstruction in well; NSA, not sampled because of well access problems; NSEQ, not sampled because of equipment problems; pCi/mL, picocurie per milliliter; pCi/L, picocurie per liter; SL, sample lost in analysis; USGS, U.S. Geological Survey. **Symbol:** ±, plus or minus]

Well No.	Date sampled	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)
CWP 1 (SP)	06-30-99	0.02 ± 0.12	**3.1 ± 0.7**	NR
	07-17-00	0.03 ± 0.12	1.4 ± 0.8	NR
	07-26-01	0 ± 0.12	1 ± 0.7	NR
CWP 2 (SP)	06-30-99	NS	NS	NS
	07-17-00	0.03 ± 0.12	0.4 ± 0.7	NR
	07-17-00 QA-3	0.01 ± 0.12	0 ± 0.7	NR
	07-26-01	-0.07 ± 0.12	-0.1 ± 0.6	NR
CWP 3 (SP)	06-30-99	0.01 ± 0.12	0.4 ± 0.7	NR
	06-30-99 QA-1	0.03 ± 0.12	1 ± 0.8	NR
	07-17-00	NS	NS	NS
	07-26-01	-0.05 ± 0.12	-0.1 ± 0.6	NR
CWP 4 (SP)	06-30-99	0.02 ± 0.12	1.7 ± 0.7	NR
	07-17-00	NS	NS	NS
	07-26-01	-0.02 ± 0.12	-0.7 ± 0.6	NR
CWP 5 (SP)	06-30-99	NS	NS	NS
	07-17-00	NS	NS	NS
	07-26-01	-0.01 ± 0.12	0 ± 0. 6	NR
CWP 6 (SP)	06-30-99	NS	NS	NS
	07-17-00	NS	NS	NS
	07-19-01	NS	NS	NS
CWP 7 (SP)	06-30-99	NS	NS	NS
	07-17-00	NS	NS	NS
	07-19-01	NS	NS	NS
CWP 8 (SP)	06-30-99	0.02 ± 0.12	0 ± 0.7	NR
	07-17-00	0.04 ± 0.12	0 ± 0.8	NR
	07-26-01	0.05 ± 0.13	0 ± 0.6	NR
PW 7 (DP)	04-22-99	NS	NS	NS
	10-19-99	NS	NS	NS
	04-06-00	NS	NS	NS
	10-02-00	NS	NS	NS
	04-18-01	NS	NS	NS
PW 8 (DP)	01-21-99	**0.93 ± 0.16**	**12.4 ± 0.7**	NR
	04-06-99	**0.57 ± 0.14**	**12.8 ± 0.9**	24 ± 30
	07-15-99	**1.15 ± 0.16**	**11.8 ± 0.9**	NR
	10-19-99	**0.55 ± 0.16**	**13 ± 0.9**	NR
	01-26-00	**0.88 ± 0.15**	**13 ± 1**	NR
	04-05-00	**0.9 ± 0.2**	**15.4 ± 0.9**	10 ± 30
	07-20-00	**1.25 ± 0.17**	**15.5 ± 1**	NR
	10-04-00	**0.84 ± 0.16**	**16.5 ± 1.1**	NR
	01-23-01	**0.67 ± 0.15**	**13.8 ± 0.8**	NR
	04-03-01	0.37 ± 0.15	**10.4 ± 0.9**	-60 ± 40
	07-26-01	0.22 ± 0.14	**7.9 ± 0.8**	NR
	10-09-01	**0.49 ± 0.14**	**9.3 ± 0.8**	NR

Table 2. Concentrations of tritium, strontium-90, and cesium-137 in perched ground water from selected wells, Reactor Technology Complex, Idaho National Laboratory, Idaho, 1999–2001.—Continued

[**Well No.:** Locations of wells are shown in figure 3. Analyses completed by the Radiological and Environmental Sciences Laboratory. Analytical uncertainties are reported as 1 times the sample standard deviation. Concentrations equal to or greater than 3 times the sample standard deviation are considered to be greater than the reporting level and are bold. **Abbreviations:** DP, well completed in deep perched water; QA-3, quality assurance replicate sample, number indicates the replicate sequence number during a sampling event; SP, well completed in shallow perched water; NR, analysis not requested; NS, not sampled due to lack of water or because water level was below pump intake; NSO, not sampled because of obstruction in well; NSA, not sampled because of well access problems; NSEQ, not sampled because of equipment problems; pCi/mL, picocurie per milliliter; pCi/L, picocurie per liter; SL, sample lost in analysis; USGS, U.S. Geological Survey. **Symbol:** ±, plus or minus]

Well No.	Date sampled	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)
PW 9 (DP)	01-20-99	**80.4 ± 2.8**	-0.8 ± 0.7	NR
	04-06-99	**75.3 ± 2.6**	0.69 ± 0.7	8 ± 30
	07-14-99	**65.3 ± 2.3**	0.4 ± 0.7	NR
	10-06-99	**62.7 ± 2.2**	0.6 ± 0.8	NR
	01-26-00	**53.3 ± 1.9**	1.2 ± 0.7	NR
	04-05-00	**53.9 ± 1.9**	1 ± 1	-40 ± 20
	07-06-00	**53.6 ± 1.9**	0.7 ± 0.8	NR
	10-04-00	**49.1 ± 1.7**	0.4 ± 0.9	NR
	04-03-01	**51.3 ± 1**	**2.3 ± 0.7**	20 ± 30
	07-26-01	**47.1 ± 0.9**	-0.12 ± 0.65	NR
	10-09-01	**39.4 ± 1.4**	0.7 ± 0.6	NR
TRA A 13 (SP)	04-26-99	0.18 ± 0.12	**32.8 ± 1**	7 ± 30
	10-06-99	0.02 ± 0.13	**38 ± 1.4**	10 ± 30
	04-13-00	0.07 ± 0.12	**34.6 ± 1.2**	20 ± 30
	09-27-00	NS	NS	NS
	04-18-01	-0.08 ± 0.13	**22.1 ± 1.1**	-60 ± 40
	10-14-01	NSO	NSO	NSO
TRA A 77 (SP)	05-26-99	NSA	NSA	NSA
	07-21-99	NS	NS	NS
	10-19-99	NS	NS	NS
	10-18-00	NS	NS	NS
	04-16-01	NS	NS	NS
	11-10-01	NS	NS	NS
USGS 53 (DP)	04-21-99	NS	NS	NS
	10-09-99	NS	NS	NS
	04-06-00	NS	NS	NS
	10-02-00	NS	NS	NS
	04-18-01	NS	NS	NS
	10-04-01	NS	NS	NS
USGS 54 (DP)	01-20-99	**0.6 ± 0.15**	**77 ± 2**	NR
	04-21-99	0.11 ± 0.12	**68.2 ± 2**	-7 ± 40
	07-14-99	**0.79 ± 0.15**	**79 ± 2**	NR
	10-06-99	0.24 ± 0.14	**70 ± 2**	10 ± 30
	01-26-00	**0.69 ± 0.14**	**85 ± 4.1**	NR
	04-11-00	0.01 ± 0.12	**76.1 ± 1.9**	-20 ± 30
	07-06-00	**1.7 ± 0.2**	**82.1 ± 2.2**	NR
	10-04-00	**0.44 ± 0.14**	**85.7 ± 2.2**	10 ± 40
	01-18-01	-0.01 ± 0.12	**86.3 ± 2.1**	NR
	04-12-01	0.16 ± 0.14	**63 ± 1.8**	-40 ± 40
	07-30-01	0.16 ± 0.13	**68.4 ± 1.9**	NR
	10-23-01	0.4 ± 0.14	**83.8 ± 2.1**	40 ± 40
USGS 55 (DP)	04-21-99	**30.7 ± 1.2**	**44 ± 2**	6 ± 20
	10-26-99	**45.8 ± 1.6**	**33 ± 1.2**	NR
	04-13-00	**36.8 ± 1.3**	**26.4 ± 1.1**	-10 ± 40
	10-05-00	NS	NS	NS
	04-19-01	**17.3 ± 0.5**	**44.4 ± 1.4**	-10 ± 20
	10-23-01	**25 ± 1**	**58.1 ± 1.6**	NR

Table 2. Concentrations of tritium, strontium-90, and cesium-137 in perched ground water from selected wells, Reactor Technology Complex, Idaho National Laboratory, Idaho, 1999–2001.—Continued

[**Well No.:** Locations of wells are shown in figure 3. Analyses completed by the Radiological and Environmental Sciences Laboratory. Analytical uncertainties are reported as 1 times the sample standard deviation. Concentrations equal to or greater than 3 times the sample standard deviation are considered to be greater than the reporting level and are bold. **Abbreviations:** DP, well completed in deep perched water; QA-3, quality assurance replicate sample, number indicates the replicate sequence number during a sampling event; SP, well completed in shallow perched water; NR, analysis not requested; NS, not sampled due to lack of water or because water level was below pump intake; NSO, not sampled because of obstruction in well; NSA, not sampled because of well access problems; NSEQ, not sampled because of equipment problems; pCi/mL, picocurie per milliliter; pCi/L, picocurie per liter; SL, sample lost in analysis; USGS, U.S. Geological Survey. **Symbol:** ±, plus or minus]

Well No.	Date sampled	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)
USGS 56 (DP)	04-26-99	NS	NS	NS
	10-19-99	NS	NS	NS
	10-18-00	NS	NS	NS
	04-16-01	NS	NS	NS
	10-10-01	NS	NS	NS
USGS 60 (DP)	04-06-99	-0.04±0.11	0.4±0.8	20±20
	10-19-99	0.06±0.14	**3.7±0.8**	NR
	04-05-00	0.09±0.12	**4±1**	13.5±34.2
	10-04-00	0.12±0.13	**8.3±1**	NR
	10-04-00 QA-2	0.13±0.13	**7.1±1**	NR
	04-03-01	0.37±0.15	**10.4±0.9**	-60±40
	10-09-01	0.08±0.12	0.7±0.6	NR
USGS 61 (DP)	04-13-99	**8.1±0.4**	0.5±0.8	10±20
	04-13-99 QA-1	**8.4±0.4**	1.6±0.8	-10±20
	10-06-99	**7.5±0.4**	1.1±0.8	NR
	04-06-00	**6.3±0.4**	1.9±0.7	20±40
	09-27-00	**5.4±0.3**	0.1±0.9	NR
	04-12-01	**5.8±0.3**	0.4±0.8	-20±40
	10-04-01	**4.5±0.3**	-1.1±0.7	NR
USGS 62 (DP)	04-13-99	0.17±0.12	**4.36±0.8**	7±30
	10-06-99	**2±0.2**	**3.6±0.8**	NR
	04-03-00	**0.3±0.1**	**3±1**	10±30
	09-27-00	0.16±0.13	**2.9±0.9**	NR
	09-27-00 QA-1	0.05±0.12	3.3±0.9	NR
	04-17-01	0.2±0.14	1.6±0.8	52±38
	10-09-01	0.23±0.13	1.4±0.6	NR
USGS 63 (DP)	04-13-99	0.16±0.12	**4.9±0.9**	-10±20
	10-25-99	0.4±0.15	**5.5±0.8**	NR
	04-06-00	0.07±0.12	**6±1**	-13.4±44.1
	10-04-00	**0.79±0.16**	**4±0.9**	NR
	04-19-01	0.15±0.14	**3.2±0.7**	0±50
	10-15-01	0.14±0.13	**2.8±0.7**	NR
USGS 66 (DP)	07-08-99	**3.3±0.2**	1.4±0.7	NR
	07-25-00	**2.6±0.2**	0.7±0.9	NR
	07-25-00 QA-8	**2.6±0.2**	0.3±0.8	NR
	07-25-01	**1.8±0.2**	0.3±0.7	NR
USGS 68 (DP)	05-26-99	NSA	NSA	NSA
	07-21-99	0.01±0.12	0.4±0.8	15±33
	10-19-99	-0.08±0.13	0.5±0.8	14.8±33.8
	10-18-00	0.1±0.1	0.4±1.1	13.1±20.5
	04-16-01	0±0.13	-0.3±0.9	0±40
	10-10-01	0.03±0.13	1.4±1.3	30±30

Table 2. Concentrations of tritium, strontium-90, and cesium-137 in perched ground water from selected wells, Reactor Technology Complex, Idaho National Laboratory, Idaho, 1999–2001.—Continued

[**Well No.:** Locations of wells are shown in figure 3. Analyses completed by the Radiological and Environmental Sciences Laboratory. Analytical uncertainties are reported as 1 times the sample standard deviation. Concentrations equal to or greater than 3 times the sample standard deviation are considered to be greater than the reporting level and are bold. **Abbreviations:** DP, well completed in deep perched water; QA-3, quality assurance replicate sample, number indicates the replicate sequence number during a sampling event; SP, well completed in shallow perched water; NR, analysis not requested; NS, not sampled due to lack of water or because water level was below pump intake; NSO, not sampled because of obstruction in well; NSA, not sampled because of well access problems; NSEQ, not sampled because of equipment problems; pCi/mL, picocurie per milliliter; pCi/L, picocurie per liter; SL, sample lost in analysis; USGS, U.S. Geological Survey. **Symbol:** ±, plus or minus]

Well No.	Date sampled	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)
USGS 69 (DP)	07-13-99	0.04±0.12	0.5±0.7	NR
	07-12-00	0.02±0.12	1.1±0.7	NR
	07-31-01	0±0.12	0.3±0.6	NR
USGS 70 (DP)	04-13-99	**5.7±0.3**	**42.5±2**	7±20
	10-26-99	**5.9±0.3**	**47±1.4**	NR
	04-06-00	**8.6±0.4**	**50.6±1.5**	10±40
	10-04-00	**11.8±0.5**	**47.8±1.5**	NR
	04-19-01	**4.5±0.3**	**40.6±1.3**	-30±20
	10-15-01	**4.8±0.3**	**50.4±1.5**	NR
USGS 71 (DP)	04-27-99	**2.9±0.2**	SL	18±20
	10-21-99	**2.6±0.2**	0±0.8	NR
	04-13-00	**NS**	NS	NS
	10-03-00	**2±0.2**	1.1±0.8	NR
	04-17-01	**NS**	NS	NS
	10-10-01	**2±0.2**	0.4±0.7	NR
USGS 72 (DP)	07-21-99	NSEQ	NSEQ	NSEQ
	10-19-99	-0.12±0.13	-0.5±0.7	20±20
	08-03-00	NSEQ	NSEQ	NSEQ
	07-19-01	NSEQ	NSEQ	NSEQ
USGS 73 (DP)	04-15-99	**37.9±1.4**	2.0±0.8	58±30
	10-21-99	**25.9±1**	0.7±0.8	NR
	04-13-00	**26.1±1**	0.3±0.8	42±30
	09-27-00	**29.9±1.1**	0±0.9	NR
	04-02-01	**19.9±0.6**	0.88±0.67	56±39
	10-10-01	**9.3±0.5**	0.5±0.6	NR
USGS 74 (DP)	04-22-99	NS	NS	NS
	10-19-99	NS	NS	NS
	04-10-00	NS	NS	NS
	10-02-00	NS	NS	NS
	04-18-01	NS	NS	NS
USGS 78 (DP)	07-08-99	0.05±0.12	-0.4±0.8	NR
	07-25-00	0.08±0.12	0.74±0.71	NR
	07-25-01	-0.07±0.12	-0.3±0.6	NR

The well was removed from the sampling schedule in October 2001. These three wells are more than 1,500 ft west of the radioactive-waste infiltration ponds (fig. 5). Historically large tritium concentrations in water from these wells indicate that the chemistry of perched ground water west of the RTC was affected by radioactive-waste infiltration pond disposals. Discontinuation of wastewater discharge to the radioactive-waste infiltration ponds and subsequent use of lined evaporation ponds, together with the radioactive decay process, may account for the decreased tritium concentrations in this area and could indicate an eastward migration of the extent of deep perched water relative to well USGS 74.

