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Scientific Investigations Report 2008-5089

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

Cover: Photograph of U.S. Geological Survey well and sampling apparatus and measurement equipment. (Photograph courtesy of the U.S. Geological Survey Idaho National Laboratory Project Office.)

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U.S. Geological Survey
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Conversion Factors, Datums, and Abbreviations and Acronyms

Conversion Factors

Multiply	By	To obtain
acre	0.4047	hectare (ha)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year (m^3/yr)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
foot (ft)	0.3048	meter (m)
foot per day (ft/d)	0.3048	meter per day (m/d)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
gallon (gal)	3.785	liter (L)
gallon per month (gal/mo)	12	gallons per year (gal/yr)
mile (mi)	1.609	kilometer (km)
million acre-feet per year (Macre-ft/yr)	1,233	million cubic meters per year (Mm^3/year)
million gallons (Mgal)	3,785	cubic meter (m^3)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
pound per year (lb/yr)	0.4536	kilogram per year (kg/yr)
pound, avoirdupois (lb)	0.4536	kilogram (kg)
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/day)
square mile (mi^2)	2.590	square kilometer (km^2)

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

$$°F=(1.8×°C)+32.$$

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

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

Datums

Vertical coordinate information is referenced to National Geodetic Vertical Datum of 1929 (NGVD 29).

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

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

Conversion Factors, Datums, and Abbreviations and Acronyms—Continued

Abbreviations and Acronyms

Abbreviation or acronym	Definition
CFA	Central Facilities Area
Ci	Curie
Ci/yr	Curie per year
DOE	Department of Energy
ICPP	Idaho Chemical Processing Plant
INEL	Idaho National Engineering Laboratory (1974–97)
INEEL	Idaho National Engineering and Environmental Laboratory (1997–2005)
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
LRL	laboratory reporting level
LT-MDL	long-term method detection level
MCL	maximum contaminant level
MRL	minimum reporting level
NRF	Naval Reactors Facility
NRTS	National Reactor Testing Station (1949–74)
NWIS	National Water Information System
NWQL	National Water Quality Laboratory (USGS)
pCi/L	picocurie per liter
pCi/mL	picocurie per milliliter
RESL	Radiological and Environmental Sciences Laboratory (DOE)
RTC	Reactor Technology Complex
RWMC	Radioactive Waste Management Complex
s	sample standard deviation
SDA	Subsurface Disposal Area
TAN	Test Area North
TOC	total organic carbon
USGS	U.S. Geological Survey
VOC	volatile organic compound

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An Update of Hydrologic Conditions and Distribution of Selected Constituents in Water, Snake River Plain Aquifer and Perched-Water Zones, Idaho National Laboratory, Idaho, Emphasis 2002–05

By Linda C. Davis

Abstract

Radiochemical and chemical wastewater discharged since 1952 to infiltration ponds, evaporation ponds, and disposal wells at the Idaho National Laboratory (INL) has affected water quality in the Snake River Plain aquifer and perched-water zones underlying the INL. The U.S. Geological Survey, in cooperation with the U.S. Department of Energy, maintains ground-water monitoring networks at the INL to determine hydrologic trends, and to delineate the movement of radiochemical and chemical wastes in the aquifer and in perched-water zones. This report presents an analysis of water-level and water-quality data collected from aquifer and perched-water wells in the USGS ground-water monitoring networks during 2002–05.

Water in the Snake River Plain aquifer primarily moves through fractures and interflow zones in basalt, generally flows southwestward, and eventually discharges at springs along the Snake River. The aquifer is recharged primarily from infiltration of irrigation water, infiltration of streamflow, ground-water inflow from adjoining mountain drainage basins, and infiltration of precipitation.

From March–May 2001 to March–May 2005, water levels in wells declined throughout the INL area. The declines ranged from about 3 to 8 feet in the southwestern part of the INL, about 10 to 15 feet in the west central part of the INL, and about 6 to 11 feet in the northern part of the INL. Water levels in perched water wells declined also, with the water level dropping below the bottom of the pump in many wells during 2002–05.

For radionuclides, concentrations that equal 3**s,** where s is the sample standard deviation, represent a measurement at the minimum detectable concentration, or "reporting level." Detectable concentrations of radiochemical constituents in water samples from wells in the Snake River Plain aquifer at the INL generally decreased or remained constant during 2002–05. Decreases in concentrations were attributed to decreased rates of radioactive-waste disposal, radioactive decay, changes in waste-disposal methods, and dilution from recharge and underflow. In October 2005, reportable concentrations of tritium in ground water ranged from 0.51±0.12 to 11.5±0.6 picocuries per milliliter and the tritium plume extended south-southwestward in the general direction of ground-water flow. Tritium concentrations in water from several wells southwest of the Idaho Nuclear Technology and Engineering Center (INTEC) decreased or remained constant as they had during 1998–2001, with the exception of well USGS 47, which increased a few picocuries per milliliter. Most wells completed in shallow perched water at the Reactor Technology Complex (RTC) were dry during 2002–05. Tritium concentrations in deep perched water exceeded the reporting level in nine wells at the RTC. The tritium concentration in water from one deep perched water well exceeded the reporting level at the INTEC. Concentrations of strontium-90 in water from 14 of 34 wells sampled during October 2005 exceeded the reporting level. Concentrations ranged from 2.2±0.7 to 33.1±1.2 picocuries per liter. However, concentrations from most wells remained relatively constant or decreased since 1989. Strontium-90 has not been detected within the eastern Snake River Plain aquifer beneath the RTC partly because of the exclusive use of waste-disposal ponds and lined evaporation ponds rather than the disposal well for radioactive-wastewater disposal at RTC. At the RTC, strontium-90 concentrations in water from six wells completed in deep perched ground water exceeded the reporting level during 2002-05. At the INTEC, the reporting level was exceeded in water from three wells completed in deep perched ground water. During 2002–05, concentrations of plutonium-238, and plutonium-239, -240 (undivided), and americium-241 were less than the reporting level in water samples from all wells sampled at the INL. During 2002–05, concentrations of cesium-137 in water from all wells sampled by the USGS at the INL were less than the reporting level.

Changes in detectable concentrations of nonradioactive chemical constituents in water from the Snake River Plain aquifer at the INL varied during 2002–05. In April 2005, water from well USGS 65, south of the Reactor Technology Complex (RTC) [formerly known as the Test Reactor Area (TRA)], contained 100 micrograms per liter (µg/L) of chromium, a decrease from the concentration of 139 µg/L detected in October 2001. Other water samples contained from less than 1.7 to 30.3 µg/L of chromium. Chromium was detected in water from 2 wells completed in shallow perched ground water, and in 17 wells completed in deep perched water. During 2002–05, the largest concentration of sodium in water samples from aquifer wells at the INL was 76 milligrams per liter (mg/L) in a sample from well USGS 113, south of INTEC. During April–October 2005, dissolved sodium concentrations in deep perched water at the RTC ranged from 6 to 27 mg/L in all wells except well USGS 68 (370 mg/L). No analyses were made for sodium in shallow perched ground water at the RTC during 2002–05. Dissolved sodium concentrations in water from 16 wells completed in deep perched water at the RTC were determined. At the INTEC, sodium concentrations were determined from one well completed in shallow perched ground water, and from two wells completed in deep perched ground water. In 2005, chloride concentrations in most water samples from the INTEC and the Central Facilities Area (CFA) exceeded ambient concentrations of 10 and 20 mg/L, respectively. Chloride concentrations in water from wells near the RTC were less than 20 mg/L. At the Radioactive Waste Management Complex (RWMC), chloride concentrations in water from wells USGS 88, 89, and 120 were 86, 41, and 20 mg/L, respectively, nearly the same as the 1999–2001 reporting period. Concentrations of chloride in all other wells near the RWMC were less than 13 mg/L. During April to October 2005, chloride concentrations in shallow perched ground water from three wells at the RTC ranged from 10 to 32 mg/L and from 3 to 35 mg/L in deep perched ground water. At the INTEC, dissolved chloride concentrations in deep perched ground water in wells closest to the percolation ponds ranged from 118 to 332 mg/L. In 2005, sulfate concentrations in water from aquifer wells USGS 34, 35, and 39, southwest of INTEC, were 42, 46, and 46 mg/L, respectively. Historically, concentrations in these wells have been at or just below 40 mg/L, the estimated background concentration of sulfate in the Snake River Plain aquifer at the INL. The maximum sulfate concentration in water from wells completed in shallow perched ground water at the RTC was 396 mg/L. During April to October 2005, concentrations of dissolved sulfate in water from wells completed in deep perched ground water at the RTC ranged from 66 to 276 mg/L. Concentrations of dissolved sulfate in water from two wells completed in deep perched ground water at the INTEC were 35 mg/L.

In October 2005, concentrations of nitrate in water from wells USGS 41, 43, 45, 47, 52, 57, 67, 77, 112, 114, and 115 near the INTEC, exceeded the regional background of 5 mg/L (as nitrate) and concentrations ranged from 6 mg/L in well USGS 45 to 34 mg/L in well USGS 43. However, since 1981, nitrate concentrations have decreased overall in water from these wells.

During April to October 2005, water samples from five aquifer wells were analyzed for fluoride; detected concentrations ranged from 0.2 to 0.3 mg/L. These concentrations are similar to the background concentrations, which indicate that wastewater disposal has not had an appreciable affect on fluoride concentrations in the Snake River Plain aquifer near the INTEC.

During 2002–05, 12 volatile organic compounds (VOCs) were detected in water from aquifer wells at the INL. Concentrations of from 1 to 9 VOCs were detected in water samples from 13 wells. Primary VOCs detected included carbon tetrachloride, chloroform, 1,1-dichloroethane, 1,1,1-trichloroethane, trichloroethylene, and tetrachloroethylene.

During 2002–05, attempts were made each year to sample well USGS 92, completed in perched water at the RWMC; however, lack of water in the well precluded obtaining an adequate sample during most sampling events. Most of the same VOCs except chloroethane that were detected during 1999–2001 were detected during 2002–03; additionally, bromodichloromethane was detected. Concentrations of 16 VOCs were detected during 2002–03. Most VOCs fluctuated through time and show no distinct trend.

Introduction

The Idaho National Laboratory (INL), operated by the U.S. Department of Energy (DOE), 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, 1949–1974), Idaho National Engineering Laboratory (INEL, 1974–1997), and Idaho National Engineering and Environmental Laboratory (INEEL, 1997–2005). The INL facilities are used in the development of peacetime atomic-energy applications, nuclear safety research, defense programs, environmental research, and advanced energy concepts. Radiochemical and chemical wastewater generated at these facilities has been discharged to either onsite infiltration ponds, evaporation ponds, disposal wells, or a combination thereof, since 1952. Wastewater disposal has resulted in detectable concentrations of several waste constituents in water from the Snake River Plain aquifer underlying 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.

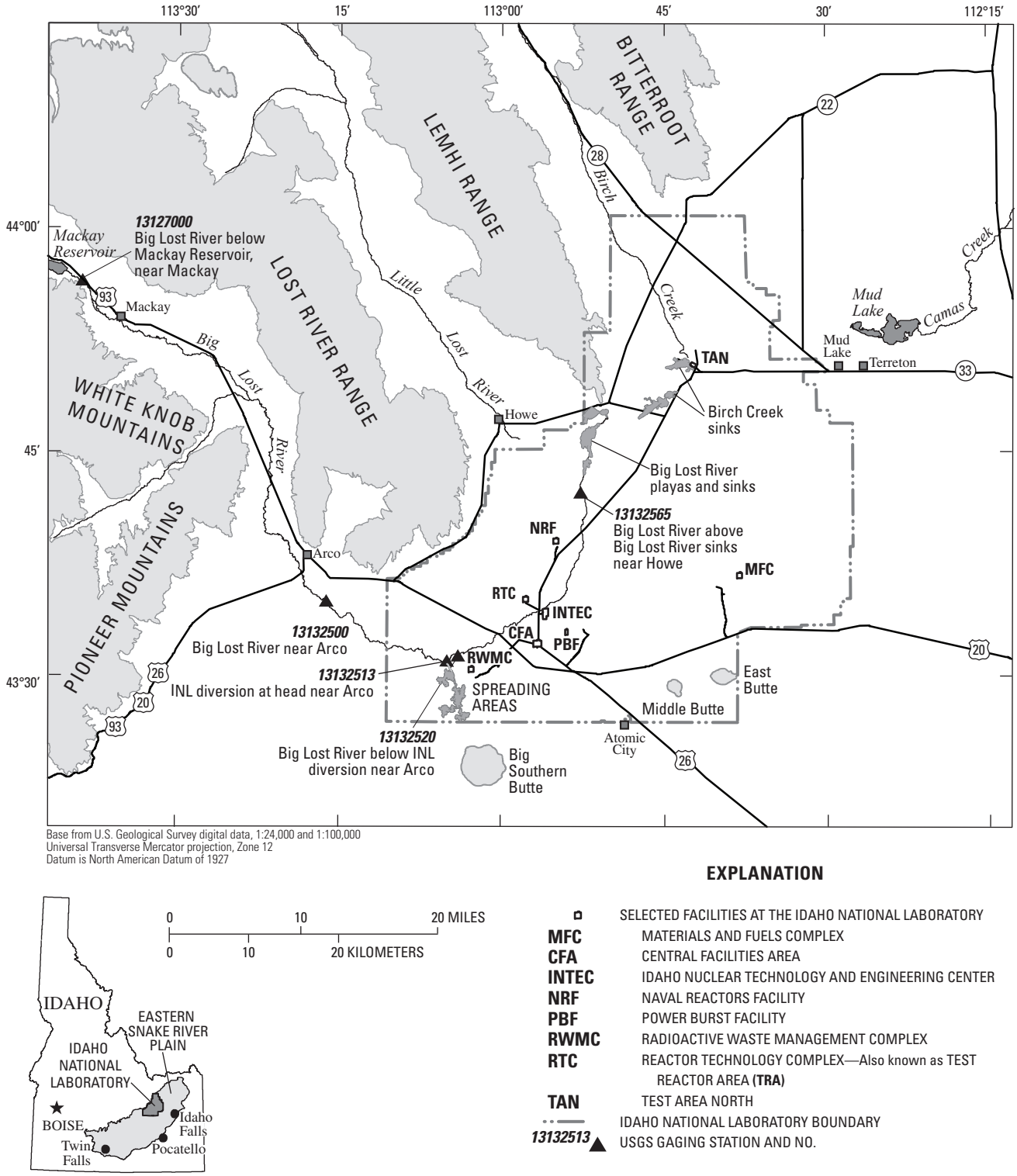


Figure 1. Location of the Idaho National Laboratory, surface-water gaging stations, and selected facilities, Idaho.

The DOE requires information about the mobility of dilute radiochemical- and chemical-waste constituents in the Snake River Plain aquifer and in perched ground water above the aquifer. Waste-constituent mobility is determined, in part, by (1) the rate and direction of ground-water flow; (2) the locations, quantities, and methods of waste disposal; (3) waste-constituent chemistry; and (4) the geochemical processes taking place in the aquifer. This study was conducted by the U.S. Geological Survey (USGS) in cooperation with the DOE 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 the INL. The purpose of the resulting study was to characterize these resources before the 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 the Snake River Plain aquifer and in perched ground water.

This report presents an analysis of water-level and water-quality data collected from wells in the USGS ground-water monitoring networks during 2002–05 as part of the continuing hydrogeologic investigations conducted by the USGS at the INL. The report describes the distribution and concentration of selected radiochemical and chemical constituents in ground water and perched ground water at the INL, and changes in the water-level regime since 2001. The report also summarizes the history of waste disposal at the Reactor Technology Complex (RTC) (formerly known as the Test Reactor Area [TRA]), Idaho Nuclear Technology and Engineering Center (INTEC) (formerly known as the Idaho Chemical Processing Plant [ICPP]) , Radioactive Waste Management Complex (RWMC), Test Area North (TAN), and the Central Facilities Area (CFA). Perched ground water 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.

Previous Investigations

A list of references and copies of published reports are available from the USGS INL Project Office or the USGS Publications Warehouse Web site at http://infotrek.er.usgs.gov/pubs/.

Hydrologic conditions and distribution of selected wastewater constituents in ground water and perched ground water are discussed in a series of reports describing the NRTS. Table 1 summarizes selected previous investigations on the hydrology, geology, and characteristics of water at and near the INL, and periods included in those investigations.

Table 1. Summary of selected previous investigations (1961–2006) on geology, hydrology, and water characteristics of ground water and perched ground water, Idaho National Laboratory, Idaho.

[**Abbreviations:** NRTS, National Reactor Testing Station; RWMC, Radioactive Waste Management Complex; INEL, Idaho National Engineering Laboratory; INEEL, Idaho National Engineering and Environmental Laboratory; INL, Idaho National Laboratory; RTC, Reactor Technology Complex; ICPP, Idaho Chemical Processing Plant; INTEC, Idaho Nuclear Technology and Engineering Center]

Reference	Investigation period	Summary
	Ground water	
Jones (1961)		Hydrology of waste disposal at the NRTS, Idaho.
Olmsted (1962)		Chemical and physical character of ground water at the NRTS, Idaho.
Morris and others (1963, 1964, 1965)		Hydrology of waste disposal at the NRTS, Idaho.
Barraclough and others (1967a)	1965	Hydrology of the NRTS, Idaho.
Barraclough and others (1967b)	1966	Hydrology of the NRTS, Idaho.
Nace and others (1975)		Generalized geologic framework of the NRTS, Idaho.
Robertson and others (1974)		Effects of waste disposal on the geochemistry of ground water at the NRTS, Idaho.
Barraclough and others (1976)		Hydrology of the solid waste burial ground (now the RWMC).
Barraclough and Jenson (1976)	1971–73	Hydrologic data for the Idaho INEL, Idaho.
Barraclough and others (1981)	1974–78	Hydrologic conditions for the INEL, Idaho.

Table 1. Summary of selected previous investigations (1961–2006) on geology, hydrology, and water characteristics of ground water and perched ground water, Idaho National Laboratory, Idaho.—Continued

[**Abbreviations:** NRTS, National Reactor Testing Station; RWMC, Radioactive Waste Management Complex; INEL, Idaho National Engineering Laboratory; INEEL, Idaho National Engineering and Environmental Laboratory; INL, Idaho National Laboratory; RTC, Reactor Technology Complex; ICPP, Idaho Chemical Processing Plant; INTEC, Idaho Nuclear Technology and Engineering Center]

Reference	Investigation period	Summary
		Ground water–Continued
Lewis and Jensen (1985)	1979–81	Hydrologic conditions for the INEL, Idaho.
Pittman and others (1988)	1982–85	Hydrologic conditions for the INEL, Idaho.
Orr and Cecil (1991)	1986–88	Hydrologic conditions and distribution of selected chemical constituents in water at the INEL, Idaho.
Bartholomay and others (1995)	1989–91	Hydrologic conditions and distribution of selected radiochemical and chemical constituents in water, INEL, Idaho.
Bartholomay and others (1997)	1992–95	Hydrologic conditions and distribution of selected radiochemical and chemical constituents in water, INEL, Idaho.
Bartholomay and others (2000)	1996–98	Hydrologic conditions and distribution of selected constituents in water, INEEL, Idaho.
Davis (2006a)	1999–2001	Hydrologic conditions and distribution of selected radiochemical and chemical constituents in water, INL, Idaho.
		Perched ground water
Barraclough, and others (1967a)	1965	Extent of perched ground water and distribution of selected wastewater constituents in perched ground water at the RTC.
Barraclough and others (1967b)	1966	Extent of perched ground water and distribution of selected wastewater constituents in perched ground water at the RTC.
Robertson and others (1974)		Analysis of perched ground water and conditions related to the disposal of wastewater to the subsurface at the INEL.
Barraclough and Jensen (1976)		Extent of perched ground water and distribution of selected wastewater constituents in perched ground water at the RTC.
Robertson (1977)		Numerical model simulating flow and transport of chemical and radionuclide constituents through perched water at the RTC.
Barraclough and others (1981)	1974–78	Hydrologic conditions for the INEL, Idaho.
Lewis and Jensen (1985)	1979–81	Hydrologic conditions for the INEL, Idaho.
Pittman and others (1988)	1982–85	Hydrologic conditions for the INEL, Idaho.
Hull (1989)		Conceptual model that described migration pathways for wastewater and constituents from the radioactive-waste infiltration ponds at the RTC.
Anderson and Lewis (1989)		Correlation of drill cores and geophysical logs to describe a sequence of basalt flows and sedimentary interbeds in the unsaturated zones underlying the RWMC.
Anderson (1991)		Correlation of drill cores and geophysical logs to describe a sequence of basalt flows and sedimentary interbeds in the unsaturated zones underlying the RTC, and INTEC.
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.
Cecil and others (1991)	1986–88	Mechanisms for formation of perched water at the RTC, ICPP, and RWMC, INEL, Idaho; distribution of chemical and radiochemical constituents in perched water at the RTC, ICPP and RWMC.

Ground-Water Monitoring Networks

The USGS maintains ground-water monitoring networks at the INL to characterize the occurrence, movement, and quality of water, and to delineate waste-constituent plumes in the Snake River Plain aquifer and perched-water zones. Periodic water-level and water-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 aquifer water-level monitoring network was designed to determine hydraulic-gradient changes that affect the rate and direction of ground-water and waste-constituent movement in the Snake River Plain aquifer, to identify sources of recharge to the aquifer, and to measure the effects of recharge. Water levels were monitored in 173 aquifer wells during 2002–05. Water levels were measured annually in 25 wells, semiannually in 51 wells, quarterly in 62 wells, monthly in 24 wells, and continuously recorded in 4 wells. Figures 2 and 3 show the location of aquifer wells and the frequency of water-level measurements as of December 2005.

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 36 wells (fig. 4) were monitored during 2002–05. At the RTC, the network included 22 wells to monitor deep perched ground-water levels and 9 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 depth. 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 three wells to monitor deep perched ground-water levels around the original INTEC percolation 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 2005 are shown in figure 4.

Water-Quality Monitoring Network

The radiochemical and chemical character of ground water and perched ground water in the Snake River Plain aquifer was determined from analyses of water samples collected as part of a comprehensive sampling program to identify contaminant concentrations and define patterns of waste migration in the aquifer and perched zones. Water samples from surface-water sites at or near the INL and from wells in perched ground-water zones were analyzed to document the chemical quality of water that recharges the aquifer. Water samples were collected from wells that penetrate the aquifer to various depths and with differing well completions and were analyzed to identify trends in water quality. Numerous water samples were collected from ground-water and perched ground-water wells near areas of detailed study, such as the RTC, INTEC, RWMC, TAN, and CFA. Water samples from the Naval Reactors Facility (NRF) were collected and analyzed as part of a separate study and results are presented in series of separate reports (most recently, Bartholomay and others, 2001a, 2001b).

The type, frequency, and depth of ground-water sampling generally depend on the information needed in a specific area. Water samples were routinely collected and analyzed for concentrations of tritium, strontium-90, cobalt-60, cesium-137, plutonium-238, plutonium-239, -240 (undivided), americium-241, gross alpha- and beta-particle radioactivity, chromium, sodium, chloride, sulfate, nitrate, volatile organic compounds, and measurements of specific conductance, pH, and temperature. Additionally, as part of the INL ground-water monitoring program adopted in 1994 (Sehlke and Bickford, 1993), samples from several wells also were analyzed for fluoride, an extensive suite of trace elements, and total organic carbon. Water samples were analyzed for the radiochemical constituents at the Radiological and Environmental Sciences Laboratory (RESL) at the INL and for chemical constituents at the USGS National Water Quality Laboratory (NWQL) in Lakewood, Colo. The location of wells in the aquifer water-quality monitoring network as of December 2005, and the frequency of sample collection are shown in figures 5 and 6, and in table 2. Well locations in the USGS water-quality monitoring network for perched ground water beneath INL facilities during 2002–05 and the frequency of sample collection are shown in figure 7 and table 3. A sample schedule that lists the constituents analyzed at each site is given in a report by Bartholomay and others (2003, attachment 1).

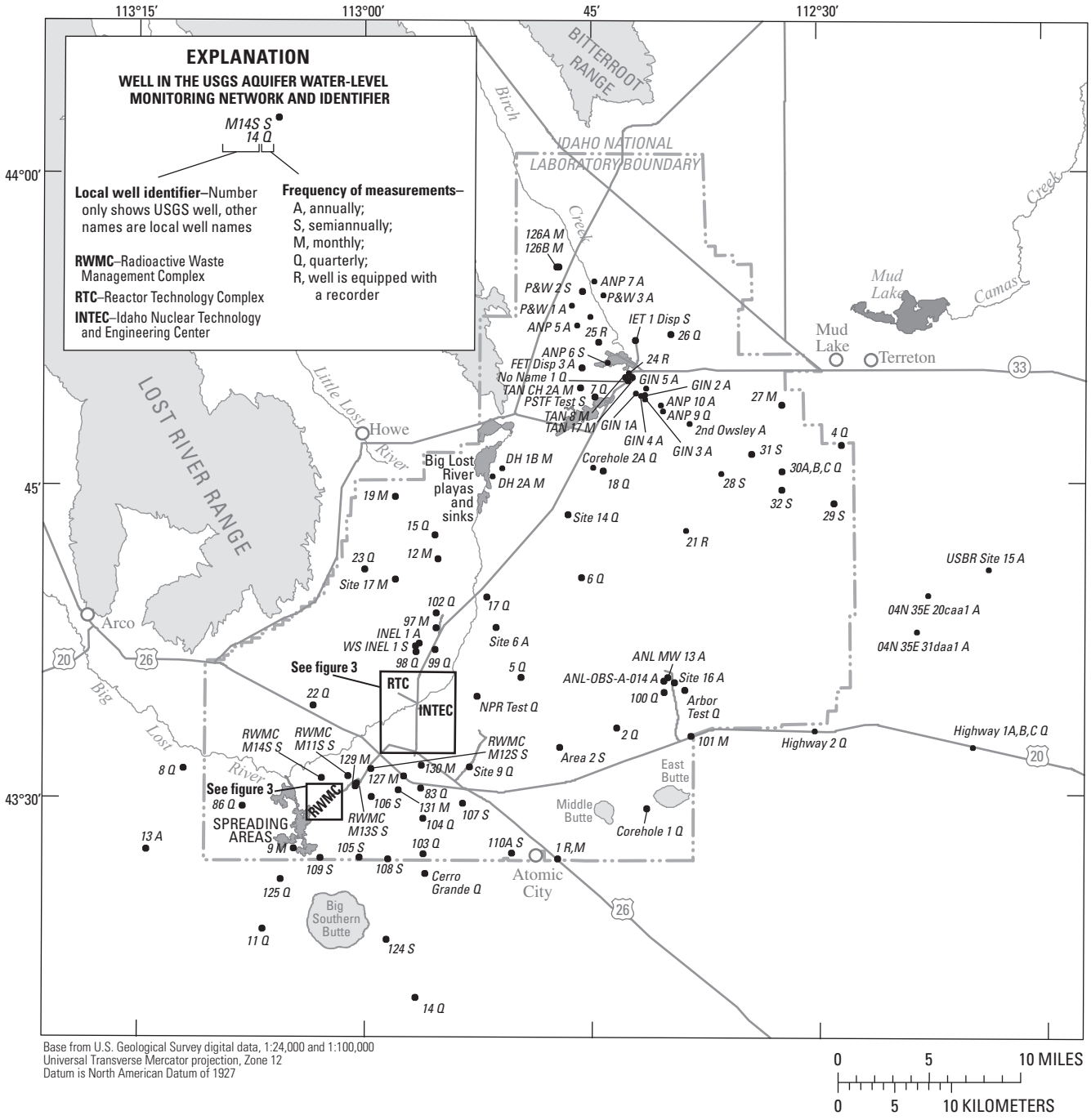
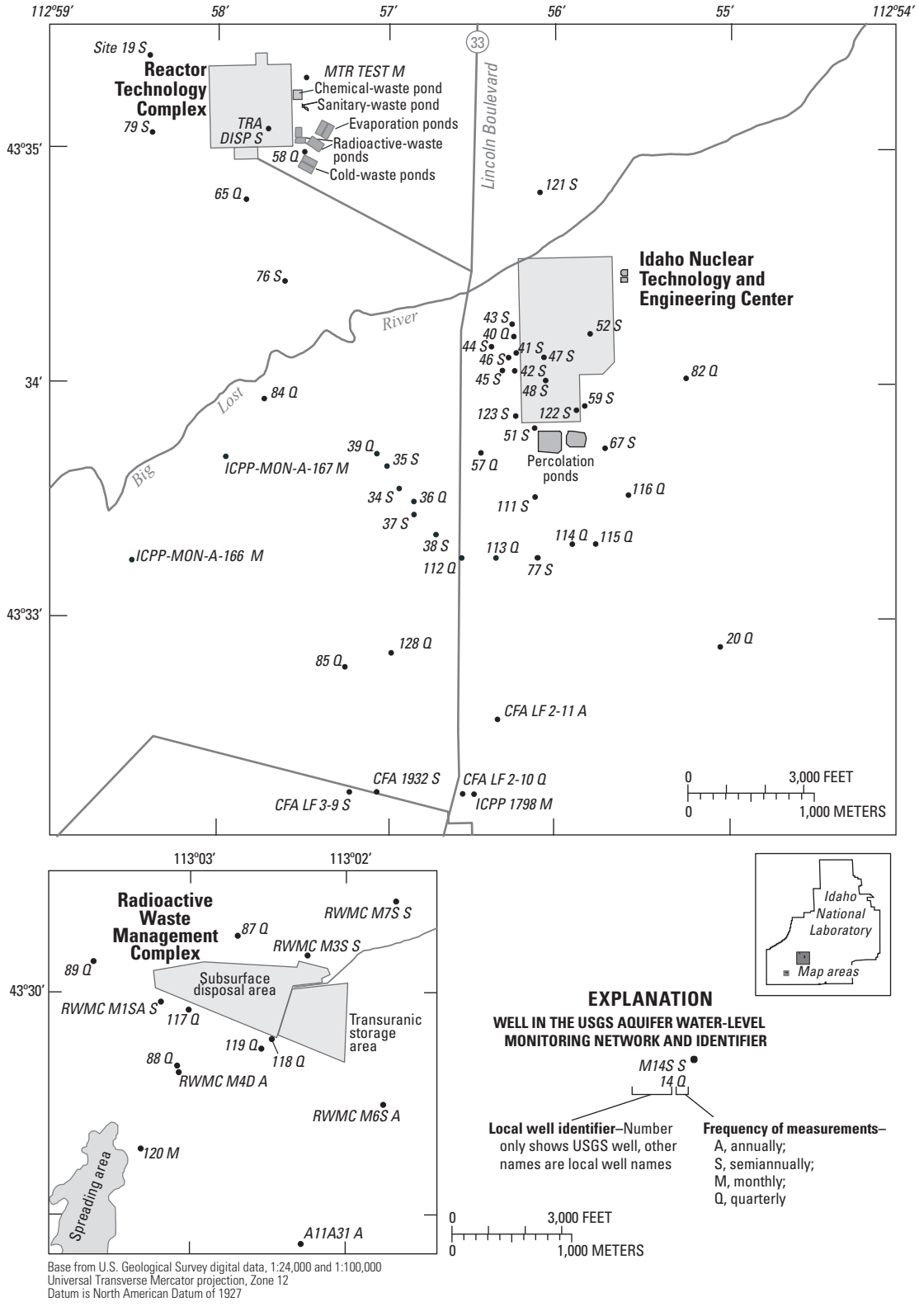


Figure 2. Location of wells in the U.S. Geological Survey aquifer water-level monitoring network at and near the Idaho National Laboratory (INL), Idaho, and frequency of water-level measurements, as of December 2005.



Base from U.S. Geological Survey digital data, 1:24,000 and 1:100,000
Universal Transverse Mercator projection, Zone 12
Datum is North American Datum of 1927

Figure 3. Location of wells in the U.S. Geological Survey aquifer water-level monitoring network at the Reactor Technology Complex (RTC), Idaho Nuclear Technology and Engineering Center (INTEC), and Radioactive Waste Management Complex (RWMC), Idaho National Laboratory (INL), Idaho, and frequency of water-level measurements, as of December 2005.

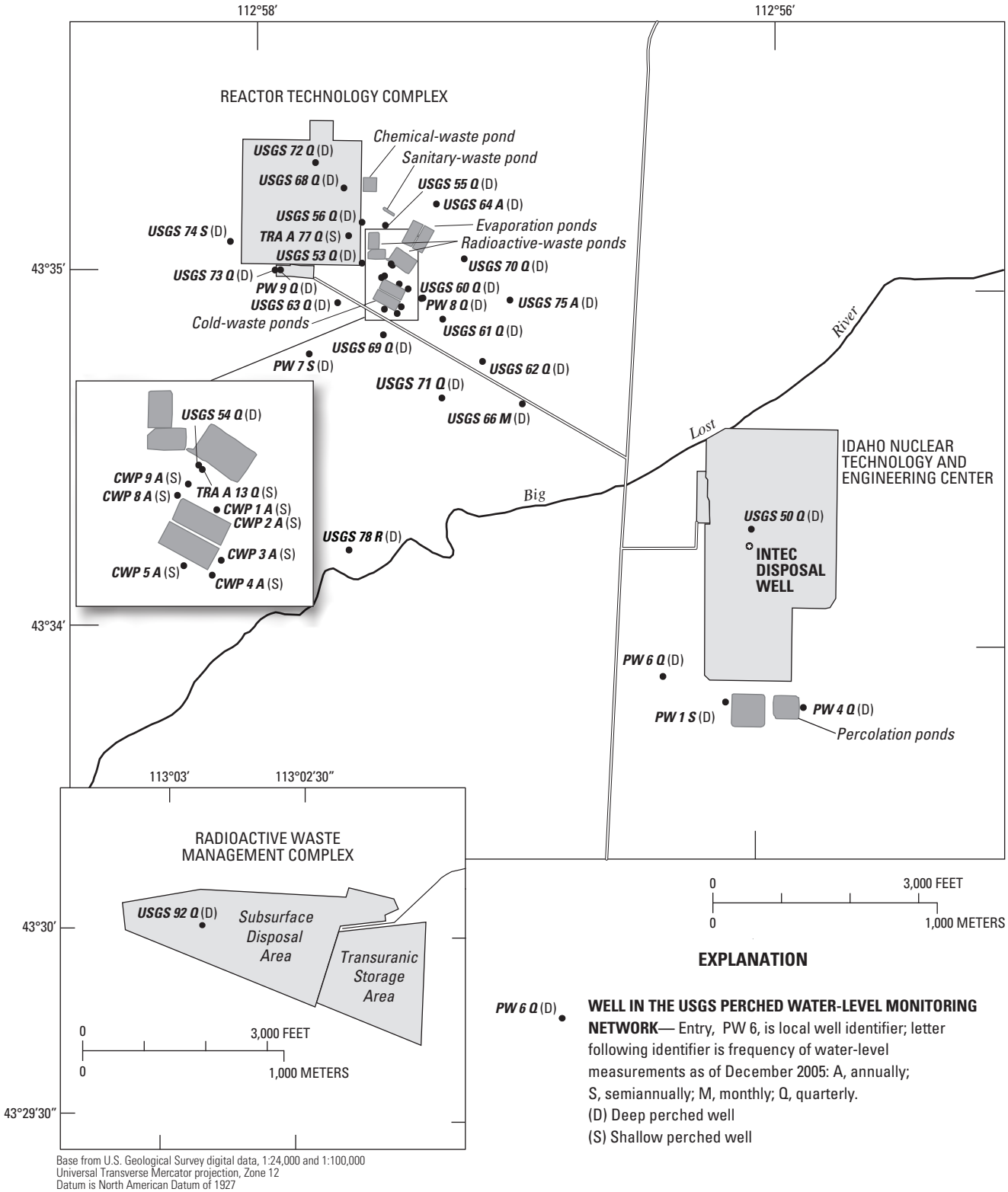


Figure 4. Location of wells in the U.S. Geological Survey perched water-level monitoring network at the Reactor Technology Complex (RTC), Idaho Nuclear Technology and Engineering Center (INTEC), and Radioactive Waste Management Complex (RWMC), Idaho National Laboratory (INL), Idaho, and frequency of water-level measurements, as of December 2005.

