HYDROLOGIC CONDITIONS AND DISTRIBUTION OF SELECTED RADIOCHEMICAL AND CHEMICAL CONSTITUENTS IN WATER, SNAKE RIVER PLAIN AQUIFER, IDAHO NATIONAL ENGINEERING LABORATORY, IDAHO, 1992 THROUGH 1995

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FIGURES

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED UNITS

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
acre	0.4047	hectare
square mile (mi^2)	2.590	square kilometer
gallon (gal)	3.785	liter
acre-foot (acre-ft)	1,233	cubic meter
foot per mile (ft/mi)	0.1894	meter per kilometer
foot squared per day (ft^2/day)	0.09290	meter squared per day
cubic foot per second per mile ((ft^3/s)/mi)	0.01760	cubic meter per second per kilometer
pound (lb)	0.4536	kilogram
curie (Ci)	$3.7x10^{10}$	becquerel
picocurie per milliliter (pCi/mL)	0.037	becquerel per milliliter
picocurie per liter (pCi/L)	0.037	becquerel per liter

For temperature, degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) by using the formula °F = (1.8)(°C)+32.

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviated units used in report: µg/L (microgram per liter), mg/L (milligram per liter), and µS/cm (microsiemens per centimeter) at 25°C.

TABLES

HYDROLOGIC CONDITIONS AND DISTRIBUTION OF SELECTED RADIOCHEMICAL AND CHEMICAL CONSTITUENTS IN WATER, SNAKE RIVER PLAIN AQUIFER, IDAHO NATIONAL ENGINEERING LABORATORY, IDAHO, 1992 THROUGH 1995

By Roy C. Bartholomay, Betty J. Tucker, Daniel J. Ackerman, *and* Michael J. Liszewski

Abstract

Radiochemical and chemical wastewater discharged since 1952 to infiltration ponds and disposal wells at the Idaho National Engineering Laboratory (INEL) has affected water quality in the Snake River Plain aquifer. The U.S. Geological Survey, in cooperation with the U.S. Department of Energy, maintains a monitoring network at the INEL to determine hydrologic trends and to delineate the movement of radiochemical and chemical wastes in the aquifer. This report presents an analysis of water-level and water-quality data collected from the Snake River Plain aquifer during 1992–95.

Water in the Snake River Plain aquifer moves principally through fractures and interflow zones in basalt, generally flows southwestward, and eventually discharges at springs along the Snake River. The aquifer is recharged principally from infiltration of irrigation water, infiltration of streamflow, and ground-water inflow from adjoining mountain drainage basins. Water levels in wells throughout the INEL generally declined during 1992–95 because of drought.

Detectable concentrations of radiochemical constituents in water samples from wells in the Snake River Plain aquifer at the INEL decreased or remained constant during 1992–95. Decreased concentrations are attributed to reduced rates of radioactive-waste disposal, sorption processes, radioactive decay, and changes in waste-disposal practices. Tritium concentrations in water samples decreased as much as 16.6 picocuries per milliliter (pCi/mL) during 1992–95 and ranged from 0.6±0.2 to 25.1±1.0 pCi/mL in 1995. Strontium-90 concentrations remained constant during 1992–95 and ranged from 2.6±0.7 to 76±3 picocuries per liter in 1995. During 1992–95, the concentrations of cobalt-60, cesium-137, plutonium-238, and plutonium-239, -240 (undivided) in water samples from all wells sampled at the INEL were below the reporting level.

Detectable concentrations of chemical constituents in water from the Snake River Plain aquifer at the INEL were variable during 1992–95. In 1995, water from one well south of the Test Reactor Area contained 170 micrograms per liter (µg/L) of dissolved chromium; other water samples contained from less than 5 to 20 µg/L. Sodium and chloride concentrations in the southern part of the INEL increased slightly or remained constant during 1992–95 because of long-term increased waste-disposal rates and a lack of recharge from the Big Lost River. Nitrate concentrations remained relatively constant during 1992–95 even though waste-disposal rates decreased.

During 1992–95, concentrations of 1 to 14 purgeable organic compounds were detected in water from wells at the INEL. A plume of 1,1,1-trichloroethane has developed near the Idaho Chemical Processing Plant. Concentrations of several purgeable organic compounds exceeded their reporting levels in wells at or near the

Radioactive Waste Management Complex as a result of waste-disposal practices.

INTRODUCTION

The Idaho National Engineering Laboratory (INEL), encompassing about 890 mi^2 of the eastern Snake River Plain in southeastern Idaho (fig. 1), is operated by the U.S. Department of Energy (DOE). INEL facilities are used in the development of peacetime atomic-energy applications, nuclear safety research, defense programs, and advanced energy concepts. Radiochemical and chemical wastewater generated at these facilities has been discharged to onsite infiltration ponds and disposal wells since 1952. Wastewater disposal has resulted in detectable concentrations of several waste constituents in water from the Snake River Plain aquifer underlying the INEL.