Water-level hydrographs for wells USGS 60 and 73 (fig. 6) indicate that wastewater disposal to the cold-waste ponds since 1982 has hydraulically affected perched ground water flow to the west and east. Disposal to the cold-waste ponds affected water levels much less in wells USGS 54 and 70, to the north and northeast of the cold-waste ponds (fig. 6). Water levels in all four wells decreased significantly in 1992 (fig. 6), when wastewater discharge to the cold-waste ponds was much less than during other years (Bartholomay and Tucker, 2000). Because of the effect of disposal to the cold-waste ponds on water levels and the removal of the radioactive-waste infiltration ponds as a water source, tritium concentrations in perched ground water at the RTC likely decreased as nonradioactive wastewater from the cold-waste ponds mixed with water derived from earlier radioactive-waste infiltration pond disposal (Bartholomay and Tucker, 2000).

Bartholomay (1998) determined that increases in tritium concentrations in water from wells USGS 53, 56, and 70 corresponded partly to tritium disposal rates. The hydraulic connection between the radioactive-waste infiltration ponds and wells USGS 53 and 56 is also demonstrated by the fact that well USGS 53 dried up and the water level in well USGS 56 declined below the pump intake subsequent to cessation of wastewater disposal to the ponds.

Bartholomay (1998) noted that increases and decreases in tritium concentrations in water from well USGS 73 lagged from 3 to 13 months behind increases and decreases in well USGS 56. This time lag indicated that tritium in ground water moved from the radioactive-waste infiltration ponds to well USGS 73 during that period. Bartholomay (1998) also determined that changes in tritium concentrations in water from well USGS 54 did not correspond directly to monthly changes in tritium disposal. The lack of correspondence indicated that other factors, including hydraulic effects and dilution from the cold-waste ponds, affected tritium concentrations in water from that well.

Several factors have affected the distribution of tritium in perched ground water at the RTC. These factors include proximity of the wells to the radioactive-waste infiltration ponds, depth of the water below the ponds, variations in the tritium disposal rate, and radioactive decay. Since 1982, tritium concentrations also have been affected by dilution from the cold-waste ponds. Replacement of the radioactive-waste infiltration ponds with the lined evaporation ponds in 1993 contributed to decreases in tritium concentrations in perched ground water and decreases in the amount of perched water in some wells. Infiltration from the Big Lost River during 1999 and early 2000 may have contributed to diluted tritium concentrations in perched ground water southeast of the RTC . Tritium concentrations in wells USGS 62, 66, and 71 decreased slightly during 1999–2001.

Strontium-90

Strontium-90 has a half-life of 29.1 years (Walker and others, 1989, p. 29). During 1952–93, about 93 Ci of strontium-90 was in wastewater discharged to the radioactive-waste infiltration ponds at the RTC, an average of 2.3 Ci/yr (Bartholomay and Tucker, 2000). During 1996–98, about 0.03 Ci was discharged to the lined evaporation ponds (Bartholomay and Tucker, 2000). During 1999, less than 0.001 Ci of strontium-90 was discharged at the RTC (Stoller Corp., 2002a, table 7-2); during 2000, 0.21 Ci of strontium-90/yttrium-90 was discharged at the RTC (Stoller Corp., 2002b, table 6-2). Data are not available for the amount of strontium-90 discharged in 2001.

During 1996–98, strontium-90 concentrations in water from wells TRA A 77 and TRA A 13, completed in shallow perched ground water, were above the reporting levels (Bartholomay and Tucker, 2000, table 2). Concentrations in water from well TRA A 77 ranged from 4,710±140 pCi/L in October 1996 to 6,800±200 pCi/L in April 1997. Well TRA A 77 was not sampled during 1999–2001 because of well access problems or lack of water in the well. In October 1998, the concentration of strontium-90 in water from well TRA A 13 was 23.5±1.2 pCi/L. Water from well TRA A 13 exceeded the reporting level during 1999–2001 and in April 2001 the concentration was 22.1±1.1 pCi/L (table 2), consistent with the October 1998 concentration. The well was not sampled in October 2001 because of an obstruction in the well. Well CWP 1, also completed in shallow perched ground water, exceeded the reporting level in June 1999 with a concentration of 3.1±0.7 pCi/L, however, by July 2001, the concentration was less than the reporting level.

In October 2001, concentrations of strontium-90 in water from wells PW 8, USGS 54, 55, 63, and 70, completed in deep perched ground water at the RTC were greater than reporting levels (table 2 and fig. 7); concentrations ranged from 2.8±0.7 pCi/L in well USGS 63 to 83.8±2.1 pCi/L in well USGS 54. The distribution of strontium-90 concentrations in water from these wells during 1999–2001 is attributed to exchange reactions between strontium-90 in solution and sediments beneath the radioactive-waste infiltration ponds.

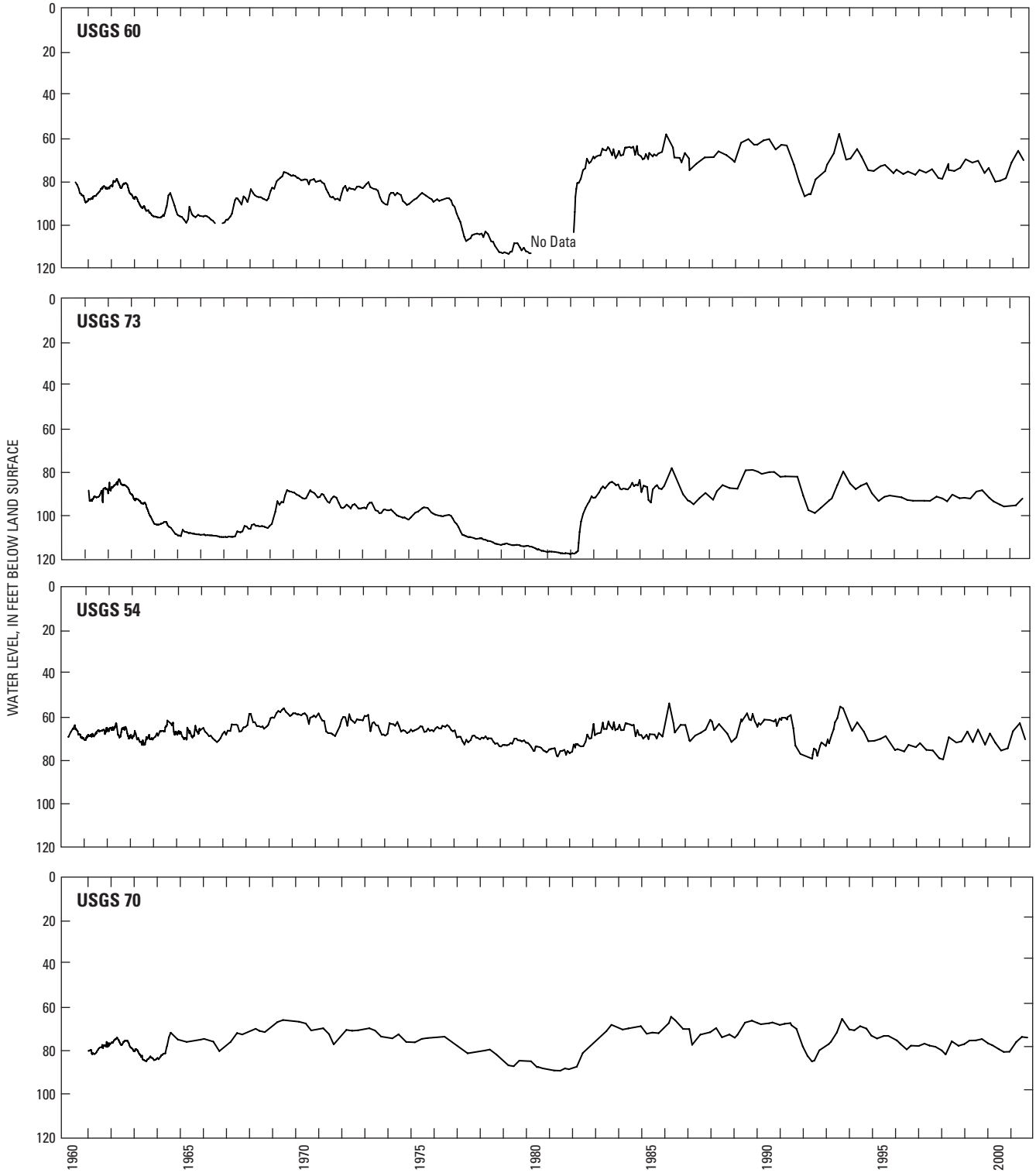

Figure 6. Water-level changes in selected wells, Reactor Technology Complex, Idaho National Laboratory, Idaho, 1960–2001.

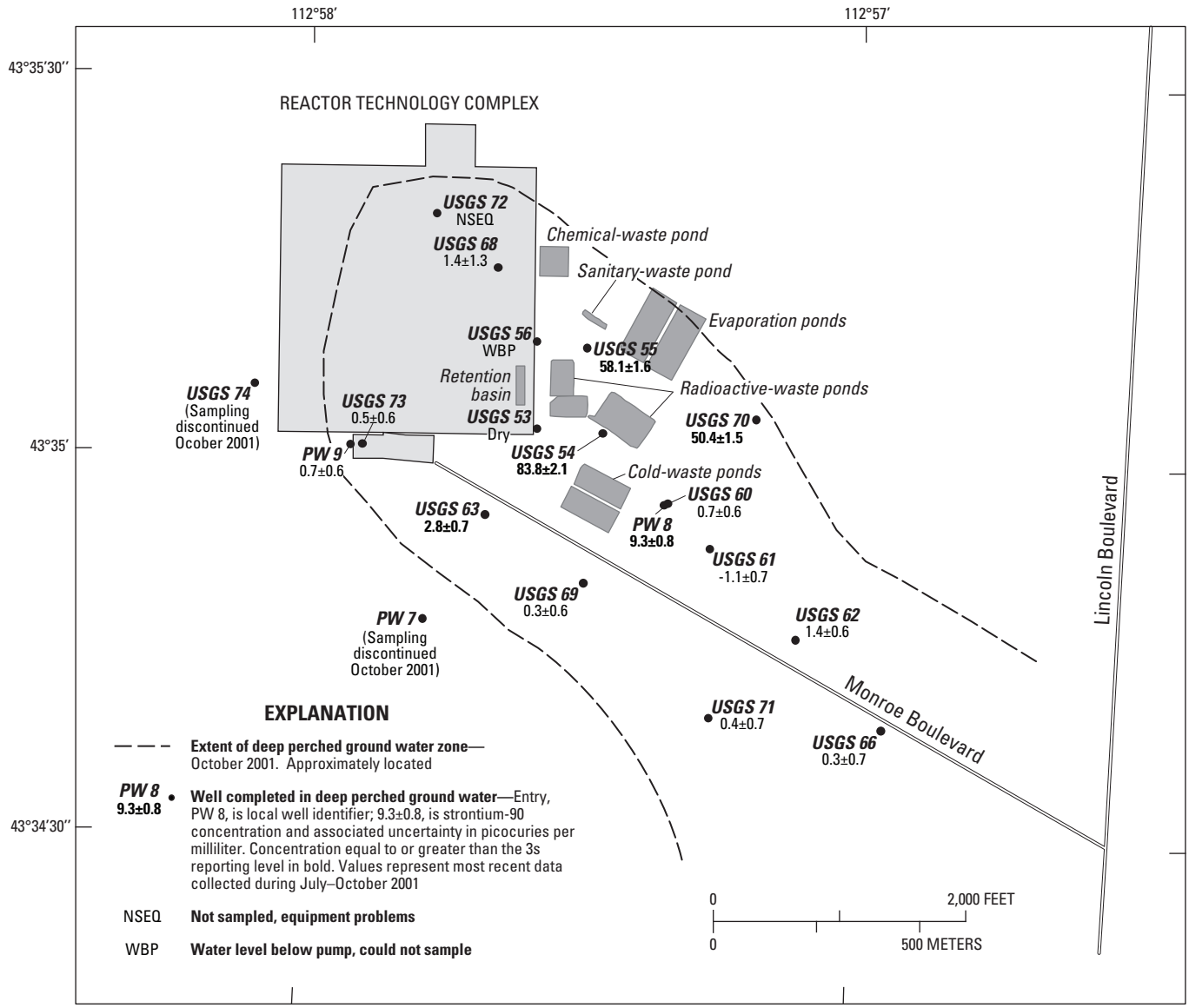

Figure 7. Concentrations of strontium-90 in water from wells completed in deep perched ground water, Reactor Technology Complex, Idaho National Laboratory, Idaho, July–October 2001.

Strontium-90 was not detected in water from the Snake River Plain aquifer beneath the RTC (Bartholomay and others, 1997, p. 30); the absence of detectable concentrations indicates that strontium-90 in solution is removed possibly by sorption and (or) exchange reactions in the unsaturated zone. Study of strontium distribution coefficients for samples of surficial sediment, sedimentary interbeds, and sediment-filled fractures in basalts (Liszewski and others, 1997, 1998; Pace and others, 1999) at the INL support this theory.

Water in wells PW 9 and USGS 62 contained strontium-90 at concentrations less than reporting levels in some samples collected during 1999–2001, but greater than reporting levels in other samples (table 2). Because 2001 strontium-90 disposal data were not available, fluctuations could not be correlated with disposal during 1999–2001. In addition, lined evaporation ponds were in use, which probably prevented contaminated water from percolating into the ground.

Cesium-137

Cesium-137 has a half-life of 30.17 years (Walker and others, 1989, p. 34). About 138 Ci of cesium-137 was in wastewater discharged to the radioactive-waste infiltration ponds at the RTC during 1952–93. The average disposal rate decreased from 2.0 Ci/yr during 1979–81 (Lewis and Jensen, 1985) to 0.65 Ci/yr during 1982–85 (Pittman and others, 1988, p. 35). The average disposal rate of cesium-137 during 1986–88 was 0.23 Ci/yr (Cecil and others, 1991, p. 36). The rate decreased during 1989–91 to 0.02 Ci/yr (Tucker and Orr, 1998, p. 17), and averaged 0.7 Ci/yr during 1992–93 (Bartholomay, 1998, p. 16). After 1993, wastewater was discharged to lined evaporation ponds, which probably prevents any cesium-137 from percolating into the ground.

During 1999–2001, no reportable concentrations of cesium-137 were detected in water from any wells completed in either shallow or deep perched ground water. The general absence of reportable concentrations of cesium-137 in perched ground water at the RTC probably is due to decreasing cesium-137 disposal rates, change from using the radioactive-waste infiltration ponds to lined evaporation ponds, and sorption and (or) exchange of cesium-137 to minerals in sediments. During 1996–97, cesium-137 concentrations in water from shallow well TRA A 77 exceeded the reporting level and ranged from 42,300±1,800 pCi/L in April 1996 to 1,200±110 pCi/L in April 1997. No samples were collected from well TRA A 77 during 1998–2001 because the well was dry. The intermittent presence of cesium-137 in water from well TRA A 77 may have been due to the proximity of the well to the retention basin and to the amount of suspended sediment in water samples collected onto which cesium-137 may have sorbed.