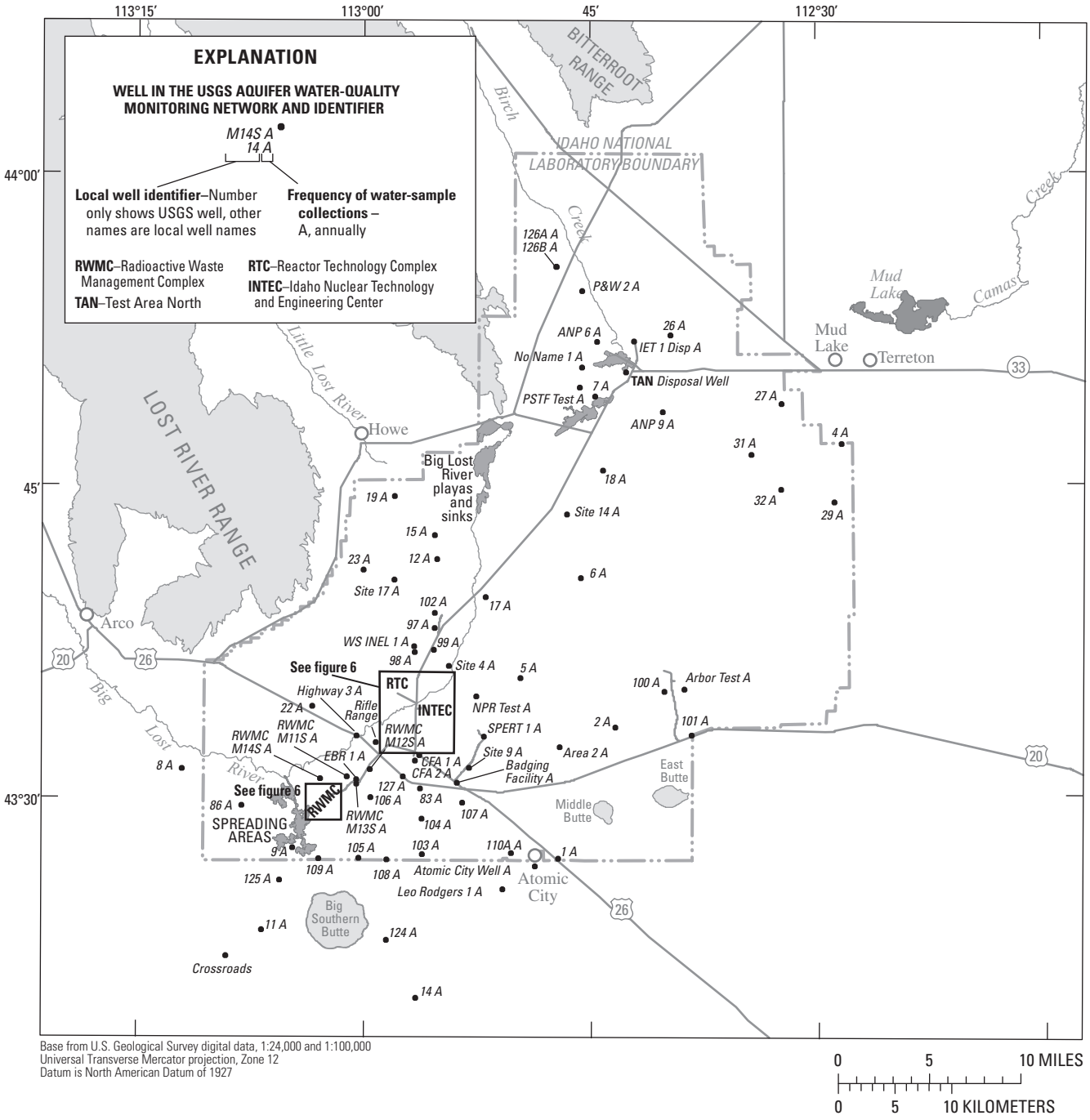


Figure 5. Location of wells in the U.S. Geological Survey aquifer water-quality monitoring network, Idaho National Laboratory (INL) and vicinity, Idaho, and frequency of water-sample collections, as of December 2005.

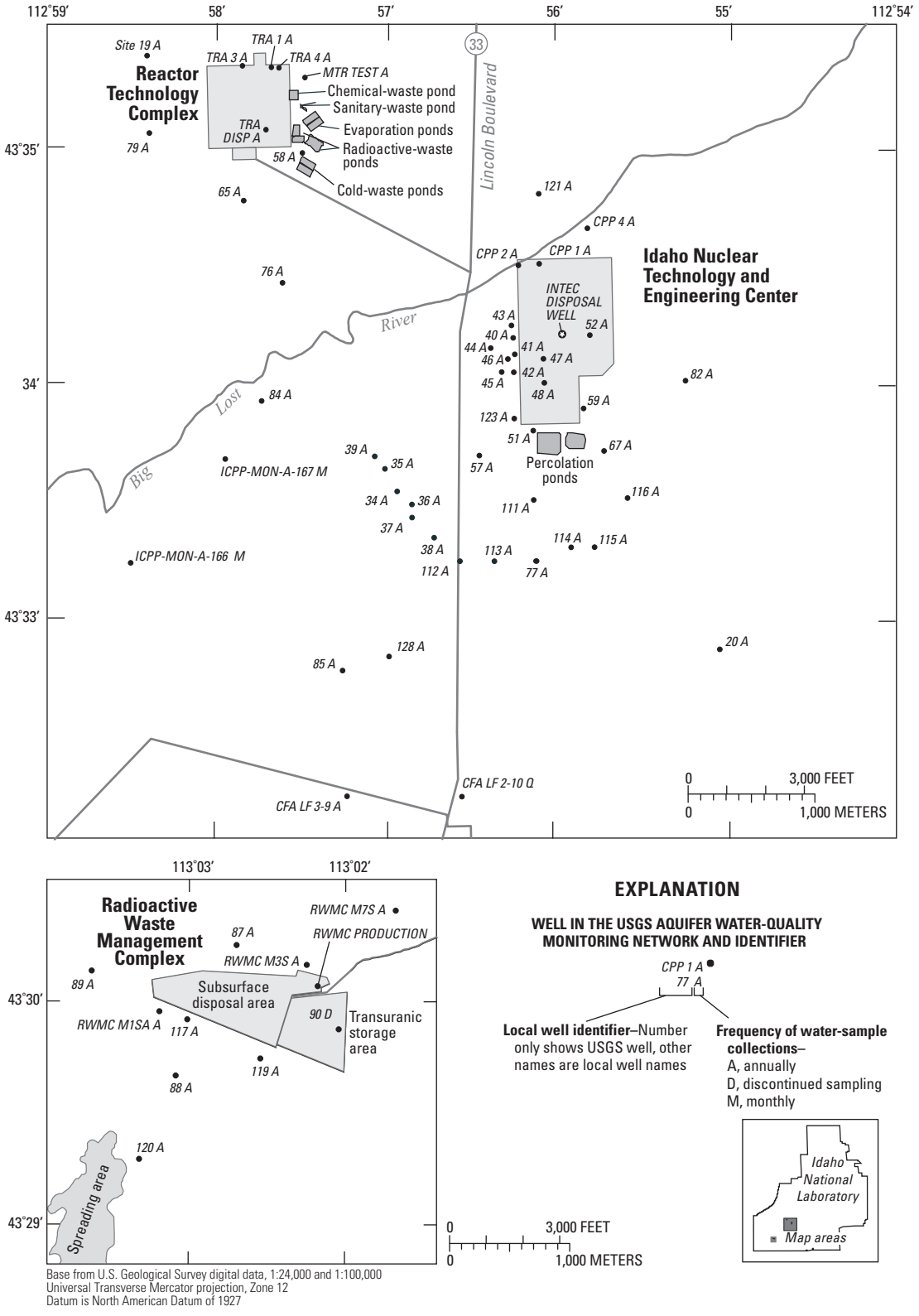


Figure 6. Location of wells in the U.S. Geological Survey aquifer water-quality monitoring network at the Reactor Technology Complex (RTC), Idaho Nuclear Technology and Engineering Center (INTEC), and Radioactive Waste Management Complex (RWMC), Idaho National Laboratory (INL), Idaho, and frequency of water-sample collections, as of December 2005.

Table 2. Location and construction of wells in the U.S. Geological Survey aquifer water-quality monitoring network and sample-collection method and frequency, Idaho National Laboratory, Idaho, as of December 2005.

[**Well No.**: Well locations are shown in figures 5 and 6. **Sample-collection method:** Pump, sampled from pumping well (pumping rate in gallons per minute); Tap, sampled from faucet. **Sample-collection frequency**: A, annually. **Abbreviation**: USGS, U.S. Geological Survey]

Well No.	USGS Site No.	Well construction		Sample collection	
		Diameter (inches)	Depth (feet)	Method	Frequency
ANP 6	435152112443101	10	305	Pump (45)	A
ANP 9	434856112400001	8	322	Pump (20)	A
ARBOR TEST	433509112384801	10	790	Pump (20)	A
AREA 2	433223112470201	16	877	Pump (18)	A
ATOMIC CITY	432638112484101	8	639	Tap	A
BADGING FACILITY	433042112535101	8	644	Pump (35)	A
CFA 1	433204112562001	16	639	Pump (1,000)	A
CFA 2	433144112563501	16	681	Pump (1,400)	A
CFA LF 2-10	433216112563301	6	716	Pump (8.3)	A
CFA LF 3-9	433216112571001	4	500	Pump (7.5)	A
CPP 1	433433112560201	16	586	Pump (3,000)	A
CPP 2	433432112560801	16	605	Pump (3,000)	A
CPP 4	433440112554401	16	700	Pump (400)	A
CROSSROADS	432128113092701	8	607	Pump (35)	A
EBR 1	433051113002601	10	1,075	Pump (25)	A
HIGHWAY 3	433256113002501	8	750	Tap	A
ICPP-MON-A-166	433300112583301	6	527	Pump (6)	A
ICPP-MON-A-167	433331112580701	6	502	Pump (4)	A
IET 1 DISP	435153112420501	12	324	Pump (46)	A
LEO RODGERS 1	432533112504901	20	720	Pump (20)	A
MTR TEST	433520112572601	8	588	Pump (26)	A
NO NAME 1	435038112453401	12	550	Pump (42)	A
NPR TEST	433449112523101	6	599	Pump (28)	A
PSTF TEST	434941112454201	10	319	Pump (44)	A
P&W 2	435419112453101	10	386	Pump (35)	A
RIFLE RANGE	433243112591101	5	620	Pump (25)	A
RWMC M1SA	432956113030901	6	638	Pump (3.4)	A
RWMC M3S	433008113021801	6	633	Pump (3.7)	A
RWMC M7S	433023113014801	6	628	Pump (4.1)	A
RWMC M11S	433058113010401	6	624	Pump (6)	A
RWMC M12S	433118112593401	6	572	Pump (6)	A
RWMC M13S	433037113002701	6	643	Pump (6)	A
RWMC M14S	433052113025001	6	635	Pump (6)	A
RWMC PROD	433002113021701	10, 14	685	Pump (200)	A
SITE 4	433617112542001	8	495	Pump (500)	A
SITE 9	433123112530101	10	1,057	Pump (25)	A
SITE 14	434334112463101	8, 12	717	Pump (40)	A
SITE 17	434027112575701	15	600	Pump (25)	A
SITE 19	433522112582101	8, 10	860	Pump (30)	A
SPERT 1	433252112520301	14	653	Pump (400)	A
TRA 1	433521112573801	18	600	Pump (3,400)	A
TRA 3	433522112573501	20	602	Pump (3,800)	A
TRA 4	433521112574201	16, 18	965	Pump (2,000)	A
TRA DISP	433506112572301	6, 8	1,267	Pump (25)	A
USGS 1	432700112470801	5	636	Pump (19)	A
USGS 2	433320112432301	5	686	Pump (16)	A
USGS 4	434657112282201	6	553	Pump (40)	A

Table 2. Location and construction of wells in the U.S. Geological Survey aquifer water-quality monitoring network and sample-collection method and frequency, Idaho National Laboratory, Idaho, as of December 2005—Continued.

[**Well No.**: Well locations are shown in figures 5 and 6. **Sample-collection method:** Pump, sampled from pumping well (pumping rate in gallons per minute); Tap, sampled from faucet. **Sample-collection frequency**: A, annually. **Abbreviations**: USGS, U.S. Geological Survey]

Well No.	USGS Site No.	Well construction		Sample collection	
		Diameter (inches)	Depth (feet)	Method	Frequency
USGS 5	433543112493801	6	494	Pump (5)	A
USGS 6	434031112453701	4	620	Pump (25)	A
USGS 7	434915112443901	4, 6	903	Pump (45)	A
USGS 8	433121113115801	6	812	Pump (16)	A
USGS 9	432740113044501	6	632	Pump (19)	A
USGS 11	432336113064201	6	704	Pump (23)	A
USGS 12	434126112550701	10	563	Pump (32)	A
USGS 14	432019112563201	5	751	Pump (16)	A
USGS 15	434234112551701	10	610	Pump (40)	A
USGS 17	433937112515401	5, 6	498	Pump (32)	A
USGS 18	434540112440901	4	329	Pump (30)	A
USGS 19	434426112575701	6	399	Pump (33)	A
USGS 20	433253112545901	6	658	Pump (30)	A
USGS 22	433422113031701	6	657	Pump (2.5)	A
USGS 23	434055112595901	5, 6	463	Pump (25)	A
USGS 26	435212112394001	6	266	Pump (40)	A
USGS 27	434851112321801	6	312	Pump (20)	A
USGS 29	434407112285101	6	426	Pump (32)	A
USGS 31	434625112342101	8, 10	428	Pump (40)	A
USGS 32	434444112322101	5.5, 6	392	Pump (28)	A
USGS 34	433334112565501	10	700	Pump (30)	A
USGS 35	433339112565801	7	579	Pump (25)	A
USGS 36	433330112565201	6	567	Pump (25)	A
USGS 37	433326112564801	6	573	Pump (25)	A
USGS 38	433322112564301	4	612	Pump (4)	A
USGS 39	433343112570001	8	493	Pump (25)	A
USGS 40	433411112561101	4	483	Pump (8)	A
USGS 41	433409112561301	6	674	Pump (25)	A
USGS 42	433404112561301	6	678	Pump (25)	A
USGS 43	433415112561501	6	676	Pump (6)	A
USGS 44	433409112562101	6	650	Pump (25)	A
USGS 45	433402112561801	6	651	Pump (25)	A
USGS 46	433407112561501	6	651	Pump (25)	A
USGS 47	433407112560301	6	652	Pump (8)	A
USGS 48	433401112560301	6	750	Pump (29)	A
USGS 51	433350112560601	6	647	Pump (4)	A
USGS 52	433414112554201	6	650	Pump (30)	A
USGS 57	433344112562601	6	582	Pump (30)	A
USGS 58	433500112572502	6	503	Pump (26)	A
USGS 59	433354112554701	6	657	Pump (1)	A
USGS 65	433447112574501	4	498	Pump (8)	A
USGS 67	433344112554101	4, 6	694	Pump (8)	A
USGS 76	433425112573201	6	718	Pump (29)	A
USGS 77	433315112560301	6	586	Pump (25)	A
USGS 79	433505112581901	6	702	Pump (30)	A
USGS 82	433401112551001	6	693	Pump (25)	A
USGS 83	433023112561501	6	752	Pump (28)	A

Table 2. Location and construction of wells in the U.S. Geological Survey aquifer water-quality monitoring network and sample-collection method and frequency, Idaho National Laboratory, Idaho, as of December 2005—Continued.

[**Well No.**: Well locations are shown in figures 5 and 6. **Sample-collection method:** Pump, sampled from pumping well (pumping rate in gallons per minute); Tap, sampled from faucet. **Sample-collection frequency**: A, annually. **Abbreviations**: USGS, U.S. Geological Survey]

Well No.	USGS Site No.	Well construction		Sample collection	
		Diameter (inches)	Depth (feet)	Method	Frequency
USGS 84	433356112574201	6	505	Pump (5)	A
USGS 85	433246112571201	6	614	Pump (23)	A
USGS 86	432935113080001	8	691	Pump (19)	A
USGS 87	433013113024201	4	673	Pump (2)	A
USGS 88	432940113030201	4	662	Pump (2)	A
USGS 89	433005113032801	6	650	Pump (5)	A
USGS 97	433807112551501	4	510	Pump (27)	A
USGS 98	433657112563601	4	505	Pump (25)	A
USGS 99	433705112552101	4	440	Pump (25)	A
USGS 100	433503112400701	6	750	Pump (10)	A
USGS 101	433255112381801	4, 6	865	Pump (13)	A
USGS 102	433853112551601	6	445	Pump (29)	A
USGS 103	432714112560701	8	760	Pump (21)	A
USGS 104	432856112560801	8	700	Pump (26)	A
USGS 105	432703113001801	4	800	Pump (24)	A
USGS 106	432959112593101	8	760	Pump (24)	A
USGS 107	432942112532801	8	690	Pump (30)	A
USGS 108	432659112582601	8	760	Pump (24)	A
USGS 109	432701113025601	4	800	Pump (22)	A
USGS 110A	432717112501502	6	644	Pump (24)	A
USGS 111	433331112560501	8	560	Pump (15)	A
USGS 112	433314112563001	8	563	Pump (30)	A
USGS 113	433314112561801	6	564	Pump (25)	A
USGS 114	433318112555001	6	560	Pump (10)	A
USGS 115	433320112554101	6	581	Pump (5)	A
USGS 116	433331112553201	6	572	Pump (20)	A
USGS 117	432955113025901	6.5	655	Pump (12)	A
USGS 119	432945113023401	6.5	705	Pump (3)	A
USGS 120	432919113031501	6.5	705	Pump (27)	A
USGS 121	433450112560301	6	475	Pump (8)	A
USGS 123	433352112561401	6	481	Pump (3)	A
USGS 124	432307112583101	4	800	Pump (19)	A
USGS 125	432602113052801	5	774	Pump (21)	A
USGS 126A	435529112471301	5	648	Pump	A
USGS 126B	435529112471401	6	452	Pump	A
USGS 127	433058112572201	6	596	Pump (25)	A
USGS 128	433250112565601	4.5	615	Pump (23)	A
WS INEL1	433716112563601	6, 8	595	Pump (30)	A

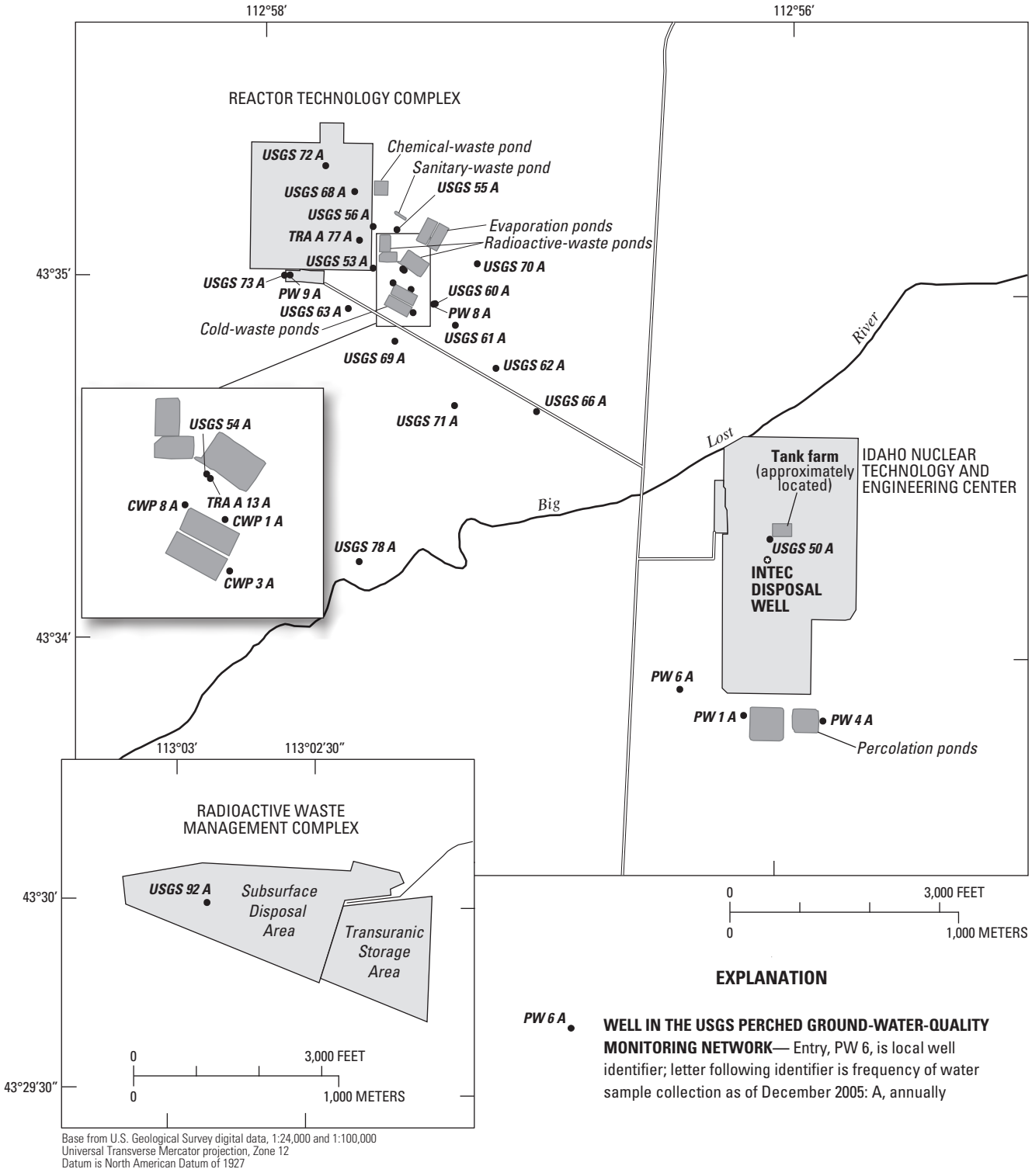


Figure 7. Location of wells in the U.S. Geological Survey perched ground-water-quality monitoring network at the Reactor Technology Complex (RTC), Idaho Nuclear Technology and Engineering Center (INTEC), and Radioactive Waste Management Complex (RWMC), Idaho National Laboratory (INL), Idaho, and frequency of water-sample collections, as of December 2005.

Table 3. Location and construction of wells in the U.S. Geological Survey perched ground water-quality monitoring network and sample-collection method and frequency at the Reactor Technology Complex, Idaho Nuclear Technology and Engineering Center, and Radioactive Waste Management Complex, Idaho National Laboratory, Idaho, as of December 2005.

[**Well No.:** Well locations are shown in figure 7. **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. **Abbreviation:** USGS, U.S. Geological Survey]

Well No.	USGS Site No.	Well construction		Sample collection	
		Diameter (inches)	Depth (feet)	Method	Frequency
CWP 1	433459112572601	6	58	Bail (55)	A
CWP 3	433455112572501	6	55	Bail (50)	A
CWP 8	433500112573001	6	64	Bail (63)	A
PW 1	433349112560701	6	117	Bail (115)	A
PW 4	433348112554901	6	150	Bail (126)	A
PW 6	433353112562201	6	125	Bail (125)	A
PW 8	433456112572001	6	166	Pump (8)	A
PW 9	433500112575401	6	200	Pump (5)	A
TRA A 13	433502112572802	2	59	Bail (59)	A
TRA A 77	433507112573801	2	34	Bail (34)	A
USGS 50	433419112560201	6	405	Pump (0.5)	A
USGS 53	433503112573401	6	71	Bail (71)	A
USGS 54	433503112572801	6	91	Pump (4)	A
USGS 55	433508112573001	6	81	Pump (1)	A
USGS 56	433509112573501	6	80	Pump (1)	A
USGS 60	433456112571901	6	117	Pump (6)	A
USGS 61	433453112571601	4	123	Pump (6)	A
USGS 62	433446112570701	8	165	Pump (5)	A
USGS 63	433455112574001	10	97	Pump (5)	A
USGS 66	433436112564801	4	475	Bail (214)	A
USGS 68	433516112573901	10	128	Pump (1)	A
USGS 69	433450112573001	4	115	Pump (5)	A
USGS 70	433504112571001	8	100	Pump (6)	A
USGS 71	433439112571501	5	184	Bail (160)	A
USGS 72	433519112574601	4	175	Pump (1)	A
USGS 73	433502112575401	6	127	Pump (1.5)	A
USGS 78	433413112573501	7	204	Bail (160)	A
USGS 92	433000113025301	3.5	214	Bail (213)	A

Methods used to sample and analyze for selected constituents generally follow the guidelines established by the USGS (Goerlitz and Brown, 1972; Stevens and others, 1975; Wood, 1976; Claassen, 1982; Wershaw and others, 1987; Fishman and Friedman, 1989; Faires, 1993; Fishman, 1993; and Wilde and others, 1998). Water samples were collected according to a quality-assurance plan for water-quality activities conducted by personnel at the USGS INL Project Office. The plan was finalized in June 1989, revised in March 1992, in 1996 (Mann, 1996), and in 2003 (Bartholomay and others, 2003) and is available for inspection at the USGS INL Project Office. 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. 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);
5. An analysis of two analytical methods to determine gross alpha- and beta-particle activity (Bartholomay and others, 1999); and
6. An evaluation of well-purging effects on water-quality results (Knobel, 2006).

Waste-Disposal Sites at Idaho National Laboratory

Wastewater disposal sites at INL facilities have been the principal sources of radioactive- and chemical-waste constituents in water from the Snake River Plain aquifer and in perched-water zones at and near the INL. In the past, wastewater disposal sites included infiltration ponds and ditches, evaporation ponds, drain fields, and disposal wells. Solid and liquid wastes buried at the RWMC (fig. 1) also are sources of some constituents in ground water.

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 Corporation, 2002a, 2002b, and 2002c) provide some radioactive waste disposal data for 1999–2001. Amounts and types of radioactive- and chemical-wastes discharged at the various INL facilities are not published for 2002–05 and are not presented in this report.

Reactor Technology Complex

Since 1952, low-level radioactive, chemical, and sanitary wastewater has been discharged to infiltration and lined evaporation ponds. Nonradioactive cooling-tower wastewater was discharged to radioactive-waste infiltration ponds from 1952 to 1964, to the Snake River Plain aquifer through a 1,267-ft-deep disposal well (TRA DISP, fig. 3) from 1964 until March 1982, and into two cold-waste infiltration ponds from 1982 to present.

In 1976, the DOE contractor at the RTC began a three-phase program to reduce radioactivity in wastewater. The first phase ran from 1976 to 1980 and the second phase ran from 1981 to 1987. The contractor finished the final phase of the program in 1993. During 1977–78, the average number of Curies (Ci) discharged to the RTC radioactive-waste infiltration ponds was about 1,300 Curies per year (Ci/yr) (Barraclough and others, 1981); during 1992–95, about 430 Ci of tritium was discharged to the RTC radioactive-waste infiltration ponds. During 1992–95, tritium accounted for about 96 percent of radioactivity in wastewater discharged at the RTC (Bartholomay and others, 1997). About 2,390 Ci of chromium-51 was in wastewater discharged to the radioactive-waste infiltration and lined evaporation ponds during 1979–98. No data are available for chromium-51 discharged during 1999–2005. The average disposal rate of chromium-51 during 1979–81 was 766 Ci/yr (Pittman and others, 1988, p. 35). During 1986–88, 25.7 Ci of chromium-51 was discharged, 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 this waste reduction program, by 1993, the volume of radioactive wastewater and total Curies of radioactivity discharged at the RTC was reduced to a volume that could be disposed in two lined evaporation ponds, replacing the radioactive-waste infiltration ponds. The evaporation ponds may prevent radioactive wastewater from entering the aquifer.

The average annual discharge to the radioactive-waste infiltration and evaporation ponds (fig. 3) was about 116 Mgal during 1960–98. During 2000–2001, effluent waste disposal to the evaporation ponds averaged about 5 Mgal (Richard Kauffman, U.S. Department of Energy, written commun., 2005), which is less than the long-term average. The volume of wastewater and the amount of tritium discharged to the radioactive-waste and evaporation ponds during 1962–2005 are shown in figure 8.

During 1974–79, about 10 percent of radioactivity in wastewater discharged was attributed to tritium; most other radioactivity consisted of radionuclides with half-lives of about several weeks, as well as small amounts of strontium-90, cesium-137, and cobalt-60 (Barraclough and others, 1981).

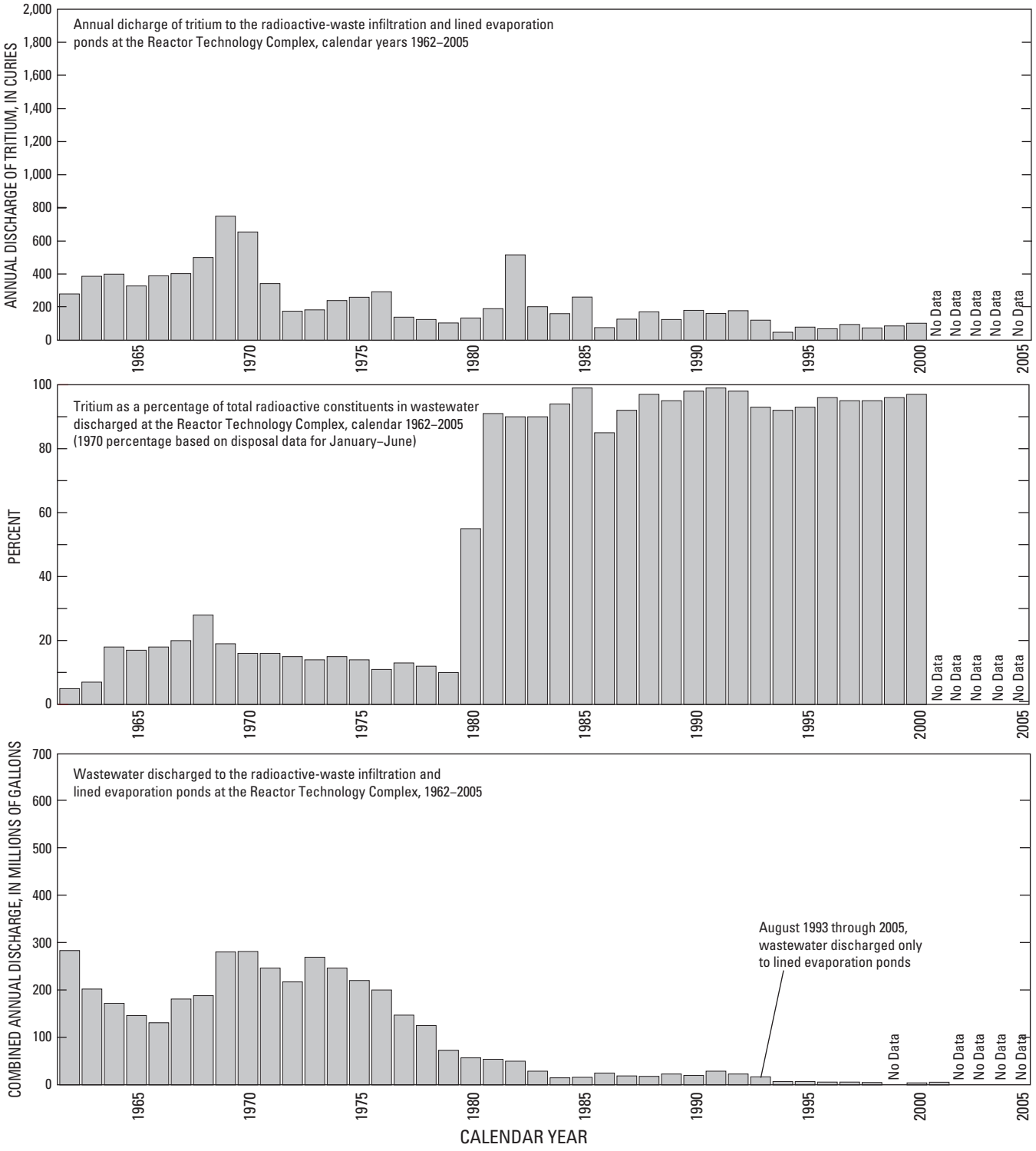


Figure 8. Amount of tritium discharged, tritium as a percentage of total radioactive constituents in wastewater discharged, and volume of wastewater discharged to the radioactive-waste infiltration and evaporation ponds at the Reactor Technology Complex, Idaho National Laboratory, Idaho, 1962–2005.

In 1980, about 50 percent of radioactivity was attributed to tritium, and during 1981–85, about 90 percent was attributed to tritium (Pittman and others, 1988, p. 22). From 1986–2000, about 97 percent of radioactivity in wastewater discharged at the RTC has been attributed to tritium (fig. 8). No tritium data are available for 2001–05.

A chemical-waste infiltration pond was used for disposal of chemical wastewater from an ion-exchange system at the RTC (fig. 3) from 1962 to 1999. The average annual discharge to this pond was about 17.5 Mgal during 1962–98 (Bartholomay and others, 2000). The average annual discharge for 1996–98 was 5.8 Mgal, 33 percent of the long-term average (Bartholomay and others, 2000). Sulfate and sodium hydrate were the predominant constituents in the chemical wastewater. The sodium hydrate consists of a 50 percent sodium hydroxide solution (Bartholomay and others, 2000). During 1996–98, average annual amounts of about 210,280 lb of sulfate and 98,800 lb of sodium hydrate were discharged to the chemical-waste infiltration pond. Additionally, about 11,100 lb of sodium ion was discharged in October 1996 (French and others, 1997a). Average annual concentrations of sulfate and sodium hydrate in the wastewater were about 4,300 and 2,000 mg/L, respectively (Bartholomay and others, 2000). In 1999, the chemical-waste infiltration pond was closed and covered with a protective cap (Stoller Corporation, 2002a).

The TRA disposal well, currently used as an observation well, was used from 1964 to March 1982 to inject nonradioactive wastewater from cooling-tower operations at the RTC into the Snake River Plain aquifer. Since March 1982, this wastewater has been discharged to two cold-waste infiltration ponds (fig. 3). The average annual discharge to the well and the infiltration ponds was about 226 Mgal during 1964–95 and about 181 Mgal during 1996–98 (Bartholomay and others, 2000). This wastewater contained an average annual amount of about 402,000 lb of sulfate and 94,000 lb of other chemicals during 1996–98 (Bartholomay and others, 2000).

Sewage effluent discharged to sanitary-waste ponds (fig. 3) at the RTC was about 28 Mgal/yr during 1996–98 (Bartholomay and others, 2000), about 17 Mgal in 2000, and about 52 Mgal in 2001 (Richard Kauffman, U.S. Department of Energy, written commun., 2005). In 1989, the sewage effluent contained about 1,070 lb of chloride and 1,550 lb of hypochlorite. Chloride and hypochlorite were not reported as part of the sewage effluent after February 1990 (Bartholomay and others, 2000).