The DOE requires information about the mobility of dilute radiochemical- and chemical-waste constituents in the Snake River Plain 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's Idaho Operations Office.

Purpose and Scope

In 1949, the U.S. Atomic Energy Commission, which later became the DOE, requested that the USGS describe the water resources of the area now known as the INEL. The purpose of the resulting study was to characterize these resources before the development of nuclear-reactor testing facilities. The USGS since has maintained a monitoring network at the INEL to determine hydrologic trends and to delineate the movement of facility-related radiochemical and chemical wastes in the Snake River Plain aquifer.

This report presents an analysis of water-level and water-quality data collected from wells in the Snake River Plain aquifer during 1992–95 as part of the continuing hydrogeologic investigation at the INEL. The report describes the distribution and concentration of selected radiochemical and chemical constituents in ground water at the INEL. An analysis of water-level and water-quality data collected during 1992–95 from perched ground-water zones in unsaturated rocks beneath infiltration ponds and waste-burial sites overlying the Snake River Plain aquifer at several INEL facilities will be presented in a separate report. Several reports generated from previous investigations of the geology and hydrology of the area are listed in the references and copies can be obtained at the USGS Project Office at the INEL.

Acknowledgments

The DOE's Radiological and Environmental Sciences Laboratory (RESL) provided radiochemical analyses of water samples. Technical staff at the RESL during 1992–95 were under the supervision of several different people, most recently R. Douglas Carlson, Director. The authors are grateful for technical review of the manuscript by USGS hydrologists, Susan Thiros, Salt Lake City, Utah, and Deborah Parliman, Boise, Idaho.

Ground-Water Monitoring Networks

Ground-water monitoring networks are maintained at the INEL to characterize the occurrence, movement, and quality of water and to delineate waste-constituent plumes in the Snake River Plain aquifer. These networks consist of wells from which periodic water-level and water-quality data are obtained. Data from the monitoring networks are on file at the USGS Project Office at the INEL.

Water-level monitoring network.—The water-level network was designed to determine hydraulic-gradient changes that influence 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 in 140 wells were monitored during 1992–95. Water levels were measured annually in