Chromium-51

Chromium-51 has a half-life of 27.7 days (Walker and others, 1989, p. 24). About 2,390 Ci of chromium-51 was in wastewater discharged to the radioactive-waste infiltration and lined evaporation ponds during 1979–98. Data are not available for the amount of chromium-51 discharged during 1999–2001. The average disposal rate of chromium-51 during 1979–81 was 766 Ci/yr (Pittman and others, 1988, p. 35). A total of 25.7 Ci of chromium-51 was discharged during 1986-88, an average of 8.6 Ci/yr (Cecil and others, 1991, p. 35). During 1989–91,11.6 Ci was discharged for an average of 3.9 Ci/yr (Tucker and Orr, 1998, p. 17). During 1992–95, 10 Ci was discharged, an average of 2.5 Ci/yr (Bartholomay, 1998, p. 16). During 1996–98, 6.2 Ci was discharged, an average of 2.1 Ci/yr (Bartholomay and Tucker, 2000).

Because of the decreased amount of chromium-51 discharged and the relatively short half-life, this radionuclide was not detected in water from wells completed in deep perched ground water during 1986–88 (Cecil and others, 1991, p. 35). Chromium-51 was not detected in shallow perched ground water from wells TRA A 13 and CWP 1 through CWP 9 during 1982–88. During 1989–91, chromium-51 was detected in water from wells TRA A 77, USGS 53, and USGS 56 (Tucker and Orr, 1998, p. 17). During 1992–95, chromium-51 was detected only in shallow well TRA A 77; concentrations ranged from 2,700±500 to 24,500±1,300 pCi/L (Bartholomay, 1998, p. 16). Chromium-51 was not detected in any wells during 1996–2001.

Cobalt-60

Cobalt-60 has a half-life of 5.27 years (Walker and others, 1989, p. 25). About 442 Ci of cobalt-60 was in wastewater discharged to the radioactive-waste infiltration ponds at the RTC during 1952–88. The average cobalt-60 disposal rate decreased from 2.3 Ci/yr during 1979–81 to 1 Ci/yr during 1982–85 (Pittman and others, 1988). The average disposal rate was 2.2 Ci/yr during 1986–88, 0.15 Ci/yr during 1989–91, 0.8 Ci/yr during 1992–95 (Bartholomay, 1998, p. 16) and about 0.3 Ci/yr during 1996–98.

During 1996–98, cobalt-60 concentrations in water from wells TRA A 77 and USGS 56 exceeded the reporting level. Concentrations of cobalt-60 in water from well TRA A 77 ranged from 7,700±260 to 44,000±1,400 pCi/L. The concentration in water from well USGS 56 was 220±30 pCi/L (Bartholomay and Tucker, 2000). The presence of cobalt-60 in these wells probably is due to their proximity to the ponds and retention basin. During 1999–2001, no samples were collected from these two wells because well TRA A 77 was dry and water was below the pump intake level in well USGS 56. Cobalt-60 was not detected in any other water samples analyzed during 1999–2001.

Chromium

An estimated 24,000 lb of nonradioactive chromium in wastewater from RTC cooling-tower operations was discharged to the radioactive-waste infiltration ponds during 1952–64 (Mann and Knobel, 1988, p. 7–10). During 1964–72, a disposal well at the RTC was used to dispose chromium directly to the Snake River Plain aquifer. In October 1972, chromium was replaced by polyphosphate as a corrosion inhibitor in cooling-tower operations. No disposal of chromium to the subsurface was reported after 1972.

During 1996–98, dissolved chromium concentrations in shallow perched ground water ranged from less than 5 µg/L in several wells to 26 µg/L in well TRA A 77 (Bartholomay and Tucker, 2000). During 1999–2001, wells TRA A 77, CWP 6, and CWP 7 could not be sampled because the wells were dry. During 1999–2001, dissolved chromium was not detected in shallow perched ground water (table 3).

Table 3. Concentrations of selected dissolved ions in perched ground water from selected wells, Reactor Technology Complex, Idaho National Laboratory, Idaho, 1999–2001.

[**Well No.:** Locations of wells are shown in figures 3, 8, and 9. Analyses completed by the National Water Quality Laboratory. **Abbreviations:** DP, well completed in deep perched water; SP, well completed in shallow perched water; QA-3, quality assurance replicate sample, number indicates the replicate sequence number during a sampling event; µg/L, microgram per liter; mg/L, milligram per liter; NR, analysis not requested; NS, not sampled due to lack of water or because water level was below pump intake; NSA, not sampled because of well access problems; NSEQ, not sampled because of equipment problems; E, estimated; USGS, U.S. Geological Survey. **Symbol:** <, less than respective reporting level]

Well No.	Date sampled	Chromium, dissolved (µg/L)	Sodium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)
CWP 1 (SP)	06-30-99	<14	NR	26	332
	07-17-00	<14	NR	31	419
	07-26-01	<10	NR	10	31
CWP 2 (SP)	06-30-99	NS	NS	NS	NS
	07-17-00	<14	NR	17	123
	07-17-00 QA-3	<14	NR	17	123
	07-26-01	<10	NR	12	78
CWP 3 (SP)	06-30-99	<14	NR	24	295
	06-30-99 QA-1	<14	NR	24	293
	07-17-00	NS	NS	NS	NS
	07-26-01	<10	NR	10	35
CWP 4 (SP)	06-30-99	<14	NR	12	74
	07-17-00	NS	NS	NS	NS
	07-26-01	<10	NR	10	48
CWP 5 (SP)	06-30-99	NS	NS	NS	NS
	07-17-00	NS	NS	NS	NS
	07-26-01	<10	NR	11	58
CWP 6 (SP)	06-30-99	NS	NS	NS	NS
	07-17-00	NS	NS	NS	NS
	07-19-01	NS	NS	NS	NS
CWP 7 (SP)	06-30-99	NS	NS	NS	NS
	07-17-00	NS	NS	NS	NS
	07-19-01	NS	NS	NS	NS
CWP 8 (SP)	06-30-99	<14	NR	13	78
	07-17-00	<14	NR	15	134
	07-26-01	<10	NR	11	48
PW 7 (DP)	04-22-99	NS	NS	NS	NS
	10-19-99	NS	NS	NS	NS
	04-06-00	NS	NS	NS	NS
	10-02-00	NS	NS	NS	NS
	04-18-01	NS	NS	NS	NS
PW 8 (DP)	01-21-99	E12	NR	20	200
	04-06-99	<14	NR	11	NR
	07-15-99	<14	NR	18	203
	10-19-99	E12	17	19	206
	01-26-00	E13	NR	21	220
	04-05-00	E11	NR	22	NR
	07-20-00	<14	NR	22	270
	10-04-00	E7	19	24	293
	01-23-01	14	NR	22	283
	04-03-01	E7	NR	20	NR
	07-26-01	E7	NR	15	129
	10-09-01	E6	15	20	179

Table 3. Concentrations of selected dissolved ions in perched ground water from selected wells, Reactor Technology Complex, Idaho National Laboratory, Idaho, 1999–2001.—Continued

[**Well No.:** Locations of wells are shown in figures 3, 8, and 9. Analyses completed by the National Water Quality Laboratory. **Abbreviations:** DP, well completed in deep perched water; SP, well completed in shallow perched water; QA-3, quality assurance replicate sample, number indicates the replicate sequence number during a sampling event; µg/L, microgram per liter; mg/L, milligram per liter; NR, analysis not requested; NS, not sampled due to lack of water or because water level was below pump intake; NSA, not sampled because of well access problems; NSEQ, not sampled because of equipment problems; E, estimated; USGS, U.S. Geological Survey. **Symbol:** <, less than respective reporting level]

Well No.	Date sampled	Chromium, dissolved (µg/L)	Sodium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)
PW 9 (DP)	01-20-99	90	NR	27	107
	04-06-99	80	NR	10	NR
	07-14-99	57	NR	26	110
	10-06-99	57	20	27	110
	01-26-00	52	NR	28	108
	04-05-00	48	NR	26	NR
	07-06-00	45	NR	27	110
	10-04-00	43	21	29	110
	01-23-01	53	NR	30	104
	04-03-01	47	NR	32	NR
	07-26-01	47	NR	31	105
	10-09-01	35	20	33	107
TRA A 13 (SP)	04-26-99	<14	NR	41	NR
	10-06-99	<14	23	48	222
	04-13-00	<14	NR	53	NR
	09-27-00	NS	NS	NS	NS
	04-18-01	<10	NR	27	NR
TRA A 77 (SP)	05-26-99	NSA	NSA	NSA	NSA
	07-21-99	NS	NS	NS	NS
	10-19-99	NS	NS	NS	NS
	10-18-00	NS	NS	NS	NS
	04-16-01	NS	NS	NS	NS
	11-10-01	NS	NS	NS	NS
USGS 53 (DP)	04-21-99	NS	NS	NS	NS
	10-09-99	NS	NS	NS	NS
	04-06-00	NS	NS	NS	NS
	10-02-00	NS	NS	NS	NS
	04-18-01	NS	NS	NS	NS
	10-04-01	NS	NS	NS	NS
USGS 54 (DP)	01-20-99	E9	NR	18	170
	04-21-99	<14	NR	41	NR
	07-14-99	E8	NR	21	252
	10-06-99	E7	16	16	125
	01-26-00	E11	NR	24	276
	04-11-00	E9	NR	16	NR
	07-06-00	E11	NR	24	297
	10-04-00	E6	21	25	321
	01-18-01	E9	NR	23	308
	04-12-01	E5	NR	17	NR
	07-30-01	E5	NR	13	107
	10-23-01	14	18	25	285
USGS 55 (DP)	04-21-99	44	NR	19	NR
	10-26-99	72	19	20	125
	04-13-00	63	NR	21	NR
	10-05-00	NS	NS	NS	NS
	04-19-01	33	NR	17	NR
	10-23-01	82	18	27	149

Table 3. Concentrations of selected dissolved ions in perched ground water from selected wells, Reactor Technology Complex, Idaho National Laboratory, Idaho, 1999–2001.—Continued

[**Well No.:** Locations of wells are shown in figures 3, 8, and 9. Analyses completed by the National Water Quality Laboratory. **Abbreviations:** DP, well completed in deep perched water; SP, well completed in shallow perched water; QA-3, quality assurance replicate sample, number indicates the replicate sequence number during a sampling event; µg/L, microgram per liter; mg/L, milligram per liter; NR, analysis not requested; NS, not sampled due to lack of water or because water level was below pump intake; NSA, not sampled because of well access problems; NSEQ, not sampled because of equipment problems; E, estimated; USGS, U.S. Geological Survey. **Symbol:** <, less than respective reporting level]

Well No.	Date sampled	Chromium, dissolved (µg/L)	Sodium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)
USGS 56 (DP)	04-26-99	NS	NS	NS	NS
	10-19-99	NS	NS	NS	NS
	10-18-00	NS	NS	NS	NS
	04-16-01	NS	NS	NS	NS
	10-10-01	NS	NS	NS	NS
USGS 60 (DP)	04-06-99	<14	NR	10	NR
	10-19-99	E9	14	16	146
	04-05-00	E12	NR	21	NR
	10-04-00	E7	19	23	282
	10-04-00 QA-2	<10	18	24	282
	04-03-01	E6	NR	16	NR
	10-09-01	E6	13	17	124
USGS 61 (DP)	04-13-99	<14	NR	20	NR
	04-13-99 QA-1	E10	NR	20	NR
	10-06-99	25	13	19	178
	04-06-00	<14	NR	19	NR
	09-27-00	10	14	18	181
	04-12-01	16	NR	21	NR
	10-04-01	10	14	20	182
USGS 62 (DP)	04-13-99	<14	NR	20	NR
	10-06-99	E13	17	21	231
	04-03-00	<14	NR	21	NR
	09-27-00	E9	18	22	262
	09-27-00 QA-1	E8	18	22	260
	04-17-01	E7	NR	20	NR
	10-09-01	<10	16	20	189
USGS 63 (DP)	04-13-99	<14	NR	19	NR
	10-25-99	18	17	21	220
	04-06-00	19	NR	22	NR
	10-04-00	35	19	23	244
	04-19-01	11	NR	20	NR
	10-15-01	E9	16	20	196
USGS 66 (DP)	07-08-99	<14	16	21	217
	07-25-00	<14	15	18	197
	07-25-00 QA-8	<14	15	18	189
	07-25-01	<10	16	21	224

Table 3. Concentrations of selected dissolved ions in perched ground water from selected wells, Reactor Technology Complex, Idaho National Laboratory, Idaho, 1999–2001.—Continued

[**Well No.:** Locations of wells are shown in figures 3, 8, and 9. Analyses completed by the National Water Quality Laboratory. **Abbreviations:** DP, well completed in deep perched water; SP, well completed in shallow perched water; QA-3, quality assurance replicate sample, number indicates the replicate sequence number during a sampling event; µg/L, microgram per liter; mg/L, milligram per liter; NR, analysis not requested; NS, not sampled due to lack of water or because water level was below pump intake; NSA, not sampled because of well access problems; NSEQ, not sampled because of equipment problems; E, estimated; USGS, U.S. Geological Survey. **Symbol:** <, less than respective reporting level]

Well No.	Date sampled	Chromium, dissolved (µg/L)	Sodium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)
USGS 68 (DP)	05-26-99	NSA	NSA	NSA	NSA
	07-21-99	E8	NR	21	NR
	10-19-99	19	623	22	2,184
	10-18-00	42	504	22	1,835
	04-16-01	45	NR	23	NR
	10-10-01	55	413	23	1,409
USGS 69 (DP)	07-13-99	<14	12	19	145
	07-12-00	<14	12	17	135
	07-31-01	E6	11	16	115
USGS 70 (DP)	04-13-99	<14	NR	17	NR
	10-26-99	15	16	17	150
	04-06-00	26	NR	21	NR
	10-04-00	32	18	19	196
	04-19-01	12	NR	17	NR
	10-15-01	15	15	19	165
USGS 71 (DP)	04-27-99	20	NR	19	NR
	10-21-99	47	12	19	169
	04-13-00	NS	NS	NS	NS
	10-03-00	32	12	19	173
	04-17-01	NS	NS	NS	NS
	10-10-01	27	12	21	176
USGS 72 (DP)	07-21-99	NSEQ	NSEQ	NSEQ	NSEQ
	10-19-99	<14	25	13	32
	08-03-00	NSEQ	NSEQ	NSEQ	NSEQ
	07-19-01	NSEQ	NSEQ	NSEQ	NSEQ
USGS 73 (DP)	04-15-99	37	NR	14	NR
	10-21-99	37	18	39	62
	04-13-00	33	NR	70	NR
	09-27-00	28	17	46	55
	04-02-01	21	NR	91	NR
	10-10-01	<10	14	30	47
USGS 74 (DP)	04-22-99	NS	NS	NS	NS
	10-19-99	NS	NS	NS	NS
	04-10-00	NS	NS	NS	NS
	10-02-00	NS	NS	NS	NS
	04-18-01	NS	NS	NS	NS
USGS 78 (DP)	07-08-99	<14	7	5	19
	07-25-00	<14	7	5	20
	07-25-01	<10	7	5	19

The LRL for dissolved chromium varied from 14 µg/L in October 1998 to 0.8 µg/L in October 2001; consequently, concentrations within that range were designated according to those LRLs as detections or nondetections during 1999–2001. Estimated concentrations (table 3) less than the LRLs are treated as nondetected concentrations for consistency with treatment in previous publications, and because an estimated concentration is considered a "qualitatively detected analyte" (Childress and others, 1999, p. 7).