Idaho Nuclear Technology and Engineering Center

From 1952 to February 1984, the INTEC discharged most low-level radioactive, chemical, and sanitary wastewater into the Snake River Plain aquifer through a 600-ft-deep disposal well (fig. 6). The average annual discharge of wastewater to the well was about 363 Mgal (Pittman and others, 1988, p. 24). Two percolation ponds (also called infiltration ponds) were used for wastewater disposal during 1984 through August 25, 2002 (fig. 3). The first pond was completed in February 1984 and the second pond was completed in October 1985. The annual discharge to the disposal well and ponds ranged from 260 Mgal in 1963 to 665 Mgal in 1993. Discharge to the ponds during 2001 was about 544 Mgal (Stoller Corporation, 2002c, p 5-9); data for 1999 and 2000 are not available, however, an estimated 1–2 Mgal/d of wastewater was generated (Stoller Corporation, 2003). About 402 Mgal were discharged to the existing percolation ponds during 2002. The volume of wastewater discharged to the disposal well and existing percolation ponds during 1962–98 and 2001 is shown in figure 9. No data were available for volume of wastewater discharged during 1999–2000 or 2002–05. On August 26, 2002, the existing percolation ponds were taken out of service and wastewater was discharged to the new percolation ponds. The new percolation ponds were designed to be a rapid infiltration system, and each pond can accommodate up to 3 Mgal/d of continuous discharge (Stoller Corporation, 2004)

Most radioactivity in wastewater discharged to the percolation ponds at the INTEC was attributed to tritium. Tritium accounted for most of the radioactivity in wastewater discharged at the INTEC since 1970 (fig. 9). During 1986–88, 556 Ci of tritium was discharged at the INTEC; the average annual amount discharged was 185 Ci (Orr and Cecil, 1991, p. 20). During 1990–91, 2.7 Ci of tritium was discharged; during 1992 and 1995 about 0.3 Ci was discharged; no tritium was discharged during 1989, 1993, 1994, and 1996–99; and 0.03 Ci was discharged during 2000 (fig. 9). No data were available for tritium discharged during 2001–05.

During 1996–98, chloride, fluoride, nitrate, sodium, and sulfate were the predominant chemical constituents in wastewater discharged to the INTEC percolation ponds. During this period, average annual amounts of about 1,166,000 lb of chloride; 1,070 lb of fluoride; 86,700 lb of nitrate; 708,000 lb of sodium, and 146,000 lb of sulfate were in wastewater discharged at the INTEC. Data have not been compiled for predominant constituents and amounts in wastewater discharged during 1999–2005.

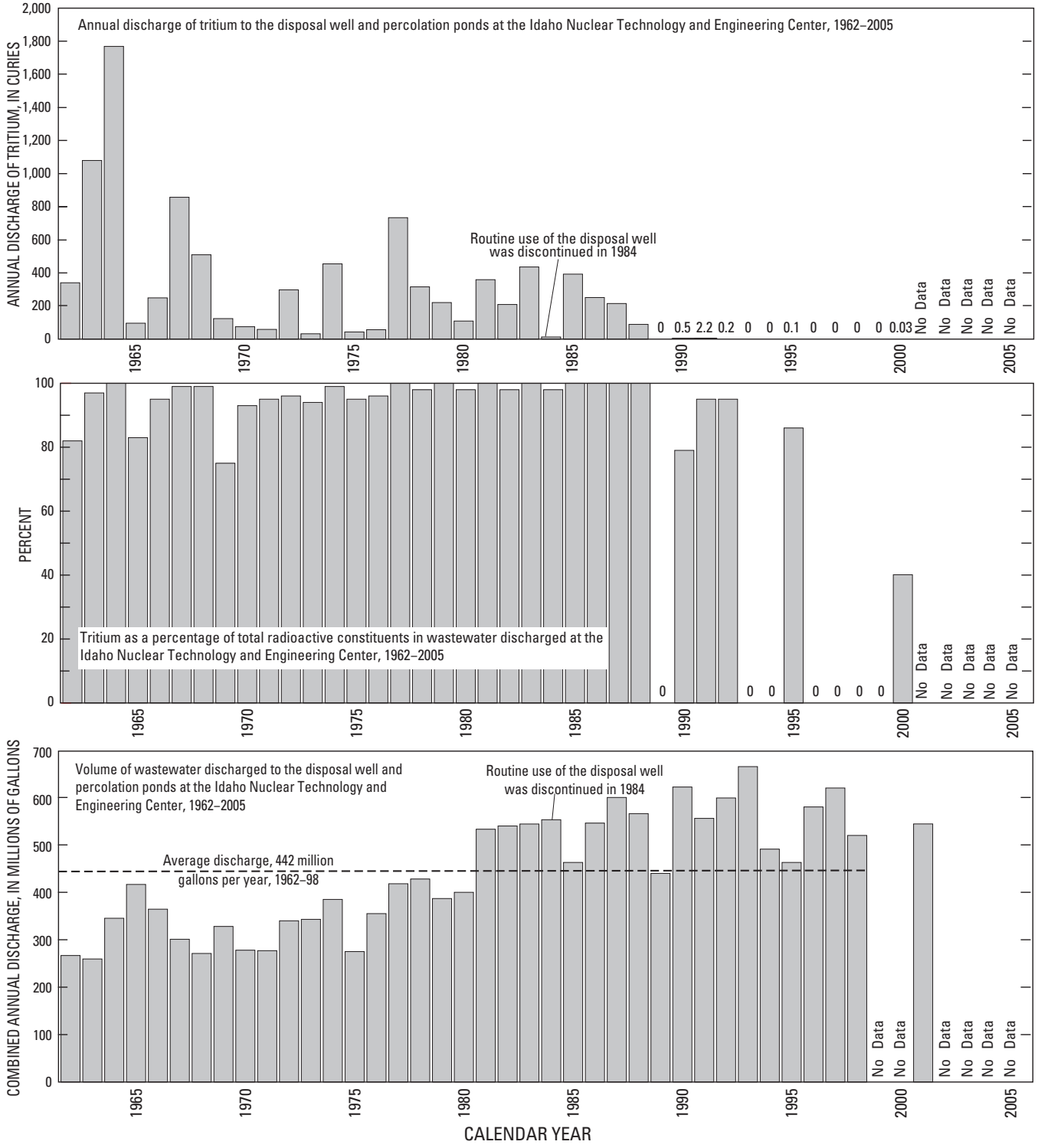


Figure 9. Amount of tritium discharged, tritium as a percentage of total radioactive constituents in wastewater, and volume of wastewater discharged to disposal well and percolation ponds, Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, Idaho, 1962–2005.

About 18,100 Ci of strontium-90 and 19,100 Ci of cesium-137 have been released to soil at the INTEC Tank Farm (Cahn and others, 2006). In 1972, during a failed transfer of waste between two underground storage tanks, about 18,600 gal of sodium-bearing waste was leaked at an INTEC Tank Farm site (fig. 7). This accounts for about 88 percent (approximately 15,900 Ci) of the source of strontium-90 and cesium-137 to groundwater at the Tank Farm. Three other locations at the Tank Farm are the source of the remaining 12 percent of strontium-90 (Cahn and others, 2006).

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 (fig. 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.

Test Area North

From 1953 to 1972, low-level radioactive, chemical, and sanitary wastewater was discharged at TAN (fig. 1) into the Snake River Plain aquifer through a 310-ft-deep disposal well (TAN Disposal Well, fig. 5). In 1972, the disposal well was replaced by a 35-acre infiltration pond. No records are available that indicate the amount of radioactivity in wastewater discharged at TAN before 1959. During 1959–93, about 61 Ci of radioactivity in wastewater were discharged to the disposal well and infiltration pond. Of this amount, about 20 Ci were discharged to the disposal well in 1968 and 1969 in response to problems with an evaporator used to reduce the volume of liquid waste (Energy Research and Development Administration, 1977, p. II–110, II–111). No radioactive wastewater has been discharged since 1993 (Bartholomay and others, 2000).

An average of about 6.6 Mgal/yr of chemical wastewater was discharged to the infiltration pond at the Technical Support Facility during 1996–98 (Bartholomay and others, 2000). The predominant constituents were chloride and sodium. Average annual amounts of 6,900 lb of chloride and 4,500 lb of sodium were discharged. The average annual amount of all other chemical constituents in the wastewater was about 760 lb (Bartholomay and others, 2000). During 1999–2001, about 28.5 Mgal of wastewater was discharged (Teresa Meachum, CH2M-WG Idaho, LLC, written commun., 2005). Based on 2001 records, an average of 838,000 gal/mo (10 Mgal/yr) of wastewater is discharged to the infiltration pond (U.S. Department of Energy, 2002). No data were available for total amounts of individual constituents disposed in wastewater for 1999–2005.

Central Facilities Area

About 65 Ci of radioactivity in about 1,500 Mgal of wastewater were discharged to the sewage-plant tile drain field at the CFA (fig. 1) during 1952–93. Most radioactive wastes discharged to this drain field were from aquifer water pumped from well CFA 1 (fig. 5), which obtains water from within the INTEC contaminant plume in the Snake River Plain aquifer. Most radioactivity in wastewater discharged at the CFA was attributed to tritium. During 1993–98, no radioactivity was recorded in wastewater discharged at the CFA (Bartholomay and others, 2000). No data were available for radioactivity in wastewater at the CFA for 1999–2005.

An average of about 42.1 Mgal/yr of wastewater was discharged to a pond at CFA and a computerized central pivot system discharged about 13.6 Mgal/yr to native desert rangeland during 1999–2001 (Stoller Corporation, 2002c; Teresa Meachum, CH2M-WG Idaho, LLC, written commun., 2005). Chloride and sodium were the predominant chemical constituents in wastewater during 1996–98. Average annual amounts of about 7,800 lb of chloride and 5,300 lb of sodium were discharged during 1996–98. The average annual amount of all other constituents in the wastewater was about 6,300 lb; about 5,400 lb was from disposal of janitorial supplies (Bartholomay and others, 2000). No data were available for total amounts of individual constituents disposed in wastewater for 1999–2005.

Hydrologic Conditions

The Snake River Plain aquifer is one of the most productive aquifers in the United States (U.S. Geological Survey, 1985, p. 193). The aquifer consists of a thick sequence of basalts and sedimentary interbeds filling a large, arcuate, structural basin in southeastern Idaho (fig. 1). Recharge to the Snake River Plain aquifer primarily is from infiltration of applied irrigation water, infiltration of streamflow, ground-water inflow from adjoining mountain drainage basins, and infiltration of precipitation.

Surface Water

The Big Lost River drains more than 1,400 mi^2 of mountainous area that includes parts of the Lost River Range and Pioneer Mountains west of the INL (fig. 1). Flow in the Big Lost River infiltrates to the Snake River Plain aquifer along its channel and at sinks and playas at the terminus of the river. To avoid flooding at the INL facilities, excess runoff has been diverted since 1965 to spreading areas in the southwestern part of the INL (Bennett, 1990, p. 15), where much of the water rapidly infiltrates to the aquifer. Other surface drainages that provide recharge to the Snake River Plain aquifer at the INL include Birch Creek, Little Lost River, and Camas Creek (fig. 1).

The average streamflow at gaging station 13127000, Big Lost River below Mackay Reservoir (fig. 1) for complete water years from 1904 to 2005 was 220,100 acre-ft/yr (Brennan and others, 2005, p. 269) (fig. 10). Streamflow at gaging stations at and downstream of gaging station 13127000 (fig. 1) for water years 2002–05 are shown in table 4 and figure 10.

Recharge to the Snake River Plain aquifer downstream of Arco is substantial during wet years because of streamflow infiltration from the Big Lost River channel, diversion areas, sinks, and playas. For example, measured infiltration losses at various discharges measured during 1951–85 ranged from 1 $(ft^3/s)/mi$ in the river channel to 28 $(ft^3/s)/mi$ in the sinks (Bennett, 1990, p. 24-26). Bennett (1990) considered streamflow losses to evapotranspiration minor compared with infiltration losses. However, infiltration can be zero in years when little or no flow is in the Big Lost River channel as during 2002–04 at and downstream of gaging station 13132500 (table 4).

Table 4. Average annual streamflow at gaging stations along Big Lost River, Idaho, water years 2002–05.

[**Gaging station:** Gaging station locations are shown in figure 1. **Streamflow:** Data for 2002 from Brennan and others (2002); for 2003, from Brennan and others (2003); for 2004, from Brennan and others (2004); for 2005, from Brennan and others (2005). **Abbreviations:** INL, Idaho National Laboratory; WY, water year]

Gaging station	Streamflow (in acre-feet)			
	WY 2002	WY 2003	WY 2004	WY 2005
13127000—Big Lost River below Mackay Reservoir, near Mackay	122,400	139,600	120,100	191,100
13132500—Big Lost River near Arco	0	0	0	3,980
13132513—INL diversion at head, near Arco	0	0	0	0
13132520—Big Lost River below the INL Diversion, near Arco	0	0	0	2,070
13132565—Big Lost River above Big Lost River Sinks, near Howe	0	0	0	268

Ground Water

Water in the Snake River Plain aquifer primarily moves through interflow and fracture zones in the basalt. A large proportion of ground water moves through the upper 200 to 800 ft of basaltic rocks (Mann, 1986, p. 21). Ackerman (1991, p. 30) and Bartholomay and others (2000, p. 15) reported a range of transmissivity of basalt in the upper part of the aquifer of 1.1 to 760,000 ft^2/d. Anderson and others (1999) reported a range of hydraulic conductivity at the INL of 0.01 to 32,000 ft/d. The hydraulic conductivity of rocks underlying the aquifer is from 0.002 to 0.03 ft/d, several orders of magnitude smaller (Mann, 1986, p. 21). The effective base of the Snake River Plain aquifer probably ranges from about 815 to 1,710 ft below land surface in the western one-half of the INL (Anderson and others, 1996, table 3).

Depth to water in wells completed in the Snake River Plain aquifer ranges from about 200 ft in the northern part of the INL to more than 900 ft in the southeastern part. During March–May 2005, the altitude of the water table was about 4,570 ft in the northern part of the INL (fig. 11) and about 4,400 ft in the southwestern part. Water flowed southward and southwestward beneath the INL (fig. 11) at an average hydraulic gradient of about 4 ft/mi.

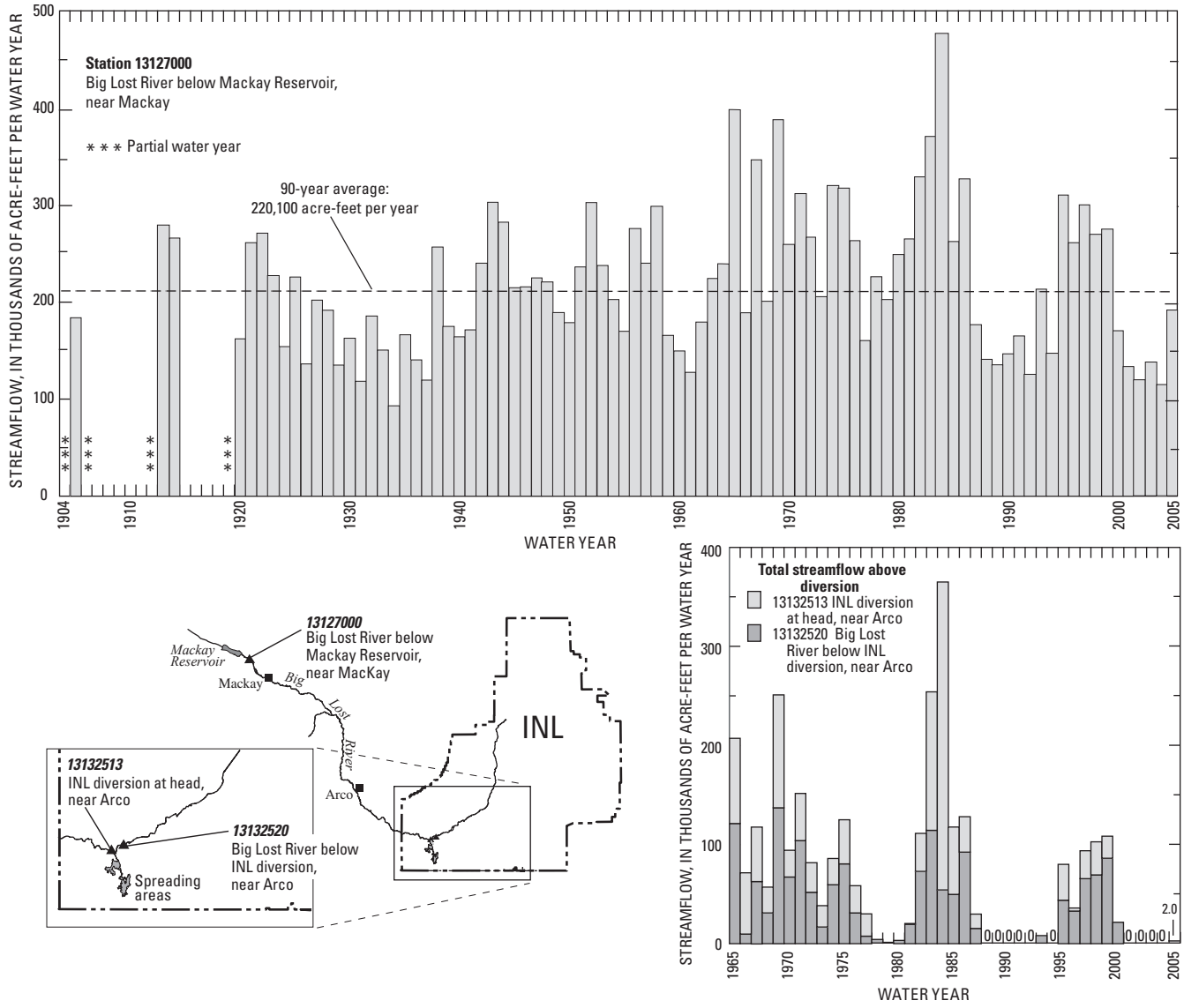


Figure 10. Streamflow at gaging stations along the Big Lost River: Big Lost River below Mackay Reservoir, water years 1904–06, 1912–14, and 1919–2005; Big Lost River below the Idaho National Laboratory (INL) diversion, near Arco; and INL diversion at head, near Arco, Idaho, water years 1965–2005.

Water levels in wells declined in the INL area from March–May 2001 to March–May 2005 (fig. 12). The declines ranged from about 3 to 8 ft in the southwestern part of the INL, about 10 to 15 ft in the west central part of the INL, and about 6 to 11 ft in the northern part of the INL (fig. 12). Water levels in perched water wells also declined, as evidenced by lack of any water in many wells during 2002–05. These declines may be attributed to lack of infiltration to the spreading areas, lack of infiltration of water in the Big Lost River channel (table 4), and a decrease in recharge at the INL during 2002–05.

Water levels monitored in wells USGS 12, USGS 17, and USGS 23 (fig. 2), and USGS 20 (fig. 3) show long-term water-level changes in the Snake River Plain aquifer at different locations at the INL in response to infiltration of streamflow (fig. 13). Long-term water-level fluctuations have ranged from about 16 ft in well USGS 20 to about 34 ft in well USGS 12. Water levels in these wells steadily declined from 2002 to 2005 because of lack of streamflow infiltration from the Big Lost River, and an overall decrease in recharge to the Snake River Plain aquifer.

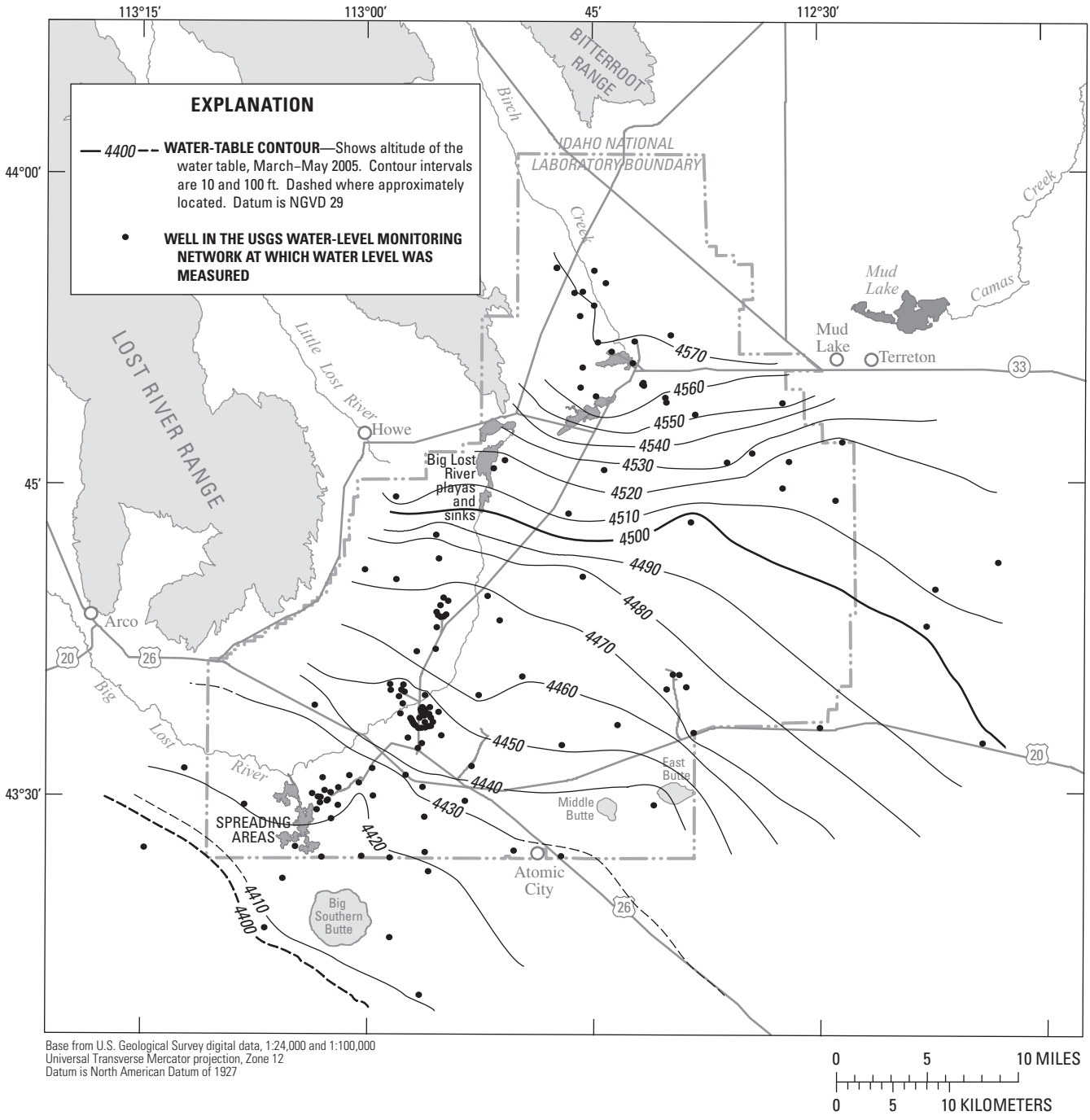


Figure 11. Altitude of the water table in the Snake River Plain aquifer at and near the Idaho National Laboratory, Idaho, March–May 2005.

Ground water moves southwestward from the INL and eventually is discharged to springs along the Snake River near Twin Falls, Idaho, about 100 mi southwest of the INL. Discharge from the springs estimated by methods given by Kjelstrom (1995) was about 3.54 million acre-ft/yr for the 2005 water year (Tom Brennan, U.S. Geological Survey, written commun., 2006). Historically, the discharge to these springs has ranged from 2.97 million acre-ft/yr in 1904 to 4.94 million acre-ft/yr in 1951 (Daniel J. Ackerman, U.S. Geological Survey, written commun., 2007).

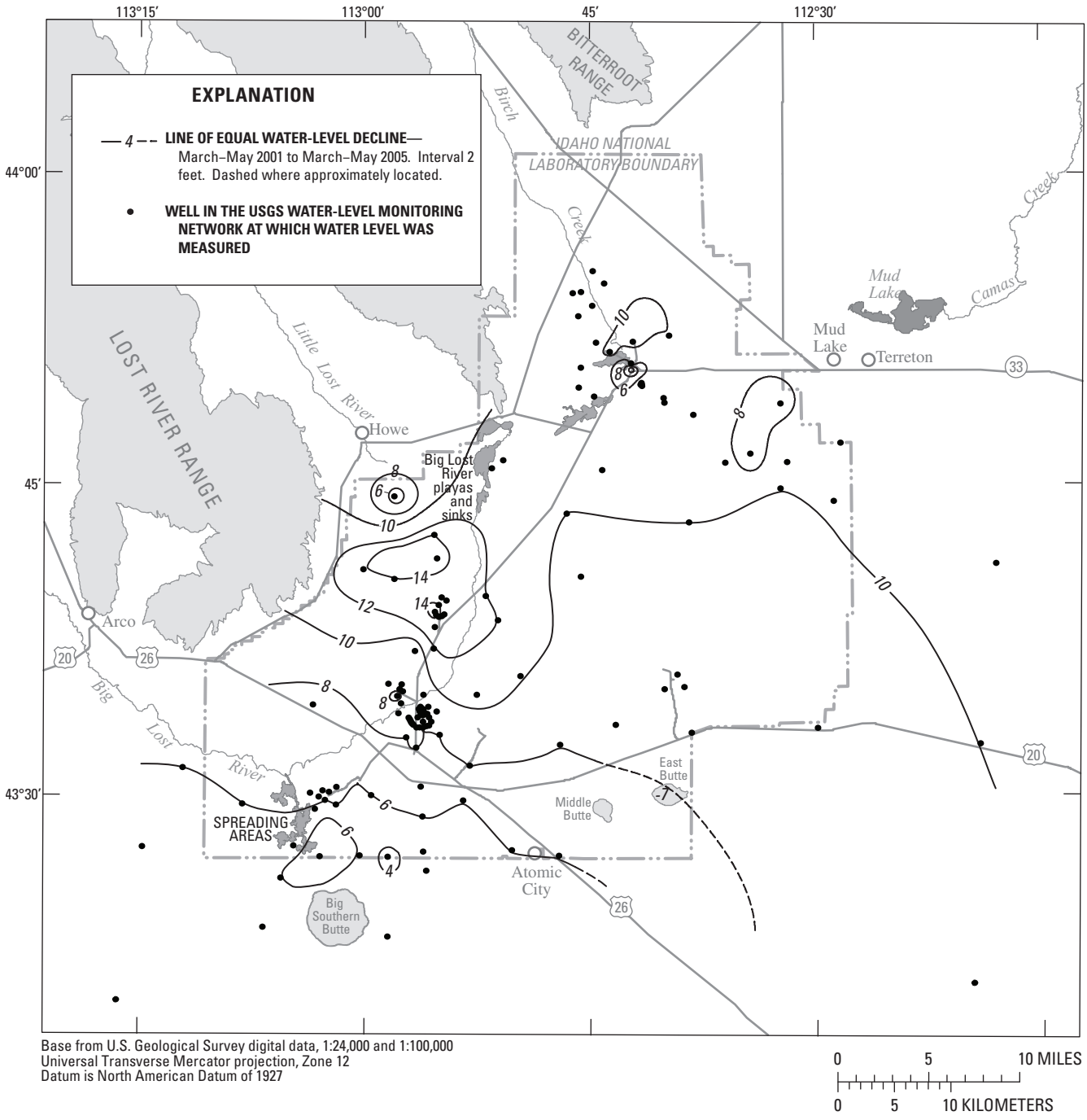


Figure 12. Generalized decline in ground-water levels in the Snake River Plain aquifer at and near Idaho National Laboratory (INL), Idaho, March–May 2001 to March–May 2005.

Perched 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. 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 extent of this perched ground water is affected by the waste-disposal practices.

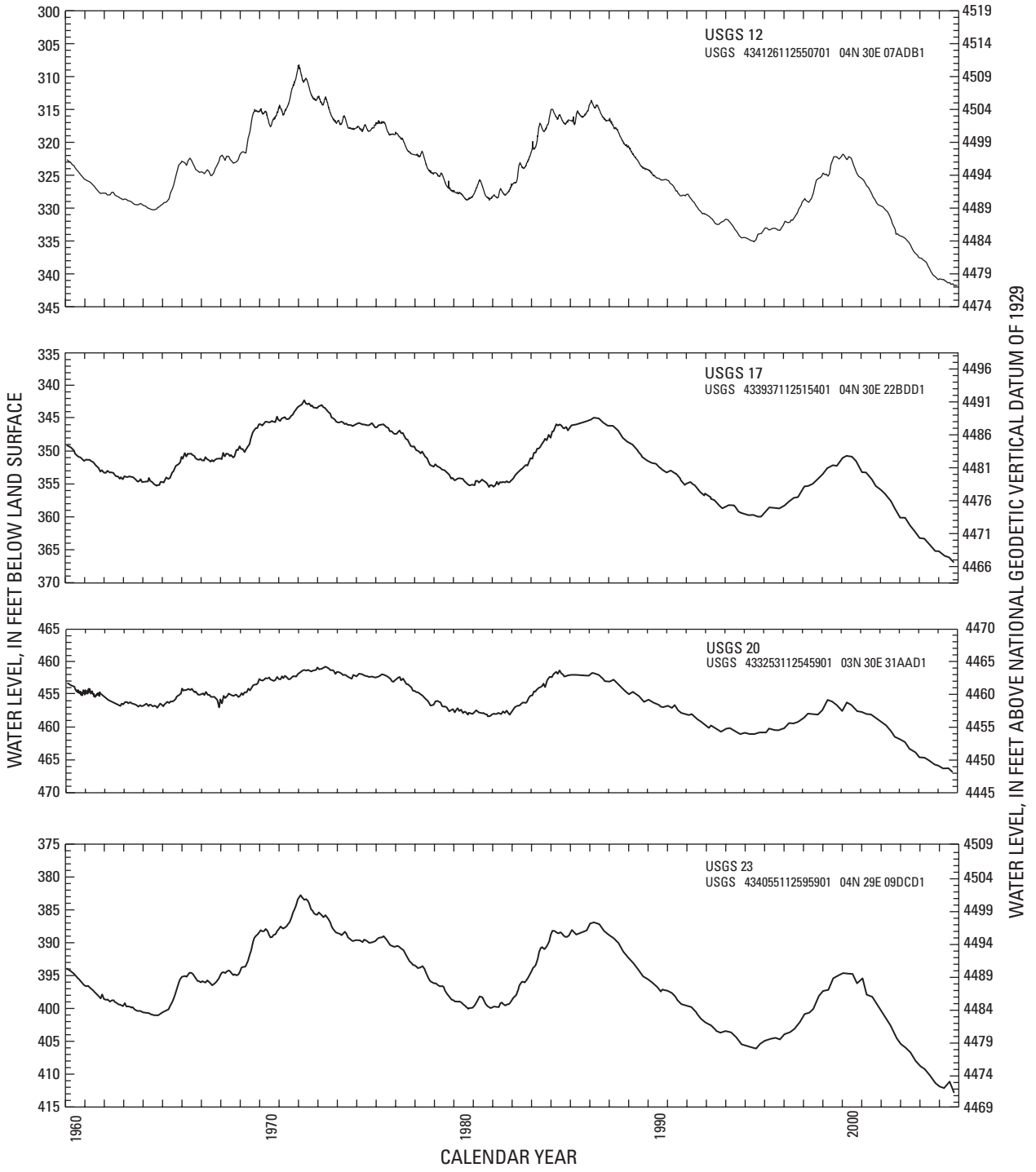


Figure 13. Water levels in four wells in the central part of the Idaho National Laboratory, Idaho, 1960–2005.

Guidelines for Interpreting Results of Radiochemical Analyses

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

In the 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, distinguishing between two key aspects of the problem of detection is essential: (1) the instrument signal for the sample must be larger than the signal observed for the blank before a decision can be made that the radionuclide was detected, and (2) an estimation must be made of the minimum radionuclide concentration that will yield a sufficiently large observed signal before a correct decision can be made for detection or nondetection of the radionuclide. The first aspect of the problem is a qualitative decision based on an observed signal and a definite criterion for detection. The second aspect of the problem is an estimation of the detection capabilities of a given measurement process.

In the laboratory, instrument signals must exceed a critical level of 1.6**s**, where **s** is the sample standard deviation, before the qualitative decision can be made as to whether the radionuclide was detected. At 1.6**s**, there is about a 95-percent probability that the correct conclusion—not detected—will be made. 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**, concluded 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** has been defined, the minimum detectable concentration may be determined. Concentrations that equal 3**s** represent a measurement at the minimum detectable concentration. For actual concentrations equal to or greater than 3**s**, there is a 95-percent or higher probability 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 the samples that contain actual 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.

Actual 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 actual 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 concentrations 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 less than a "reporting level." The critical level, minimum detectable concentration, and reporting level aid the reader to interpret analytical results and do not represent absolute concentrations of radioactivity, which may or may not have been detected. Analytical uncertainties in this report are reported as 1**s** for consistency with conventions used in previous reports.

Guidelines for Interpreting Results of Chemical Analyses

Historically, the NWQL has 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 concentration of a constituent (the "less than" value reported by NWQL) that may be reliably reported using a given analytical method (Timme, 1995). However, the NWQL determined that establishment of MRLs often was inconsistent, undefined, undocumented, and subjective (Childress and others, 1999). In 1998, the NWQL implemented 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 as:

> "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 that are 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 2002–05. 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).

Selected Radiochemical and Chemical Constituents and Physical Properties of Water in the Snake River Plain Aquifer

Contaminant plumes of radiochemical and chemical constituents in the Snake River Plain aquifer at the INL are attributed to waste-disposal practices. Areal distribution of the plumes was interpreted from analyses of samples collected from a 3-dimensional flow system. Concentrations of these constituents represent samples collected during October 2005 from wells completed at various depths in the aquifer and differing well completions; for example, single and multiple screened intervals and open boreholes. No attempt was made to determine the vertical extent and distribution of these plumes. Radiochemical and chemical constituents analyzed for in ground-water samples collected from wells at the INL during 2002–05 include tritium, strontium-90, cesium-137, plutonium-238, plutonium-239, -240 (undivided), americium-241, gross alpha- and beta-particle radioactivity, chromium and other trace elements, sodium, chloride, sulfate, nitrate, fluoride, trace elements, volatile organic compounds, and total organic carbon. Physical properties of water measured during sampling events included specific conductance, temperature, and pH.

Tritium

A tritium plume has developed in the Snake River Plain aquifer from discharge of wastewater at the INL since the 1950s. Tritium has a half-life of 12.3 years (Walker and others, 1989, p. 20). The primary sources of tritium in the aquifer have been the injection of wastewater through the disposal well at INTEC and the discharge of wastewater to the percolation ponds at the INTEC and RTC (fig. 4). Routine use of the disposal well at INTEC ended in February 1984; subsequently, radioactive wastewater has been discharged to the percolation ponds. About 31,620 Ci of tritium in wastewater was discharged to the well and percolation ponds from 1952 to 1998 (Bartholomay and others, 2000). Since 1993, tritium in wastewater at the RTC has been discharged to lined evaporation ponds, which should prevent migration to the aquifer. About 191 Ci of tritium were released in wastewater to the RTC lined evaporation ponds during 1999–2000 (Stoller Corporation, 2002a, 2002b). During 1996–99, no tritium was discharged to the ponds at the INTEC; during 2000, 0.03 Ci of tritium was discharged (Stoller Corporation, 2002a, 2002b) (fig. 9). Data are unavailable for the total amount of tritium in wastewater discharged during 2001–05.

In October 2005, reportable concentrations of tritium in ground water ranged from 0.51±0.12 to 11.5±0.6 pCi/mL and the tritium plume extended south-southwestward in the general direction of ground-water flow (fig. 14). In 1991, the area of the plume where concentrations exceeded the maximum contaminant level (MCL) of 20 pCi/mL (U.S. Environmental Protection Agency, 2001) was about 2.4 mi^2 (Bartholomay and others, 1995). In 1995, five wells sampled by the USGS in different areas of the INL had concentrations of tritium that exceeded the MCL, but no plume representing values equal to or greater than the MCL was discernible (Bartholomay and others, 1997). By October 1998, concentrations of tritium in all water samples were less than the MCL. This trend continued through October 2005, when concentrations of tritium in water samples generally decreased and were all less than the MCL.