Dissolved chromium was detected in water from 10 wells (PW 8, 9, USGS 54, 55, 61, 63, 68, 70, 71, and 73) completed in deep perched ground water at the RTC during 1999–2001 (table 3). During 1996–98, the maximum concentration of dissolved chromium was 200 µg/L in well USGS 56 in April 1996; this well was not sampled during 1999–2001 because the water level was below the pump intake. During 1999–2001, the maximum concentration of dissolved chromium in deep perched ground water was 90 µg/L in well PW 9 in January 1999. This concentration decreased to 35 µg/L by October 2001. During July–October 2001, the most recent concentrations of dissolved chromium in wells completed in deep perched ground water near the RTC ranged from 10 µg/L in well USGS 61 to 82 µg/L in well USGS 55 (table 3 and fig. 8). The largest concentrations were in water from

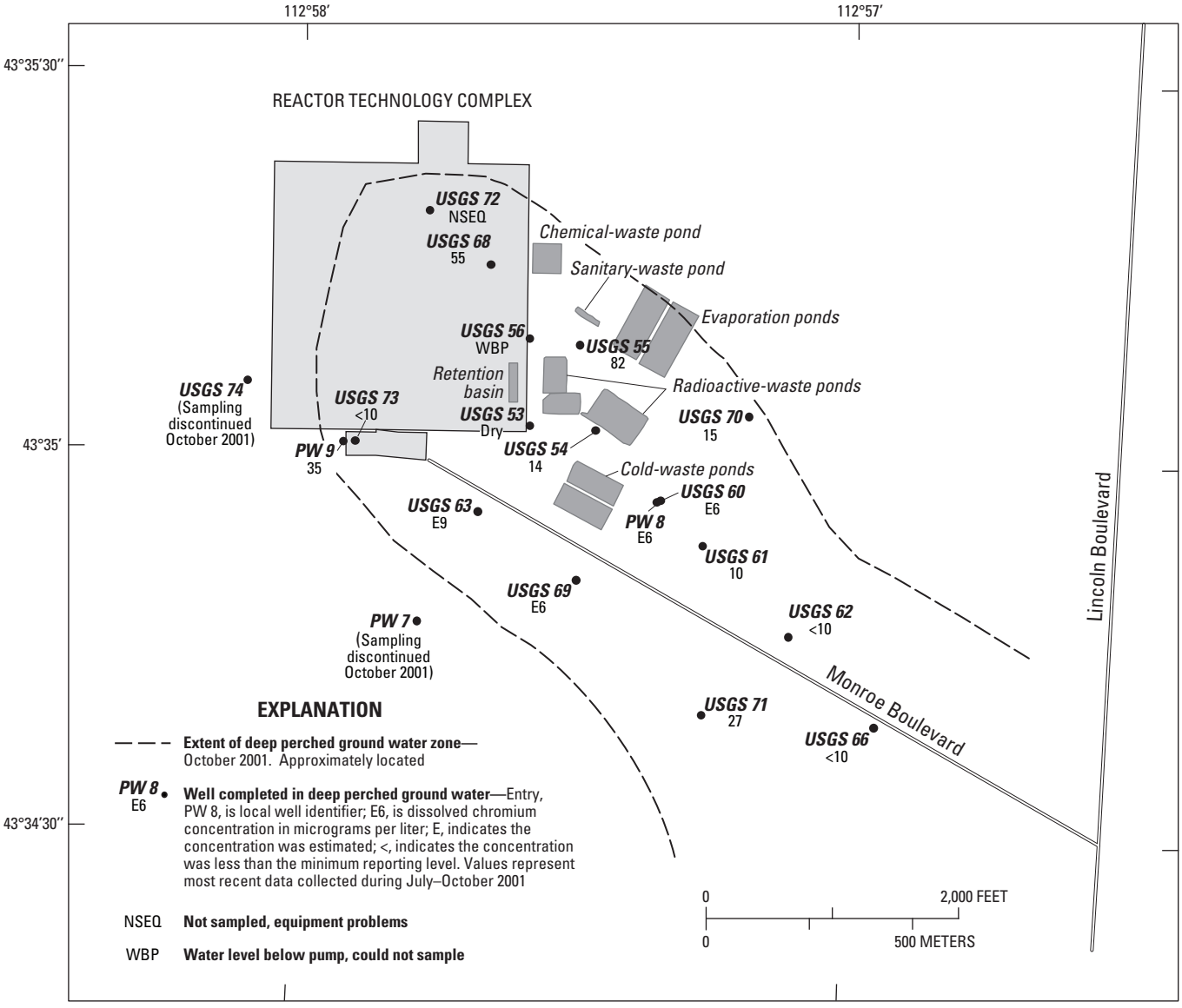

Figure 8. Concentrations of dissolved chromium in water from wells completed in deep perched ground water, Reactor Technology Complex, Idaho National Laboratory, Idaho, July–October 2001.

wells north and west of the radioactive-waste infiltration ponds (PW 9 and USGS 55, 68). The presence of dissolved chromium in water from wells completed in perched water indicates that water from these wells contains chromium and other constituents that were discharged to the radioactive-waste infiltration ponds before 1965, when disposal practices changed to injection of cooling-tower blowdown water to the disposal well.

Sodium

During 1962–70, wastewater containing about 500 tons/yr of sodium hydroxide and 50 tons/yr of sodium chloride were discharged to the chemical-waste pond (Robertson and others, 1974). Average annual sodium disposal was 188,000 lb during 1971–73 (Barraclough and Jensen (1976); 117,600 lb during 1974–78 (Barraclough and others, 1981); 101,000 lbs during 1979–81 (Lewis and Jensen, 1985); 85,000 lb during 1982–85 (Pittman and others, 1988); 183,000 lbs during 1986–88 (Cecil and others, 1991); 171,000 lb during 1989–91 (Tucker and Orr, 1998); and 168,000 lbs during 1992–95 (Bartholomay, 1998). An estimated 173,000 lb of sodium was contained in wastewater discharged to the chemical-waste pond during 1996–98. Average dissolved sodium concentration in wastewater discharged to the chemical-waste pond was about 2,000 mg/L (Bartholomay and Tucker, 2000). Total sodium discharged at the RTC is the amount of sodium ion estimated from the discharged sodium hydrate solution (Bartholomay and Tucker, 2000). The total amount of sodium in wastewater discharged at the RTC from 1999 to 2001 has not been compiled.

During 1999–2001, only one analysis was made for dissolved sodium concentrations (23 mg/L) in shallow perched ground water from well TRA A 13. Concentrations of dissolved sodium in other wells completed in shallow perched ground water were not available because (1) wells were dry during 1999–2001, (2) wells could not be sampled because of access problems, or (3) analyses for dissolved sodium were not requested from the laboratory (table 3). Dissolved sodium concentrations in water from 16 wells completed in deep perched ground water also were determined. During July–October 2001, dissolved sodium concentrations ranged from 7 to 20 mg/L in all wells except well USGS 68, with a concentration of 413 mg/L (table 3), a decrease from December 1998 when the concentration was 662 mg/L (Bartholomay and Tucker, 2000, table 3). The decreased concentration of dissolved sodium in water from well USGS 68 may be attributed to the closure of the chemical-waste pond in 1999.

Chloride

Robertson and others (1974, pg. 92) estimated that chloride (in the form of sodium chloride) was discharged to the chemical-waste pond at a rate of about 50 tons/yr during 1962–70. Negligible chloride concentrations were discharged in wastewater during 1974–78 (Barraclough and Jensen, 1976). Average annual disposal of chloride to the chemical-waste pond was 1,540 lb during 1979–81 and 2,000 lb during 1982–85 (Pittman and others, 1988). About 1,975 lb/yr of chloride were discharged to the chemical- and sanitary-waste ponds during 1986–88 (Cecil and others, 1991). About 1,215 lb/yr of chloride were discharged to the chemical-waste pond during 1989–91; discharge of chloride to the sanitary-waste pond was curtailed after 1989 (Tucker and Orr, 1998). About 4,430 lb of chloride contained in wastewater was discharged to the cold-waste ponds during 1992–95 (Bartholomay, 1998). During 1996–98, about 3,600 lb of chloride was in wastewater discharged to the cold-waste ponds. Data are not available for chloride in wastewater discharged during 1999–2001.

During 1999–2001, dissolved chloride concentrations in shallow perched ground water ranged from 10 mg/L in wells CWP 1, 3, and 4 to 53 mg/L in well TRA A 13. Dissolved chloride concentrations in deep perched ground water ranged from 5 mg/L in well USGS 78 to 91 mg/L in well USGS 73 (table 3).

Sulfate

Compiled data are not available for sulfate in wastewater discharged during 1999–2001. During 1996–98, about 833,000 lb of sulfate was in wastewater discharged to the chemical- and cold-waste ponds at RTC, an average of 278,000 lb/yr (Bartholomay and Tucker, 2000). This represents a decrease from the sulfate discharge of 920,000 lb/yr during 1989–1991 (Tucker and Orr, 1998) and 595,500 lb/yr discharged during 1992–95 (Bartholomay, 1998).

The maximum dissolved sulfate concentration in shallow perched ground water was 419 mg/L in well CWP 1 in July 2000. This concentration is attributed to sulfate disposal to nearby cold-waste ponds. The dissolved sulfate concentration in well CWP 1 decreased to 31 mg/L by July 2001. The most recent detected concentrations of dissolved sulfate in water from wells USGS 54, 60, 63, 69, and PW 8, completed in deep perched ground water near the cold-waste ponds, ranged from 115 to 285 mg/L during July–October 2001 (fig. 9). These large concentrations indicate that water in the wells also was affected by discharge into the cold-waste ponds.

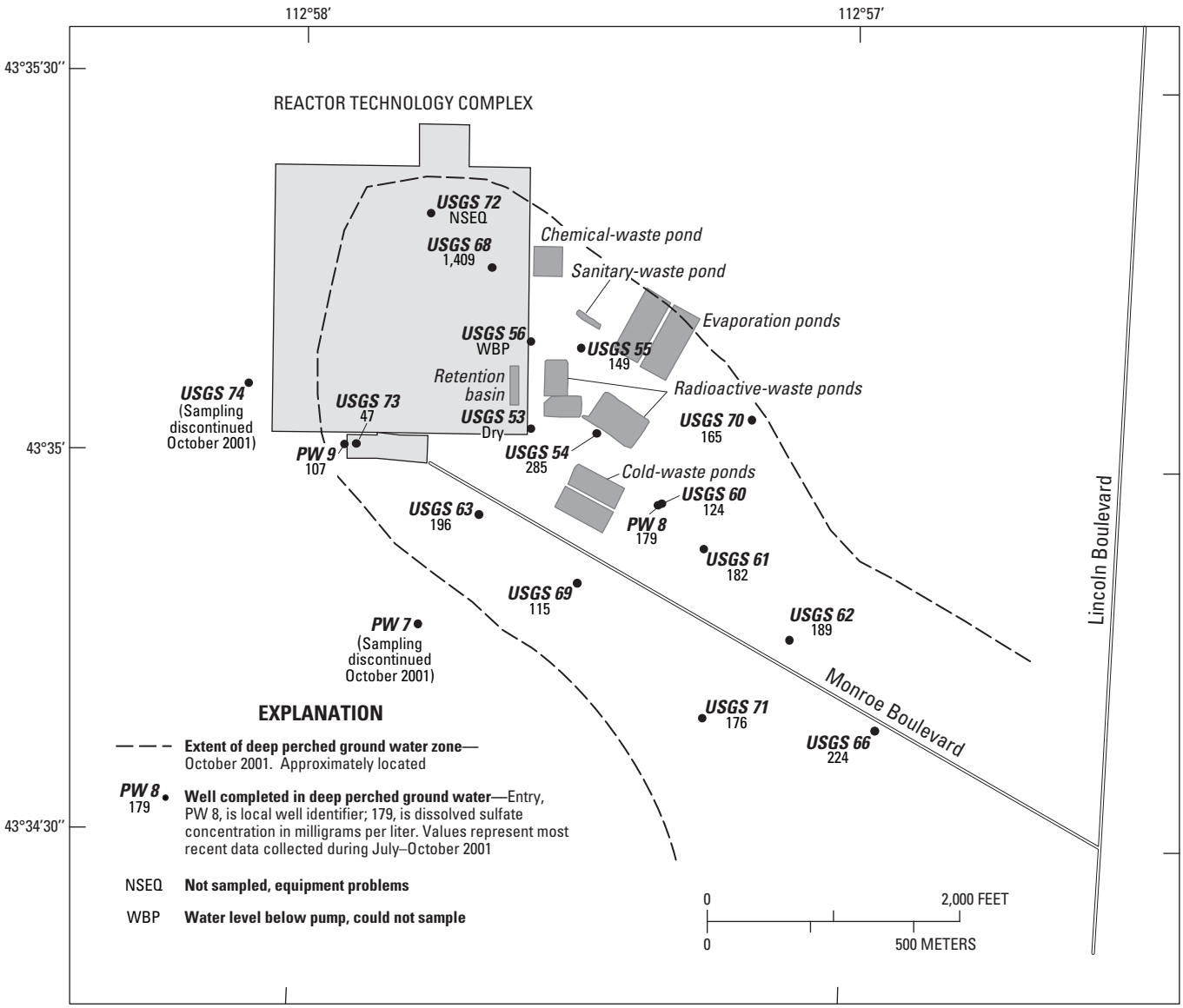

Figure 9. Concentrations of dissolved sulfate in water from wells completed in deep perched ground water, Reactor Technology Complex, Idaho National Laboratory, Idaho, July–October 2001.

Monitoring data for dissolved sulfate concentrations in wastewater discharged to the cold-waste pond for 1999–2001 are summarized in Stoller Corp. (2002a, 2002b, 2002c).

During July–October 2001, the maximum concentration of dissolved sulfate in deep perched ground water was 1,409 mg/L in well USGS 68 (table 3), west of the chemical-waste pond (fig. 9). This dissolved sulfate concentration had decreased from 2,278 mg/L in December 1998 (Bartholomay and Tucker, 2000, table 3), which in part may be the result of the chemical-waste pond closure in 1999 (fig. 9) or a decrease in disposal rates.

Idaho Nuclear Technology and Engineering Center

Two wastewater-infiltration ponds were constructed south of the INTEC in 1984 and 1985 to replace the INTEC disposal well (fig. 3). Wastewater infiltrating from these ponds formed perched ground water in the basalt and sedimentary interbeds above the eastern Snake River Plain aquifer. The volumes of wastewater discharged to the well and infiltration ponds during 1962–2001 are shown in figure 10.

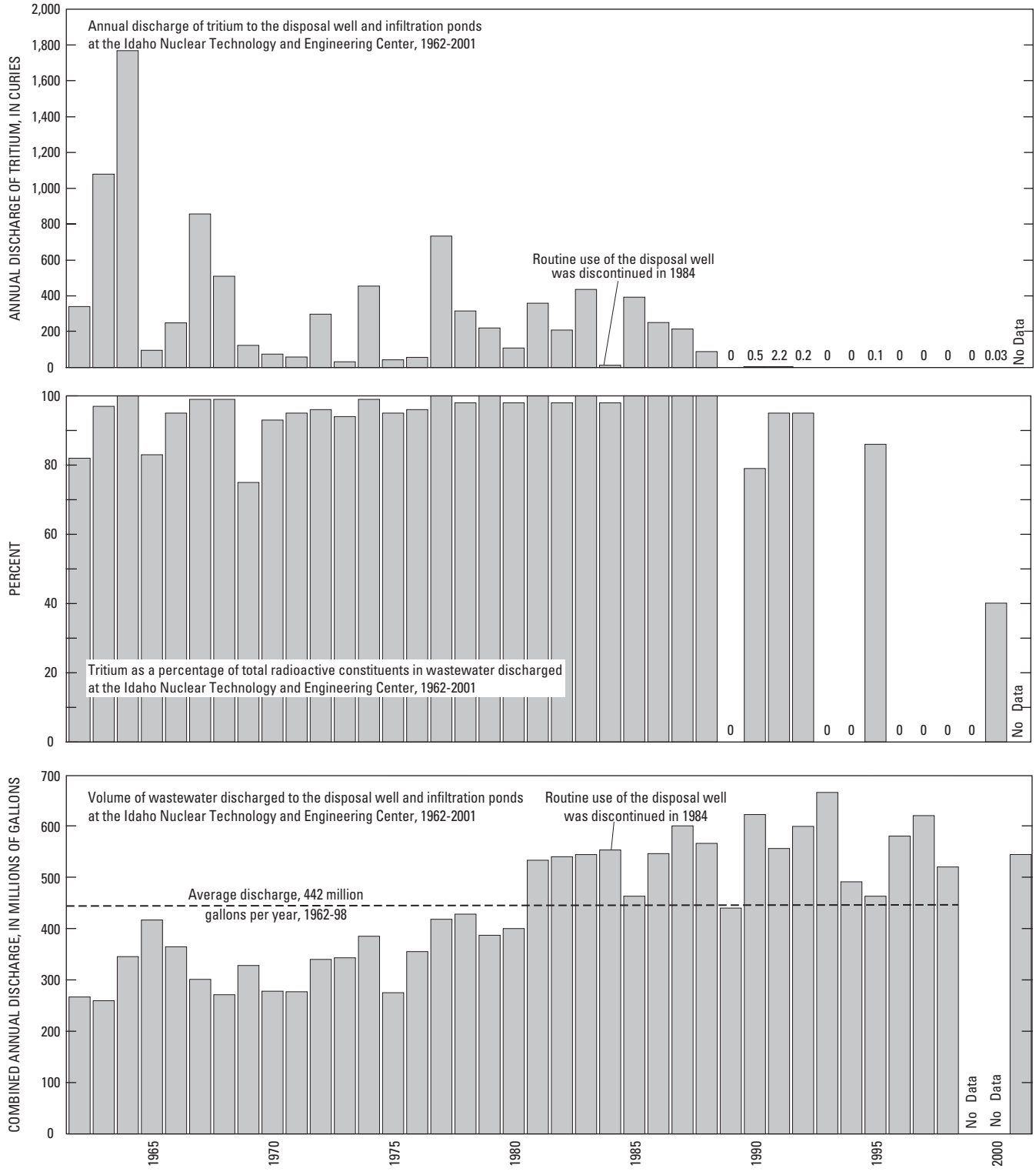

Figure 10. Amount of tritium discharged, tritium as a percentage of total radioactive constituents in wastewater discharged, and volume of wastewater discharged to the disposal well and infiltration ponds at the Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, Idaho, 1962–2001.

Annual discharge to the disposal well and ponds ranged from 260 Mgal in 1963 to 665 Mgal in 1993 and averaged about 442 Mgal (Bartholomay and Tucker, 2000). The average annual discharge during 1996–98 to the ponds was about 570 Mgal. Discharge to the ponds during 2001 was about 544 Mgal (Stoller Corp., 2002c, p 5–9); data for 1999 and 2000 are not available. This report focuses on perched water derived from the INTEC infiltration ponds, however, perched ground water also has been identified in other areas beneath the INTEC and may be attributed to other infiltration ponds, leaking wastewater lines, leach fields, ruptured casing in the upper part of the INTEC disposal well, and landscape irrigation (Tucker and Orr, 1998).

Many auger holes were drilled in 1983 to obtain geohydrologic and engineering data at the site of the planned INTEC infiltration ponds. Two holes (SWP 8 and 13 [fig. 3]) subsequently were used as monitoring wells to sample and measure water levels in shallow perched ground water in surficial sediment at the ponds. Attempts were made to sample wells SWP 8 and 13 annually during 1999–2001, however in some years, the wells were dry. Wells PW 1, 2, 3, 4, 5, and 6 were completed in 1986 to monitor deep perched ground-water levels and water-quality changes under the INTEC infiltration ponds (fig. 3). Well USGS 50 was used to monitor deep perched ground water near the INTEC disposal well. All these wells were sampled quarterly or semiannually during 1999–2001 (table 1). The following sections summarize concentrations of selected constituents in water from these wells and auger holes used to monitor water-quality changes related to infiltration of water from the INTEC infiltration ponds.

Tritium

Overall, most radioactivity in wastewater discharged to the infiltration ponds at the INTEC has been from tritium. About 960 Ci of tritium in wastewater was discharged to the INTEC infiltration ponds during 1984–88. During 1986–88, the average rate of tritium disposal was 185 Ci/yr (Cecil and others, 1991). During 1989–91, 2.7 Ci of tritium was discharged to the ponds and during 1992–95, 0.3 Ci was discharged (Bartholomay, 1998). There was no discharge during 1996–99; however, during 2000, 0.03 Ci of tritium was discharged (Stoller Corp., 2002a, 2002b) (fig. 10). Data are not available for the total tritium discharged in 2001.

Well SWP 13 (fig. 3), completed in shallow perched ground water, was not sampled in 1999 and 2000 because the well was dry. In 2001, the tritium concentration in well SWP 13 was less than the reporting level (table 4). Well SWP 8 (fig. 3) was dry during 1999. During 2000–01, the tritium concentrations in well SWP 8 were less than the reporting level. During 1999–2001, tritium concentrations in water from wells completed in deep perched ground water beneath the infiltration ponds ranged from less than the reporting level in wells PW 1 and PW 5 to 9.7±0.5 pCi/mL in well PW 6 (table 4), the same concentration as in October 1998. Tritium concentrations in water from well PW 6 varied during 1999–2000 and remained similar to concentrations reported during 1996–98 (Bartholomay and Tucker, 2000). No water was in well PW 6 in from July 2000 through October 2001. Tritium concentrations in water from wells near the infiltration ponds had decreased significantly from concentrations during 1986–88, when disposal of tritium was about 185 Ci/yr (Orr and Cecil, 1991). During 1999–2001, tritium concentrations in perched ground water in the wells closest to the ponds (PW 1 through 5, and SWP 8) decreased or remained less than 1 pCi/mL (table 4). These concentration decreases likely are due to decreased tritium disposal to the ponds and radioactive decay. During 1999–2001, tritium concentrations in water from well USGS 50 (fig. 11), near the disposal well, decreased slightly from 37.5±1.4 pCi/mL in April 1999 to 31.7±1.2 pCi/mL in October 2001 (table 4; fig. 11). The large tritium concentrations in water from well USGS 50 may be due to leakage of wastewater from ruptures in the upper part of the disposal well casing or to leakage from wastewater lines at the INTEC (Tucker and Orr, 1998). The slight decrease in tritium concentrations can be attributed mostly to radioactive decay or dilution of well water from a nonradioactive source such as landscape irrigation. Figure 11 shows concentrations of tritium in wells near the INTEC as of October 2001. Many wells were dry or were not sampled because of well access problems.

Strontium-90

About 0.3 Ci of strontium-90 was in wastewater discharged to the INTEC infiltration ponds during 1984–95 and about 0.03 Ci was discharged during 1996–98 (Bartholomay and Tucker, 2000). During 1999–2000, less than 0.001 Ci/yr of strontium-90 was discharged at the INTEC (Stoller Corp., 2002a, table 7-2, footnote b; 2002b, table 6-2, footnote b); data are not available for the amount of strontium-90 discharged in 2001. Additional sources of strontium-90 in perched ground water at the INTEC include more than 33 Ci of strontium-90 reportedly discharged to a shallow pit (fig. 12) in 1962–63 (Robertson and others, 1974, p. 119).

Table 4. Concentrations of tritium, strontium-90, and cesium-137 in perched ground water from selected wells, Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, Idaho, 1999–2001.

[**Well No.:** Locations of wells are shown in figures 3, 11, and 12. Analyses completed by the Radiological and Environmental Sciences Laboratory. Analytical uncertainties are reported as 1 times the sample standard deviation. Concentrations equal to or greater than 3 times the sample standard deviation are considered to be greater than the reporting level and are bold. **Abbreviations:** DP, well completed in deep perched water; SP, well completed in shallow perched water. QA-4, quality assurance replicate sample, number indicates the replicate sequence number during a sampling event. NR, analysis not requested; NS, not sampled due to lack of water or because water level was below pump intake; NSA, not sampled because of well access problems; pCi/mL, picocurie per milliliter; pCi/L, picocurie per liter. **Symbol:** ±, plus or minus]

Well No.	Date	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)
PW 1 (DP)	01-14-99	0.03 ± 0.12	1.5 ± 0.6	NR
	04-06-99	0.1 ± 0.12	**3.4 ± 0.8**	43 ± 20
	07-20-99	0.08 ± 0.12	1.7 ± 0.7	NR
	10-05-99	-0.08 ± 0.13	**2.6 ± 0.8**	NR
	01-18-00	0.09 ± 0.11	0.6 ± 0.8	NR
	05-01-00	NSA	NSA	NSA
	07-19-00	NS	NS	NS
	10-02-00	NS	NS	NS
	01-18-01	NS	NS	NS
	04-18-01	0.18 ± 0.14	2 ± 0.8	20 ± 30
	07-31-01	0.09 ± 0.13	0.3 ± 0.6	NR
	10-11-01	NS	NS	NS
PW 2 (DP)	04-22-99	0.13 ± 0.12	2 ± 0.8	30 ± 30
	04-22-99 QA-4	0.14 ± 0.12	2 ± 0.8	-31 ± 20
	10-19-99	0.03 ± 0.13	2.3 ± 0.8	NR
	04-24-00	0.36 ± 0.14	**2.9 ± 0.8**	0 ± 40
	10-03-00	0.16 ± 0.13	2 ± 0.9	NR
	04-18-01	0.3 ± 0.15	1.1 ± 0.8	-20 ± 30
	10-02-01	**0.5 ± 0.14**	-0.1 ± 0.8	NR
PW 3 (DP)	04-22-99	0.2 ± 0.12	**3.3 ± 0.8**	-48 ± 30
	10-19-99	NS	NS	NS
	04-24-00	**0.73 ± 0.15**	**2.5 ± 0.8**	-30 ± 20
	10-03-00	0.19 ± 0.13	1.9 ± 0.9	NR
	04-18-01	0.24 ± 0.14	**2.1 ± 0.7**	20 ± 30
	10-02-01	0.34 ± 0.14	-0.8 ± 0.7	NR
PW 4 (DP)	01-19-99	**0.56 ± 0.14**	**2.2 ± 0.6**	NR
	04-13-99	**0.48 ± 0.14**	**2.2 ± 0.7**	-11 ± 40
	07-15-99	**0.79 ± 0.15**	**3.6 ± 0.8**	NR
	10-06-99	**0.48 ± 0.15**	**3.4 ± 0.8**	NR
	10-06-99 QA-1	**0.46 ± 0.15**	**3.8 ± 0.8**	NR
	01-18-00	**0.51 ± 0.13**	2.1 ± 0.8	NR
	05-01-00	NSA	NSA	NSA
	07-25-00	NSA	NSA	NSA
	10-05-00	-0.06 ± 0.12	2.4 ± 0.9	NR
	01-18-01	-0.04 ± 0.12	1 ± 0.6	NR
	04-12-01	0.05 ± 0.13	0.79 ± 0.79	20 ± 30
	07-24-01	0.05 ± 0.13	0.8 ± 0.6	NR
	10-31-01	NSA	NSA	NSA

Table 4. Concentrations of tritium, strontium-90, and cesium-137 in perched ground water from selected wells, Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, Idaho, 1999–2001.—Continued

[**Well No.:** Locations of wells are shown in figures 3, 11, and 12. Analyses completed by the Radiological and Environmental Sciences Laboratory. Analytical uncertainties are reported as 1 times the sample standard deviation. Concentrations equal to or greater than 3 times the sample standard deviation are considered to be greater than the reporting level and are bold. **Abbreviations:** DP, well completed in deep perched water; SP, well completed in shallow perched water. QA-4, quality assurance replicate sample, number indicates the replicate sequence number during a sampling event. NR, analysis not requested; NS, not sampled due to lack of water or because water level was below pump intake; NSA, not sampled because of well access problems; pCi/mL, picocurie per milliliter; pCi/L, picocurie per liter. **Symbol:** ±, plus or minus]

Well No.	Date	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)
PW 5 (DP)	04-08-99	0.11±0.12	1.2±0.7	34±20
	10-25-99	-0.05±0.13	2.3±0.8	NR
	10-25-99 QA-4	0±0.1	2.1±0.8	NR
	05-01-00	NSA	NSA	NSA
	10-26-00	0.04±0.12	**2.5±0.8**	NR
	04-30-01	0.04±0.13	**2.5±0.7**	-50±40
	10-31-01	NSA	NSA	NSA
PW 6 (DP)	01-14-99	**9.7±0.5**	-0.4±0.7	NR
	04-21-99	**9.5±0.5**	-0.92±0.9	25±20
	07-15-99	**9.1±0.4**	-0.4±0.7	NR
	10-11-99	**9.4±0.5**	-0.1±0.8	NR
	01-18-00	**9±0.4**	1.6±0.9	NR
	04-24-00	**8.6±0.4**	-2±0.9	0±30
	07-24-00	NS	NS	NS
	10-02-00	NS	NS	NS
	01-18-01	NS	NS	NS
	04-08-01	NS	NS	NS
	07-25-01	NS	NS	NS
	10-11-01	NS	NS	NS
SWP 8 (SP)	07-15-99	NS	NS	NS
	07-24-00	0.04±0.12	**5.5±0.8**	0±30
	07-25-01	0.07±0.13	**2.1±0.7**	60±30
SWP 13 (SP)	07-15-99	NS	NS	NS
	07-24-00	NS	NS	NS
	07-25-01	0±0.13	-1.8±0.9	-20±20
USGS 50 (DP)	04-27-99	**37.5±1.4**	**186±5**	-16±23
	10-20-99	**35.2±1.3**	**204±5**	20±20
	05-02-00	NSA	NSA	NSA
	10-10-00	**28±1.1**	**172±4**	10±30
	04-10-01	**31.4±0.7**	**150±3**	-10±30
	10-24-01	**31.7±1.2**	**134±3**	20±30

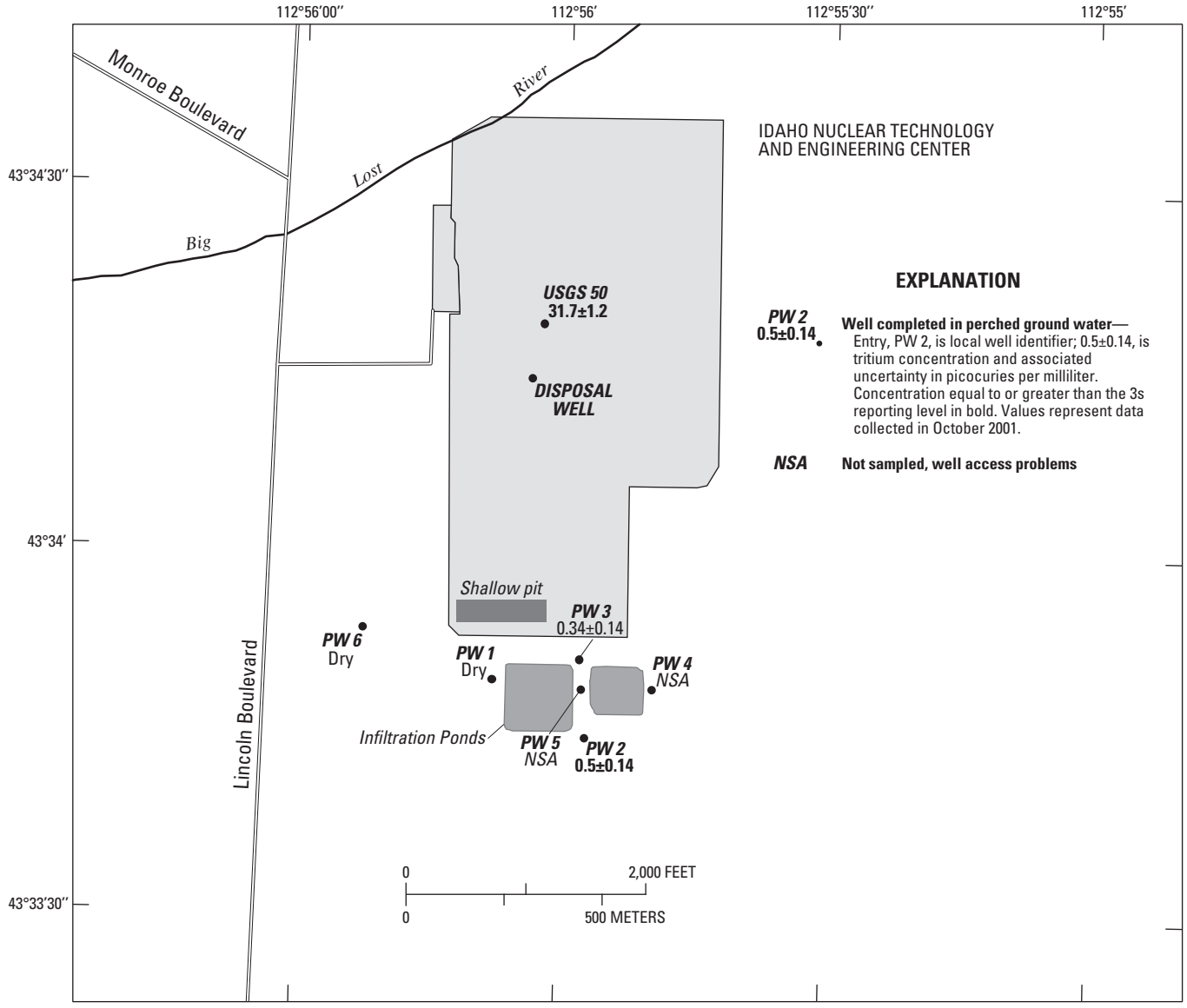

Figure 11. Concentrations of tritium in water from wells completed in deep perched ground water, Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, Idaho, October 2001.