Long-term radioactive-decay processes and an overall decrease in tritium disposal rates contributed to decreased concentrations of tritium in water from most wells at the INL during 2002–05. Tritium concentrations in water from several wells southwest of the INTEC decreased or remained constant as they had during 1998–2001, with the exception of well USGS 47 (fig. 3), which increased a few picocuries per milliliter. Concentration decreases ranged from about 2.5 to 3.7 pCi/mL during 2002–05. Concentrations in water from well USGS 123 (fig. 6), southwest of the INTEC, decreased from 8.3±0.4 pCi/mL in April 2001 to 4.6±0.3 pCi/mL in October 2005. Concentrations in water from well USGS 114 decreased from 13.2±0.5 to 10.5±0.5 pCi/mL from July 2001 to October 2005. Concentrations in water from well USGS 77 decreased from 14.1±0.5 pCi/mL in April 2001 to 11.5±0.6 pCi/mL in October 2005. Concentrations in water from well CFA LF 3-9 decreased from 9.3±0.5 pCi/mL in October 2001 to 6.8±0.4 pCi/mL in October 2005. The decrease in tritium concentrations in water from wells south of the INTEC could be the result of decreased discharge of tritium to the percolation ponds since the early 1990s.

Near the southern boundary of the INL, tritium concentrations in water from wells USGS 103, 105, and 108 (fig. 5), exceeded the reporting level during 1983–85 (Pittman and others, 1988, p. 51; Mann and Cecil, 1990, p. 27). From

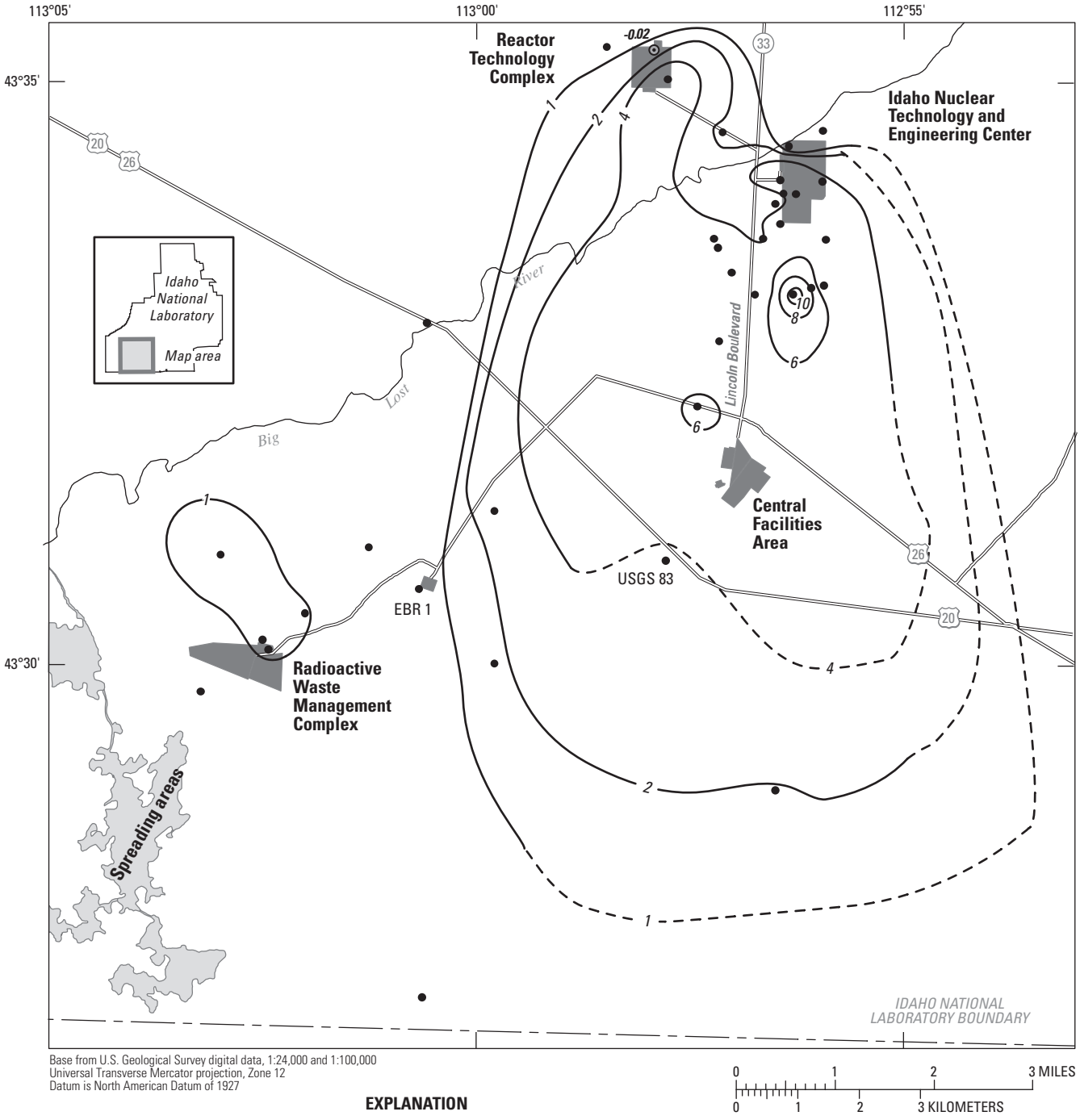


Figure 14. Distribution of tritium in water from wells at and near the Reactor Technology Complex, Idaho Nuclear Technology and Engineering Center, Central Facilities Area, and Radioactive Waste Management Complex at the Idaho National Laboratory, Idaho, October 2005.

1985 to 1995, tritium concentrations in water from these wells were less than the reporting level (Bartholomay and others, 1997, p. 27). In October 1998, concentrations in water from well USGS 105, at the boundary, and from well USGS 124, south of the boundary, exceeded the reporting level and were 0.31±0.06 and 0.3±0.06 pCi/mL, respectively. These concentrations are similar to tritium concentrations reported by Busenberg and others (2000) from these two wells. Lower detection limits for tritium established by the RESL in the mid-1990s enabled the identification of smaller concentrations of tritium during 1996–98. During 1999–2005, concentrations of tritium in water from wells near the southern boundary of the INL (USGS 1, 103, 105, 108, 109, 110A) (fig. 5) and all wells sampled south of the INL boundary were less than the reporting level.

Tritium concentrations in water from wells USGS 83 and EBR 1 (fig. 14) within and near the tritium plume (fig. 14) were less than the reporting level during 2002–05. Well USGS 83 penetrates about 250 ft of the Snake River Plain aquifer and well EBR 1 penetrates about 490 ft of the aquifer. Most of the other wells in the tritium plume penetrate only the uppermost 50 to 200 ft of the aquifer. Tritium concentrations in water from wells USGS 83 and EBR 1 were less than the reporting level possibly because of dilution by water from deeper zones, a phenomena described by Mann and Cecil (1990, p. 18) for these wells.

Tritium concentrations in water from wells south of the disposal well at INTEC (fig. 6) generally decreased during 1980–2005 (table 5) possibly in response to a decreased rate of tritium disposal from the INTEC and radioactive decay. Tritium concentrations in water from well USGS 59, near the INTEC percolation ponds (fig. 6), generally have decreased since 1980, but were unusually large in October 1983, 1985, 1991, and 1995 (table 5). The larger concentrations in 1983 and 1985 correlate with higher annual tritium discharge rates, however, annual tritium discharge was low in 1991 and 1995 (fig. 9). In 1986, perched water was detected outside the casing in well USGS 59. Following modifications to the well to prevent seepage of water into the well, a video log showed that some water from the perched zone was still seeping into the well. The larger concentrations in 1991 and 1995 could be the result of seepage from a perched zone. The larger concentrations also correlate with the use of the east infiltration pond and with disposal of tritium to the ponds.

Table 5. Tritium concentrations in water from selected wells at and near the Central Facilities Area and the Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, Idaho, 1980–2005.

[Well No.: Well locations are shown in figures 5 and 6. Concentrations and associated uncertainties in picocuries per milliliter. 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 greater than the reporting level. **Abbreviations**: USGS, U.S. Geological Survey; NS, not sampled. **Symbols**: ±, plus or minus; –, no data, well drilled in 1984]

Well No.											
CFA 1		USGS 38		USGS 47		USGS 59		USGS 77		USGS 111	
Date	Concentration	Date	Concentration	Date	Concentration	Date	Concentration	Date	Concentration	Date	Concentration
10-21-80	41.0±0.6	10-17-80	87.8±1.1	10-13-80	27.9±0.6	10-24-80	31.5±0.6	10-13-80	93.7±1.1	–	–
10-13-81	35.6±0.6	10-08-81	77.5±0.8	10-08-81	27.9±0.6	10-06-81	29.7±0.6	10-05-81	79.9±0.8	–	–
10-11-82	33.1±0.6	10-07-82	74.1±0.8	10-07-82	15.3±0.4	10-06-82	25.2±0.4	09-30-82	81.5±0.8	–	–
10-06-83	31.5±0.6	10-13-83	70.9±0.9	10-17-83	73.0±0.9	10-13-83	59.7±0.9	10-04-83	63.5±0.9	–	–
10-12-84	33.8±1.2	10-09-84	66.7±0.9	10-23-84	14.0±0.5	10-10-84	14.1±0.5	10-09-84	70.5±0.9	–	–
10-25-85	32.4±1.1	10-28-85	55.8±1.7	10-29-85	12.0±0.6	10-30-85	42.0±1.3	10-29-85	46.3±1.4	11-05-85	29.5±1.0
10-31-86	34.8±1.1	11-18-86	59.5±1.7	10-29-86	5.8±0.4	11-14-86	16.7±0.7	11-13-86	70.0±1.7	10-27-86	49.2±1.4
10-15-87	32.1±1.0	10-16-87	65.9±1.9	10-26-87	3.5±0.4	10-06-87	3.6±0.4	10-20-87	60.2±1.7	09-25-87	57.5±1.7
10-28-88	27.3±0.7	11-07-88	53.2±1.1	09-30-88	3.5±0.3	10-21-88	3.3±0.3	11-06-88	50.5±1.0	10-04-88	37.6±0.8
10-26-89	22.0±0.6	10-31-89	40.2±0.9	10-19-89	5.0±0.3	10-23-89	2.4±0.2	10-30-89	41.2±0.9	10-04-89	29.4±0.7
10-15-90	17.2±0.5	10-05-90	31.9±0.8	10-31-90	7.5±0.4	10-12-90	6.7±0.3	10-25-90	40.7±0.9	09-24-90	32.9±0.8
10-10-91	21.1±0.6	10-03-91	26.3±0.7	10-24-91	6.2±0.3	10-21-91	19.3±0.6	10-09-91	41.7±1.0	10-25-91	18.3±0.6
10-08-92	16.4±0.5	10-14-92	21.3±0.6	10-21-92	10.8±0.4	10-23-92	5.6±0.3	10-09-92	36.8±0.9	10-09-92	16.0±0.5
10-07-93	NS	10-23-93	16.2±0.7	10-26-93	6.0±0.4	10-25-93	3.4±0.3	10-23-93	31.5±1.2	10-21-93	13.0±0.6
10-06-94	NS	10-14-94	15.1±0.7	10-19-94	9.9±0.5	11-01-94	3.5±0.3	10-07-94	28.7±1.1	10-13-94	10.5±0.5
10-11-95	13.4±0.6	10-12-95	13.0±0.6	10-16-95	7.6±0.4	10-23-95	13.0±0.6	10-24-95	25.1±1.0	10-26-95	7.0±0.4
10-16-96	17.8±0.8	10-25-96	11.8±0.6	10-21-96	13.6±0.7	10-29-96	3.1±0.3	10-17-96	24.0±1.0	10-17-96	8.2±0.5
10-21-97	14.2±0.6	10-09-97	8.2±0.4	10-14-97	9.7±0.5	10-22-97	2.5±0.2	10-16-97	18.2±0.7	10-28-97	7.8±0.4
10-19-98	12.6±0.6	10-19-98	7.9±0.4	10-28-98	4.6±0.3	10-27-98	1.9±0.2	10-13-98	18.2±0.7	10-26-98	6.4±0.3
10-20-99	13.9±0.6	10-19-99	6.6±0.4	10-20-99	1.9±0.2	10-06-99	1.6±0.2	10-05-99	15.0±0.6	10-06-99	5.8±0.3
10-11-00	11.0±0.5	10-11-00	5.0±0.3	10-18-00	1.1±0.2	10-02-00	0.9±0.2	10-06-00	11.8±0.5	10-03-00	3.6±0.3
10-09-01	10.4±0.5	10-11-01	6.0±0.4	10-15-01	4.0±0.3	10-18-01	3.4±0.3	10-24-01	13.4±0.6	10-18-01	4.7±0.3
10-16-02	10.6±0.4	10-17-02	5.4±0.3	10-16-02	4.7±0.3	10-16-02	6.2±0.3	10-03-02	13.7±0.5	10-10-02	4.2±0.3
10-15-03	10.7±0.3	11-13-03	3.1±0.2	11-17-03	2.0±0.2	04-07-03	1.7±0.2	11-03-03	13.1±0.4	11-05-03	3.7±0.2
04-06-04	8.7±0.3	04-21-04	2.6±0.2	10-21-04	1.7±0.2	11-17-04	1.2±0.1	10-20-04	12.9±0.6	04-19-04	4.1±0.2
04-18-05	8.7±0.4	04-06-05	2.1±0.1	10-11-05	3.3±0.2	04-05-05	1.1±0.1	10-11-05	11.5±0.6	04-06-05	3.9±0.2

The smaller concentrations in water from well USGS 59 in 1989, 1993, 1994, and from 1996 to 2000 correlate with years in which little or no tritium was discharged to the percolation ponds (fig. 9). The slight increase in tritium concentrations in wells USGS 38, 47, 59, 77, and 111 between 2000 and 2001 (table 5), could have resulted from disposal of 0.03 Ci of tritium (Stoller Corporation, 2002b) to the INTEC percolation ponds and the lack of dilution by ground-water recharge because of low streamflows in the Big Lost River during 2000.

Strontium-90

A strontium-90 plume developed in the Snake River Plain aquifer from wastewater disposal at the INL. Strontium-90 has a half-life of 29.1 years (Walker and others, 1989, p. 29). During 1952–98, about 24 Ci of strontium-90 was in wastewater injected directly into the aquifer through the disposal well and discharged to percolation ponds at the INTEC (Bartholomay and others, 2000). During this period, about 93 Ci of strontium-90 also was discharged to radioactive-waste infiltration and evaporation ponds at the RTC. During 1962–63, more than 33 Ci of strontium-90 in wastewater was discharged into a pit at the INTEC (Robertson and others, 1974, p. 117). During 1996–98, about 0.03 Ci of strontium-90 was discharged to percolation ponds at the INTEC (Bartholomay and others, 2000). During 1999, less than 0.001 Ci of strontium-90 was discharged at the INTEC or RTC (Stoller Corporation, 2002a, table 7-2); during 2000, 0.21 Ci of strontium-90/yttrium-90 was discharged at the RTC (Stoller Corporation, 2002b, table 6-2). No data are available for strontium-90 discharged during 2001–05.

In October 2005, 34 aquifer wells were sampled for strontium-90 throughout the INL. Concentrations of strontium-90 in water from 14 wells exceeded the reporting level. Concentrations ranged from 2.2±0.7 to 33.1±1.2 pCi/L. However, concentrations from most wells have remained relatively constant or decreased since 1989 (table 6). The area

Table 6. Strontium-90 concentrations in water from selected wells at and near the Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, Idaho, 1980–2005.

[**Well No.**: Well locations are shown in figures 5 and 6. Concentrations and associated uncertainties in picocuries per liter. 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 greater than the reporting level. **Abbreviations**: QA, quality-assurance replicate. NSM, not sampled, well down for maintenance; USGS, U.S. Geological Survey. **Symbols**: ±, plus or minus; –, no data, well drilled in 1984]

Well No.							
USGS 36		USGS 37		USGS 38		USGS 45	
Date	Concentration	Date	Concentration	Date	Concentration	Date	Concentration
10-17-80	17±2	10-13-80	22±3	10-17-80	22±3	10-24-80	23±3
10-08-81	24±2	10-07-81	25±3	10-08-81	28±3	10-06-81	71±5
10-07-82	10±2	10-07-82	30±3	10-07-82	27±3	10-06-82	79±5
10-13-83	15±2	10-10-83	26±3	10-13-83	12±2	10-12-83	37±3
10-09-84	32±4	10-10-84	17±2	10-09-84	26±4	10-09-84	2±2
10-28-85	40±4	10-28-85	18±3	10-28-85	14±2	10-29-85	6±2
11-18-86	10±2	10-27-86	21±2	11-18-86	13±2	11-14-86	5±2
10-16-87	33±3	10-05-87	17±2	10-16-87	13±2	10-20-87	2.8±1.4
11-07-88	16±2	10-07-88	14±2	11-07-88	32±3	11-06-88	0±2
10-31-89	25±3	09-29-89	16±2	10-31-89	9±2	11-02-89	0.4±1.6
10-25-90	17±2	10-17-90	14±2	10-05-90	22±3	10-26-90	14±2
10-08-91	14±3	10-07-91	-3±2	10-03-91	9±3	10-09-91	16±2
10-28-92	16±2	10-02-92	11±2	10-14-92	27±3	11-13-92	1.1±2.0
10-20-93	14±3	10-21-93	20±3	10-23-93	25±3	11-01-93	8±2
10-13-94	14±2	10-07-94	13±2	10-14-94	27±3	10-17-94	2.2±1.6
10-11-95	8.7±1.0	10-11-95	0.3±1.1	10-12-95	23.5±1.4	10-11-95	1.6±0.9
10-23-96	11.8±1.0	10-24-96	9.1±1	10-25-96	26±1.4	10-11-95	12±2 QA
10-07-97	13.4±1.1	10-08-97	9.9±1.2	10-09-97	22±2	10-29-96	1.9±1
10-15-98	12.9±0.8	10-15-98	13.4±1	10-19-98	20.7±1.1	10-16-97	1.1±0.8
10-05-99	13.0±0.9	10-14-99	11.0±0.9	10-19-99	20.0±1.1	10-14-98	2.1±0.6
10-17-00	9.8±0.9	10-11-00	11.6±0.8	10-11-00	16.5±0.9	10-20-99	2.3±0.8
10-25-01	8.9±0.8	10-24-01	9.3±0.8	10-11-01	16.8±1.0	10-18-00	1.9±0.8
10-01-02	8.2±0.7	04-22-02	8.5±0.7	04-16-02	14.0±0.9	10-15-01	0.4±0.6
11-13-03	7.7±0.7	11-13-03	6.9±0.7	11-13-03	13.1±0.8	10-07-02	2.8±0.6
04-13-04	6.2±0.6	10-19-04	9.8±0.9	04-21-04	11.8±1.1	11-12-03	3.8±0.6
04-06-05	6.5±0.6	10-11-05	6.0±0.9	04-06-05	12.3±0.8	10-13-04	2.0±0.6
						10-19-05	4.6±0.7

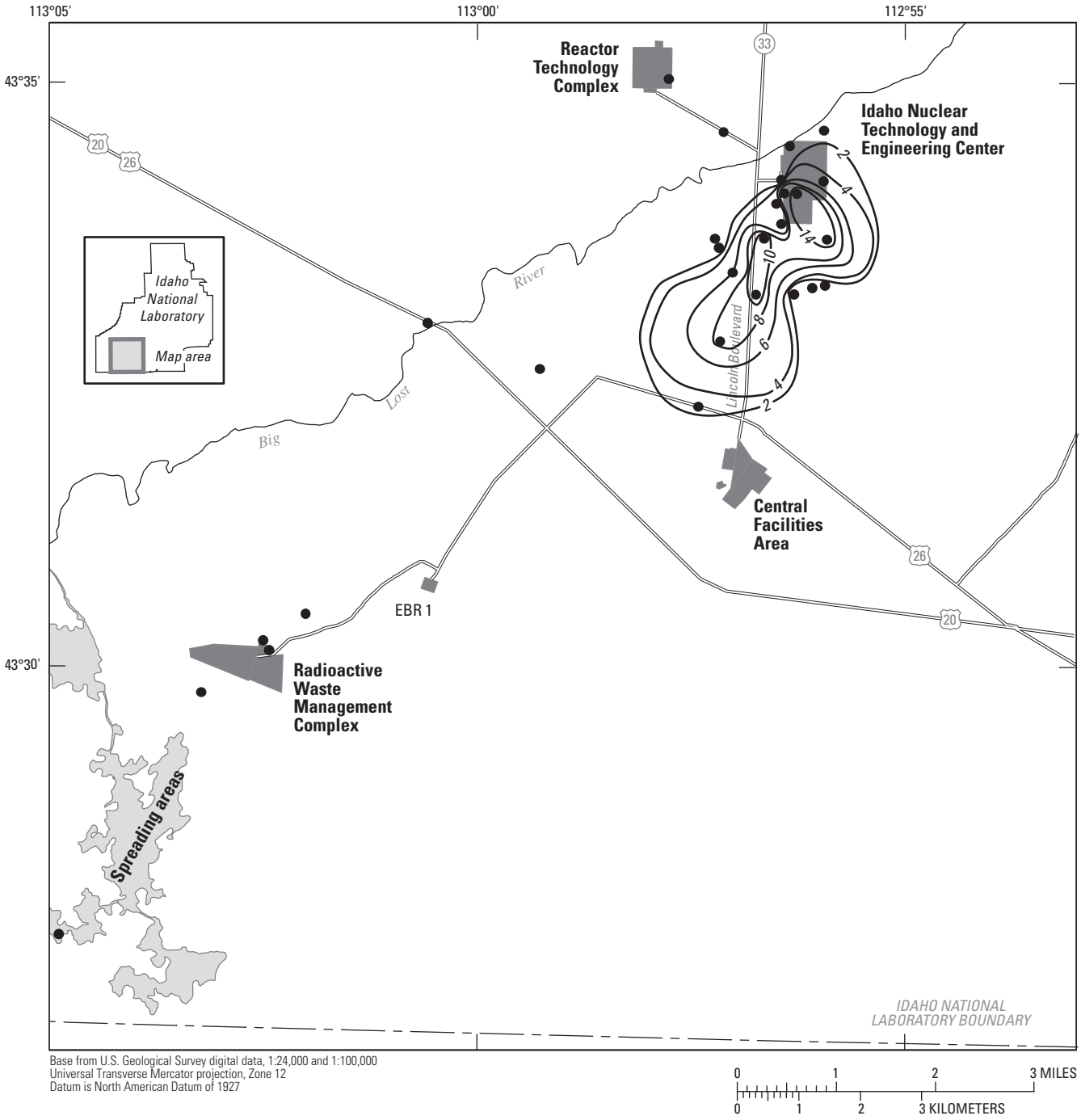
Table 6. Strontium-90 concentrations in water from selected wells at and near the Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, Idaho, 1980–2005—Continued.

[**Well No.**: Well locations are shown in figures 5 and 6. Concentrations and associated uncertainties in picocuries per liter. 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 greater than the reporting level. **Abbreviations**: QA, quality-assurance replicate. NSM, not sampled, well down for maintenance; USGS, U.S. Geological Survey. **Symbols**: ±, plus or minus; –, no data, well drilled in 1984]

Well No.					
USGS 47		USGS 57		USGS 113	
Date	Concentration	Date	Concentration	Date	Concentration
10-13-80	107±6	10-24-80	88±5	–	–
10-08-81	79±5	10-05-81	93±6	–	–
10-07-82	60±4	10-06-82	90±5	–	–
10-17-83	130±7	10-13-83	83±5	–	–
10-23-84	61±4	10-10-84	66±5	–	–
10-29-85	63±5	10-29-85	74±5	11-01-85	30±3
10-29-86	56±4	11-14-86	42±3	10-27-86	27±3
10-26-87	54±3	10-09-87	49±3	10-02-87	28±3
09-30-88	48±3	10-05-88	41±3	09-27-88	27±3
10-19-89	59±4	12-22-89	45±4	10-06-89	20±2
10-31-90	51±4	10-29-90	41±4	10-03-90	16±3
10-24-91	55±4	10-24-91	40±4	10-08-91	23±2
10-21-92	56±4	10-06-92	41±4	10-22-92	16±2
10-26-93	54±4	10-12-93	36±3	10-23-93	13±3
10-19-94	55±4	10-03-94	27±3	10-17-94	14±2
10-16-95	76±3	10-11-95	29.2±1.5	10-17-95	14.1±1.0
10-16-95	47±2 QA	10-18-96	30.5±1.5	10-18-96	14.8±1.1
10-21-96	58±2	10-14-97	18.5±1.6	10-16-97	13±1.5
10-14-97	41.8±1.6	10-06-98	20.8±1.1	10-15-98	12.2±0.9
10-28-98	41.1±1.5	10-05-99	17.0±1.0	10-19-99	12.0±0.9
10-28-98	43.9±1.6 QA	10-05-00	15.7±0.9	10-18-00	11.5±1.0
10-20-99	40.5±1.5	10-25-01	20.9±1.0	10-10-01	10.4±0.8
10-18-00	35.8±1.3	04-24-02	21.8±0.9	04-16-02	10.3±0.8
10-15-01	42.4±1.4	04-07-03	19.4±0.8	11-04-03	10.2±0.8
04-15-02	41.3±1.3	11-05-03	18.5±0.9	04-12-04	8.9±1.1
11-17-03	39.2±1.2	10-13-04	19.6±1.0	04-06-05	NSM
10-21-04	3.8±0.8	10-12-05	12.1±1.2		
10-11-05	33.1±1.2				

of the strontium-90 plume near the INTEC extended south-southwestward in the general direction of ground-water flow (fig. 15). The concentrations in water from wells USGS 37 and 45 have varied since 1980; the concentrations in water from well USGS 37 decreased during 2002–05, but increased slightly in water from well USGS 45 (table 6). Concentrations in water from well USGS 37 exceeded the reporting level in most years during 1980–2005, but were less than the reporting level in 1991 and 1995 (table 6). Concentrations in water from well USGS 45 were equal to or less than the reporting level for most years from 1984 to 2001, but exceeded the reporting level in 1990, 1991, 1993, 1998, in a replicate sample collected in 1995, and from 2002-05 (table 6). The October 1995 concentration of 76±3 pCi/L in water from well USGS 47 was larger than concentrations in most previous samples, but the quality-assurance replicate concentration of 47±2 pCi/L was similar to concentrations in most previous samples. Concentrations of strontium-90 in this well show an overall decrease since 1996. The concentrations in wells USGS 57 and 113 generally decreased from the 1980s to 2005, although concentrations in well USGS 57 increased during 2001–02 (table 6). The MCL for strontium-90 in drinking water is 8 pCi/L (U.S. Environmental Protection Agency, 2001).

Before 1989, strontium-90 concentrations in most wells had been decreasing likely because of factors including radioactive decay, diffusion, dispersion, changes in disposal methods, and dilution from natural recharge (Orr and Cecil, 1991, p. 35). The relatively constant concentrations in water from most of the wells sampled during 1992–95 could have resulted partly due to a lack of recharge from the Big Lost River. An increase in disposal of other chemical constituents



EXPLANATION

2 — **LINE OF EQUAL STRONTIUM-90 CONCENTRATION**—October 2005. Lines of equal concentration were interpreted from analyses of samples collected from a 3-dimensional flow system. Mapped concentrations represent samples collected from various depths in boreholes with differing well completions; for example, single- and multiple- screened intervals, and open boreholes. Location is approximate. Interval, in picocuries per liter, is variable.

● **WELL IN THE USGS AQUIFER WATER-QUALITY MONITORING NETWORK**— Samples analyzed for strontium-90.

Figure 15. Distribution of strontium-90 in water from wells at and near the Reactor Technology Complex (RTC), Idaho Nuclear Technology and Engineering Center (INTEC), Central Facilities Area (CFA), and Radioactive Waste Management Complex (RWMC), Idaho National Laboratory (INL), Idaho, October 2005.

into the percolation ponds also could have affected the exchange capacity of strontium-90 in the unsaturated zone (Bartholomay and others, 1997). The decrease of strontium-90 concentrations in water from some wells during 1999–2005 could be the result of the factors previously mentioned.

Strontium-90 has not been detected in the eastern Snake River Plain aquifer beneath the RTC partly because of the exclusive use of waste-disposal ponds and lined evaporation ponds rather than the disposal well for radioactive-wastewater disposal at the RTC. Sorption processes in sediments in the unsaturated zone beneath the radioactive waste-disposal pond could have minimized or prevented strontium-90 migration to the aquifer at the RTC. Additionally, the stratigraphy beneath the RTC includes more sediment than the stratigraphy beneath the INTEC (Anderson, 1991, p. 22–28).

In 1988, a DOE contractor was given the responsibility for monitoring areas around TAN and the TAN disposal well as part of the Environmental Restoration Program. The USGS collected samples from wells in the area for special studies in 1989, but the USGS has collected no samples in this area since December 1989. During 1988–96, four samples analyzed for strontium-90 from well USGS 24, just south of the TAN area, yielded one reportable concentration in 1990.

Cobalt-60

During 1952–93, about 438 Ci of cobalt-60 in wastewater was discharged to the RTC radioactive-waste infiltration ponds. Before 1974, the average disposal rate was about 18 Ci/yr; during 1974–88, the average disposal rate was 2.3 Ci/yr (Orr and Cecil, 1991, p. 35). During 1989–91, about 0.5 Ci of cobalt-60 was discharged to the ponds; during 1992–93, about 3.1 Ci of cobalt was discharged to the ponds. The half-life of cobalt-60 is 5.27 years (Walker and others, 1989, p. 25).

Cobalt-60 concentrations in water from well USGS 65 (fig. 6), south of the RTC, exceeded the reporting level through 1985 (Orr and Cecil, 1991, p. 35); however, cobalt-60 has not been detected since 1985. The decreased discharge of cobalt-60 to the RTC radioactive-waste infiltration ponds, the use of lined evaporation ponds, and processes of radioactive decay and sorption in the unsaturated and perched ground-water zones could have contributed to the absence of detectable concentrations of cobalt-60 in ground water near the RTC since 1985.

Cobalt-60 concentrations in water from the TAN disposal well (fig. 5) exceeded the reporting level because of radioactive wastewater discharged to the well before 1972. In 1988, a DOE contractor was given the responsibility for monitoring areas around TAN and the TAN disposal well as part of the Environmental Restoration Program. Samples were collected by the USGS in 1989 for special studies but no samples have been collected since December 1989. Water from the TAN disposal well contained 170±40 pCi/L of cobalt-60 in December 1989.

During 1996–98, cobalt-60 concentrations in water from all wells sampled by the USGS at the INL were less than the reporting level. Cobalt-60 was not detected in any samples collected during 1999–2005.

Cesium-137

From 1952 to 2000, about 138 Ci of cesium-137 in wastewater was discharged to the RTC radioactive-waste infiltration and lined evaporation ponds and about 23 Ci was discharged to the INTEC disposal well and infiltration ponds. During 1999–2000, about 0.009 Ci was discharged to the RTC lined evaporation ponds, and less than 0.001 Ci/yr was discharged to the INTEC percolation ponds (Stoller Corporation, 2002a, table 7-2, footnote b; 2002b, table 6-2, footnote b). No data are available for cesium-137 discharged during 2001–05. The half-life of cesium-137 is 30.17 years (Walker and others, 1989, p. 34).

Concentrations of cesium-137 in water from wells USGS 40 and 47 (fig. 6) exceeded the reporting levels through 1985 (Orr and Cecil, 1991, p. 35) but were less than the reporting level since 1985. The absence of detectable concentrations of cesium-137 probably resulted from discontinuation of wastewater discharge to the INTEC disposal well and to sorption processes in the unsaturated and perched ground-water zones.

Cesium-137 concentrations in water from the TAN disposal well (fig. 5) exceeded the reporting level because of wastewater discharge to the well before 1972. Because the responsibility for monitoring the TAN disposal well was turned over to a DOE contractor in 1988, samples collected by the USGS were in December 1989 only for special studies. The cesium-137 concentration at that time was 4,400±200 pCi/L (http://waterdata.usgs.gov/id/nwis/qw, accessed June 29, 2006).

During 2002–05, concentrations of cesium-137 were less than the reporting level in water from all wells sampled by the USGS at the INL.

Plutonium

Monitoring of plutonium-238 and plutonium-239, -240 (undivided) in wastewater discharged to the Snake River Plain aquifer through the disposal well (fig. 6) at INTEC began in 1974. Before that time, alpha radioactivity from disintegration of plutonium was not separable from the monitored, undifferentiated alpha radioactivity. The half-lives of plutonium-238, plutonium-239, and plutonium-240 are 87.7, 24,100, and 6,560 years, respectively (Walker and others, 1989, p. 46). During 1974–95, about 0.26 Ci of plutonium in wastewater was discharged to the disposal well and percolation ponds at the INTEC (Bartholomay and others, 1997). During 1996–98, about 0.004 Ci of plutonium in

wastewater was discharged to percolation ponds at the INTEC. During 1999–2000, less than 0.001 Ci of plutonium was discharged (Stoller Corporation, 2002a, table 7-2, footnote b; 2002b, table 6-2, footnote b). No discharge data are available for 2001–05.

Because of radioactive wastewater discharged to the disposal well at INTEC, concentrations of plutonium isotopes in some samples from wells USGS 40 and 47 (fig. 6) through January 1987 exceeded the reporting level (Orr and Cecil, 1991, p. 37). Concentrations in samples collected from these wells since 1987 have been less than the reporting level.

Plutonium isotopes in water from the TAN disposal well (fig. 5) exceeded the reporting level because of radioactive-wastewater discharges before 1972. Because the responsibility for monitoring TAN disposal well was turned over to a DOE contractor in 1988, the only samples collected by the USGS since that time were collected in December 1989. The concentration of plutonium-238 in water from the TAN disposal well at that time was 0.26±0.04 pCi/L and the concentration of plutonium-239, -240 (undivided) was 0.71±0.06 pCi/L (Bartholomay and others, 1995).

During 2002–2005, concentrations of plutonium-238 and plutonium-239, -240 (undivided) in water from all wells sampled by the USGS at the INL were less than the reporting level.

Americium-241

Americium-241 is a decay product of plutonium-241 and plutonium isotopes have been detected in wastewater discharged to the Snake River Plain aquifer at the INL and are in wastes buried at the RWMC. The half-life of americium-241 is 432.7 years (Walker and others, 1989, p. 46). Concentrations of americium-241 in water samples collected between September 1972 and July 1982 from wells USGS 87, 88, 89, and 90 at the RWMC (fig. 6) and in water samples collected through 1988 from the TAN disposal well (fig. 5) exceeded the reporting level (Orr and Cecil, 1991, p. 38–39). During 1992–95, concentrations of americium-241 in samples from two wells were equal to the reporting level. On October 2, 1992, the concentration in water from well USGS 37 was 0.09±0.03 pCi/L; on April 20, 1993, the concentration in water from well USGS 120 was 0.06±0.02 pCi/L (Bartholomay and others, 1997). During 1996–2005, concentrations in all samples were less than the reporting level except one sample collected April 12, 2001, from the RWMC Production Well (RWMC PROD) with a concentration of 0.003±0.001 pCi/L, equal to the reporting level.

Gross Alpha- and Beta-Particle Radioactivity

Gross alpha- and beta-particle radioactivity is a measure of the total radioactivity given off as alpha and beta particles during the radioactive decay process. Gross alpha and beta measurements are used to screen for radioactivity in the aquifer as a possible indicator of ground-water contamination. Background concentrations of gross beta-particle radioactivity in the Snake River Plain aquifer in Idaho generally range from 0 to 7 pCi/L as cesium-137 (Knobel and others, 1992). Background concentrations of gross alpha particle radioactivity range from 0 to 3 µg/L as natural uranium (Knobel and others, 1992).