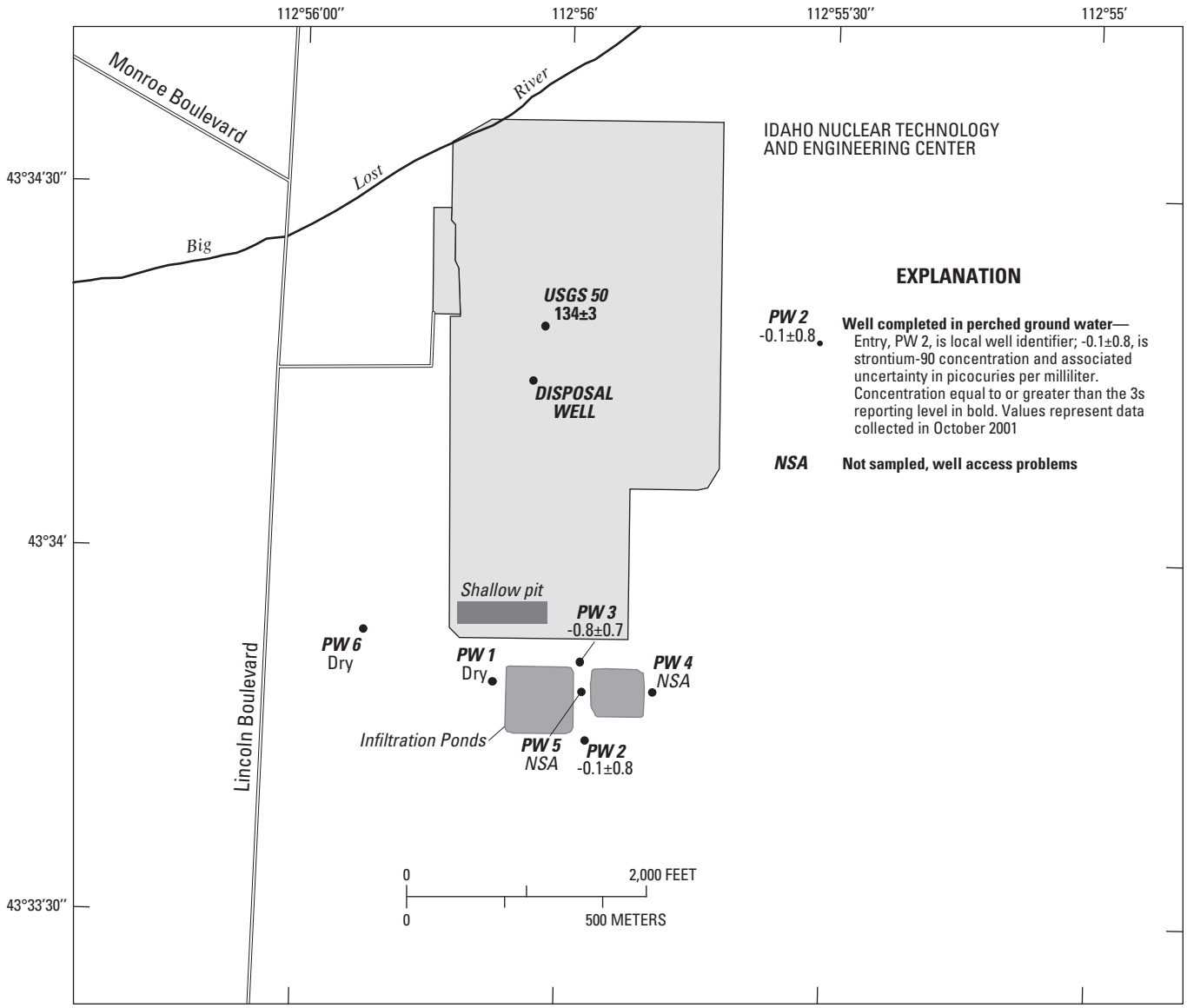

Figure 12. Concentrations of strontium-90 in water from wells completed in deep perched ground water, Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, Idaho, October 2001.

A strontium-90 concentration of 2.1±0.7 pCi/L in July 2001 in water from well SWP 8 (fig. 3) completed in shallow perched ground water continued the steady decrease in strontium-90 concentrations in water from this well since 1991. During 1999–2001, concentrations of strontium-90 varied in water from all wells completed in deep perched ground water beneath the INTEC infiltration ponds. In October 2001, strontium-90 concentrations in deep perched ground water in wells closest to the ponds were less than the reporting level, not sampled because of access problems, or the wells were dry (fig. 12).

The largest concentrations of strontium-90 in perched ground water at the INTEC were in well USGS 50 near the INTEC disposal well. During 1999–2001, strontium-90 concentrations in water from well USGS 50 were variable and ranged from 204±5 pCi/L in October 1999 to 134±3 pCi/L in October 2001 (table 4), indicating an overall decrease in strontium-90 concentrations since the mid–1980s. Strontium-90 concentrations in water from well USGS 50 may be due to leakage of wastewater from ruptures in the disposal well casing or leakage from wastewater pipelines at the INTEC.

Cesium-137

Wastewater discharged to the INTEC infiltration ponds during 1984–95 contained about 0.5 Ci of cesium-137. During 1996, wastewater discharged to the ponds contained about 0.0006 Ci of cesium-137; no cesium-137 was discharged during 1997–98. During 1999–2000, less than 0.001 Ci/yr of cesium-137 was discharged to the INTEC infiltration ponds (Stoller Corp., 2002a, table 7-2, footnote b; 2002b, table 6-2, footnote b). Data are not available for cesium-137 discharged during 2001.

During 1999–2001, concentrations of cesium-137 did not exceed the reporting level in shallow or deep perched ground water in wells closest to the infiltration ponds or in well USGS 50. The absence of reportable concentrations of cesium-137 in perched ground water at the INTEC probably is due to decreased disposal and to sorption and (or) exchange of cesium-137 to minerals in sediments.

Sodium

Robertson and others (1974, pg. 121) stated that the quantity of wastes disposed at the INTEC were not routinely monitored during 1952–70; however, the most abundant waste product discharged to the INTEC disposal well was sodium chloride. Barraclough and Jensen (1976) reported that 254,000 lb/yr of sodium were discharged to the INTEC disposal well during 1971–73. During 1974–78, about 310,000 lb/yr of sodium were discharged to the disposal well (Barraclough and others, 1981); and 397,000 lb/yr were discharged during 1979–81 (Lewis and Jensen, 1984). About 324,000 lb/yr of sodium were discharged at the INTEC during 1982–85; however, in 1984 the new INTEC infiltration ponds were put in use. About 72 percent of the sodium was discharged to the infiltration ponds and about 28 percent was discharged to the disposal well (Pittman and others, 1988). In 1985, nearly all sodium was discharged to the INTEC infiltration ponds (Pittman and others, 1988). During 1986–88, an estimated 22 million lb of sodium was discharged to the INTEC infiltration ponds (Cecil and others, 1991); during 1989–91, no sodium discharge data were available, however chloride discharge records were used to estimate that about 23 million lb of sodium may have been discharged to the INTEC infiltration ponds (Tucker and Orr, 1998); and during 1992–95 about 3 million lb of sodium was discharged to the infiltration ponds (Bartholomay, 1998). About 708,000 lb of sodium was discharged to the INTEC infiltration ponds during 1996–98 (Bartholomay and Tucker, 2000). No compilation was made of the total amount of sodium discharged to the INTEC infiltration ponds during 1999–2001. The concentration of sodium in wastewater decreased from an average of 127 mg/L in 1999 to 111 mg/L in 2001 (Stoller Corp., 2002a, table 7-3; 2002b, table 6-3; 2002c, table 5-6).

Water from well SWP 8, completed in shallow perched ground water, contained a maximum concentration of 133 mg/L of dissolved sodium in July 2000. This concentration decreased to 102 mg/L in July 2001. Water from well SWP 13, also completed in shallow perched ground water, contained a dissolved sodium concentration of 92 mg/L in July 2001. This well was not sampled in 1999 or 2000 because the well was dry (table 5). During 1999–2001, dissolved sodium concentrations in deep perched ground water in wells closest to the infiltration ponds (PW 1 through 5) ranged from 109 mg/L in well PW 2 in October 2001 to 164 mg/L in well PW 5 in October 1999 (table 5). By October 2001, most wells could not be sampled due to lack of water in the well or well access problems. Dissolved sodium concentrations in shallow and deep perched ground water at the INTEC infiltration ponds during 1999–2001 were similar to or less than those in wastewater (Stoller Corp., 2002a, table 7-3; 2002b, table 6-3; 2002c, table 5-6).

Dissolved sodium concentrations in two water samples from well USGS 50 were nearly constant during 1999–2000. The concentration in October 2000 was 60 mg/L (table 5), nearly the same as concentrations reported in Bartholomay and Tucker (2000, table 5) for 1996–98. Analysis for dissolved sodium in water from well USGS 50 was not requested in 2001. These dissolved sodium concentrations may be due to leakage of wastewater from pipelines or infiltration of landscape irrigation at the INTEC.

Table 5. Concentrations of selected dissolved ions in perched ground water from selected wells, Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, Idaho, 1999–2001.

[**Well No.:** Locations of wells are shown in figures 3 and 13. Analyses completed by the National Water Quality Laboratory. Analytical results in milligrams per liter. **Abbreviations:** DP, well completed in deep perched water; SP, well completed in shallow perched water. QA-4, quality assurance replicate sample, number indicates the replicate sequence number during a sampling event. NR, analysis not requested; NS, not sampled due to lack of water or because water level was below pump intake; NSA, not sampled because of well access problems]

Well No.	Date	Sodium, dissolved	Chloride, dissolved	Sulfate, dissolved	Nitrite plus nitrate, as nitrogen, dissolved
PW 1 (DP)	01-14-99	NR	170	NR	NR
	04-06-99	NR	167	NR	NR
	07-20-99	NR	134	NR	NR
	10-05-99	132	196	27	NR
	01-18-00	NR	152	NR	NR
	05-01-00	NSA	NSA	NSA	NSA
	07-19-00	NS	NS	NS	NS
	10-02-00	NS	NS	NS	NS
	01-18-01	NS	NS	NS	NS
	04-18-01	NR	151	NR	NR
	07-31-01	NR	148	NR	NR
	10-11-01	NS	NS	NS	NS
PW 2 (DP)	04-22-99	NR	200	NR	NR
	04-22-99 QA-4	NR	198	NR	NR
	10-19-99	137	240	28	NR
	04-24-00	NR	258	NR	NR
	10-03-00	130	212	25	NR
	04-18-01	NR	148	NR	NR
	10-02-01	109	167	28	NR
PW 3 (DP)	04-22-99	NR	198	NR	NR
	10-19-99	NS	NS	NS	NS
	04-24-00	NR	258	NR	NR
	10-03-00	127	197	27	NR
	04-18-01	NR	150	NR	NR
	10-02-01	NR	175	30	NR
PW 4 (DP)	01-19-99	NR	221	NR	NR
	04-13-99	NR	213	NR	NR
	07-15-99	NR	217	NR	NR
	10-06-99	152	316	29	NR
	10-06-99 QA-1	152	308	29	NR
	01-18-00	NR	210	NR	NR
	07-25-00	NSA	NSA	NSA	NSA
	10-05-00	124	188	25	NR
	01-18-01	NR	79	NR	NR
	04-12-01	NR	152	NR	NR
	07-24-01	NR	155	NR	NR
	10-31-01	NSA	NSA	NSA	NSA
PW 5 (DP)	04-08-99	NR	213	NR	NR
	10-25-99	163	348	27	NR
	10-25-99 QA-4	164	344	27	NR
	05-01-00	NSA	NSA	NSA	NSA
	10-26-00	137	227	25	NR
	04-30-01	NR	149	NR	NR
	10-31-01	NSA	NSA	NSA	NSA

Table 5. Concentrations of selected dissolved ions in perched ground water from selected wells, Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, Idaho, 1999–2001.—Continued

[**Well No.:** Locations of wells are shown in figures 3 and 13. Analyses completed by the National Water Quality Laboratory. Analytical results in milligrams per liter. **Abbreviations:** DP, well completed in deep perched water; SP, well completed in shallow perched water. QA-4, quality assurance replicate sample, number indicates the replicate sequence number during a sampling event. NR, analysis not requested; NS, not sampled due to lack of water or because water level was below pump intake; NSA, not sampled because of well access problems]

Well No.	Date	Sodium, dissolved	Chloride, dissolved	Sulfate, dissolved	Nitrite plus nitrate, as nitrogen, dissolved
PW 6 (DP)	01-14-99	NR	125	NR	NR
	04-21-99	NR	63	NR	NR
	07-15-99	NR	113	NR	NR
	10-11-99	108	151	18	NR
	01-18-00	NR	99	NR	NR
	04-24-00	NR	37	NR	NR
	07-24-00	NS	NS	NS	NS
	10-02-00	NS	NS	NS	NS
	01-18-01	NS	NS	NS	NS
	04-08-01	NS	NS	NS	NS
	07-25-01	NS	NS	NS	NS
	10-11-01	NS	NS	NS	NS
SWP 8 (SP)	07-15-99	NS	NS	NS	NS
	07-24-00	133	241	43	0.7
	07-25-01	102	153	34	1.3
SWP 13 (SP)	07-15-99	NS	NS	NS	NS
	07-24-00	NS	NS	NS	NS
	07-25-01	92	157	30	.6
USGS 50 (DP)	04-27-99	NR	59	NR	NR
	10-20-99	63	57	39	58.4
	05-02-00	NS	NS	NS	NS
	10-10-00	60	57	41	43.1
	04-10-01	NR	55	NR	NR
	10-24-01	NR	NR	NR	4.7

Chloride

Robertson and others (1974, pg. 121) stated that the quantity of wastes disposed at the INTEC were not routinely monitored during 1952–1970, however, the most abundant waste product discharged to the INTEC disposal well was sodium chloride. Barraclough and Jensen (1976) reported that 386,000 lb/yr of chloride were discharged to the INTEC disposal well during 1971–73. During 1974–78, about 548,000 lb/yr of chloride were discharged (Barraclough and others, 1981); about 875,000 lb/yr during 1979–81 (Lewis and Jensen, 1984); and about 735,000 lb/yr during 1982–85; however, in 1984, waste discharge ceased to the INTEC disposal well, and wastes were discharged to the INTEC infiltration ponds. About 35 million lb of chloride was discharged to the INTEC infiltration ponds during 1986–88 (Cecil and others, 1991); 36 million lb was discharged during 1989–91 (Tucker and Orr, 1998); 49 million lb was discharged during 1992–95 (Bartholomay, 1998); and 35 million lb was discharged during 1996–98 (Bartholomay and Tucker, 2000). The total chloride discharged to the infiltration ponds at the INTEC was not compiled for 1999–2001; however, the concentration of dissolved chloride in wastewater decreased from an average of 193 mg/L in 1999 to 153 mg/L in 2001 (Stoller Corp., 2002a, table 7-3; 2002b, table 6-3; 2002c, table 5-6).

During 1999, well SWP 8 (fig. 3) was not sampled because the well was dry. The dissolved chloride concentration in well SWP 8 decreased from 241 mg/L in July 2000 to 153 mg/L in July 2001. No samples were collected from well SWP 13 during 1999–2000 because the well was dry; the dissolved chloride concentration in July 2001 was 157 mg/L. During 1999–2001, dissolved chloride concentrations in deep perched ground water in wells closest to the infiltration ponds (PW 1 through 5) ranged from 79 mg/L in well PW 4 to 348 mg/L in well PW 5 (table 5). In October 2001, wells PW 1 and 6

were dry and wells PW 4 and 5 were not sampled because of well access problems. Dissolved chloride concentrations in water from wells PW 2 and 3 were 167 and 175 mg/L, respectively (table 5; fig. 13). When water was present, lower concentrations were measured in water from well PW 6 than wells PW 1 through 5 (table 5). Dissolved chloride concentrations in shallow and deep perched ground water at the INTEC infiltration ponds were similar to or less than the dissolved chloride concentrations in wastewater (Stoller Corp., 2002a, table 7-3; 2002b, table 6-3; 2002c, table 5-6).

During 1999–2001, dissolved chloride concentrations in water from well USGS 50 were consistent, ranging from 59 mg/L in April 1999 to 55 mg/L in April 2001 (table 5). The dissolved chloride concentrations may be due to leakage of wastewater from ruptures in the disposal well casing or leakage from wastewater pipelines at the INTEC. Dissolved chloride concentrations in water from this well steadily decreased since sampling began in 1959.

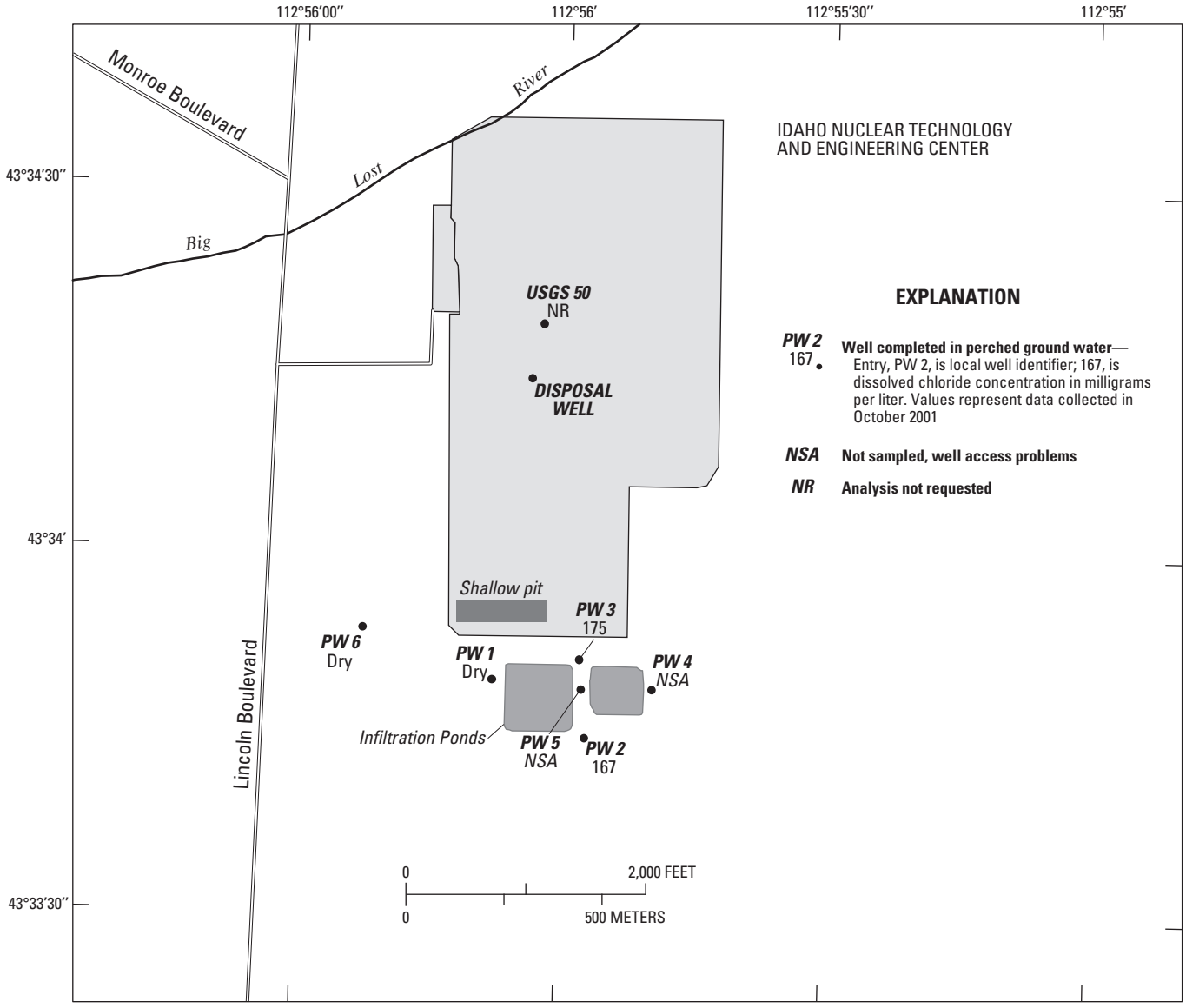

Figure 13. Concentrations of dissolved chloride in water from wells completed in deep perched ground water, Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, Idaho, October 2001.

Sulfate

The quantity of wastes disposed at the INTEC was not routinely monitored during 1952–1970; however, high values of sulfate near the center of the INL may be associated with waste disposal (Robertson and others, 1974, p. 70, 121). The estimated average wastewater dissolved sulfate concentration was about 25 mg/L (Robertson and others, 1974, p. 124). About 73,000 lb/yr of sulfate were discharged to the INTEC disposal well during 1971–73 (Barraclough and Jensen, 1976), 103,000 lb/yr during 1974–78, except during 1976 when no sulfate disposal was reported (Barraclough and others, 1981), and 146,000 lb/yr during 1979–81. During 1982–85, 575,000 lb/yr were discharged to the disposal well and INTEC infiltration ponds (Pittman and others, 1988). About 227,000 lb/yr of sulfate were discharged to the infiltration ponds during 1986–88 (Cecil and others, 1991) and 575,000 lb/yr during 1989–91 (Tucker and Orr, 1998). During 1992–95, about 166,000 lb/yr of sulfate were discharged to the INTEC infiltration ponds (Bartholomay, 1998) and during 1996–98, about 146,000 lb/yr was discharged (Bartholomay and Tucker, 2000). Total sulfate discharged to the infiltration ponds at the INTEC has not been compiled for 1999–2001. The average concentrations of dissolved sulfate in wastewater were about 34 mg/L in 1999, 30 mg/L in 2000, and 34 mg/L in 2001 (Stoller Corp., 2002a, table 7-3; 2002b, table 6-3; 2002c, table 5-16).

Dissolved sulfate concentrations in shallow perched ground water from wells SWP 8 and 13 were 34 and 30 mg/L, respectively, in July 2001 (table 5), which were similar to the average wastewater concentration. Dissolved sulfate concentrations in water from wells completed in the deep perched ground water closest to the INTEC infiltration ponds (PW 1 through 5) ranged from 28 to 30 mg/L in 2001 (table 5). These concentrations also were consistent with the average concentration in the wastewater. Historically, dissolved sulfate concentrations in these wells have fluctuated between about 22 and 41 mg/L. The dissolved sulfate concentration in water from well PW 6 was 18 mg/L in 1999; this well was dry during 2000–01. Concentrations of dissolved sulfate in water from well PW 6 have historically fluctuated between 13 and 24 mg/L.

Concentrations of dissolved sulfate in samples from well USGS 50 (table 5) ranged from 39 to 41 mg/L during 1999–2001. Historically, dissolved sulfate concentrations in water from well USGS 50 have fluctuated slightly around these values. The dissolved sulfate concentrations in water from this well are attributed to leakage from wastewater pipelines at the INTEC.

Nitrate

Robertson and others (1974, p. 121) reported that insignificant amounts of nitrate probably were discharged to the INTEC disposal well during 1952–70. In 1973, about 101,000 lb of nitrate was discharged (Barraclough and Jensen, 1976. During 1974–78, about 131,000 lb/yr was discharged to the disposal well (Barraclough and others, 1981) and 288,000 lb/yr during 1979–81 (Lewis and Jensen, 1984). During 1982–85, 274,000 lb/yr were discharged at the INTEC and after February 1984, most wastewater was disposed to the new INTEC infiltration ponds (Pittman and others, 1988). During 1986-88, 160,400 lb/yr of nitrate were discharged to the infiltration ponds (Cecil and others, 1991); 56,000 lb/yr during 1989–91; and 41,000 lb/yr during 1992–95 (Bartholomay and others, 1997). Wastewater discharged to the INTEC infiltration ponds during 1996–98 contained about 260,000 lb of nitrate; of that amount, about 221,000 lb was discharged in February 1996. Annual discharge amounts of nitrate for 1999–2001 have not been compiled. The concentration of nitrate (as nitrogen) in wastewater was nearly constant with an average of 0.92 mg/L in 1999 to 0.91 mg/L in 2001 (Stoller Corp., 2002a, 2002b, 2002c).

Dissolved nitrite plus nitrate (as nitrogen) analyses are done annually on water from shallow perched ground water wells at the infiltration ponds and on water from well USGS 50. Nitrite analyses indicated that almost all dissolved nitrite plus nitrate concentration is from nitrate. Well SWP 8, completed in shallow perched ground water, was not sampled in 1999 because the well was dry. The dissolved nitrite plus nitrate (as nitrogen) concentration in water from SWP 8 was 0.7 mg/L in July 2000 and 1.3 mg/L in July 2001. Well SWP 13 was not sampled in 1999 or 2000 because the well was dry; the dissolved nitrite plus nitrate (as nitrogen) concentration in July 2001 was 0.6 mg/L. During 1999–2001, dissolved nitrite plus nitrate (as nitrogen) concentrations in water from well USGS 50 ranged from 58.4 mg/L in October 1999 to 4.7 mg/L in October 2001 (table 5), a fluctuating but overall decreasing trend since sampling began in 1988. The nitrate concentrations may be due to leakage from wastewater pipelines at the INTEC.

Radioactive Waste Management Complex

Solid and liquid radioactive and chemical wastes have been buried in trenches and pits at the Subsurface Disposal Area (SDA) at the RWMC (figs. 1, 3) since 1952. These include transuranic wastes, other radiochemical and

inorganic chemical constituents, and organic compounds. The transuranic wastes were buried in trenches until 1970 and stored above ground at the RWMC after 1970. Only low-level mixed waste has been buried at the RWMC since 1970. Before 1970, little or no sediment was retained between the excavation bottoms and the underlying basalt. Since 1970, a layer of sediment has been retained in excavations to inhibit downward migration of waste constituents.

About 17,100 Ci of plutonium-238, 64,900 Ci of plutonium-239, 17,100 Ci of plutonium-240, and 183,000 Ci of americium-241 were buried in the SDA during 1952–99 (Holdren and others, 2002, table 4-1). An estimated 88,400 gal of organic waste was buried before 1970 (Mann and Knobel, 1987, p. 1). These buried wastes included about 24,400 gal of carbon tetrachloride, 39,000 gal of lubricating oil, and about 25,000 gal of other organic compounds, including trichloroethane, trichloroethylene, perchloroethylene, toluene, and benzene.

Perched ground water beneath the RWMC is in sedimentary interbeds in basalts and can be attributed primarily to local snowmelt and rain infiltration and recharge from the Big Lost River and the INL spreading areas.

Well USGS 92 (fig. 3) is in the SDA at the RWMC and is completed in a sedimentary interbed (Anderson and Lewis, 1989, p. 29) 214 ft below land surface. Perched water in this well has moved through overlying sediments and basalt and may contain waste constituents leached from radiochemical and organic chemical wastes buried in the SDA. Small amounts of water in well USGS 92 frequently preclude collection of an adequate sample for all requested analyses. Adequate samples for requested analyses were collected during October 1999 and in the spring of 1996–98. The sample collected in October 2000 yielded only enough water for tritium, strontium-90, and cesium-137 analyses; part of the October 2001 sample was lost prior to analysis (table 6).

During 1999–2001, radiochemical constituents in all water samples from well USGS 92 (table 6) were less than the reporting level with the exception of the April 2000 and October 2001 samples analyzed for tritium. The tritium concentration was at the reporting level at 0.3±.0.1 pCi/mL in April 2000, and near the reporting level at .45±.14 pCi/mL in October 2001 (table 6). Tritium concentrations in water from well USGS 92 have been variable through time.

Historically, the concentration of americium-241 was above the reporting level in October 1992, and the concentration of plutonium-238 was above the reporting level in November 1994 (Bartholomay, 1998).

Dissolved chloride concentrations in water from four samples collected from well USGS 92 ranged from 78.0 to 81.2 mg/L during 1999–2001 (table 6). These dissolved chloride concentrations are consistent with concentrations measured historically.

Table 6. Concentrations of tritium, strontium-90, cesium-137, selected transuranic elements, and dissolved chloride in perched ground water from well USGS 92, Radioactive Waste Management Complex, Idaho National Laboratory, Idaho, 1999–2001.