Before 1994, gross alpha- and beta-particle radioactivity in water from three wells west and south of the INL (wells USGS 8, 11, and 14, fig. 5) and four surface-water sites along the Big Lost River (fig. 1) were sampled. As part of the INL ground-water monitoring program adopted in 1994 (Sehlke and Bickford, 1993), the USGS expanded the number of wells at the INL used for sampling gross alpha- and gross beta-particle radioactivity.

During 2002–05, water from 54 wells was sampled for gross alpha- and gross-beta particle radioactivity. As in October 2001, concentrations of gross alpha-particle radioactivity were less than the reporting level in all samples. Concentrations of gross-beta particle radioactivity greater than the reporting level in at least one sample collected during 2002–05 were detected in water samples from 18 of the 54 wells and ranged from 6±2 to 44±4 pCi/L, a decrease in the number of wells with reportable concentrations and the maximum concentration from the 1999–2001 reporting period. A concentration of 60±5 pCi/L was detected in well USGS 57 on July 6, 1999; however, this well was not sampled for gross-beta particle activity during 2002–05. Gross-beta particle activity in most of the 18 wells showed steady or decreasing concentration trends during 2002–05.

During April or October 2005, water in 48 wells was sampled for gross alpha- and gross beta-particle radioactivity. Concentrations of gross alpha-particle radioactivity were less than the reporting level in all samples. Concentrations of gross beta-particle radioactivity in water from 4 of the 48 wells sampled in 2005 were greater than the reporting level and ranged from 6±2 to 25±3 pCi/L. Of the 48 wells sampled in 2005, the largest concentration was in well USGS 38, but the concentration decreased in water from this well since the 1999–2001 reporting period.

Chromium

Wastewater from RTC cooling-tower operations contained an estimated 24,000 lb of chromium discharged to an infiltration pond during 1952–64 and an estimated 31,000 lb discharged to an injection well during 1965–72 (Mann and Knobel, 1988, p. 7). In October 1972, chromium used as a corrosion inhibitor in cooling-tower operations was replaced by a polyphosphate. No disposal of chromium to the subsurface at the RTC was reported after 1972. During 1971–83, about 265 lb of chromium in wastewater were discharged to the disposal well at INTEC and 720 lb of chromate were discharged at the Power Burst Facility (fig. 1) (Cassidy, 1984, p. 3). About 86 lbs of chromium were discharged to the INTEC percolation ponds during 1992–95 (Bartholomay and others, 1997) and 44 lbs during 1996–98 (Bartholomay and others, 2000). No information has been compiled on the total amount of chromium discharged during 1999–2005.

Background concentrations of chromium in the Snake River Plain aquifer range from 2 to 3 µg/L (Orr and others, 1991, p. 41). In April 2005, the MCL of 100 µg/L (U.S. Environmental Protection Agency, 2001) for total chromium in drinking water was equaled in water from one well, USGS 65, south of RTC (fig. 6). The concentration of chromium in water from that well was 100 µg/L, a decrease from 139 µg/L in October 2001 (Bartholomay and others, 2000). Concentrations in water samples from other wells ranged from 1.7 to 30.3 µg/L. The LRL for chromium ranged from 2 to10 µg/L during 2002–05; consequently, concentrations within that range were designated according to those LRLs as detections or nondetections during 2002–05.

Sodium

During 1989–98, an estimated average annual 1.3 million lb/yr of sodium in wastewater were discharged at the INL (Bartholomay and others, 1995, 1997, and 2000). During 1996–98 about 708,000 lb/yr of sodium were discharged to the INTEC percolation ponds; about 58,000 lb/yr were discharged to the RTC chemical-waste infiltration pond; about 524,000 lb/yr were discharged to the NRF industrial-waste ditch; and about 5,000 lb/yr were discharged at CFA (Bartholomay and others, 2000) (fig. 1). The total amount of sodium discharged at the RTC was the amount of sodium ion estimated from the sodium hydrate solution discharged (Bartholomay and others, 2000). The total amount of sodium in wastewater discharged at individual facilities from 1999–2005 has not been compiled.

The background concentration of sodium in water from the Snake River Plain aquifer near the INL generally is less than 10 mg/L (Robertson and others, 1974, p. 155). In October 2001, concentrations in water from most wells in the southern part of the INL were greater than 10 mg/L.

Concentrations of sodium in water from wells near the INTEC generally have been variable since 1984 when disposal practices were changed from injection to the disposal well to discharge to percolation ponds (fig. 6; table 7, wells USGS 37, 40, 47, 57, 59, 111, and 113). During 1984–98, estimated discharge rates increased slightly at the INTEC, so the variability in concentrations in water from some wells could have resulted from this increase in discharge rates (Bartholomay and others, 2000). During 1999–2001, the larger concentrations of sodium were in water from wells at or near INTEC. During 2002–05, the largest concentration in water samples from aquifer wells at the INL was 76 mg/L in a sample from well USGS 113 (fig. 6, table 7), south of INTEC. Water from this well had the highest concentration of sodium of 76 mg/L in October 2002 but concentrations decreased through 2004 (table 7). Concentrations of sodium in water from other wells south of INTEC during 2002–05 generally were equal to or less than sodium concentrations detected in October 2001, with the exception of well USGS 40, which was slightly higher (table 7).

In 2004–05, sodium concentrations in water from wells USGS 88 and 120 (fig. 6), near the RWMC, were 41 and 24 mg/L. In March 2005, water from well MTR Test at the RTC (fig. 6), contained a sodium concentration of 10 mg/L, significantly less than the 1998 concentration of 42 µg/L and slightly less than the October 2001 concentration of 15 mg/L.

Chloride

About 2.3 million lb/yr of chloride in wastewater was discharged to infiltration ponds at the INL during 1996–98, an increase from the estimated 1.5 million lb/yr discharged during 1992–95 (Bartholomay and others, 1997, p. 36). Of the 2.3 million lb/yr discharged during 1996–98, about 1.17 million lb/yr were discharged to the INTEC percolation ponds (fig. 3; Bartholomay and others, 2000), which was about the same amount discharged during 1986–95 (Orr and Cecil, 1991, p. 40; Bartholomay and others, 1995, p. 31; Bartholomay and others, 1997, p. 36). No information has been compiled for the total amount of chloride discharged in wastewater during 1999–2005.

Table 7. Sodium concentrations in water from selected wells at and near the Central Facilities Area and the Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, Idaho, 1981–2005.

[**Well No.**: Well locations are shown in figures 5 and 6. Concentrations in milligrams per liter. **Abbreviations**: CFA, Central Facilities Area; NS, not sampled; USGS, U.S. Geological Survey. **Symbol:** –, no data]

Well No.							
CFA 1		USGS 37		USGS 40		USGS 47	
Date	Concentration	Date	Concentration	Date	Concentration	Date	Concentration
10-13-81	21	10-07-81	34	10-12-81	94	10-08-81	21
10-11-82	16	10-07-82	30	10-07-82	69	10-07-82	15
10-06-83	10	10-10-83	37	10-10-83	46	10-17-83	52
10-12-84	14	10-10-84	34	10-16-84	33	10-23-84	22
10-25-85	15	10-28-85	31	10-29-85	18	10-29-85	18
10-31-86	22	10-27-86	28	10-30-86	15	10-29-86	12
10-15-87	26	10-05-87	33	10-13-87	13	10-26-87	11
10-28-88	15	10-07-88	19	11-09-88	11	09-30-88	12
10-26-89	26	09-29-89	NS	10-18-89	12	10-19-89	13
10-15-90	17	10-17-90	32	10-16-90	14	10-31-90	15
10-10-91	26	10-07-91	31	10-29-91	16	10-24-91	14
10-08-92	26	10-02-92	38	11-17-92	16	10-21-92	18
10-07-93	NS	10-21-93	45	10-08-93	16	10-26-93	15
10-06-94	NS	10-07-94	46	10-18-94	15	10-19-94	19
10-11-95	30	10-11-95	41	10-19-95	20	10-16-95	17
10-16-96	18	10-24-96	42	10-17-96	15	10-21-96	22
10-21-97	24	10-08-97	48	10-20-97	11	10-14-97	19
10-19-98	27	10-15-98	50	10-07-98	12	10-28-98	15
10-20-99	22	10-14-99	49	10-25-99	10	10-20-99	12
10-11-00	20	10-11-00	46	10-18-00	11	10-18-00	11
10-09-01	25	10-24-01	38	10-17-01	12	10-15-01	15
10-16-02	23	10-01-02	35	10-08-02	14	10-16-02	7
10-15-03	20	11-13-03	25	11-10-03	15	11-17-03	12
04-06-04	34	10-19-04	21	04-15-04	15	10-21-04	12
04-18-05	35	10-11-05	19	04-06-05	15	10-11-05	14
USGS 57		USGS 59		USGS 111		USGS 113	
Date	Concentration	Date	Concentration	Date	Concentration	Date	Concentration
10-05-81	63	10-06-81	19	–	–	–	–
10-06-82	51	10-06-82	17	–	–	–	–
10-13-83	24	10-13-83	28	–	–	–	–
10-10-84	45	10-10-84	17	–	–	–	–
10-29-85	36	10-30-85	45	11-05-85	15	11-01-85	41
11-14-86	28	11-14-86	37	10-27-86	25	10-27-86	43
10-09-87	31	10-06-87	12	09-25-87	27	10-02-87	49
10-05-88	27	10-21-88	5	10-04-88	28	09-27-88	41
12-22-89	29	10-23-89	12	10-04-89	NS	10-06-89	NS
10-29-90	38	10-12-90	21	09-24-90	33	10-03-90	71
10-24-91	42	10-21-91	75	10-25-91	22	10-08-91	64
10-06-92	59	10-23-92	36	10-09-92	28	10-22-92	81
10-12-93	72	10-25-93	23	10-21-93	33	10-23-93	87
10-03-94	69	11-01-94	25	10-13-94	32	10-17-94	90
10-11-95	62	10-23-95	65	10-26-95	23	10-17-95	79
10-18-96	78	10-29-96	38	10-17-96	39	10-18-96	93
10-14-97	78	10-22-97	36	10-28-97	40	10-16-97	94
10-06-98	69	10-27-98	14	10-26-98	39	10-15-98	96
10-05-99	59	10-06-99	10	10-06-99	36	10-19-99	99
10-05-00	44	10-02-00	11	10-03-00	29	10-18-00	80
10-25-01	51	10-18-01	28	10-18-01	26	10-10-01	75
10-17-02	57	10-16-02	60	10-10-02	26	10-02-02	76
11-05-03	30	04-07-03	NS	11-05-03	25	11-04-03	67
10-13-04	24	11-17-04	12	04-19-04	24	04-12-04	66
10-12-05	16	04-05-05	12	04-06-05	25	04-06-05	NS

The background chloride concentration in water from the Snake River Plain aquifer at the INL generally is about 15 mg/L (Robertson and others, 1974, p. 150); the ambient chloride concentration near the INTEC is about 10 mg/L and, near the CFA, about 20 mg/L. In 2005, concentrations of chloride in most water samples from wells closest to the INTEC and the CFA (fig. 16) exceeded 20 mg/L.

Chloride concentrations in water from wells near the INTEC generally have increased or remained constant since disposal practices were changed from injection to the disposal well to discharge to percolation ponds in 1984 through about 2001. During 2002–05, concentrations decreased in some wells, and increased in others (fig. 6; table 8, wells USGS 37, 40, 47, 57, 59, 111, and 113). Trends in concentrations in water from wells downgradient from the percolation ponds correlated with discharge rates into the ponds when travel time was considered. For example, chloride concentrations in water from wells USGS 37 and 57 were smallest in 1985, during the period (1984–98) when the smallest amount of chloride was discharged to the ponds (fig. 17). Water from well USGS 37 had smaller concentrations of 27 mg/L in April 2001, 24 mg/L in October 2004, and 22 mg/L in October 2005; however, no disposal data are available for 1999–2005. These small values may indicate decreased disposal rates at some time prior to collection of the sample. Concentrations in water from well USGS 37 generally correlated with discharge rates into ponds when longer travel time was considered (fig. 17). Concentrations of chloride in water from well USGS 57 increased as discharge rates increased through 1993; concentrations then decreased through 1995, increased in 1996, and decreased again in 1997 and 1998. Concentrations continued decreasing through October 2000, and then increased through October 2001. Since 2001, concentrations have steadily decreased in both wells. Chloride concentrations in water from USGS 59, near the INTEC percolation ponds, were variable during 1984–2005; concentrations were unusually large in October 1991, 1995, and 2002 (table 8). The larger concentrations probably were caused by seepage down the well from the perched groundwater zone, in which chloride concentrations in perched water wells near the percolation ponds were about 270 mg/L in 1991 and 1995 (Bartholomay and others, 1997). In April 2004, the chloride concentration in water from well USGS 113, south of the INTEC, was 127 mg/L, (table 8), a decrease from the concentration of 175 mg/L in October 2001. In April 2005, water from well CFA 1, also south of INTEC had a slight increase in concentration since October 2001, at 114 mg/L.

In April 2005, the chloride concentration in water from well USGS 65 near the RTC was 19 mg/L. Chloride concentrations in water from all other wells completed in the Snake River Plain aquifer at or near the RTC ranged between 9 and 12 mg/L during 2002–05. During 2002–05, chloride concentrations in water from wells USGS 88, 89, and 120 at the RWMC were 86, 41, and 20 mg/L, respectively, nearly the same as the 1999–2001 reporting period. Concentrations of chloride in all other wells near the RWMC were less than 13 mg/L. The secondary MCL for chloride in drinking water is 250 mg/L (U.S. Environmental Protection Agency, 2001).

Sulfate

During 1996–98, about 0.8 million lb/yr of sulfate in wastewater were discharged at the INL, a decrease from the 1.05 million lb/yr discharged during 1992–95 (Bartholomay and others, 2000). Of the 0.8 million lb/yr discharged during 1996–98, about 610,000 lb/yr were discharged to infiltration ponds at the RTC, 146,000 lb/yr were discharged to percolation ponds at the INTEC, and 45,000 lb/year was discharged to the NRF industrial-waste ditch (Bartholomay and others, 2000). Background concentrations of sulfate in the Snake River Plain aquifer in the south-central part of the INL range from about 10 to 40 mg/L (Robertson and others, 1974, p. 72). No compiled data were available for sulfate in wastewater discharged during 1999–2005.

Because of the sulfate disposal history at the various facilities, water-sample collection for sulfate analyses at several wells was added to the water-quality monitoring network in 1995. In 2005, sulfate concentrations in water samples from nine wells in the south-central part of the INL exceeded the 40-mg/L background concentration of sulfate. Concentrations in water samples from MTR Test decreased from 64 mg/L in October 2001 to 23 mg/L in March 2005. A water sample was collected from well USGS 65 with a concentration of 155 mg/L (similar to the October 2001 concentration). The larger-than-background concentrations in water from these wells probably resulted from sulfate disposal at the RTC infiltration ponds.

In October 2005, sulfate concentrations in water samples from USGS 88 and USGS 119 (fig. 6), near the RWMC, were 53 and 40 mg/L, respectively. The concentration of sulfate in well USGS 88 represented a slight decrease in concentration from the October 2001 value of 63 mg/L. The concentration of sulfate in well USGS 119 indicated a slight increase in concentration from the October 2001 value of 34 mg/L, bringing it above background. The larger-than-background concentration in water from these wells could have resulted from the well construction and (or) waste disposal at the RWMC (Pittman and others, 1988, p. 57–61). In October 2004, the sulfate concentration in well CFA 2 (fig. 5), 42 mg/L, also exceeded the background concentration. This was a slight decrease from the October 2001 concentration of 47 mg/L. In 2005, concentrations were 42, 46, and 46 mg/L in water from wells USGS 34, 35, and 39, respectively, southwest of INTEC. Historically, concentrations in these wells were at or just below background. The secondary MCL for sulfate in drinking water is 250 mg/L (U.S. Environmental Protection Agency, 2001).

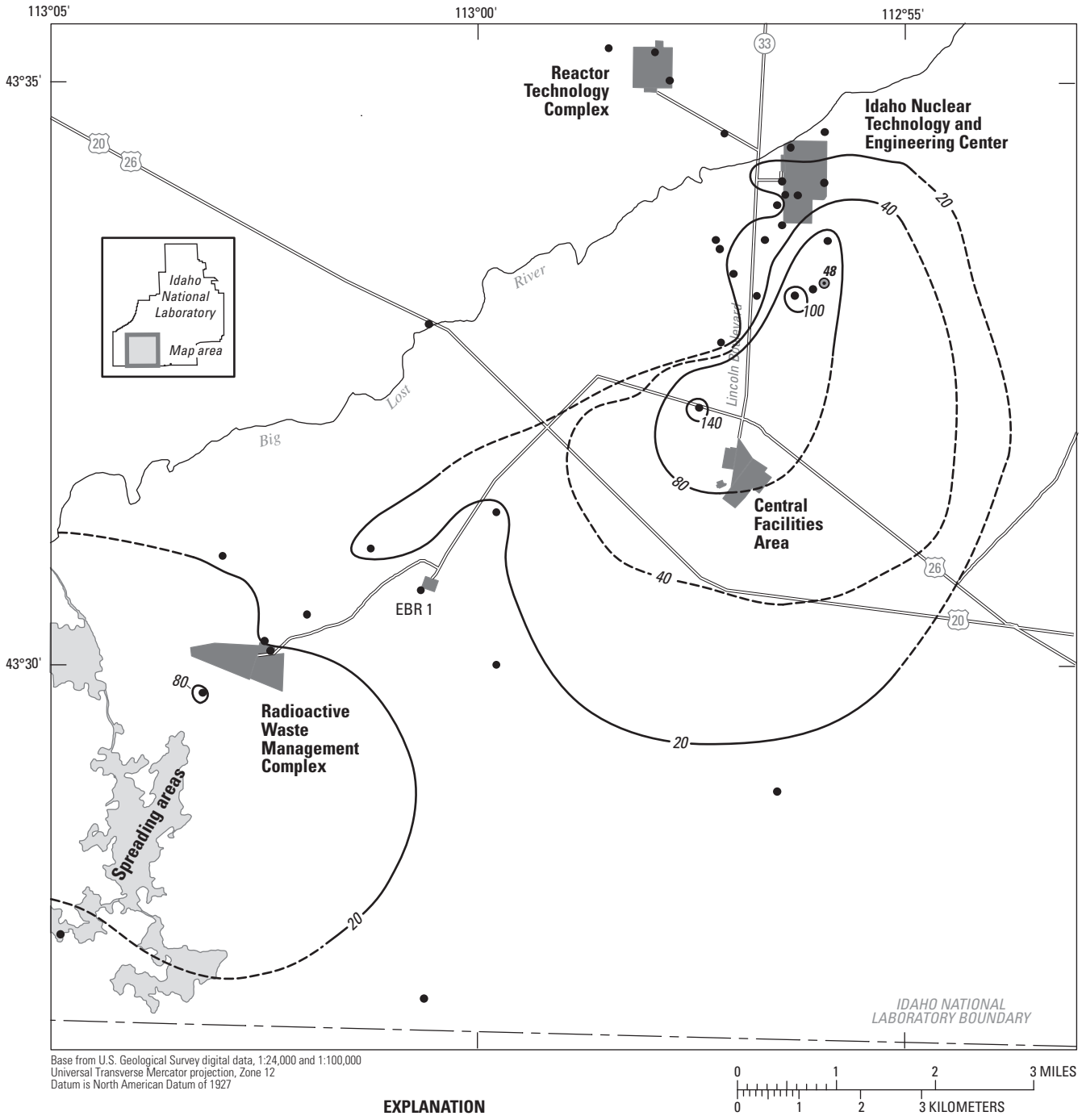


Figure 16. Distribution of chloride in water from wells at and near the Reactor Technology Complex (RTC), Idaho Nuclear Technology and Engineering Center (INTEC), Central Facilities Area (CFA), and Radioactive Waste Management Complex (RWMC), Idaho National Laboratory (INL), Idaho, October 2005.

Table 8. Chloride concentrations in water from selected wells at and near the Central Facilities Area and the Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, Idaho, 1980–2005.

[**Well No.**: Well locations are shown in figures 5 and 6. Concentrations in milligrams per liter. **Abbreviations:** CFA, Central Facilities Area; NSM, not sampled, well down for maintenance; USGS, U.S. Geological Survey. **Symbol:** –, no data]

Well No.							
CFA 1		USGS 37		USGS 40		USGS 47	
Date	Concentration	Date	Concentration	Date	Concentration	Date	Concentration
10-21-80	80	10-13-80	72	10-13-80	210	10-13-80	54
10-13-81	82	10-07-81	66	10-12-81	150	10-08-81	48
10-11-82	86	10-07-82	85	10-07-82	150	10-07-82	32
10-06-83	78	10-10-83	59	10-10-83	150	10-17-83	160
10-12-84	53	10-10-84	53	10-16-84	44	10-23-84	27
10-25-85	51	10-28-85	37	10-29-85	23	10-29-85	21
10-31-86	78	10-27-86	50	10-30-86	23	10-29-86	23
10-15-87	83	10-05-87	70	10-13-87	24	10-26-87	23
10-28-88	86	10-07-88	86	11-09-88	23	09-30-88	23
10-26-89	93	09-29-89	92	10-18-89	23	10-19-89	24
10-15-90	86	10-17-90	78	10-16-90	27	10-31-90	31
10-10-91	100	10-07-91	75	10-29-91	31	10-24-91	30
10-08-92	100	10-02-92	110	11-17-92	29	10-21-92	36
10-07-93	NS	10-21-93	140	10-08-93	30	10-26-93	31
10-06-94	NS	10-07-94	140	10-18-94	30	10-19-94	38
10-11-95	100	10-11-95	100	10-19-95	37	10-16-95	35
10-16-96	70	10-24-96	120	10-17-96	27	10-21-96	44
10-21-97	100	10-08-97	138	10-20-97	21	10-14-97	38
10-19-98	108	10-15-98	147	10-07-98	19	10-28-98	26
10-20-99	85	10-14-99	132	10-25-99	16	10-20-99	20
10-11-00	89	10-11-00	103	10-18-00	17	10-18-00	22
10-09-01	103	10-24-01	79	10-17-01	20	10-15-01	29
10-16-02	96	10-01-02	65	10-08-02	23	10-16-02	11
10-15-03	86	11-13-03	31	11-10-04	24	11-17-03	23
04-06-04	118	10-19-04	24	04-15-04	24	10-21-04	20
04-18-05	114	10-11-05	22	04-06-05	24	10-11-05	25

USGS 57		USGS 59		USGS 111		USGS 113	
Date	Concentration	Date	Concentration	Date	Concentration	Date	Concentration
10-24-80	80	10-24-80	37	–	–	–	–
10-05-81	100	10-06-81	37	–	–	–	–
10-06-82	140	10-06-82	47	–	–	–	–
10-13-83	130	10-13-83	60	–	–	–	–
10-10-84	64	10-10-84	26	–	–	–	–
10-29-85	42	10-30-85	40	11-05-85	50	11-01-85	67
11-14-86	64	11-14-86	35	10-27-86	100	10-27-86	110
10-09-87	67	10-06-87	23	09-25-87	120	10-02-87	150
10-05-88	74	10-21-88	24	10-04-88	120	09-27-88	160
12-22-89	67	10-23-89	22	10-04-89	120	10-06-89	160
10-29-90	85	10-12-90	44	09-24-90	140	10-03-90	180
10-24-91	120	10-21-91	190	10-25-91	110	10-08-91	170
10-06-92	160	10-23-92	67	10-09-92	130	10-22-92	200
10-12-93	180	10-25-93	44	10-21-93	140	10-23-93	220
10-03-94	170	11-01-94	47	10-13-94	130	10-17-94	210
10-11-95	150	10-23-95	150	10-26-95	100	10-17-95	190
10-18-96	200	10-29-96	75	10-17-96	160	10-18-96	230
10-14-97	185	10-22-97	71	10-28-97	159	10-16-97	238
10-06-98	161	10-27-98	29	10-26-98	145	10-15-98	220
10-05-99	134	10-06-99	22	10-06-99	132	10-19-99	204
10-05-00	91	10-02-00	21	10-03-00	98	10-18-00	171
10-25-01	117	10-18-01	66	10-18-01	101	10-10-01	175
10-17-02	125	10-16-02	170	10-10-02	92	10-02-02	175
11-05-03	60	04-07-03	35	11-05-03	98	11-04-03	141
10-13-04	44	11-17-04	23	04-19-04	98	04-12-04	127
10-12-05	25	04-05-05	22	04-06-05	103	04-06-05	NSM

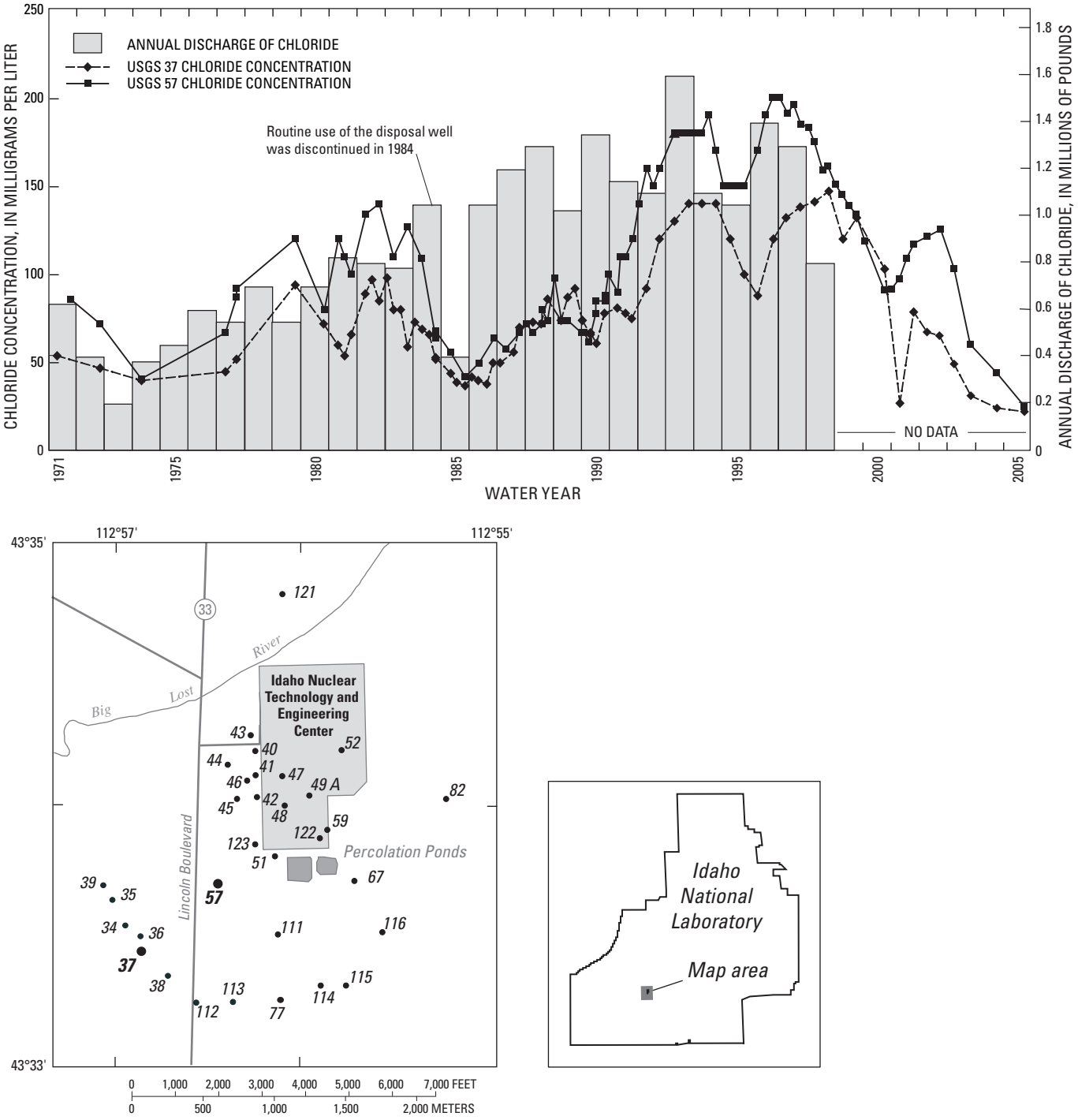


Figure 17. Amount of chloride in wastewater discharged to the disposal well and percolation ponds at the Idaho Nuclear Technology and Engineering Center (INTEC), and the location and amount of chloride in water from wells USGS 37 and USGS 57, Idaho National Laboratory (INL), Idaho, 1971–2005.

Nitrate

Wastewater containing nitrate was injected into the Snake River Plain aquifer through the INTEC disposal well from 1952 to February 1984 and discharged to the INTEC percolation ponds after February 1984 (Orr and Cecil, 1991). About 260,000 lb of nitrate were discharged to the INTEC percolation ponds during 1996–98, 220,000 lb of which were discharged during February 1996 (Bartholomay and others, 2000). The average annual discharge rate during 1996–98 was about 86,700 lb, about 50 percent of the discharge rate during 1986–88 and 30 percent of the rate during 1979–85 (Bartholomay and others, 2000). Annual discharge rates of nitrate for 1999–2005 have not been compiled. Concentrations of nitrate in ground water not affected by wastewater disposal from INL facilities generally are less than 5 mg/L (as nitrate) (Robertson and others, 1974, p. 73).

Concentrations of nitrite plus nitrate reported by the NWQL as nitrogen in milligrams per liter have been converted to nitrate in milligrams per liter because (1) nitrate concentrations for aquifer wells are reported as nitrate in this report so that comparisons between plume maps in this report and in previous reports can be made and (2) nitrite analyses indicate that almost all nitrite plus nitrate concentrations in water are nitrate at and near the INL.

Nitrate concentrations at the INL have changed in response to reduced disposal rates and the transition from injection of wastewater to the INTEC disposal well to percolation ponds in 1984. In 1981, the maximum nitrate concentration for wells near the INTEC was 62 mg/L (as nitrate) in water from well USGS 43 at the INTEC (Lewis and Jensen, 1985). By 1985, maximum concentrations in wells near the INTEC ranged from less than 5 to 27 mg/L (as nitrate) (Pittman and others, 1988, p. 61). By 1995, concentrations in wells near the INTEC ranged from less than 5 to 49 mg/L (as nitrate). In 1998, nitrate concentrations in samples from wells CFA 1, USGS 40, 43, and 77 (figs. 5 and 6) were 17, 14, 31, and 18 mg/L (as nitrate), respectively (Bartholomay and others, 2000). The 1998 concentrations represent either a continuation of or a decrease in concentrations from those reported in 1995 (Bartholomay and others, 1997, p. 41). In October 2001, concentrations in samples from these wells were 14, 16, 21, and 16 mg/L (as nitrate), respectively, generally similar to or less than the 1998 concentrations. The decreases could have resulted from dilution by recharge from the Big Lost River and long-term decreases in discharge rates.

In October 2005, concentrations of nitrate in water from wells USGS 41, 43, 45, 47, 52, 57, 67, 77, 112, 114, 115 near the INTEC, exceeded 5 mg/L (as nitrate) and concentrations ranged from 6 mg/L in well USGS 45 to 34 mg/L in well USGS 43.

Historically, nitrate concentrations in water from wells near the RWMC slightly exceeded the regional background concentration of about 5 mg/L (as nitrate) (Orr and Cecil, 1991) or 1 to 2 mg/L as nitrogen (Knobel and others, 1992). In 1998, nitrate concentrations in water samples from wells USGS 88, 89, and 119, near the RWMC, exceeded the expected background and were 7, 9, and 6 mg/L, respectively (as nitrate) (Bartholomay and others, 2000). In 2001, the concentrations of nitrate in water from wells USGS 88, 89, and 119 were relatively unchanged at 7, 8, and 6 mg/L (as nitrate), respectively. In 2005, concentrations of nitrate in water from wells USGS 88, 89, and 119 also remained relatively unchanged at 4, 8, and 7 mg/L (as nitrate), respectively. Near the RTC, the concentration of nitrate in water from well USGS 65 was 7 mg/L, a slight decrease from the 2001 concentration of 8 mg/L (as nitrate). Figure 18 shows the generalized distribution of nitrate concentrations in water samples collected in October 2005. All concentrations measured in 2005 were less than the MCL for drinking water of 44 mg/L [as nitrate, or 10 mg/L as nitrogen (U.S. Environmental Protection Agency, 2001)].

Fluoride

About 39,710 lb of fluoride in wastewater was discharged to percolation ponds at the INTEC during 1971–98 (Bartholomay and others, 2000). Background concentrations of fluoride in the Snake River Plain aquifer in the southwestern part of the INL range from about 0.1 to 0.3 mg/L (Robertson and others, 1974, p. 75). Amounts of fluoride discharged since 1998 have not been compiled.

As part of the INL ground-water monitoring program adopted in 1994, the USGS began analyzing samples collected near the INTEC for concentrations of fluoride. During April through October 2005, water samples from five wells were analyzed for fluoride; detected concentrations ranged from 0.2 to 0.3 mg/L. These concentrations are similar to the background concentrations reported by Robertson and others (1974), which indicates that wastewater disposal has not had an appreciable affect on fluoride concentrations in the Snake River Plain aquifer near the INTEC. The LRL for fluoride was set at 0.16 mg/L beginning October 16, 2000, revised to 0.11 mg/L on October 1, 2001, and to 0.10 mg/L on October 1, 2004. The previous MRL was 0.1 mg/L.

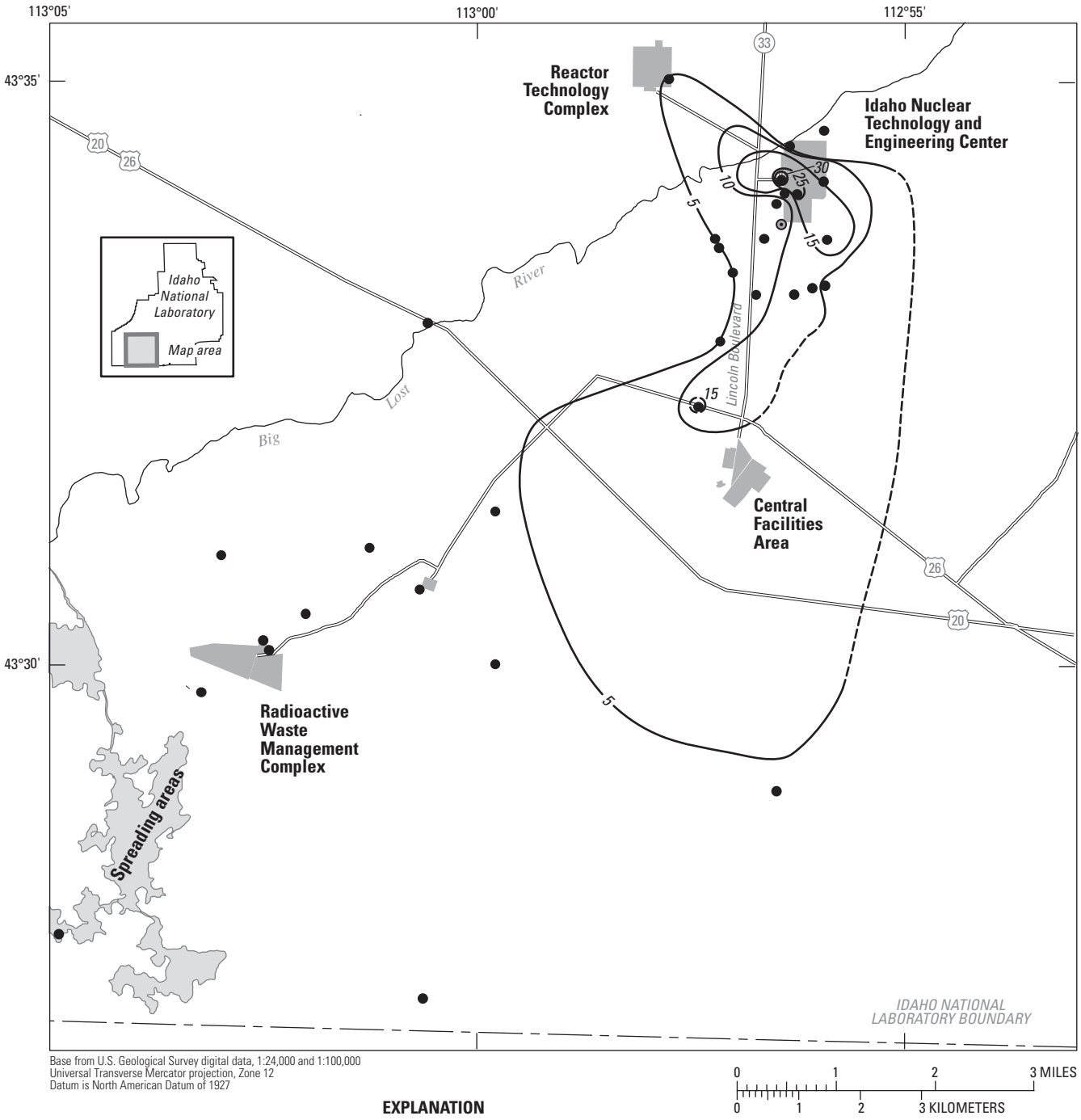


Figure 18. Distribution of nitrate in water from wells at and near the Reactor Technology Complex (RTC), Idaho Nuclear Technology and Engineering Center (INTEC), Central Facilities Area (CFA), and Radioactive Waste Management Complex (RWMC), Idaho National Laboratory (INL), Idaho, October 2005.