[**Well No.:** Location of well is shown in figure 2. Analyses completed by the Radiological and Environmental Sciences Laboratory and the National Water Quality Laboratory. Analyses for radionuclides, analytical uncertainties are reported as 1 times the sample standard deviation. Concentrations equal to or greater than 3 times the sample standard deviation are considered to be greater than the reporting level and are bold. **Abbreviations:** pCi/mL, picocurie per milliliter; pCi/L, picocurie per liter; mg/L, milligram per liter. NR, analysis not requested; SL, sample lost prior to analysis; Insufficient sample, inadequate amount of sample collected for requested analysis; USGS, U.S. Geological Survey. **Symbol**: ±, plus or minus]

Well No.	Date	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)	Plutonium-238 (pCi/L)	Plutonium-239, 240 (undivided) (pCi/L)	Americium-241 (pCi/L)	Chloride, dissolved (mg/L)
USGS 92	03-30-99	0.26±0.13	2.6±1	-15±20	0.005±0.005	0.005±0.005	0.03±0.02	81.2
	10-21-99	0.33±0.15	1.4±0.9	-12±24	-0.015±0.011	-0.008±0.013	0.02±0.02	79.7
	04-17-00	**0.3±0.1**	0.2±0.8	30±30	-0.007±0.007	-0.004±0.006	-0.004±0.012	80.2
	10-18-00	0.13±0.13	–0.8±1.1	0±40	Insufficient sample	Insufficient sample	Insufficient sample	NR
	04-17-01	0.42±0.15	0.6±0.7	0±30	–0.003±0.003	0.003±0.008	0.007±0.012	78.0
	10-11-01	**0.45±0.14**	NR	–17±22	SL	SL	SL	NR

In 1987, 9 VOCs were detected in water from well USGS 92 (Mann and Knobel, 1987, p. 16–17); in January 1990, 6 VOCs were detected (Tucker and Orr, 1998); and in April 1992, water samples contained concentrations of 18 VOCs (Bartholomay, 1998, p. 28; Greene and Tucker, 1998). During 1996–98, 14 VOCs were detected (Bartholomay and Tucker, 2000). During 1999–2001, water from well USGS 92 was analyzed for the same VOCs as in previous years. Most of the same VOCs detected during 1996–98 were detected during 1999–2001, except toluene was not detected and benzene and chloroethane were detected. Table 7 lists the concentrations of 15 VOCs detected in 1999–2001 as well as VOCs detected during 1996–98. Most VOCs fluctuated through time and show no distinct trend. The MRL for some VOCs was changed from 0.2 to 0.1 µg/L during 1998–2001, a change that could result in detections of smaller concentrations and (or) different VOCs than detected in previous years.

Table 7. Concentrations of selected volatile organic compounds in perched ground water from well USGS 92, Radioactive Waste Management Complex, Idaho National Laboratory, Idaho, 1996–2001.

[Analyses completed by the National Water Quality Laboratory using an analytical method that conforms to U.S. Environmental Protection Agency method 524.2. Analytical results in micrograms per liter. Names in parentheses are alternate compound names. **Abbreviations:** NWIS, National Water Information System; E, estimated. **Symbol:** <, less than respective reporting level]

Date	Compound name							
	Carbon tetrachloride (Tetrachloro-methane)	1,2-Dichloro-ethane	Chloroform (Trichloro-methane)	Methylene chloride (Dichloro-methane)	Tetrachloro-ethylene (Tetrachloro-ethene)	1,1,-dichloro-ethane	1,1-Dichloro-ethylene (1,1-Dichloro-ethene)	1,1,-Trichloro-ethane
	NWIS Parameter Code							
	32102	32103	32106	34423	34475	34496	34501	34506
02-29-1996	1,800	1.8	920	<0.2	180	15	2.2	170
04-08-1997	990	1.2	633	.2	110	8.8	1.4	97.9
03-31-1998	260	1	540	5.3	50	7.7	1	55
03-30-1999	13.6	.5	285	3.5	22.9	4.5	.41	28.7
04-17-2000	291	.7	325	E2.4	43	6	E1.1	47.2
04-17-2001	377	1	602	22.4	125	8.5	.93	109

Date	Compound name							
	1,1,2-Trichlo-ro-ethane	1,2-Dichloro-propane	Trichloro-ethylene (Trichloro-ethene)	*Cis*-1,2-dichloro-ethene	Freon-113 (CFC-113) (1,1,2-Trichloro-1,2,2-Trifluoro-ethane)	Toluene	Benzene	Chloro-ethane
	NWIS Parameter Code							
	34511	34541	39180	77093	77652	34010	34030	34311
02-29-1996	0.6	6.7	1,400	0.8	3.6	<0.2	<0.2	<0.2
04-08-1997	.3	4	786	.4	2.4	.3	<.4	<.4
03-31-1998	<.7	3.2	360	.3	1.3	<.2	<.2	<.2
03-30-1999	<.4	1.9	179	.3	.8	<.4	2.1	<.4
04-17-2000	.2	2.7	280	.4	1.3	<.2	.9	<.2
04-17-2001	.3	3.2	798	.7	1	<.2	.3	.2

Summary

Shallow and deep perched ground water is present in basalt and sediments beneath several facilities at the Idaho National Laboratory (INL) resulting from low-level radioactive, chemical, and sanitary wastewater discharge to infiltration ponds since 1952. During 2001, about 293 million gallons (Mgal) was discharged to infiltration and lined evaporation ponds at the Reactor Technology Complex (RTC), and 544 Mgal was discharged to infiltration ponds at the Idaho Nuclear Technology and Engineering Center (INTEC).

During 1952–93, about 10,500 Curies (Ci) of tritium was in wastewater discharged to the RTC radioactive-waste infiltration ponds. Since 1993, tritium in wastewater has been discharged to two lined evaporation ponds, which replaced the radioactive-waste infiltration ponds. About 191 Ci of tritium was released in wastewater to the RTC lined evaporation ponds during 1999–2000. Data are not available for the total amount to tritium in wastewater discharged in 2001.

In 2001, tritium concentrations in water from seven wells completed in shallow perched ground water near the cold-waste pond at RTC were less than the reporting level. Two wells completed in shallow perched water could not be sampled in 2001 because of either a lack of water or an obstruction in the wells. During July–October 2001, tritium concentrations in water from eight wells completed in deep perched ground water at the RTC were greater than the reporting levels. Tritium concentrations ranged from 0.49±0.14 to 39.4±1.4 picocuries per milliliter (pCi/mL). During July–October 2001, reportable concentrations of tritium in water from wells completed in deep perched ground water were less than the reported concentrations measured during July–December 1998.

Several factors likely affected the distribution of tritium in perched ground water in wells at the RTC. These factors include proximity of the well to the radioactive-waste infiltration ponds, depth of water below the ponds, variations in tritium disposal rates, radioactive decay, dilution from infiltration from the cold-waste ponds, and infiltration of Big Lost River water. The replacement of the radioactive-waste infiltration ponds by lined evaporation ponds in 1993 also contributed to decreased tritium concentrations in perched ground water.

Less than 0.001 Ci of strontium-90 was discharged at the RTC during 1999; during 2000, 0.21 Ci of strontium-90/yttrium-90 was discharged at the RTC. Data are not available for the amount of strontium-90 discharged in 2001. Water from well TRA A 13 completed in shallow perched ground water, exceeded the reporting level during 1999–2001, concentrations ranged from 38±1.4 to 22.1±1.1 pCi/L (picocuries per liter). Well CWP 1, also completed in shallow perched ground water, exceeded the reporting level in June 1999 with a concentration of 3.1±0.7 pCi/L; however, by October 2001, the concentration was less than the reporting level.

Concentrations of strontium-90 in water from five wells completed in deep perched ground water at the RTC exceeded reporting levels in October 2001; concentrations ranged from 2.8±0.7 to 83.8±2.1 pCi/L. The distribution of strontium-90 concentrations in water from these wells during 1999-2001 is attributed to sorption and (or) exchange reactions between strontium-90 in solution and sediments beneath the radioactive-waste infiltration ponds.

No reportable concentrations of cesium-137 were detected in water from any wells completed in either shallow or deep perched ground water at the RTC during 1999–2001. The general absence of reportable concentrations of cesium-137 in perched ground water at the RTC probably is due to decreased cesium disposal rates, use of lined evaporation ponds instead of the radioactive-waste infiltration ponds, and sorption and (or) exchange reactions with sediments.

Chromium-51 and cobalt-60 were not detected in any water samples collected during 1999–2001. Decreased disposal and relatively short half-lives probably account for their absence.

Wastewater from RTC cooling-tower operations containing an estimated 24,000 lb of non-radioactive chromium was discharged to the radioactive-waste infiltration ponds during 1952–64. During 1964–72, chromium was discharged to a disposal well; no discharges of chromium were reported after 1972. During 1999–2001, no dissolved chromium was detected in shallow perched ground water. Dissolved chromium was detected in water from 10 wells completed in deep perched ground water at the RTC. The maximum concentration of dissolved chromium in deep perched ground water was 90 micrograms per liter (µg/L) in January 1999. This concentration decreased to 35 µg/L by October 2001. During July–October 2001, concentrations of dissolved chromium in deep perched ground water near the RTC ranged from 10 to 82 µg/L. The largest concentrations were in water from wells north and west of the radioactive-waste infiltration ponds, and the presence of dissolved chromium indicates that water from these wells contained constituents that were discharged to the radioactive-waste infiltration ponds before 1965.

About 173,000 pounds of sodium was discharged to the RTC chemical-waste pond during 1996–98. The total amount of sodium in wastewater discharged at the RTC from 1999–2001 has not been compiled. During 1999–2001, the maximum concentration of sodium in water from wells in shallow perched ground water was 23 milligrams per liter (mg/L). During July–October 2001, sodium concentrations

in water from wells completed in deep perched ground water generally ranged from 7 to 20 mg/L in all wells except well USGS 68, with a concentration of 413 mg/L, a decrease from December 1998 when the concentration was 662 mg/L.

About 3,600 pounds of chloride was in wastewater discharged to the cold-waste ponds during 1996-98. Data are not available for chloride in wastewater discharged during 1999–2001. During 1999–2001, chloride concentrations in shallow perched ground water ranged from 10 to 53 mg/L. Chloride concentrations in deep perched ground water ranged from 5 to 91 mg/L.

Wastewater that contained about 833,000 pounds of sulfate was discharged to the chemical- and cold-waste ponds at RTC during 1996–98. Compiled data are not available for the amount of sulfate in wastewater discharged during 1999–2001. During July–October 2001, concentrations of dissolved sulfate in water from wells completed in deep perched ground water ranged from 115 to 1,409 mg/L. The maximum concentration of dissolved sulfate in deep perched ground water was from water from well USGS 68, west of the chemical-waste pond.

Two infiltration ponds were constructed south of the INTEC in 1984 and 1985 to replace the INTEC disposal well. Wastewater from these ponds formed perched ground water in the basalt and sedimentary interbeds above the Snake River Plain aquifer. The discharge to the ponds during 2001 was about 544 Mgal; data for 1999 and 2000 are not available. Perched ground water has been identified in other areas beneath the INTEC and may be attributed to other infiltration ponds, leaking wastewater lines, leach fields, ruptured casing in the upper part of the INTEC disposal well, and landscape irrigation.

Tritium discharged to the ponds decreased over the years from 960 Ci during 1984–88 to 0.03 Ci in 2000. Data are not available for tritium discharged in 2001. In 2001, tritium concentrations in water from wells completed in shallow perched ground water were less than the reporting level. During 1999–2001, the tritium concentration in water from wells completed in deep perched ground water beneath the infiltration ponds ranged from less than the reporting level to 9.7±0.5 pCi/mL. Tritium concentrations have decreased in shallow and deep perched ground water near the INTEC since 1986–88.

During 1999–2000, less than 0.001 Curie per year (Ci/yr) of strontium-90 was discharged at the INTEC; data are not available for strontium-90 discharged in 2001. A concentration of 2.1±0.7 pCi/L was detected in July 2001 in one well completed in shallow perched ground water. During 1999–2001, concentrations of strontium-90 were variable in water from all wells completed in the deep perched ground water beneath the INTEC infiltration ponds. In October 2001, strontium-90 concentrations in deep perched ground water in wells closest to the ponds were less than the reporting level, not sampled because of access problems, or the wells were dry. Overall, concentrations of strontium-90 have been decreasing in wells near the INTEC.

During 1999–2000, less than 0.001 Ci/yr of cesium-137 was discharged to the INTEC infiltration ponds. Data are not available for cesium-137 discharged during 2001. Concentrations of cesium-137 did not exceed the reporting level in perched ground water. The absence of reportable cesium-137 concentrations in perched ground water at the INTEC probably is due to decreased disposal and to sorption and (or) exchange of cesium-137 to minerals in sediments.

Estimates of sodium discharged at the INTEC are not available for 1999–2001. Sodium concentrations in water from two wells completed in shallow perched ground water ranged from 92 to 102 mg/L in July 2001, which was similar to the average wastewater concentration. During 1999–2001, dissolved sodium concentrations in deep perched ground water in wells closest to the infiltration ponds ranged from 109 mg/L in October 2001 to 164 mg/L in October 1999. By October 2001, most wells could not be sampled due to lack of water in the well or well access problems. Dissolved sodium concentrations in shallow and deep perched ground water at the INTEC infiltration ponds during 1999–2001 were similar to or less than those in wastewater.

Estimates of chloride discharged at the INTEC are not available for 1999–2001. In July 2001, dissolved chloride concentrations in two wells completed in shallow perched ground water ranged from 153 to 157 mg/L. During 1999-2001, dissolved chloride concentrations in deep perched ground water in wells closest to the infiltration ponds ranged from 79 to 348 mg/L. In October 2001, some wells were dry, some were not sampled because of well access problems, and water in two wells contained dissolved chloride concentrations of 167 mg/L and 175 mg/L. Dissolved chloride concentrations in shallow and deep perched ground water at the INTEC infiltration ponds were similar to or less than the dissolved chloride concentrations in wastewater. During 1999–2001, dissolved chloride concentrations in water from well USGS 50 were consistent, ranging from 59 mg/L in April 1999 to 55 mg/L in April 2001. Dissolved chloride concentrations in water from this well steadily decreased since sampling began in 1959.

Estimates of sulfate discharged during 1999–2001 are not available. Dissolved sulfate concentrations in water from two wells completed in shallow perched ground water ranged from 30 to 34 mg/L in July 2001. Dissolved sulfate concentrations in water from wells completed in the deep perched ground water closest to the INTEC infiltration ponds ranged from 28 to 30 mg/L in 2001. Historically, dissolved sulfate

concentrations in these wells have fluctuated between about 22 and 41 mg/L. Concentrations of dissolved sulfate in samples from well USGS 50 ranged from 39 to 41 mg/L during 1999-2001. Historically, dissolved sulfate concentrations in water from well USGS 50 have fluctuated slightly around these values. These concentrations are consistent with the average concentration of dissolved sulfate in wastewater.

Estimates of dissolved nitrite plus nitrate (as nitrogen) discharged during 1999–2001 are not available. In July 2001, the concentration of dissolved nitrite plus nitrate (as nitrogen) in wells completed in shallow perched ground water ranged from 0.6 to 1.3 mg/L. Dissolved nitrite plus nitrate (as nitrogen) concentrations in deep perched ground water near the INTEC disposal well ranged from 58.4 mg/L in 1999 to 4.7 mg/L in 2001.

Perched ground water beneath the Radioactive Waste Management Complex (RWMC) is in sedimentary interbeds in basalts and can be attributed primarily to infiltration of snowmelt and rainfall and to recharge from the Big Lost River and the INL spreading areas and, therefore, may contain waste constituents leached from liquid and solid radiochemical and organic chemical wastes buried at the RWMC. During 1999–2001, radiochemical constituents in all water samples from well USGS 92 were less than the reporting level with the exception of two samples analyzed for tritium. The tritium concentration in water from well USGS 92 was at the reporting level at 0.3±.0.1 pCi/mL in April 2000 and near the reporting level at 0.45±14 pCi/mL in October 2001. Tritium concentrations in water from well USGS 92 have been variable through time.

Dissolved chloride concentrations in water from four samples collected from well USGS 92 at the RWMC ranged from 78.0 to 81.2 mg/L during 1999–2001. These dissolved chloride concentrations are consistent with concentrations measured historically.

During 1999–2001, samples from well USGS 92 contained concentrations greater than the reporting levels of 15 volatile organic compounds (VOCs). Water from well USGS 92 was analyzed for the same VOCs as in previous years. Mostly the same VOCs detected during 1996–98 were detected during 1999–2001, except that toluene was not detected and benzene and chloroethane were detected. Most VOCs have fluctuated through time and showed no distinct trend.

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