Trace Elements

As part of the INL ground-water monitoring program adopted in 1994 and several special sampling programs, water samples from several wells were collected and analyzed for various trace elements during 2002–05. These trace elements were aluminum, antimony, arsenic, barium, beryllium, cadmium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, uranium, vanadium, and zinc. A summary of background concentrations of selected constituents in Snake River Plain aquifer water samples is presented in Knobel and others (1992, p. 52). Because the amounts of each constituent in wastewater discharged from INL facilities have not been compiled annually from monitoring data since 1998, these amounts are unavailable for 2002–05.

Beginning in 1998, the NWQL began implementing new reporting procedures based on long-term method detection levels (LT-MDLs) for some analytical methods (Childress and others, 1999). This change in LRLs (as opposed to MRLs) for some elements accounts for concentrations of some elements detected during 1999–2005, although historically the concentrations were less than the MRL. Table 9 presents a summary of disposal data, disposal periods, and trace element concentration ranges in water samples analyzed during 2002–05 by the USGS.

Table 9. Trace elements disposed during various periods, number of wells sampled, and range of concentrations detected, Idaho National Laboratory, Idaho, 2002–05.

[Because the amounts of each constituent in wastewater discharged from INL facilities have not been compiled annually from monitoring data since 1998, no amounts are available for 1999–2005. **Amount disposed, disposal period,** and **disposal facility** from Bartholomay and others, 2000. **Abbreviations**: LRL, Laboratory Reporting Level; NR, none recorded; ND, not detected; INL, Idaho National Laboratory; INTEC, Idaho Nuclear Technology and Engineering Center; NWQL SH/LC, National Water Quality Laboratory Schedule/Lab Code; lb, pound; µg/L, microgram per liter. **Symbol:** < less than]

Constituent	Approximate amount disposed (lb)	Disposal period	Disposal facility	Number of wells sampled at the INL 2002–05	Range of concentrations (µg/L)	LRL(s) used 2002–05 (µg/L)	NWQL SH/LC
Aluminum	117	1995–98	INTEC	13	1.43–5.66	1.00,1.6 or 15	SH 1050
Antimony	NR	NR	INL	9	0.12–0.19	0.048, 0.05, 0.2,0.3	SH 1050
Arsenic	11	1971–98	INL	10	1.59–3.16	1.9, 2	SH 1281, LC 2160
Barium	4,740	1971–98	INL	13	14.9–70.5	0.050,0.2	SH 1050, SH 1281
Beryllium	<1	1971–98	INL	10	ND	0.06	SH 1050
Cadmium	22	1971–98	INL	10	0.04–028	0.037, 0.04	SH 1050, SH 1281
Cobalt	NR	NR	INL	10	0.04–0.31	0.04	SH 1050
Copper	81	1995–98	INTEC	10	0.23–9.7	0.4	SH 1050
Iron	752	1995–98	INTEC	9	0.18–1.0	10	SH 1254, LC 645
Lead	556	1971–98	INL	12	0.32–15.57	0.08	SH 1050, SH 1281
Lithium	NR	NR	INL	4	2.6–24.4	0.3, 0.5, 0.6	SH 1254
Manganese	44	1995–98	INTEC	13	0.19–6.2	0.1, 0.18, 0.2	SH 1050
Mercury	141	1971–98	INL	13	ND	0.011, 0.018, 0.020, 0.010	SH 1281, LC 2707
Molybdenum	NR	NR	INL	11	0.98–6.3	0.1, 0.17, 0.2	SH 1050
Nickel	NR	NR	INL	10	0.07–4.3	0.06	SH 1050
Selenium	9	1971–98	INL	4	1.18–2.46	2.0, 2.6	SH 1281, LC 2161
Silver	190	1971–98	INL	10	ND	1.0, 0.2	SH 1050, SH 1281
Strontium (stable)	NR	NR	INL	4	164.8–259.6	0.08, 0.2, 0.4	SH 1254
Thallium	NR	NR	INL	5	ND	0.041, .04	LC 2508
Uranium	NR	NR	INL	9	1.4–2.9	0.018-0.04	SH 1050
Vanadium	NR	NR	INL	2	4.6–4.8	0.21, 0.13, 0.14	LC 2509
Zinc	5,240	1971–98	INL	13	0.67–472.4	0.6	SH 1050

Volatile Organic Compounds

Volatile organic compounds (VOCs) are present in water from the Snake River Plain aquifer because of waste-disposal practices at the INL. In 1987, water samples from 81 wells completed in the Snake River Plain aquifer at and near the INL were analyzed for 36 VOCs as part of a reconnaissance sampling program (Mann and Knobel, 1987). Analyses indicated that concentrations of from 1 to 12 VOCs in samples from 45 wells exceeded their reporting levels. The prevalent compounds were trichloroethylene, 1,1,1-trichloroethane, toluene, tetrachloroethylene, carbon tetrachloride, chloroform, 1,1-dichloroethylene, and dichlorodifluoromethane. In 1988 and 1989, water samples were collected from 38 wells as a continuation of the 1987 study (Mann, 1990). Concentrations of from 1 to 19 VOCs, primarily carbon tetrachloride, 1,1,1-trichloroethane, and trichloroethylene, in water samples from 22 wells exceeded the MRLs. In 1990 and 1991, water samples were collected from 76 wells for various water-quality studies at or near the INL (Liszewski and Mann, 1992). Concentrations of from 1 to 14 VOCs, primarily carbon tetrachloride, 1,1,1-trichloroethane, and trichloroethylene, in water samples from 31 of these wells exceeded the MRLs. During 1992–95, water samples were collected from 54 wells at or near the INL for various water-quality studies (Greene and Tucker, 1998). Concentrations of from 1 to 14 VOCs, primarily carbon tetrachloride, 1,1,1-trichloroethane, trichloroethylene, and chloroform, in water samples from 23 of these wells exceeded the MRLs. During 1996–98, water samples were collected from 44 wells at or near the INL for various water-quality studies. Concentrations of from 1 to 12 VOCs, primarily carbon tetrachloride, 1,1,1-trichloroethane, trichloroethylene, chloroform, and tetrachloroethylene, in water samples from 15 of these wells exceeded the MRLs (Bartholomay and others, 2000). During 1999–2001, water samples from 36 wells at and near the INL were analyzed for VOCs. Ten VOCs were detected. Concentrations of from 1 to 5 VOCs, primarily carbon tetrachloride, 1,1,1-trichloroethane, trichloroethylene, chloroform, and tetrachloroethylene, in water samples from 17 of these wells exceeded the MRLs. The MRL for some VOCs was revised from 0.2 to 0.1 µg/L during 1998–2001, a change that resulted in detections of smaller concentrations than in previous years.

During 2002–05, water samples from 30 wells were collected and analyzed for VOCs. Twelve VOCs were detected. Concentrations of from 1 to 9 VOCs were detected in water samples from 13 wells. The primary VOCs detected included carbon tetrachloride, chloroform, 1,1-dichloroethane, 1,1,1-trichloroethane, trichloroethylene, and tetrachloroethylene.

A plume of 1,1,1-trichloroethane, a solvent used in industrial cleaning processes (Lucius and others, 1989, p. 450), has developed in the Snake River Plain aquifer near the INTEC because of waste-disposal practices (Bartholomay and others, 1995). During 1992–95, water samples were collected from 10 wells near the INTEC that previously contained water with concentrations of 1,1,1-trichloroethane exceeding the MRL. Concentrations in water from 8 of the 10 wells exceeded the MRL (Bartholomay and others, 1997). During 1996–98, water samples were collected from three wells near INTEC that previously contained water with concentrations of 1,1,1-trichloroethane exceeding the MRL; concentrations in water from all three of the wells exceeded the MRL.

During 2004–05, concentrations of 1,1,1-trichloroethane in water from wells USGS 34, 38, 65, and 77, south of the INTEC, exceeded the MRL. The concentrations in water from wells USGS 34 and 38 were 0.10 and 0.11 µg/L, respectively. The concentrations in water in wells USGS 65 and 77 were 0.14 and 0.2 µg/L, respectively. The MRL for 1,1,1-trichloroethane varied between 0.2 to 0.1 µg/L during 2002–05. The detection of these small concentrations resulted from the lower MRL. All 1,1,1-trichloroethane concentrations were less than the MCL for drinking water of 200 µg/L (U.S. Environmental Protection Agency, 2001). Water from wells USGS 65 and 77 also contained concentrations of 1,1-dichloroethylene ranging from 0.10 to 0.18 µg/L during 2002–05.

During 1996–98, concentrations of VOCs in water samples from several wells at and near the RWMC exceeded the reporting levels (Bartholomay and others, 2000). For example, in October 1998, water from the RWMC Production Well contained 4.5 µg/L of carbon tetrachloride, 0.8 µg/L of chloroform, 0.5 µg/L of 1,1,1-trichloroethane, 2.1 µg/L of trichloroethylene, and 0.18 µg/L of tetrachloroethylene (Bartholomay and others, 2000). In December 2005, 9 VOCs were detected in water from the RWMC Production Well. Reported concentrations were 6.3 µg/L of carbon tetrachloride, 1.7 µg/L of chloroform, 0.52 µg/L of 1,1,1-trichloroethane, 3.2 µg/L of trichloroethylene, and 0.28 µg/L of tetrachloroethylene. Concentrations of all these VOCs increased since October 2001. A plot of carbon tetrachloride concentrations in water from the RWMC Production Well (fig. 19) indicates that concentration trends generally have increased with time. Water from the RWMC Production Well also yielded detections of 0.20 µg/L of xylene, 0.33 µg/L of bromodichloromethane, 0.73 µg/L of dibromochloromethane, and 1.6 µg/L of tribromoethane.

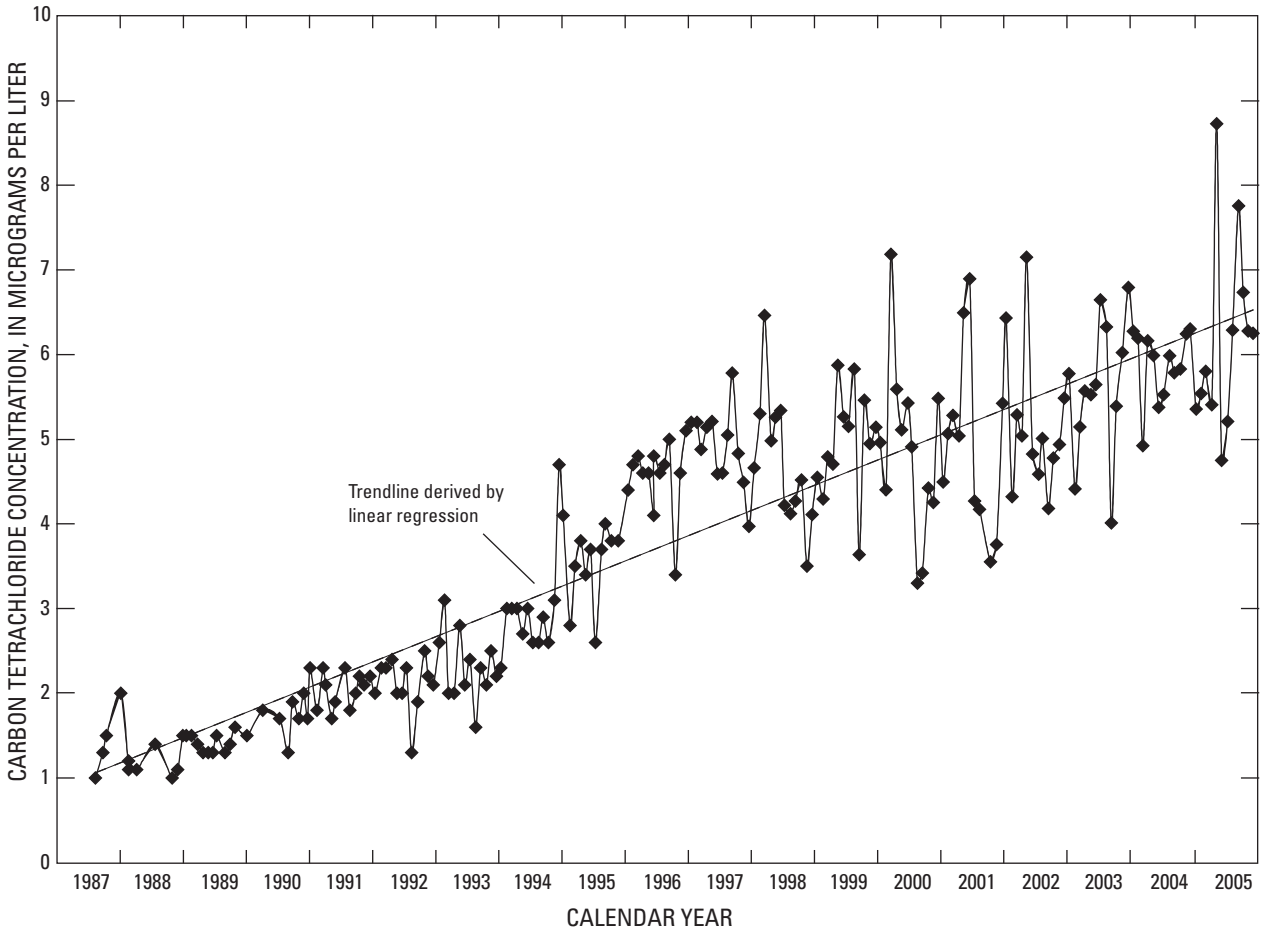


Figure 19. Carbon tetrachloride concentrations in water from the Radioactive Waste Management Complex (RWMC) Production Well, Idaho National Laboratory (INL), Idaho, 1987–2005.
Location of RWMC Production Well is shown in figure 6.

In April 2005, concentrations of carbon tetrachloride, 1,1,1-trichloroethane, tetrachloromethane, trichloroethylene, and chloroform in water from well USGS 87 (fig. 6) exceeded the reporting levels. Concentrations of carbon tetrachloride, trichloroethylene and chloroform in water from well USGS 88 (fig. 6) also exceeded the reporting levels in October 2005. In April 2004, concentrations of carbon tetrachloride, 1,1,1-trichloroethane, trichloroethylene, and chloroform in water from well USGS 120 (fig. 6) exceeded the reporting level. In April 2002, concentrations of carbon tetrachloride exceeded the reporting level in water from well USGS 119, south of the RWMC.

During 1987–89, concentrations of from 1 to 15 VOCs in water from 10 wells near the TAN exceeded their reporting levels (Mann and Knobel, 1987; Mann, 1990). Water samples from TAN wells were not collected by the USGS during 1990–93 because the wells were not part of routine sampling. During 1994–95, samples from six wells near the TAN were collected and analyzed as part of the INL ground-water monitoring program (Sehlke and Bickford, 1993). One sample from the well No Name 1 (formerly called TAN Expl. Well; fig. 2) contained 1.1 µg/L of isopropylbenzene. One sample from well ANP 9 (fig. 2) contained 11 µg/L of toluene (Bartholomay and others, 1997). During 1996–98, samples

were collected from five wells near TAN as part of the USGS ground-water monitoring program. No VOC concentrations exceeded their reporting levels. Additionally, water from well USGS 24 (fig. 2) was analyzed in 1996 and concentrations of nine VOCs exceeded their reporting levels. Concentrations of two of these VOCs, 990 µg/L of trichloroethylene and 46 µg/L of tetrachloroethylene, exceeded their respective MCLs of 5 µg/L for drinking water (U.S. Environmental Protection Agency, 1998; Bartholomay and others, 2000). During 2002–05, water samples from three wells near TAN (ANP 9, No Name 1, and PSTF Test) (fig. 2) were sampled for VOCs. Concentrations of VOCs in water from these wells were all less than the MRL with the exception of chloroform, detected in all three wells. Concentrations ranged from 0.14 to 0.2 µg/L.

Total Organic Carbon

Analyses of total organic carbon (TOC) are used to screen for organic compounds in the aquifer as a general indicator of ground-water contamination. As part of the INL ground-water monitoring program adopted in 1994, the USGS began collecting and analyzing water from several wells at the INL for TOC. During October 2005, water samples from 21 wells completed in the Snake River Plain aquifer at the INL were analyzed for TOC; detected concentrations ranged from 0.44 to 8.0 mg/L. The LRL for TOC was set at 0.27 mg/L beginning October 1, 1999, and revised to 0.6 mg/L beginning October 20, 2000. The previous MRL was 0.1 mg/L. The MRL was set to 0.4 mg/L in October 2002.

Specific Conductance, Temperature, and pH

Specific conductance is a measure of the electrical conductivity of water and is proportional to the quantities of dissolved chemical constituents in the water. Dissolved chemical constituents such as chloride, sodium, and sulfate in wastewater discharged to disposal wells and infiltration ponds at INL facilities generally have increased the specific conductance of ground water through time.

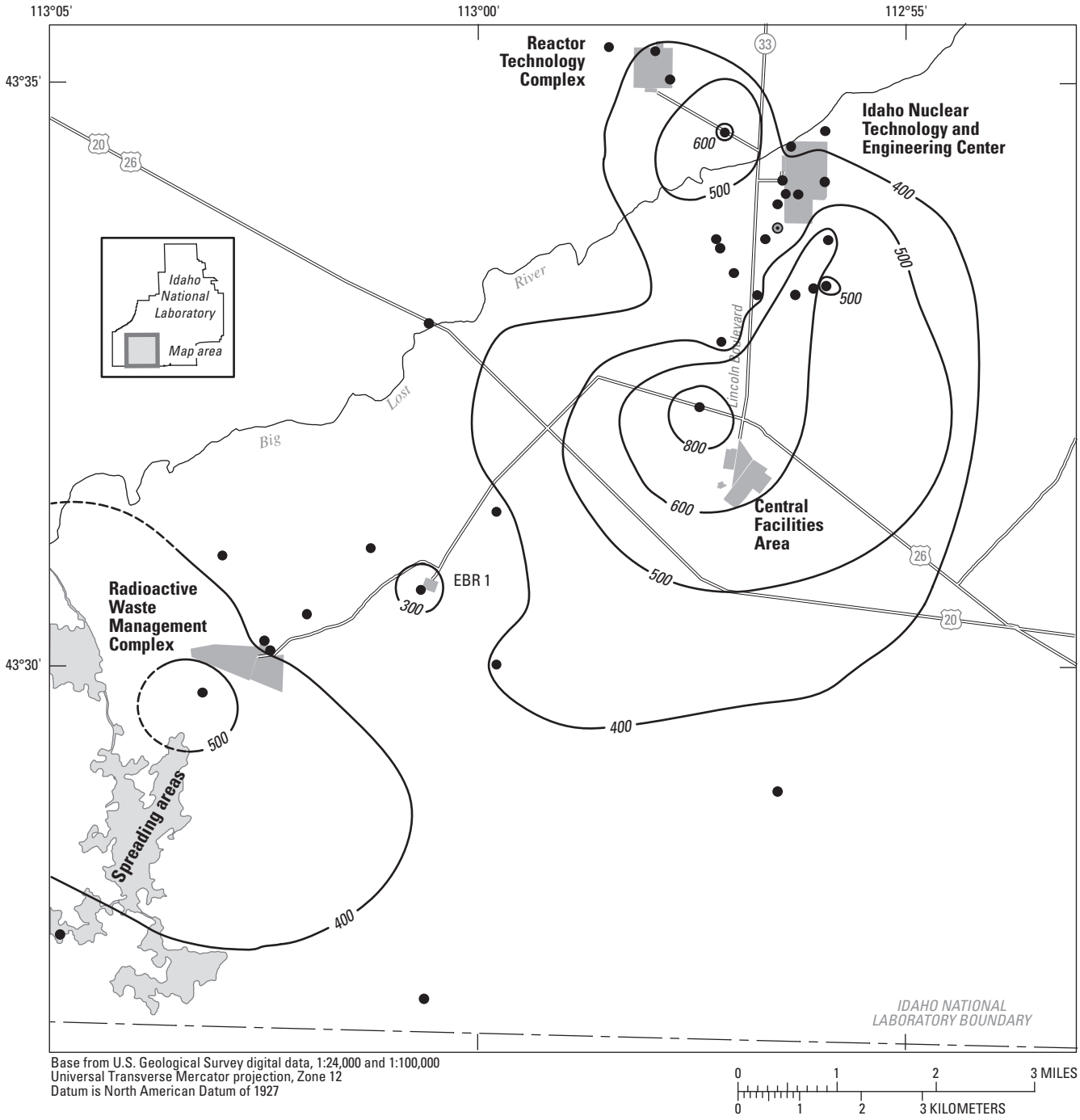
The general increase in specific conductance in ground water attributed to wastewater discharged to the aquifer since the mid-1980s is apparent in ground water downgradient from INL facilities. A plume of increased specific conductance originated from the INTEC percolation ponds (fig. 6) and extended downgradient from the INTEC to the CFA (fig. 20). The specific conductance of water from several wells within this plume increased from about 500 µS/cm in 1985 (Pittman and others, 1988, p. 64) to more than 1,000 µS/cm in 1998, but decreased to about 960 µS/cm by 2001 in water from well USGS 51. This decreasing trend continued during 2002–05; the maximum specific conductance measured in well CFA LF 3-9 (fig. 6) was 819 µS/cm in October 2005. Specific conductance of water from well USGS 113 (fig. 6) was 1,080 µS/cm in October 1998, decreased to 937 µS/cm in October 2001, and continued to decrease to 774 µS/cm by April 2004. No measurements are available from well USGS 113 for 2005 because the well was out of service for pump maintenance.

The specific conductance of water from several wells at the RTC exceeded 400 µS/cm in 2005. Specific conductance of water from well USGS 65 (fig. 6), downgradient from the infiltration ponds at the RTC, was 607 µS/cm in April 2005. Maximum specific conductance measured in water from well USGS 88, near the RWMC, was 570 µS/cm in October 2005, a slight decrease from the October 2001 measurement of 581 µS/cm.

In 2005, the specific conductance of water from 126 wells ranged from 234 to 819 µS/cm; the median specific conductance was 389 µS/cm. This represents a decrease in overall specific conductance values since 2001 when the range for 126 wells was 262–960 µS/cm and the median specific conductance was 402 µS/cm.

During each year, 2002–05, water temperature and pH were measured in water from 127, 130, 128, and 126 wells at the INL, respectively. The lowest water temperatures were consistently in well P&W 2 (fig. 5), ranging from 7.7 to 8.2°C. The highest water temperatures were consistently in well USGS 7, ranging from 18.9 to 19.5°C. The median water temperature for all wells sampled each year, 2002–05 was 12.9, 12.8, 12.8, and 12.9°C, respectively, a slight decrease from the 1999–2001 reporting period when the median was 13.0°C for each year.

In 2002, pH ranged from 7.5 in well USGS 4 (fig. 5) to 8.5 in well USGS 88 (fig. 6). In 2003, pH ranged from 7.2 in water from the RWMC Production Well to 8.4 in water from well USGS 119 (fig. 6). In 2004, pH ranged from 7.4 in water from the RWMC Production Well to 8.4 in water from well USGS 89 (fig. 6). In 2005, the pH ranged from 7.1 in well USGS 4 (fig. 5) to 8.8 in well USGS 119 (fig. 6). The median pH in water from all wells for each year 2002–05 was 8.0, 7.9, 7.9, and 7.6, representing a slight decrease in pH from the 1999-2001 reporting period when median pH was 8.0 each year.



EXPLANATION

400 — **LINE OF EQUAL SPECIFIC CONDUCTANCE MEASUREMENTS**—October 2005. Lines of equal concentration were interpreted from analyses of samples collected from a 3-dimensional flow system. Mapped concentrations represent samples collected from various depths in boreholes with differing well completions; for example, single- and multiple- screened intervals, and open boreholes. Location is approximate. Interval, in microsiemens per centimeter, is variable.

WELL IN THE USGS AQUIFER WATER-QUALITY MONITORING NETWORK— Samples measured for specific conductance.

SPECIFIC CONDUCTANCE MEASUREMENT LESS THAN LINE OF EQUAL CONCENTRATION

Figure 20. Distribution of specific conductance of water from wells at and near the Reactor Technology Complex (RTC), Idaho Nuclear Technology and Engineering Center (INTEC), Central Facilities Area (CFA), and Radioactive Waste Management Complex (RWMC), Idaho National Laboratory (INL), Idaho, October 2005.

Selected Radiochemical and Chemical Constituents and Physical Properties of Water in Perched Ground Water

Wastewater-disposal sites at INL facilities are the primary sources of radiochemical and chemical constituents in ground water at the INL. These sites included infiltration ponds and ditches, lined evaporation ponds, drain fields, pits, and disposal wells. During 2002–05, 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. Davis (2006b) provides detailed information on waste disposal amounts and types of constituents discharged at each facility.

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.

Reactor Technology Complex

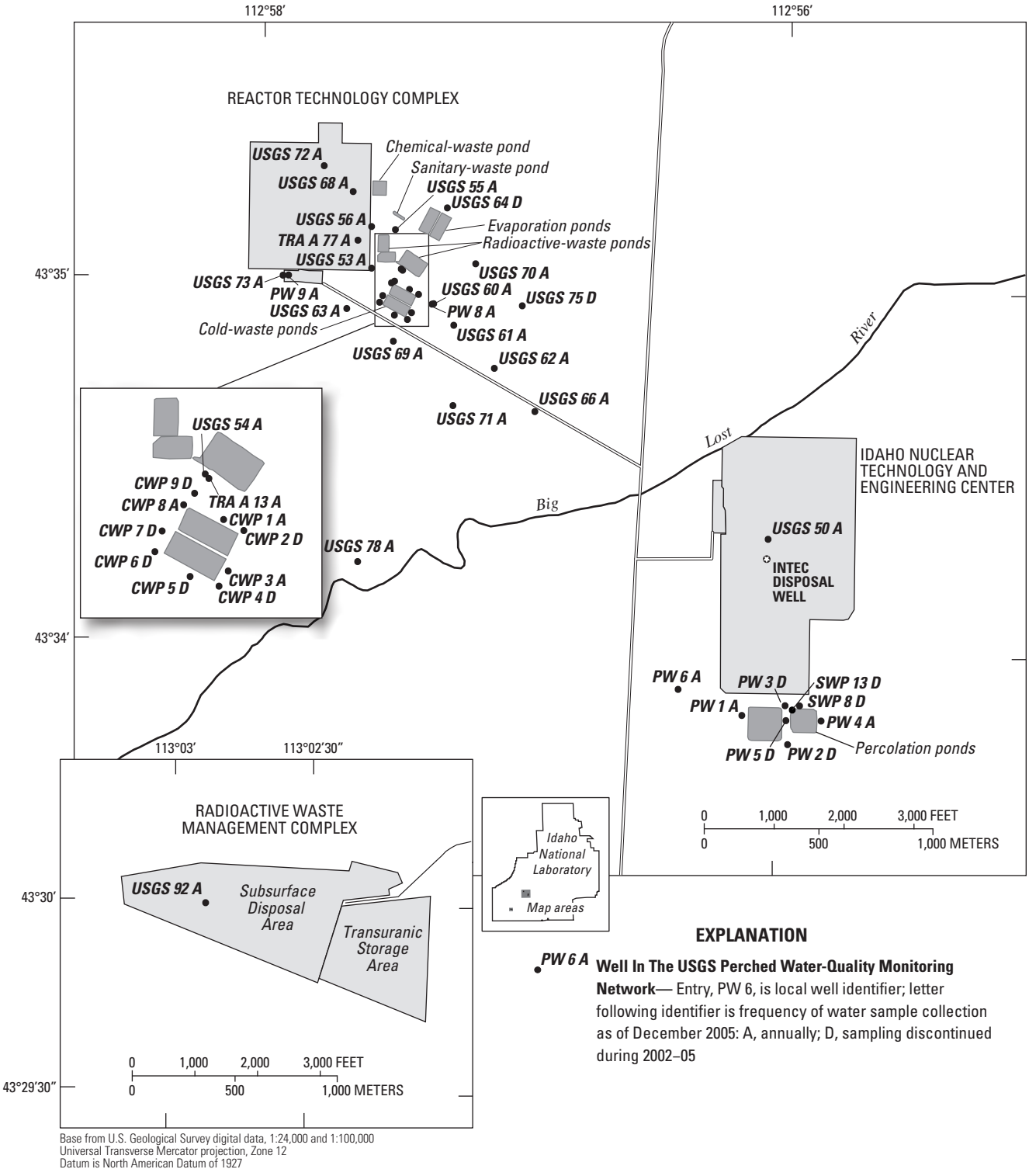
Bodies of shallow and deep perched ground water formed at the RTC in response to wastewater disposal to radioactive-, chemical-, cold-, and sanitary-waste ponds (fig. 4). Selected radiochemical and inorganic chemical constituents in wastewater have been monitored in the shallow and deep perched ground water since the early 1960s.

Water samples from five wells (CWP 1, 3, 8, TRA A 13, and TRA A77) (fig. 21) completed in shallow perched ground water near the RTC routinely were collected and analyzed for selected radiochemical and chemical constituents during 2002–05. Wells TRA A 13 and TRA A 77 were dry during this period, and no samples could be collected. Water samples also were collected from 18 wells (PW,8, 9, USGS 53 through 56, 60 through 63, 66, 68 through 73, 78) (fig. 21) completed in deep perched ground water beneath the RTC. Sampling was discontinued at many perched water wells during the 2002–05 reporting period because of lack of water in the wells (fig. 21). Selection of radiochemical and chemical constituents for analyses was based on waste-disposal history at the RTC. Selected radiochemical constituents were tritium, strontium-90, and gamma analyses (which may yield detections of cesium-137, cobalt-60, or chromium-51); chemical constituents were dissolved chromium, sodium, chloride, and sulfate.

Tritium

Well TRA A 77 (fig. 21) is completed in shallow perched ground water in alluvium near the RTC retention basin (fig. 22), where radioactive wastewater flowed before it was discharged to the radioactive-waste infiltration ponds (fig. 21). 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). By 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 resulted from changes in tritium disposal rates (Bartholomay, 1998, p. 10). No samples were collected from well TRA A 77 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. No samples were collected from this well after April 2001 because of equipment problems. The decrease in tritium concentrations in well TRA A 13, between the radioactive-waste infiltration ponds and the cold-waste ponds (fig. 21), likely is attributed to the large quantity of nonradioactive water discharged to the cold-waste ponds (Bartholomay and Tucker, 2000).



Base from U.S. Geological Survey digital data, 1:24,000 and 1:100,000
Universal Transverse Mercator projection, Zone 12
Datum is North American Datum of 1927

Figure 21. Location of wells in the U.S. Geological Survey perched water-quality monitoring network at the Reactor Technology Complex (RTC), Idaho Nuclear Technology and Engineering Center (INTEC), and Radioactive Waste Management Complex (RWMC), Idaho National Laboratory (INL), Idaho, and frequency of water-sample collections, as of December 2005.

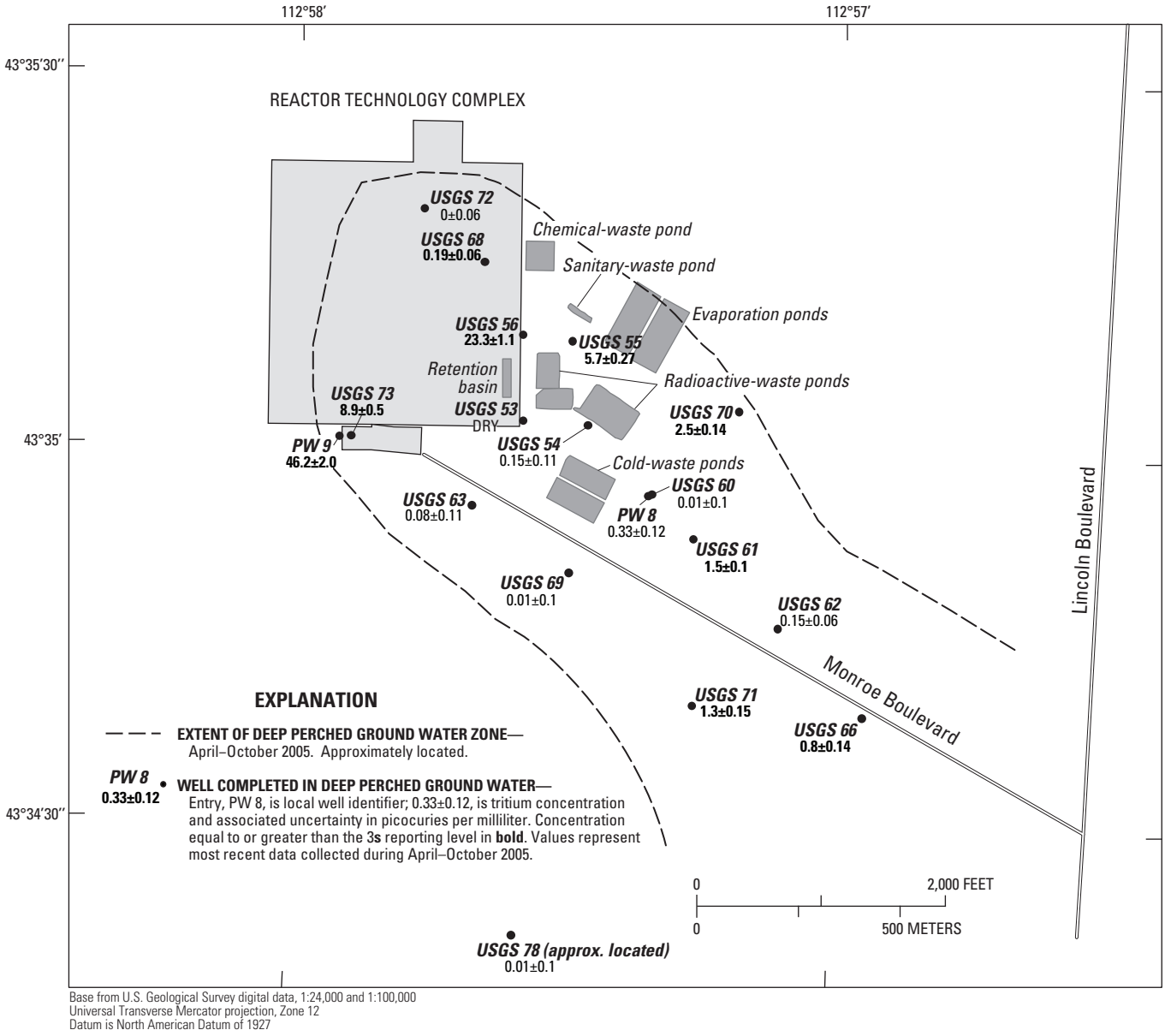


Figure 22. Concentrations of tritium in water from wells completed in deep perched ground water, Reactor Technology Complex, Idaho National Laboratory, Idaho, April–October 2005.

Wells CWP 1 through CWP 9 monitor shallow perched ground water around the cold-waste ponds at the RTC. Discharge of cooling-tower wastewater to the TRA disposal well ceased in 1982 and this water subsequently was discharged to the cold-waste ponds. During 1982–2005, 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. 21) 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. 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). Lack of available perched water to sample, and the history of non-reportable values of tritium in most of these wells resulted in the decision to remove wells CWP 2, 4, 5, 6, 7, and 9 from the sampling schedule at various times during 2002–05 (fig. 21).

Tritium concentrations in water from nine wells completed in deep perched ground water (PW 9, USGS 53, 55, 56, 61, 66, 70, 71, and 73) generally were greater than the reporting levels during at least one sampling event during 2002–05. Concentrations decreased in some wells and varied randomly in other wells (table 10). Tritium concentrations in water from six wells (USGS 60, 62, 63, 69, 72, and 78) were less than the reporting level during 2002–05 (table 10). Tritium concentrations varied between reportable and nonreportable concentrations in water from three wells, PW 8, USGS 54 and 68, during 2002–05 (table 10).

During April–October 2005, the most recent tritium concentrations in water from eight wells completed in deep perched ground water at the RTC exceeded the reporting levels (fig. 22; table 10). Tritium concentrations ranged from 0.19±0.06 pCi/mL (well USGS 68) to 46.2±2.0 pCi/mL (well PW 9). During April–October 2005, reportable tritium concentrations in water from wells completed in deep perched ground water (fig. 22) were less than concentrations measured during July–October 2001, with the exception of well PW 9, which was slightly higher (Davis, 2006b, fig. 5).

Water samples collected in October 2005 from wells USGS 73 and PW 9 contained tritium concentrations of 8.9±0.5 and 46.2±2.0 pCi/mL, respectively. These concentrations represent a decreasing trend since 1993 when the radioactive-waste infiltration ponds were taken out of service. Water in well USGS 74 (not shown in figures) contained 93.1±1.7 pCi/mL in April 1992; however, no samples have been collected since 1992 because the well was dry and 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. 21). 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. 23) 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. 23). Water levels in all four wells decreased significantly in 1992 (fig. 23), 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 also can be demonstrated because 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. Water was present and samples were collected from well USGS 53 in October 2003; the concentration of tritium was above the reporting level at 3.1±0.2 pCi/mL. However, this was a significant decrease in concentration from the sample analyzed in October 1995, which had a concentration of 126±4 pCi/mL. Samples also were collected from well USGS 56 in October 2004 and 2005, with concentrations above the reporting level at 23.3±0.9 and 23.3±1.1 pCi/mL, respectively. These concentrations were a significant decrease from the last sample analyzed in April 1997, which had a concentration of 148±5 pCi/mL.

Table 10. Concentrations of tritium, strontium-90, and cesium-137 in perched ground water from selected wells, Reactor Technology Complex, Idaho National Laboratory, Idaho, 2002–05.

[**Well No.:** Locations of wells are shown in figure 7. 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; NR, analysis not requested; pCi/mL, picocurie per milliliter; pCi/L, picocurie per liter; 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)	07-22-2002	-0.05±0.13	0.4±0.6	NR
	07-22-2003	0.08±0.1	0.7±0.6	NR
	10-25-2004	-0.01±0.13	**2±0.6**	NR
	10-18-2005	-0.1±0.1	1±0.9	NR
CWP 3 (SP)	07-22-2002	-0.15±0.13	-0.1±0.6	NR
	07-22-2003	0.17±0.11	-0.1±0.6	NR
	04-21-2004	-0.04±0.11	0.4±0.7	NR
	04-27-2005	-0.07±0.05	-1.1±0.7	NR
CWP 8 (SP)	07-22-2002	-0.13±0.13	1.4±1	NR
	07-23-2003	0.11±0.1	**6.4±1.2**	NR
	10-25-2004	0.07±0.13	1.4±0.6	NR
	10-18-2005	0±0.1	0.8±0.9	NR
PW 8 (DP)	04-02-2002	0.38±0.14	**6.7±0.8**	-40±20
	04-14-2003	**1.9±0.2**	**2.5±0.7**	10±20
	11-06-2003	0.08±0.11	**6.4±0.6**	NR
	10-25-2005	0.33±0.12	**5.5±0.9**	-20±30
PW 9 (DP)	04-02-2002	**38.7±0.8**	0.9±0.8	12±24.8
	10-02-2002	**36.7±0.8**	1±0.5	NR
	04-01-2003	**31.9±0.8**	0±0.6	12.2±37.8
	11-06-2003	**33.4±0.6**	0.9±0.5	NR
	10-25-2005	**46.2±2.0**	0±0.8	0±30
USGS 53 (DP)	10-08-2003	**3.1±0.2**	**48.7±1.4**	10±20
USGS 54 (DP)	04-02-2002	**0.49±0.14**	**60.8±1.8**	0±30
	10-07-2002	**0.48±0.15**	SL	-20±30
	04-03-2003	0.05±0.13	**61.4±1.9**	30±20
	10-15-2003	0.05±0.11	**52.2±1.6**	NR
	10-26-2004	-0.03±0.13	**50.9±1.4**	-20±30
	10-19-2005	0.15±0.11	**71.7±1.8**	-12.7±24.3
USGS 55 (DP)	10-24-2002	**35±0.8**	**37.2±1.3**	NR
	04-03-2003	**11.8±0.5**	**45±1.5**	30±16
	10-15-2003	**6.1±0.3**	**42.9±1.4**	NR
	10-27-2004	**6.7±0.4**	**62.8±1.6**	14.3±35.8
	04-19-2005	**5.7±0.27**	**66±1.8**	40±20
USGS 56 (DP)	10-19-2004	**23.3±0.9**	**18.5±1**	-30±40
	10-20-2005	**23.3±1.1**	**58.4±1.6**	40±30
USGS 60 (DP)	04-02-2002	0.09±0.12	**3.1±0.7**	30±20
	10-02-2002	-0.03±0.13	1.3±0.5	NR
	04-07-2003	-0.13±0.12	0.5±0.7	-10.2±27.9
	09-30-2003	-0.04±0.1	**2.4±0.6**	NR
	10-04-2004	-0.11±0.12	**4.1±0.8**	0±20
	10-04-2005	0.01±0.1	0.6±0.9	-10±30
USGS 61 (DP)	04-03-2002	**4.4±0.3**	1.3±0.7	15.7±24.9
	10-10-2002	**3.8±0.3**	1.1±0.5	NR
	04-08-2003	**3.2±0.3**	0.1±0.7	20±20
	10-15-2003	**2.9±0.2**	**1.7±0.5**	NR
	04-21-2004	**3±0.2**	1.2±1	0±30
	04-20-2005	**1.5±0.1**	-0.9±0.7	0±30
USGS 62 (DP)	04-03-2002	0.27±0.13	**3.5±0.7**	11.8±39.7
	10-16-2002	0.02±0.13	**2.7±0.6**	NR
	04-08-2003	0.06±0.13	**2.2±0.7**	10±20
	10-14-2003	0.12±0.11	1.2±0.6	NR
	04-21-2004	0.06±0.12	2.7±1	-10±30
	04-20-2005	0.15±0.06	0.6±0.7	30±30
USGS 63 (DP)	04-03-2002	0.09±0.12	0±2	0±20
	10-21-2002	-0.07±0.13	**2.1±0.6**	NR
	04-16-2003	0.12±0.14	1±0.6	0±30
	10-06-2003	-0.01±0.1	**2.3±0.5**	NR
	10-04-2004	0.03±0.13	**6.3±0.9**	40±20
	10-03-2005	0.08±0.11	**5.4±0.9**	10±30
USGS 66 (DP)	07-15-2002	**1.4±0.2**	-0.4±0.6	NR
	07-17-2003	**1.43±0.15**	-0.3±0.6	NR
	10-26-2004	**0.73±0.15**	**3.5±0.9**	-14.5±23.2
	10-26-2005	**0.8±0.14**	-0.3±0.8	0±20
USGS 68 (DP)	04-23-2002	0.04±0.13	1.3±0.7	-20±30
	10-23-2002	0.06±0.13	0.6±0.7	0±20
	04-07-2003	0.16±0.14	1.1±0.9	50±40
	10-15-2003	-0.01±0.1	1.1±0.7	-20±30
	04-14-2004	0.07±0.12	-0.4±1	20±20
	04-19-2005	**0.19±0.06**	1.4±0.7	40±30
USGS 69 (DP)	07-23-2002	-0.09±0.13	0.4±0.6	NR
	06-30-2003	0.13±0.1	-0.2±0.6	NR
	10-04-2004	-0.09±0.12	**2.4±0.8**	30±30
	10-03-2005	0.01±0.1	0.3±0.8	-10±20
USGS 70 (DP)	04-03-2002	**8±0.4**	**43.5±1.3**	-14.9±22.7
	10-09-2002	**3.7±0.3**	**40.9±1.3**	NR
	04-09-2003	**3.7±0.3**	**40.1±1.4**	-40±40
	10-15-2003	**2.3±0.2**	**30.5±1.1**	NR
	04-07-2004	**3.9±0.2**	**39.6±1.4**	20±20
	04-19-2005	**2.5±0.14**	**35.4±1.2**	0±20
USGS 71 (DP)	04-15-2002	**2±0.2**	-0.015±0.7	50±30
	10-08-2002	**1.7±0.2**	1±0.7	NR
	04-14-2003	**1.9±0.2**	0.1±0.7	30±30
	10-08-2003	**1.37±0.15**	0.4±0.6	NR
	10-26-2004	**1.4±0.2**	**3.7±0.8**	10.6±23.2
	10-18-2005	**1.3±0.15**	-0.4±0.8	12.4±26.5
USGS 72 (DP)	11-07-2002	-0.02±0.13	SL	0±20
	07-02-2003	0.09±0.1	0.3±0.7	-15.5±19.8
	04-14-2004	-0.03±0.11	-3.6±1.2	16.1±33.6
	04-19-2005	0±0.6	0.4±0.9	30±40
USGS 73 (DP)	04-11-2002	**12.8±0.4**	-1.7±0.7	30±30
	10-17-2002	**8.2±0.4**	0.9±0.6	NR
	04-14-2003	**16±0.5**	0.1±0.7	-20±40
	12-01-2004	**10±0.3**	**4.4±0.9**	12±22.4
	10-04-2005	**8.9±0.5**	1.2±0.8	0±20
USGS 78 (DP)	07-15-2002	-0.13±0.13	-0.5±0.5	NR
	07-17-2003	0.02±0.1	-1.1±0.6	NR
	10-26-2004	0.01±0.13	**3.1±0.8**	-11.3±28
	10-13-2005	0.01±0.1	1.3±0.9	-20±40

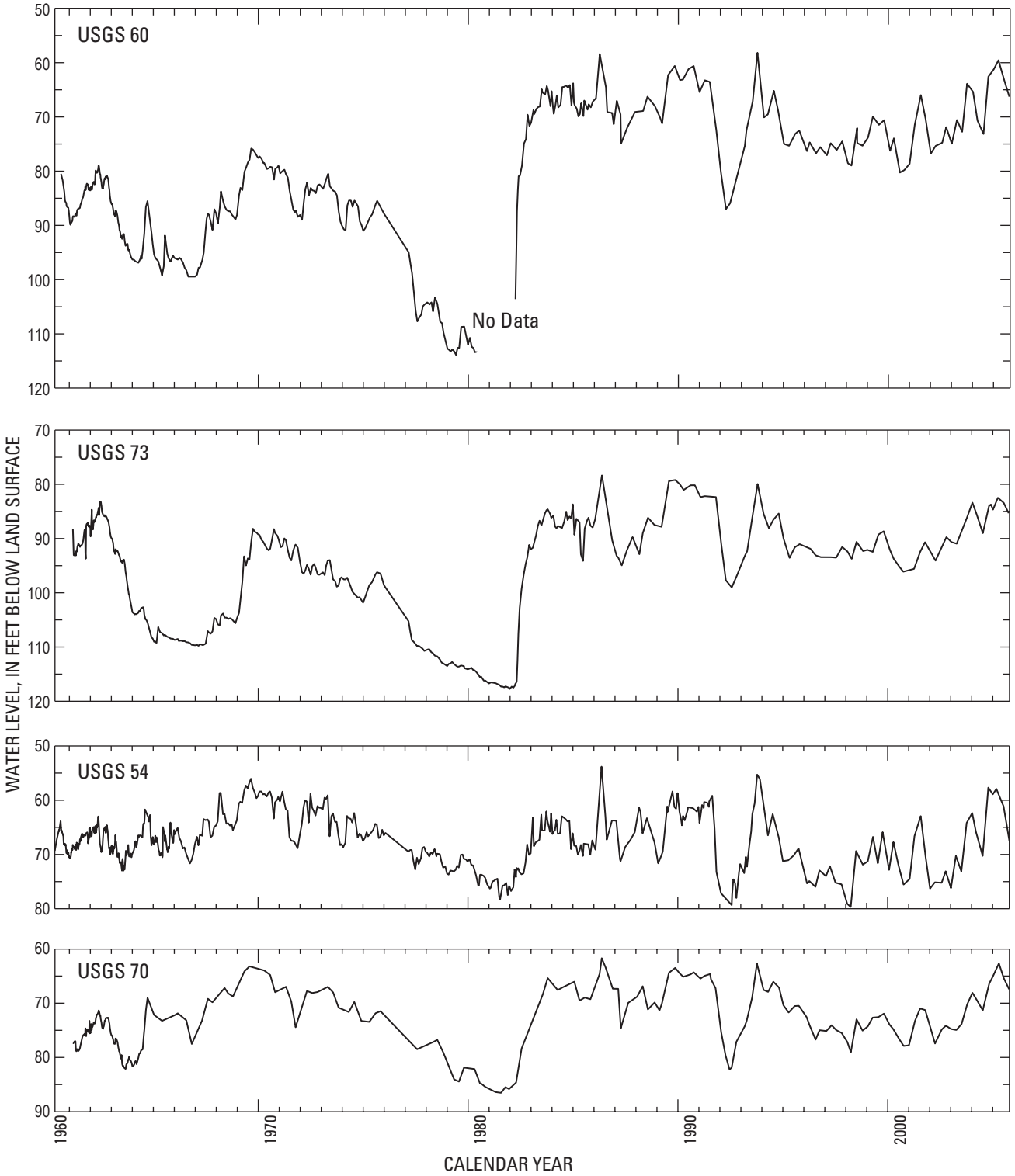


Figure 23. Water-level changes in selected wells, Reactor Technology Complex, Idaho National Laboratory, Idaho, 1960–2005.

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 affected the distribution of tritium in perched ground water at the RTC, including proximity of wells to the radioactive-waste infiltration ponds, depth of water below the ponds, variations in 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 perched water in some wells. Infiltration from the Big Lost River during 1999, early 2000, and 2005 may have contributed to diluted tritium concentrations in perched ground water southeast of the RTC . Tritium concentrations in wells USGS 54, 61, 62, 66, and 71 decreased slightly during 2002–05 (fig. 22, this report; Davis, 2006b, fig. 5).

Strontium-90

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 1999–2005 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, consistent with the October 1998 concentration. The well was not sampled in October 2001–05 because of an obstruction in the well, or the well was dry. 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 and in October 2004 with a concentration of 2.0±0.6. However, the concentrations of strontium in this well varied between reportable and non-reportable concentrations during 2000–05 (table 10, this report; Davis, 2006b, table 2).

During April through October 2005, concentrations of strontium-90 in water from wells PW 8, USGS 54, 55, 56, 63, and 70, completed in deep perched ground water at the RTC were greater than reporting levels (table 10 and fig. 24); concentrations ranged from 5.4±0.9 pCi/L in well USGS 63 to 71.7±1.8 pCi/L in well USGS 54. The concentration was slightly higher than the October 2001 concentration in water from well USGS 63 and slightly lower in water from well USGS 54. The distribution of strontium-90 concentrations in water from these wells during 2002–05 is attributed to exchange reactions between strontium-90 in solution and sediments beneath the radioactive-waste infiltration ponds. No strontium-90 concentrations were 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 USGS 60, 61, 62, 63, 66, 69, 71, 73, and 78 contained strontium-90 at concentrations less than reporting levels in some samples collected during 2002–05, but greater than reporting levels in other samples (table 10). Because 2002–05 strontium-90 disposal data were not available, fluctuations could not be correlated with disposal during 2002–05. In addition, lined evaporation ponds were in use, which probably prevented contaminated water from percolating into the ground.

Cesium-137

During 1999–2005, 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 1998–2005 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 the amount of suspended sediment in water samples collected onto which cesium-137 may have sorbed.

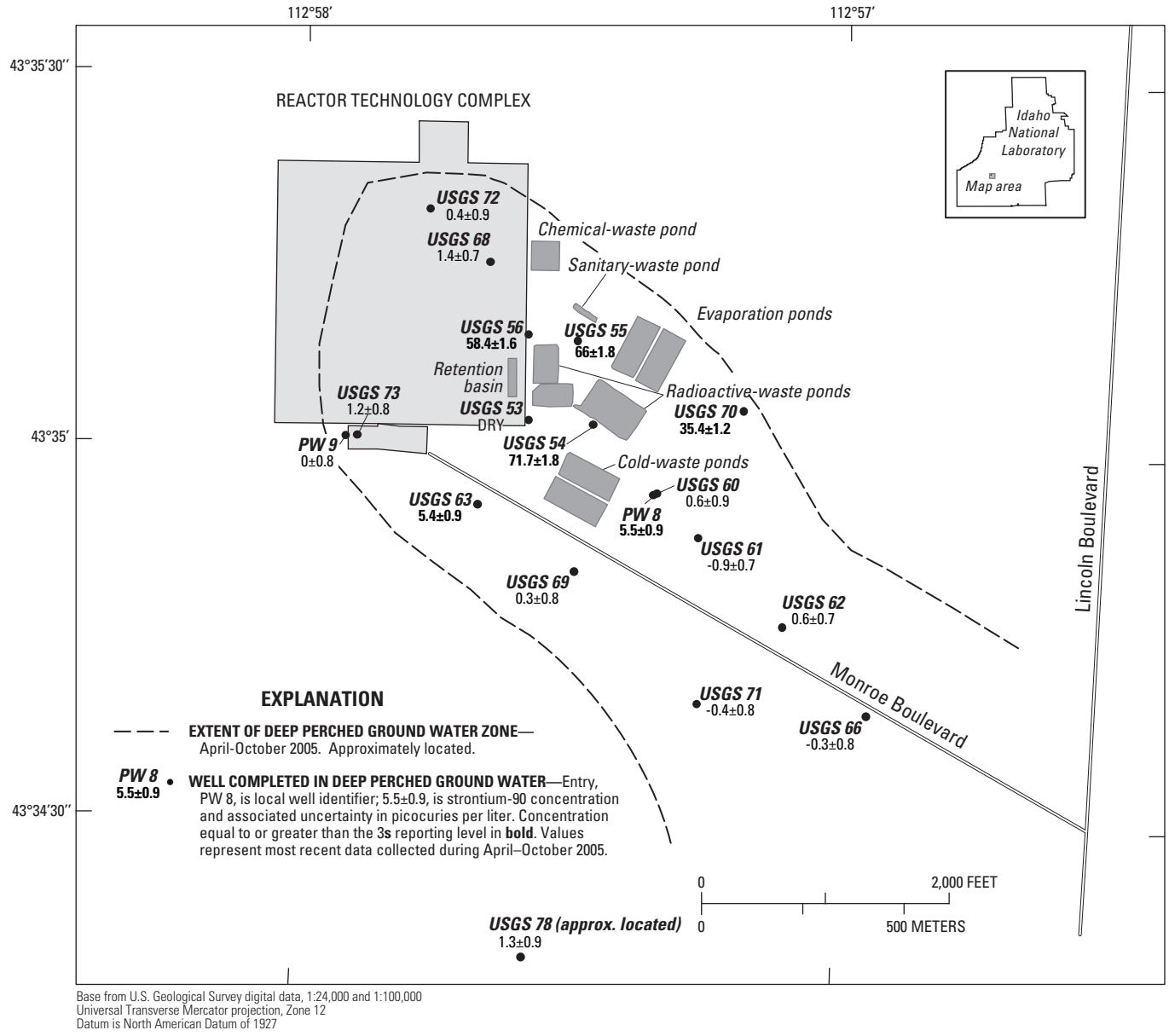


Figure 24. Concentrations of strontium-90 in water from wells completed in deep perched ground water, Reactor Technology Complex, Idaho National Laboratory, Idaho, April–October 2005.

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 were not available for the amount of chromium-51 discharged during 1999–2005. 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 through time, 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 24,500±1,300 pCi/L in October 1992 to 2,700±500 in April 1995 (Bartholomay, 1998, p. 16). Chromium-51 was not detected in any wells during 1996–2005.

Cobalt-60

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 1999–2005, no samples were collected from well TRA A 77 because the well was dry. Cobalt-60 was not detected in any water samples analyzed during 1999–2005.

Chromium

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 (Davis, 2006b). During 2002–05, dissolved chromium was detected in shallow perched ground water from wells CWP 1 and 3. The concentrations ranged from 2 to 6 µg/L (table 11). The LRL for dissolved chromium varied from 2 to 10 µg/L during 2002–05; consequently, concentrations within that range were designated according to those LRLs as detections or nondetections during 2002-05. Estimated concentrations (table 11) 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 17 wells (PW 8, 9, USGS 53-56, 60-63, 66, 68-71, 73, and 78) completed in deep perched ground water at the RTC during 2002–05 (table 11). Chromium was not detected in well USGS 72 during 2002–03; the well was not sampled for chromium during 2004–05. 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. In 2004 and 2005, water samples collected from well USGS 56 contained concentrations of chromium of 114 and 86 µg/L, respectively. The 2004 value of 114 µg/L also was the maximum concentration of chromium in deep perched water at the RTC during 2002–05. During April–October 2005, the most recent concentrations of dissolved chromium in wells completed in deep perched ground water near the RTC ranged from 3 µg/L in well USGS 69 to 86 µg/L in well USGS 56 (table 11 and fig. 25). The largest concentrations were in water from wells north and west of the radioactive-waste infiltration ponds (PW 9 and USGS 55, 68, and 73). 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 2002–05, no analyses were made for dissolved sodium concentrations in shallow perched ground water at the RTC. Concentrations of dissolved sodium wells completed in shallow perched ground water were not available because (1) wells were dry during 2002–05, (2) wells could not be sampled because of equipment problems, or (3) analyses for dissolved sodium were not requested from the laboratory (table 11). Dissolved sodium concentrations in water from 16 wells completed in deep perched ground water were determined. During April–October 2005, dissolved sodium concentrations ranged from 6 to 27 mg/L in all wells except well USGS 68 (370 mg/L) (table 11), a decrease from October 2001 when the concentration was 413 mg/L (Davis, 2006b, table 3). However, sodium concentrations in this well varied during 2002–05 and ranged from 370 to 737 mg/L. Reasons for the variability of these concentrations are unknown, but may be due to movement of remnant water through the unsaturated zone from the chemical waste pond which was closed in 1999.

Table 11. Concentrations of selected dissolved ions in perched ground water from selected wells, Reactor Technology Complex, Idaho National Laboratory, Idaho, 2002–05.

[**Well No.:** Locations of wells are shown in figure 7. Analyses completed by the National Water Quality Laboratory. **Abbreviations:** DP, well completed in deep perched water; 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; NSEQ, not sampled because of equipment problems; USGS, U.S. Geological Survey; E, estimated; µg/L, microgram per liter; mg/L, milligram per liter. **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)	07-22-2002	<10	NR	29	367
	07-22-2003	<5	NR	30	379
	10-25-2004	5	NR	10	26
	10-18-2005	2	NR	32	396
CWP 3 (SP)	07-22-2002	<10	NR	28	340
	07-22-2003	<5	NR	29	356
	04-21-2004	6	NR	29	365
	04-27-2005	3	NR	10	28
CWP 8 (SP)	07-22-2002	NR	NR	NR	NR
	07-23-2003	NR	NR	NR	NR
	10-25-2004	E2	NR	10	27
	10-18-2005	<2	NR	17	148
PW 8 (DP)	04-02-2002	E9	NR	20	NR
	11-14-2002	<10	15	21	66
	04-14-2003	<10	NR	21	NR
	11-06-2003	11	15	15	118
	04-13-2004	NSEQ	NSEQ	NSEQ	NSEQ
	10-25-2005	7	13	17	145
PW 9 (DP)	04-02-2002	37	NR	32	NR
	10-02-2002	35	19	30	108
	04-01-2003	35	NR	32	NR
	11-06-2003	39	22	31	118
	10-25-2005	44	21	33	106
TRA A 13 (SP)	04-02-2002	NS	NS	NS	NS
	07-22-2002	NSEQ	NSEQ	NSEQ	NSEQ
	04-14-2003	NS	NS	NS	NS
	04-13-2004	NSEQ	NSEQ	NSEQ	NSEQ
	10-12-2004	NSEQ	NSEQ	NSEQ	NSEQ
	04-27-2005	NSEQ	NSEQ	NSEQ	NSEQ
	10-18-2005	NSEQ	NSEQ	NSEQ	NSEQ
TRA A 77 (SP)	04-23-2002	NS	NS	NS	NS
	10-23-2002	NS	NS	NS	NS
	04-08-2003	NS	NS	NS	NS
	10-20-2005	NS	NS	NS	NS
USGS 53 (DP)	10-09-2002	NS	NS	NS	NS
	10-08-2003	6	31	21	134
	04-21-2004	NS	NS	NS	NS
	04-27-2005	NS	NS	NS	NS
USGS 54 (DP)	04-20-2002	E6	NR	18	NR
	10-07-2002	E6	17	16	174
	04-03-2003	<10	NR	18	NR
	10-15-2003	10	16	13	74
	10-26-2004	6	12	11	55
	10-19-2005	7	18	25	276
USGS 55 (DP)	10-24-2002	67	19	22	148
	04-03-2003	23	NR	21	NR
	10-15-2003	30	18	16	104
	10-27-2004	25	16	13	69
	04-19-2005	42	13	12	50
USGS 56 (DP)	04-23-2002	NS	NS	NS	NS
	10-23-2002	NS	NS	NS	NS
	04-03-2003	NS	NS	NS	NS
	10-09-2003	NS	NS	NS	NS
	10-19-2004	114	37	16	60
	10-20-2005	86	26	16	82
USGS 60 (DP)	04-02-2002	E6	NR	18	NR
	10-02-2002	E6	14	16	153
	04-07-2003	<10	NR	18	NR
	09-30-2003	9	13	14	97
	10-04-2004	7	12	12	76
	10-04-2005	6	11	15	110
USGS 61 (DP)	04-03-2002	14	NR	17	NR
	10-10-2002	14	14	17	172
	04-08-2003	E8	NR	20	NR
	10-15-2003	17	15	19	174
	04-21-2004	16	15	16	139
	04-20-2005	12	11	13	77
USGS 62 (DP)	04-03-2002	E8	NR	21	NR
	10-16-2002	E6	16	20	223
	04-08-2003	<10	NR	22	NR
	10-14-2003	13	18	20	198
	04-21-2004	9	16	17	141
	04-20-2005	15	13	12	81
USGS 63 (DP)	04-03-2002	E10	NR	21	NR
	10-21-2002	E9	17	20	214
	04-16-2003	E6	NR	20	NR
	10-06-2003	11	17	16	143
	10-04-2004	12	17	16	152
	10-03-2005	36	15	20	189

Table 11. Concentrations of selected dissolved ions in perched ground water from selected wells, Reactor Technology Complex, Idaho National Laboratory, Idaho, 2002–05—Continued.

[**Well No.:** Locations of wells are shown in figure 7. Analyses completed by the National Water Quality Laboratory. **Abbreviations:** DP, well completed in deep perched water; 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; NSEQ, not sampled because of equipment problems; USGS, U.S. Geological Survey; E, estimated; µg/L, microgram per liter; mg/L, milligram per liter. **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 66 (DP)	07-15-2002	<10	15	21	196
	07-17-2003	<5	18	21	215
	10-26-2004	3	16	18	170
	10-26-2005	E1	15	16	139
USGS 68 (DP)	04-23-2002	<10	NR	22	NR
	10-23-2002	53	456	21	1,387
	04-07-2003	87	NR	29	NR
	10-15-2003	36	665	26	1,889
	04-14-2004	64	737	44	1,205
	04-19-2005	54	370	35	951
USGS 69 (DP)	07-23-2002	<10	10	18	115
	06-30-2003	<5	11	17	112
	10-04-2004	4	10	14	82
	10-03-2005	3	9	13	66
USGS 70 (DP)	04-03-2002	29	NR	18	NR
	10-09-2002	14	16	18	192
	04-09-2003	E10	NR	20	NR
	10-15-2003	15	17	16	127
	04-07-2004	17	17	17	161
	04-19-2005	19	12	12	52
USGS 71 (DP)	04-15-2002	30	NR	19	NR
	10-08-2002	15	13	19	181
	04-14-2003	<10	NR	21	NR
	10-08-2003	28	13	20	174
	10-26-2004	25	12	20	176
	10-18-2005	13	13	19	169
USGS 72 (DP)	11-07-2002	<10	19	11	26
	07-02-2003	<5	19	12	26
	04-14-2004	NR	19	12	25
	04-19-2005	NR	27	14	26
USGS 73 (DP)	04-11-2002	11	NR	216	NR
	10-17-2002	16	16	29	57
	04-14-2003	18	NR	41	NR
	12-01-2004	37	20	34	83
	10-04-2005	38	20	30	70
USGS 78 (DP)	07-15-2002	<10	6	6	19
	07-17-2003	<5	7	5	21
	10-26-2004	2	7	5	20
	10-13-2005	E1	6	3	12

Chloride

During April–October 2005, dissolved chloride concentrations in shallow perched ground water ranged from 10 mg/L in well CWP 3 to 32 mg/L in well CWP 1. Dissolved chloride concentrations in deep perched ground water ranged from 3 mg/L in well USGS 78 to 35 mg/L in well USGS 68. Concentrations of sodium in most wells remained fairly constant or decreased slightly compared to the 1999–2001 reporting period with the exception of well USGS 68, which increased from 23 mg/L in October 2001 to 35 mg/L in April 2005. This may be a result of movement of remnant water through the unsaturated zone from the chemical waste pond which was closed in 1999.

Sulfate

The maximum dissolved sulfate concentration in shallow perched ground water was 396 mg/L in well CWP 1 in October 2005. Concentrations of dissolved sulfate in this well vary greatly. During 2002–05, the concentrations ranged from 26 to 396 mg/L. The higher concentrations are attributed to sulfate disposal to nearby cold-waste ponds. Concentrations of dissolved sulfate ranged from 66 to 276 mg/L during April–October 2005 in water from wells USGS 54, 60, 63, 69, and PW 8, completed in deep perched ground water near the cold-waste ponds (fig. 7). These large concentrations indicate that water in the wells also was affected by discharge into the cold-waste ponds. During April–October 2005, the maximum concentration of dissolved sulfate in deep perched ground water was 951 mg/L in well USGS 68 (table 11), west of the chemical-waste pond (fig. 7). The dissolved sulfate concentration in this well varied during 2002-05, however there was an overall decrease from 1,409 mg/L in October 2001 (Davis, 2006b, table 3), and from 2,278 mg/L in December 1998 (Bartholomay and Tucker, 2000, table 3), which partly may be the result of a decrease in disposal rates or movement of remnant water through the unsaturated zone from the chemical waste pond which was closed in 1999.

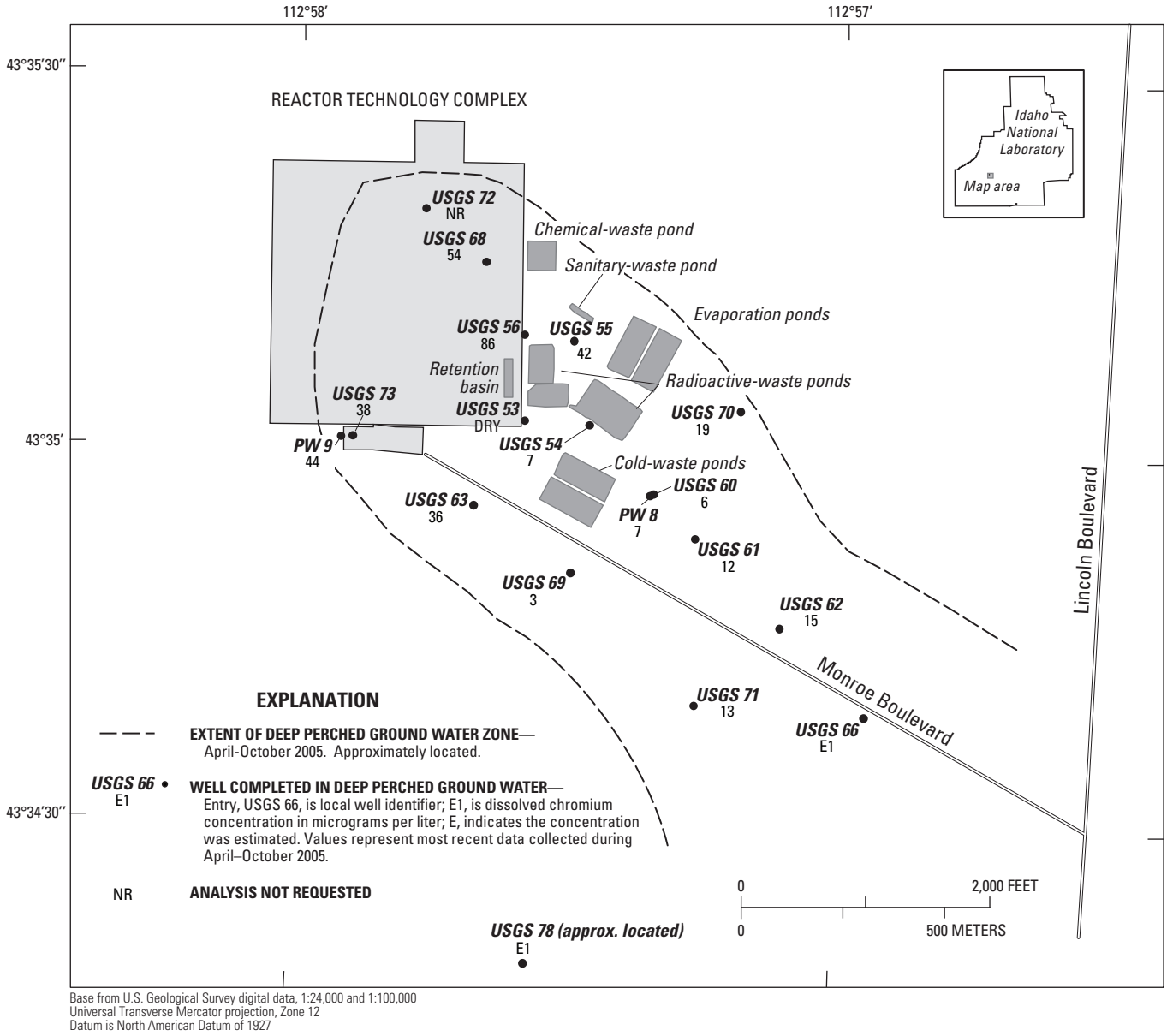


Figure 25. Concentrations of dissolved chromium in water from wells completed in deep perched ground water, Reactor Technology Complex, Idaho National Laboratory, Idaho, April–October 2005.

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. 4). 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 1962–2005 are shown in figure 9.

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. 21]) 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, the wells were dry in some years. Only one sample was obtained from SWP 8 during 2002–05. 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 percolation ponds (fig. 21). Well USGS 50 was used to monitor deep perched ground water near the INTEC disposal well. Lack of available perched water to sample, and the history of non-reportable values of tritium in most of these wells resulted in the decision to remove wells SWP 8 and 13, and PW 2, 3, and 5 from the sampling schedule at various times during 2002–05 (fig. 21).

Tritium

In July 2002, the tritium concentration in well SWP 8, completed in shallow perched water was below the reporting level with a concentration of 0.16±0.14 pCi/mL. This well was dry during 2003 and sampling was discontinued due to lack of water in the well. During 2002–05, 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 1.8±0.2 pCi/mL in well PW 4 (table 12), an increase in concentration from 2001 when all concentrations were less than the reporting level. Tritium concentrations in water from wells near the percolation ponds decreased significantly from concentrations during 1986–88, when disposal of tritium was about 185 Ci/yr (Orr and Cecil, 1991). During 2002–05, tritium concentrations in perched ground water in the wells closest to the ponds (PW 1 through 5, and SWP 8) increased slightly or remained fairly constant compared to the 1999–2001 reporting period (table 12, this report; Davis, 2006b, table 4). During 2002–04, tritium concentrations in water from well USGS 50 (fig. 7), near the disposal well, decreased slightly from 29.3±0.7 pCi/mL in April 2002 to 22.0±0.7 pCi/mL in November 2004 (table 12). Well maintenance problems prevented sample collection at this well during 2005. 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 26 shows concentrations of tritium in wells near the INTEC during April–October 2005. Many wells were dry, were not sampled because of equipment problems, or sampling was discontinued prior to 2005.

Strontium-90

During 2002, the concentration of strontium-90 in water from well SWP 8, completed in shallow perched ground water had a concentration of 0.7 ± 0.7 pCi/L. This well was dry during 2003, and sampling was subsequently discontinued.

Table 12. 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, 2002–05.

[**Well No.:** Locations of wells are shown in figure 21. 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. NR, analysis not requested; NS, not sampled due to lack of water or because water level was below pump intake; NSEQ, not sampled, equipment problems; SL, sample lost prior to analysis; pCi/mL, picocurie per milliliter; pCi/L, picocurie per liter. **Symbol:** ±, plus or minus]

Well No.	Date Sampled	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)
PW 1 (DP)	05-20-2002	0.26±0.13	1.2±0.7	-14.1±21.6
	10-08-2002	NS	NS	NS
	04-02-2003	NS	NS	NS
	10-08-2003	NS	NS	NS
	04-14-2004	NS	NS	NS
	04-07-2005	NS	NS	NS
PW 2 (DP)	04-15-2002	**0.42±0.14**	**2.6±0.7**	10±20
	10-08-2002	**1±0.2**	**3.3±0.7**	NR
	04-02-2003	NS	NS	NS
PW 3 (DP)	04-15-2002	**0.45±0.14**	**3.4±0.7**	-40±40
	10-08-2002	NS	NS	NS
	04-02-2003	NS	NS	NS
	04-14-2004	NS	NS	NS
PW 4 (DP)	05-20-2002	0.12±0.13	0.6±0.7	12.5±26.9
	10-08-2002	0.1±0.13	**1.8±0.6**	NR
	04-14-2003	**1.1±0.2**	**2.1±0.7**	13.4±31.2
	10-08-2003	**0.87±0.14**	**3.7±0.8**	NR
	10-18-2004	**1.8±0.2**	**9.7±1**	10±20
	10-13-2005	**1.4±0.16**	**11.4±1**	10±30
PW 5 (DP)	05-20-2002	0.07±0.12	0.2±0.7	-20±30
	10-09-2002	NS	NS	NS
	10-07-2003	NS	NS	NS
	04-13-2004	NS	NS	NS
SWP 8 (SP)	07-15-2002	0.16±0.14	0.7±0.7	13.4±27.4
	07-17-2003	NS	NS	NS
USGS 50 (DP)	04-09-2002	**29.3±0.7**	**150±3**	-20±20
	10-16-2002	**28.5±0.7**	SL	0±30
	04-23-2003	**28.6±0.7**	**110±3**	10±20
	11-17-2003	**25.7±0.5**	**105±2**	20±20
	11-05-2004	**22±0.7**	**145±3**	20±30
	10-26-2005	NSEQ	NSEQ	NSEQ

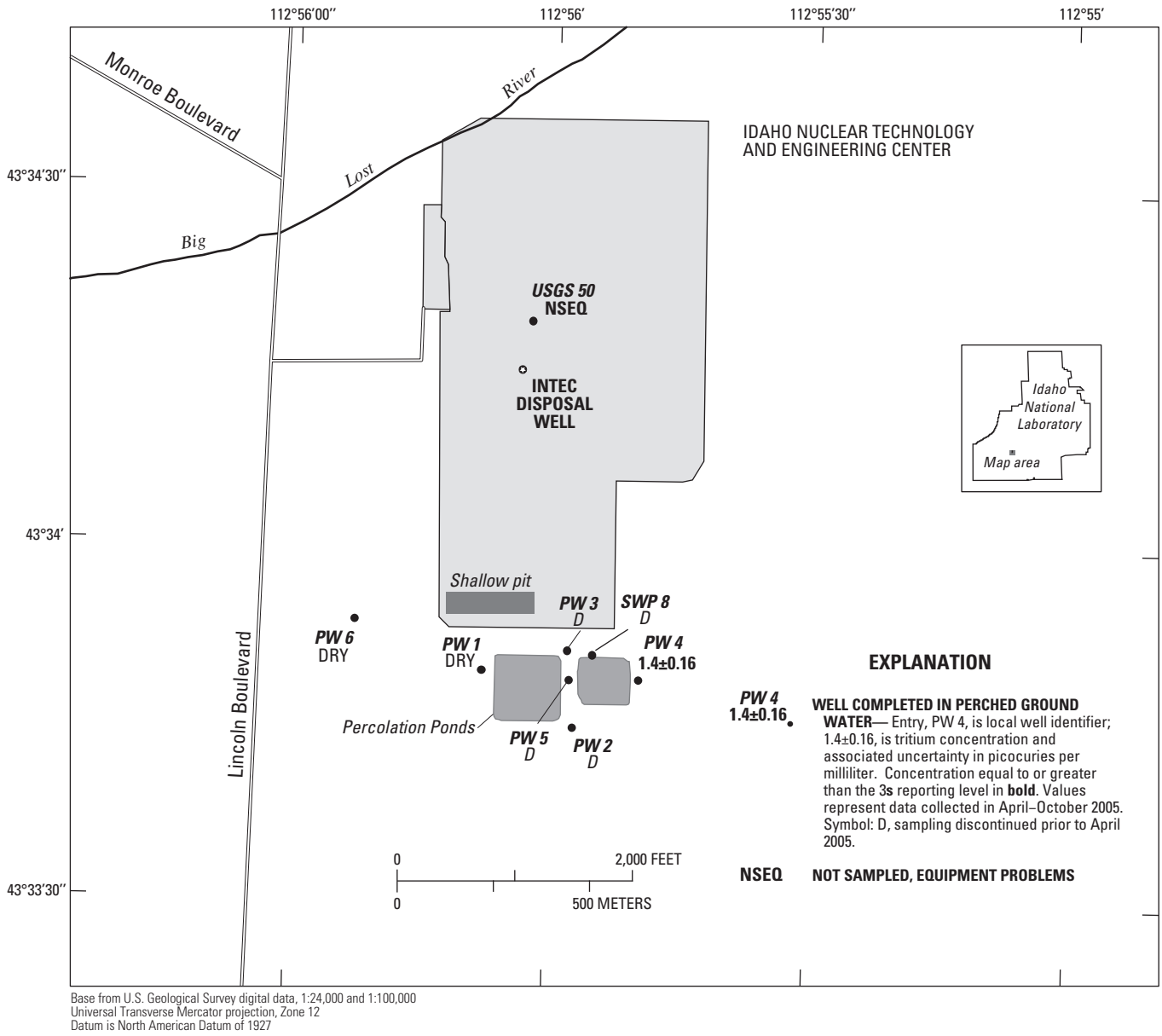


Figure 26. Concentrations of tritium in water from wells completed in perched ground water, Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, Idaho, April–October 2005.

During 2002–05, concentrations of strontium-90 varied in water from all wells completed in deep perched ground water beneath the INTEC percolation ponds. In April–October 2005, strontium-90 concentrations in deep perched ground water in wells closest to the ponds were not sampled because of access problems, dry wells, or sampling was discontinued prior to 2005 (table 12, fig. 27).

The largest concentrations of strontium-90 in perched ground water at the INTEC were in well USGS 50 near the INTEC disposal well. During 2002–04, strontium-90 concentrations in water from well USGS 50 decreased from 150±3 pCi/L in April 2002 to 105±2 pCi/L in November 2003 and then increased to 145±3 in November 2004 (table 12). These concentrations represent an overall decrease in strontium-90 concentrations since the 1980s when concentrations were as high as 620±30 in October 1982. Well maintenance problems prevented sample collection in 2005. Strontium-90 concentrations in water from well USGS 50 may be due to the 1972 leak of 18,100 Ci of strontium-90 in soils at the INTEC Tank Farm (Cahn and others, 2006), leakage of wastewater from ruptures in the disposal well casing, or leakage from wastewater pipelines at the INTEC.

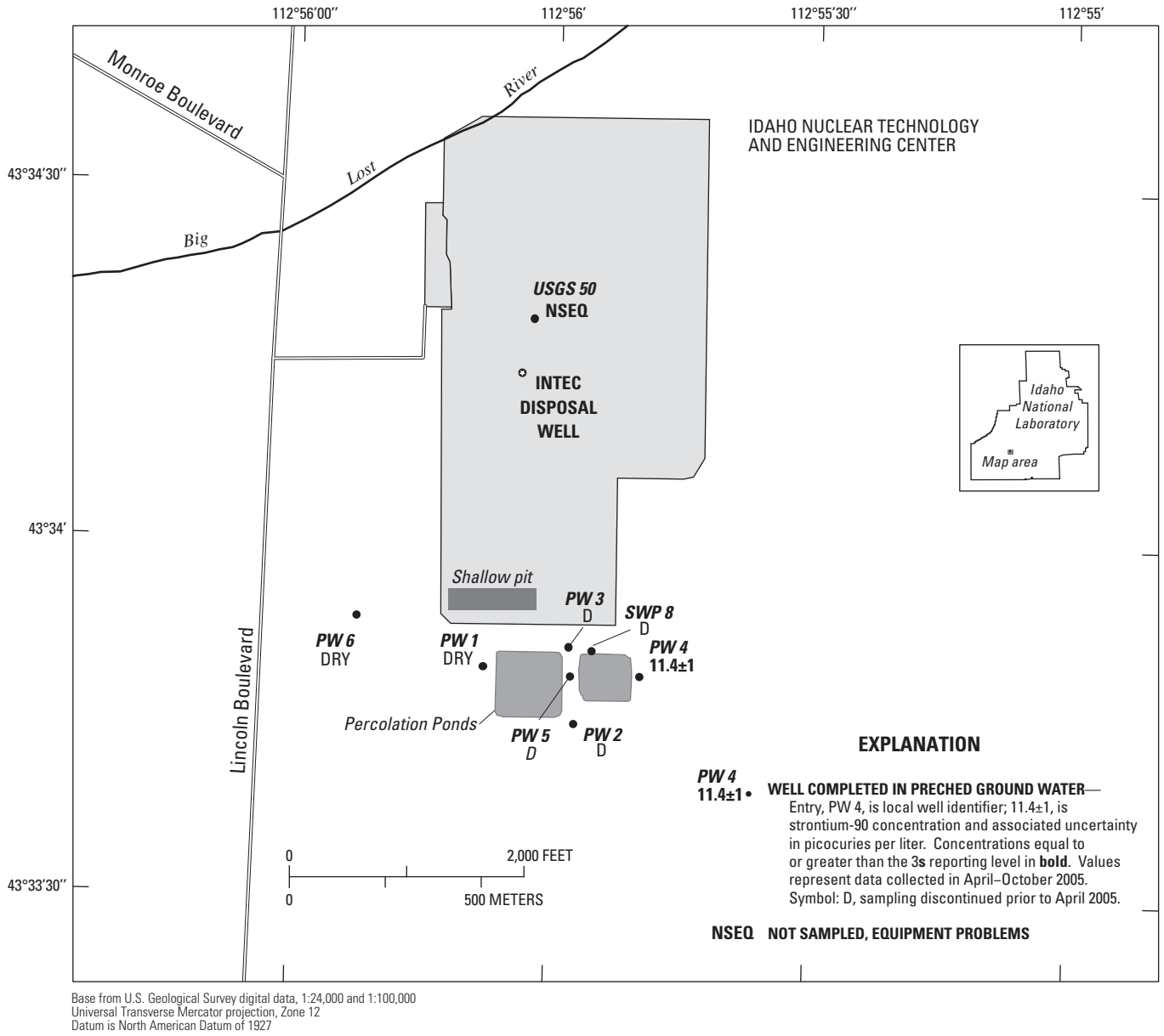


Figure 27. Concentrations of strontium-90 in water from wells completed in perched ground water, Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, Idaho, April–October 2005.

Cesium-137

During 2002–05, 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 (table 12). 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

Water from well SWP 8, completed in shallow perched ground water, contained a concentration of 120 mg/L of dissolved sodium in July 2002 (table 13). This concentration was slightly higher than the July 2001 concentration of 102 mg/L (Davis, 2006b, table 5). During 2002–05, dissolved sodium concentrations in deep perched ground water in wells closest to the infiltration ponds (PW 2 and 4) ranged from 106 mg/L in well PW 2 in October 2002 to 83 mg/L in well PW 4 in October 2003 (table 13). Some wells could not be sampled due to lack of water in the well, well maintenance problems or sampling was discontinued during 2002–05.

Table 13. Concentrations of selected dissolved ions in perched ground water from selected wells, Idaho Nuclear Technology and Engineering Center, Idaho National Laboratory, Idaho, 2002–05.

[**Well No.:** Locations of wells are shown in figure 21. 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. NR, analysis not requested; NS, not sampled due to lack of water or because water level was below pump intake]

Well No.	Date Sampled	Sodium, dissolved	Chloride, dissolved	Sulfate, dissolved	Nitrite plus nitrate, as nitrogen, dissolved
PW 1 (DP)	05-20-2002	NR	169	NR	NR
	10-08-2002	NS	NS	NS	NS
	04-02-2003	NS	NS	NS	NS
	04-14-2004	NS	NS	NS	NS
	04-07-2005	NS	NS	NS	NS
PW 2 (DP)	04-15-2002	NR	205	NR	NR
	10-08-2002	106	162	35	NR
	04-02-2003	NS	NS	NS	NS
PW 3 (DP)	04-15-2002	NR	204	NR	NR
	10-08-2002	NS	NS	NS	NS
	04-02-2003	NS	NS	NS	NS
	04-14-2004	NS	NS	NS	NS
PW 4 (DP)	05-20-2002	NR	137	NR	NR
	10-08-2002	95	118	35	NR
	04-14-2003	NR	204	NR	NR
	10-08-2003	83	240	28	NR
	10-18-2004	103	322	51	NR
	10-13-2005	85	167	40	NR
PW 5 (DP)	05-20-2002	NR	160	NR	NR
	10-09-2002	NS	NS	NS	NS
	04-02-2003	NS	NS	NS	NS
	10-07-2003	NS	NS	NS	NS
	04-13-2004	NS	NS	NS	NS
PW 6 (DP)	04-15-2002	NS	NS	NS	NS
	10-08-2002	NS	NS	NS	NS
	04-02-2003	NS	NS	NS	NS
	10-08-2003	NS	NS	NS	NS
	10-13-2004	NS	NS	NS	NS
	10-12-2005	NS	NS	NS	NS
SWP 8 (SP)	07-15-2002	120	145	49	NR
	07-17-2003	NS	NS	NS	NS
USGS 50 (DP)	04-09-2002	NR	56	NR	NR
	10-16-2002	20	44	26	3.6
	04-23-2003	NR	54	NR	NR
	11-17-2003	60	54	39	25.7
	11-05-2004	56	54	40	33.3

Dissolved sodium concentrations in three water samples from well USGS 50 varied during 2002–05. The maximum concentration was 60 mg/L in November 2003 (table 13), the same concentration reported by Davis (2006b, table 5) for 1999–2001. These dissolved sodium concentrations may be due to leakage of wastewater from pipelines or infiltration of landscape irrigation at the INTEC.

Chloride

The dissolved chloride concentration in well SWP 8 (fig. 21) was 145 mg/L in July 2002, similar to the July 2001 concentration of 153 mg/L. No samples were collected from well SWP 8 during 2003 because the well was dry, and sampling was subsequently discontinued. During 2002–05, dissolved chloride concentrations in deep perched ground water in wells closest to the infiltration ponds (PW 1 through 5) ranged from 118 to 322 mg/L in well PW 4 (table 13). The variability and values of concentrations of dissolved chloride in this well are similar to the 1999–2001 reporting period. Wells PW 1–3 and PW 5 were not sampled after 2002 because the wells were dry or sampling was discontinued during 2002-05. Dissolved chloride concentrations in water from wells PW 1, 2, and 5 were 169, 205, and 160 mg/L, respectively during April–May 2002 (table 13).

During 2002–04, dissolved chloride concentrations in water from well USGS 50 ranged from 44 mg/L in October 2002 to 56 mg/L in April 2002 (table 13), similar to concentrations during the 1999–2001 reporting period. 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.

Sulfate

The dissolved sulfate concentration in shallow perched ground water from well SWP 8 was 49 mg/L in July 2002 (table 13). Dissolved sulfate concentrations in water from wells completed in the deep perched ground water closest to the INTEC infiltration ponds (PW 2 and 4) were 35 mg/L in October 2002 (table 13). After 2002, no samples were collected from wells PW1 through 3 and PW5 because of access problems, dry wells, or sample collection discontinued during 2002–05. Historically, dissolved sulfate concentrations in these wells fluctuated between about 22 and 41 mg/L.

Concentrations of dissolved sulfate in samples from well USGS 50 (table 13) ranged from 26 to 40 mg/L during 2002–04. Historically, dissolved sulfate concentrations in water from well USGS 50 have fluctuated around these values. The dissolved sulfate concentrations in water from this well are attributed to leakage from wastewater pipelines at the INTEC.

Nitrate

Water from well USGS 50 was analyzed for dissolved nitrite plus nitrate (as nitrogen) during 2002–04. Nitrite analyses indicated that almost all dissolved nitrite plus nitrate concentration is from nitrate. During 2002–04, dissolved nitrite plus nitrate (as nitrogen) concentrations in water from well USGS 50 ranged from 3.6 mg/L in October 2002 to 33.3 mg/L in November 2004 (table 13), an increase from the 1999–2001 reporting period, but maintaining an 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

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. 4) 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 spring 2002–03. During 2002–03, radiochemical constituent concentrations in all water samples from well USGS 92 (table 14) were less than the reporting level. Tritium concentrations in water from well USGS 92 have varied 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 one sample collected from well USGS 92 was 87 mg/L in April 2002 (table 14). This dissolved chloride concentration is consistent with concentrations measured historically.

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, 18 VOCs were detected (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. During 2002–05, attempts were made each year to sample well USGS 92, completed in perched water at the RWMC; however, lack of water in the well precluded obtaining an adequate sample during most sampling events. Most of the same VOCs except chloroethane that were detected during 1999–2001 were detected during 2002–03; additionally, bromodichloromethane was detected. Table 15 lists the concentrations of 16 VOCs detected in 2002–03. Most VOCs fluctuated through time and show no distinct trend. The sample collected on April 11, 2002 was foamy or contained high levels of contaminants when received by the laboratory, so the sample was diluted 1:10. Because the sample was not analyzed full strength, the laboratory raised the reporting level to less than 2 µg/L for this sample (L. Murtagh, C. Adamson, National Water Quality Laboratory, written commun., 2002). The MRL for some VOCs varied between 0.1 to 0.2 µg/L during 2002–05, a change that could result in detections of smaller concentrations and (or) different VOCs than detected in previous years.

Table 14. 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, 2002–05.

[**Well No.:** Location of well is shown in figure 21. 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. **Abbreviations:** pCi/mL, picocurie per milliliter; pCi/L, picocurie 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; 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	03-14-2002	NR	NR	NR	0.004±0.007	-0.011±0.007	0.01±0.02	NR
	04-11-2002	0.39±0.14	0.2±0.8	-14.9±36.1	0.004±0.007	-0.004±0.009	0.012±0.0207	87
	10-23-2002	NS	NS	NS	NS	NS	NS	NS
	04-10-2003	0.3±0.14	0±0.7	-20±30	-0.003±0.003	0.003±0.006	0.003±0.009	NR
	10-09-2003	NS	NS	NS	NS	NS	NS	NS
	04-12-2004	NS	NS	NS	NS	NS	NS	NS
	04-14-2005	NS	NS	NS	NS	NS	NS	NS

Table 15. Concentrations of selected volatile organic compounds in perched ground water from well USGS 92, Radioactive Waste Management Complex, Idaho National Laboratory, Idaho, 2002–05.

[Location of well is shown in figure 21. Analyses completed by the National Water Quality Laboratory using an analytical method that conforms to U.S. Environmental Protection Agency Method 524.2 (1995). Analytical results in micrograms per liter. Names in parentheses are alternate compound names. **Abbreviations:** NS, not sampled due to lack of water; NWIS, National Water Information System. **Symbol:** <, less than respective reporting level]

Compound name	NWIS parameter code	Date						
		03-14-2002	04-11-2002	10-23-2002	04-10-2003	10-09-2003	04-12-2004	04-14-2005
Carbon tetrachloride (Tetrachloromethane)	32102	NS	150	NS	279	NS	NS	NS
1,2-Dichloroethane	32103	NS	<2	NS	0.8	NS	NS	NS
Chloroform (Trichloromethane)	32106	NS	236	NS	256	NS	NS	NS
Methylene chloride Dichloromethane)	34423	NS	4.7	NS	<.2	NS	NS	NS
Tetrachloroethylene (Tetrachloroethene)	34475	NS	29.7	NS	39.5	NS	NS	NS
1,1-dichloroethane	34496	NS	3.3	NS	4.2	NS	NS	NS
1,1-dichloroethylene (1,1,-dichloroethene)	34501	NS	<2	NS	0.7	NS	NS	NS
1,1,1-trichloroethane	34506	NS	22.4	NS	29.9	NS	NS	NS
1,1,2-trichloroethane	34511	NS	<2	NS	0.3	NS	NS	NS
1,2-dichloropropane	34541	NS	1.9	NS	2.8	NS	NS	NS
Trichloroethylene (Trichloroethene)	39180	NS	198	NS	232	NS	NS	NS
cis-1,2-dichloroethene	77093	NS	<2	NS	0.2	NS	NS	NS
Freon-113 (CFC-113) (1,1,2-Trichloro-1,2,2-Trifluoroethane)	77652	NS	<2	NS	1.1	NS	NS	NS
Toluene	34010	NS	<2	NS	<.2	NS	NS	NS
Benzene	34030	NS	<2	NS	0.1	NS	NS	NS
Bromodichloromethane	32101	NS	<2	NS	0.4	NS	NS	NS

Summary

Radiochemical and chemical wastewater discharged since 1952 to infiltration ponds and disposal wells at the Idaho National Laboratory (INL) has affected water quality in the Snake River Plain aquifer and in perched water zones at the INL. The U.S. Geological Survey, in cooperation with the U.S. Department of Energy, maintains aquifer and perched ground-water monitoring networks at the INL to determine hydrologic trends and to delineate the movement of radiochemical and chemical wastes in the aquifer and in perched water zones.

Water in the Snake River Plain aquifer primarily moves through fractures and interflow zones in basalt, generally flows southwestward, and eventually discharges at springs along the Snake River. The aquifer is recharged primarily from infiltration of irrigation water, infiltration of streamflow, ground-water inflow from adjoining mountain drainage basins, and infiltration of precipitation.

During March–May 2005, the altitude of the water table in the Snake River Plain aquifer was about 4,570 feet in the northern part of the INL, and about 4,400 feet in the southwestern part. Water flowed southward and southwestward beneath the INL at an average hydraulic gradient of about 4 feet per mile. From March–May 2001 to March–May 2005, water levels in INL declined in the area of the INL. Declines ranged from about 3 to 8 feet in wells in the southwestern part of the INL, about 10 to 15 feet in the west-central part of the INL, and about 6 to 11 feet in the northern part of the INL. Ground water moves southwestward from the INL and eventually is discharged to springs along the Snake River near Twin Falls, Idaho, about 100 miles southwest of the INL. Estimated discharge from the springs was about 3.54 million acre-feet per year for the 2005 water year.

Disposal of wastewater to infiltration ponds and infiltration of surface water at the RTC and INTEC resulted in formation of perched ground water in basalts and in sedimentary interbeds that overlie the Snake River Plain

aquifer. 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. Perched ground water is an integral part of the pathway for waste-constituent migration to the aquifer.

Data are unavailable for the total amount of tritium (in Curies) released in liquid effluent during 2002–05. A tritium plume developed in the Snake River Plain aquifer from discharge of wastewater at the INL since the 1950s. In October 2005, reportable concentrations of tritium in water from aquifer wells ranged from 0.51±0.12 to 11.5±0.6 pCi/mL and the tritium plume extended south-southwestward in the general direction of ground-water flow. In October 2005, concentrations of tritium in water samples generally decreased from the 1999–2001 reporting period and all concentrations were less than the maximum contaminant level of 20 pCi/mL.

At the RTC, wells completed in shallow perched ground water were sampled for tritium; all concentrations were less than the reporting level. Lack of available perched water to sample, and the history of non-reportable values of tritium in most of the shallow wells resulted in the decision to remove several wells from the sampling schedule at various times during 2002–05. Tritium concentrations in water from nine wells completed in deep perched ground water (PW 9, USGS 53, 55, 56, 61, 66, 70, 71, and 73) generally were greater than the reporting levels during at least one sampling event during 2002–05. Concentrations decreased in some wells and varied randomly in other wells. Tritium concentrations in water from six wells (USGS 60, 62, 63, 69, 72, and 78) were less than the reporting level during 2002–05. Tritium concentrations varied between reportable and nonreportable concentrations in water from three wells, PW 8, USGS 54 and 68, during 2002–05.

In July 2002, the tritium concentration in well SWP 8, completed in shallow perched water near INTEC was below the reporting level with a concentration of 0.16±0.14 pCi/mL. This well was dry during 2003 and sampling was discontinued due to lack of water in the well. During 2002–05, tritium concentrations in water from wells completed in deep perched ground water beneath the percolation ponds ranged from less than the reporting level in wells PW 1 and PW 5 to 1.8±0.2 pCi/mL in well PW 4, an increase in concentration from 2001 when all concentrations were less than the reporting level.

No data were available for strontium-90 discharged during 2002–05. A strontium-90 plume developed in the Snake River Plain aquifer from the disposal of wastewater at the INL. In October 2005, 34 aquifer wells were sampled for strontium-90. Concentrations of strontium-90 in water from 14 wells exceeded the reporting level. However, concentrations from most wells remained relatively constant or decreased since 1989. Concentrations ranged from 2.2±0.7 to 33.1±1.2 pCi/L and the area where strontium-90 was detected near the INTEC extended south-southwestward in the general direction of ground-water flow. Strontium-90 has not been detected within the eastern Snake River Plain aquifer beneath the RTC partly because of the exclusive use of waste-disposal ponds and lined evaporation ponds rather than the disposal well for radioactive-wastewater disposal at RTC. Sorption processes in sediments in the unsaturated zone beneath the radioactive waste-disposal pond could have minimized or prevented strontium-90 migration to the aquifer at the RTC. Additionally, the stratigraphy beneath the RTC is different from that beneath the INTEC; more sediment is present below the RTC than the INTEC.

During 2002, the concentration of strontium-90 in water from well SWP 8, completed in shallow perched ground water near INTEC had a concentration of 0.7 ± 0.7 pCi/L, below the reporting level. This well was dry during 2003, and sampling was subsequently discontinued. In April–October 2005, strontium-90 concentrations in deep perched ground water in wells closest to the percolation ponds were not sampled because of access problems, dry wells, or sampling was discontinued prior to 2005.

During 2002–05, concentrations of cesium-137 in water from all wells sampled by the USGS at the INL were less than the reporting level. Concentrations of plutonium-238, plutonium-239, -240 (undivided), and americium-241 in water from all wells sampled at the INL were less than the reporting level during 2002-05.

Detectable concentrations of nonradioactive chemical constituents in water from the Snake River Plain aquifer at the INL varied during 2002–05.

During 2002–05, water samples from several wells were analyzed for chromium. In April 2005, water from one aquifer well, USGS 65, south of RTC, equaled the MCL of 100 µg/L for total chromium. However, the concentration of chromium in water from that well decreased from 139 µg/L in October 2001. Concentrations in water samples from other aquifer wells ranged from 1.7 to 30.3 µg/L. Samples collected from well USGS 56 completed in deep perched water at the RTC, contained concentrations of chromium of 114 and 86 µg/L in 2004 and 2005, respectively.

During 2002–05, the largest concentration of sodium in water samples from aquifer wells at the INL was 76 mg/L in a sample collected from well USGS 113, south of INTEC, but concentrations decreased through 2004.

During 2002–05, no analyses were made for dissolved sodium concentrations in shallow perched ground water at the RTC. Dissolved sodium concentrations in water from 16 wells completed in deep perched ground water at the RTC were determined. During April–October 2005, dissolved sodium concentrations ranged from 6 to 27 mg/L in all wells except well USGS 68, (370 mg/L). At the INTEC, water from well SWP 8, completed in shallow perched ground water, contained a concentration of 120 mg/L of dissolved sodium in July 2002.

Dissolved sodium concentrations in deep perched ground water in wells closest to the infiltration ponds (PW 2 and 4) ranged from 106 mg/L in well PW 2 in October 2002 to 83 mg/L in well PW 4 in October 2003.

Chloride concentrations in water from aquifer wells near the INTEC generally have increased or remained constant since disposal practices were changed from injection to the disposal well to discharge to percolation ponds in 1984 through about 2001. During 2002–05, chloride concentrations decreased in some wells and increased in others. Trends in concentrations in water from wells downgradient from the percolation ponds correlated with discharge rates into the ponds when travel time was considered. In April 2005 at the RTC, the chloride concentration in water from well USGS 65 was 19 mg/L. Chloride concentrations in water from all other wells completed in the Snake River Plain aquifer at or near the RTC ranged between 9 and 12 mg/L during 2002–05. At the RWMC, chloride concentrations in water from aquifer wells USGS 88, 89, and 120 were 86, 41, and 20 mg/L, respectively, nearly the same as the 1999–2001 reporting period.

During April–October 2005, dissolved chloride concentrations in shallow perched ground water at the RTC ranged from 10 mg/L in well CWP 3 to 32 mg/L in well CWP 1. Dissolved chloride concentrations in deep perched ground water ranged from 3 mg/L in well USGS 78 to 35 mg/L in well USGS 68.

The dissolved chloride concentration in well SWP 8 at the INTEC was 145 mg/L in July 2002, similar to the July 2001 concentration of 153 mg/L. No samples were collected from well SWP 8 during 2003–05 because the well was dry. During 2002–05, dissolved chloride concentrations in deep perched ground water in wells closest to the percolation ponds (PW 1 through 5) ranged from 118 to 322 mg/L in well PW 4. The variability and values of concentrations of dissolved chloride in this well are similar to the 1999–2001 reporting period.

In 2005, sulfate concentrations in water samples from nine aquifer wells in the south-central part of the INL exceeded the 40 mg/L background concentration of sulfate. The maximum dissolved sulfate concentration in shallow perched ground water at the RTC was 396 mg/L in well CWP 1 in October 2005. Concentrations of dissolved sulfate in this well varied between 26 to 396 mg/L during 2002–05. The higher concentrations are attributed to sulfate disposal to nearby cold-waste ponds. 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 66 to 276 mg/L during April–October 2005. These large concentrations indicate that water in the wells also was affected by discharge into the cold-waste ponds. During April–October 2005, the maximum concentration of dissolved sulfate in deep perched ground water was 951 mg/L in well USGS 68, west of the chemical-waste pond. This dissolved sulfate concentration has steadily decreased from 1,409 mg/L in October 2001.

The dissolved sulfate concentration in shallow perched ground water at the INTEC from well SWP 8 was 49 mg/L in July 2002. Dissolved sulfate concentrations in water from wells completed in the deep perched ground water closest to the INTEC infiltration ponds (PW 2 and 4) were 35 mg/L in October 2002. After 2002, no samples were collected from wells PW1 through 3 and PW5 because of access problems, dry wells, or sample collection discontinued during 2002-05. 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 26 to 40 mg/L during 2002–04. Historically, dissolved sulfate concentrations in water from well USGS 50 have fluctuated around these values.

Concentrations of nitrate in ground water not affected by wastewater disposal from INL facilities generally are less than 5 mg/L (as nitrate). In October 2005, concentrations of nitrate in water from aquifer wells USGS 41, 43, 45, 47, 52, 57, 67, 77, 112, 114, 115 near the INTEC, exceeded 5 mg/L (as nitrate) and concentrations ranged from 6 mg/L in well USGS 45 to 34 mg/L in well USGS 43.

Historically, nitrate concentrations in water from aquifer wells near the RWMC slightly exceeded the regional background concentration of about 5 mg/L (as nitrate) or 1 to 2 mg/L as nitrogen. In 2005, concentrations of nitrate in water from wells USGS 88, 89, and 119 also remained relatively unchanged at 4, 8, and 7 mg/L (as nitrate), respectively. Near the RTC, the concentration of nitrate in water from aquifer well USGS 65 was 7 mg/L, a slight decrease from the 2001 value of 8 mg/L (as nitrate). All concentrations measured in aquifer wells during 2005 were less than the MCL for drinking water of 44 mg/L (as nitrate, or 10 mg/L as nitrogen).

During April to October 2005, water samples from five aquifer wells were analyzed for fluoride; detected concentrations ranged from 0.2 to 0.3 mg/L. These concentrations are similar to background concentrations, indicating that wastewater disposal has not had an appreciable affect on fluoride concentrations in the Snake River Plain aquifer near the INTEC.

During 2002–05, water samples from 30 aquifer wells were collected and analyzed for VOCs. Twelve VOCs were detected. Concentrations of from 1 to 9 VOCs were detected in water samples from 13 wells. The primary VOCs detected included carbon tetrachloride, chloroform, 1,1-dichloroethane, 1,1,1-trichloroethane, trichloroethylene, and tetrachloroethylene.

During 2002–05, attempts were made each year to sample well USGS 92, completed in perched water at the RWMC; however, lack of water in the well precluded obtaining an adequate sample during most sampling events. Concentrations of 16 VOCs were detected during 2002–03. Most of the same VOCs except chloroethane that were detected during 1999–2001 were detected during 2002–03; additionally, bromodichloromethane was detected. Most VOCs fluctuated through time and show no distinct trend.

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