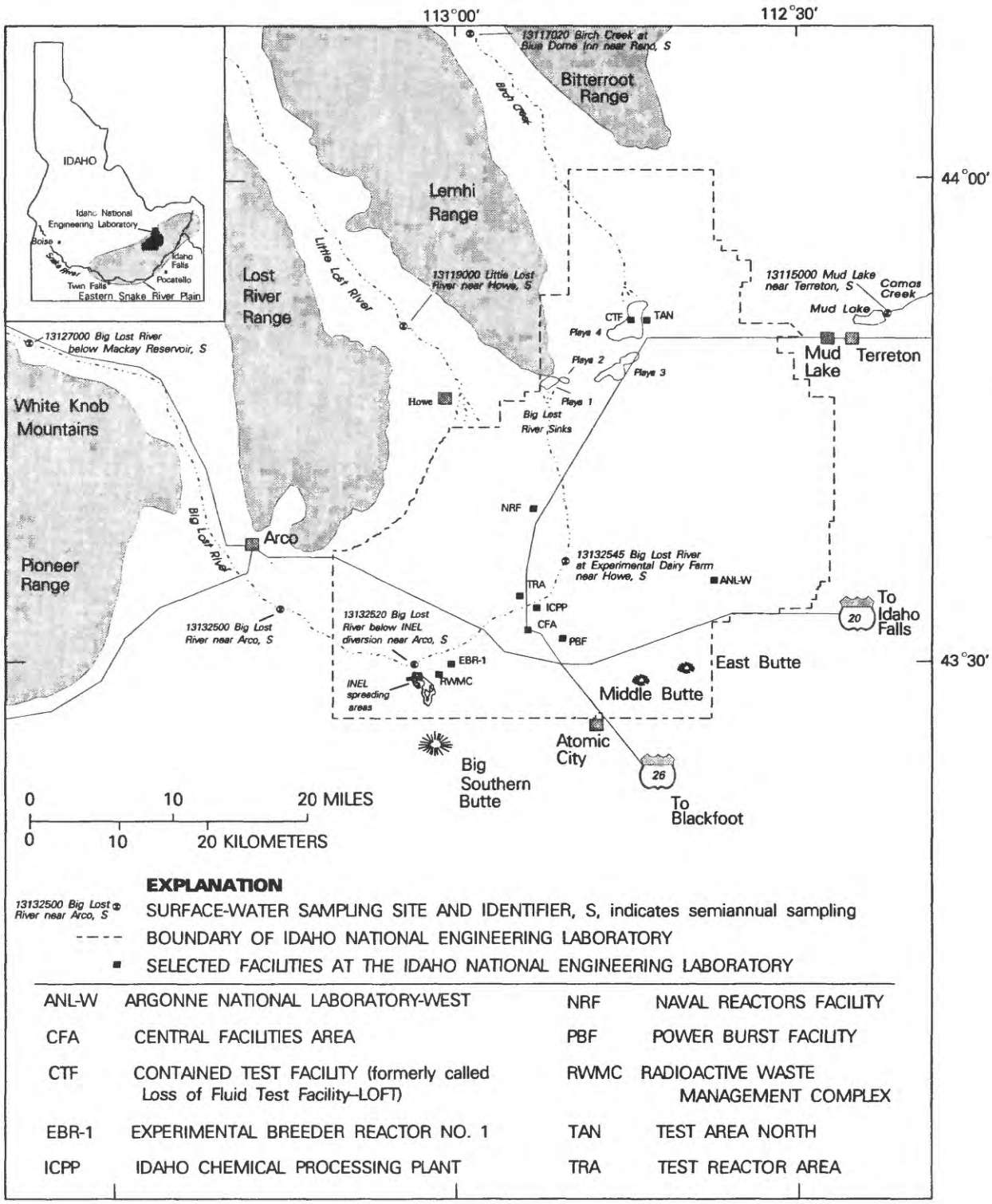


Figure 1. Location of the Idaho National Engineering Laboratory, surface-water sampling sites, and selected facilities.

32 wells, semiannually in 35 wells, quarterly in 62 wells, monthly in 8 wells, and continuously in 3 wells. The location of wells and frequency of water-level measurements as of December 1995 are shown in figures 2 and 3.

Water-quality monitoring network.—The radiochemical and chemical character of water in the Snake River Plain aquifer is determined from analyses of water samples collected as part of a comprehensive sampling program to identify contaminant concentrations and to define the pattern of waste migration in the aquifer. Water samples from surface-water sites at or near the INEL and from wells in perched ground-water zones are analyzed to document the chemical quality of water that recharges the aquifer. Numerous water samples are collected near areas of detailed study, such as the Test Reactor Area (TRA), Idaho Chemical Processing Plant (ICPP), Radioactive Waste Management Complex (RWMC), and Test Area North (TAN).

The type, frequency, and depth of ground-water sampling generally depend on the information needed in a specific area. Water samples routinely are collected and analyzed for concentrations of tritium, strontium-90, cobalt-60, cesium-137, plutonium-238, the sum of plutonium-239 and plutonium-240 (undivided), americium-241, gross alpha- and beta-particle radioactivity, dissolved and hexavalent chromium, sodium, chloride, sulfate, nitrate, purgeable organic compounds and measurements of specific conductance, pH and temperature. In addition, as part of the INEL ground-water monitoring program adopted in 1994 (Sehlke and Bickford, 1993), several wells also were sampled for fluoride, an extensive suite of trace elements, and total organic carbon. Water samples are analyzed for the radiochemical constituents at the RESL at the INEL and for chemical constituents at the National Water Quality Laboratory (NWQL) in Arvada, Colo. The location of surface-water sites and wells that constituted the water-quality monitoring network as of December 1995, and the frequency of sample collection are shown in figures 1, 4, and 5 and in table 1. A sample schedule that lists the constituents analyzed at each site is given by Mann (1996, attachment 1).

The methods used in sampling and analyzing for selected constituents generally follow the guidelines established by the USGS (Goerlitz and Brown, 1972; Stevens and others, 1975; Wood, 1981; Claassen, 1982; W.L. Bradford, written commun., 1985; Wershaw and others, 1987; Fishman and Friedman, 1989; Faires, 1992; and Fishman, 1993). Water samples analyzed by the NWQL and RESL are collected in accordance with a quality-assurance plan for quality-of-water activities conducted by personnel at the INEL Project Office. The plan was finalized in June 1989, revised in March 1992 and again in 1996, (Mann, 1996) and is available for inspection at the USGS Project Office at the INEL. In general, about 10 percent of the samples collected are for quality assurance. Quality-assurance samples include blanks, equipment blanks, splits, duplicates, and replicates. Comparative studies to determine agreement among analytical results for water-sample pairs analyzed by laboratories involved in the INEL Project Office quality-assurance program are summarized by Wegner (1989), Williams (1996), and Williams (1997). Additional quality-assurance studies by personnel at the INEL Project Office include an evaluation of field-sampling and preservation methods for strontium-90 (Cecil and others, 1989), a comparison of different pump types used for sampling purgeable organic compounds (Knobel and Mann, 1993), an analysis of tritium and strontium-90 concentrations in water from wells after purging different borehole volumes (Bartholomay, 1993), and an analysis of the effect of different preservation methods on nutrient concentrations (Bartholomay and Williams, 1996).

Guidelines for Interpreting Results of Radiochemical Analyses

Concentrations of radionuclides are reported with an estimated sample standard deviation, s, that 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).

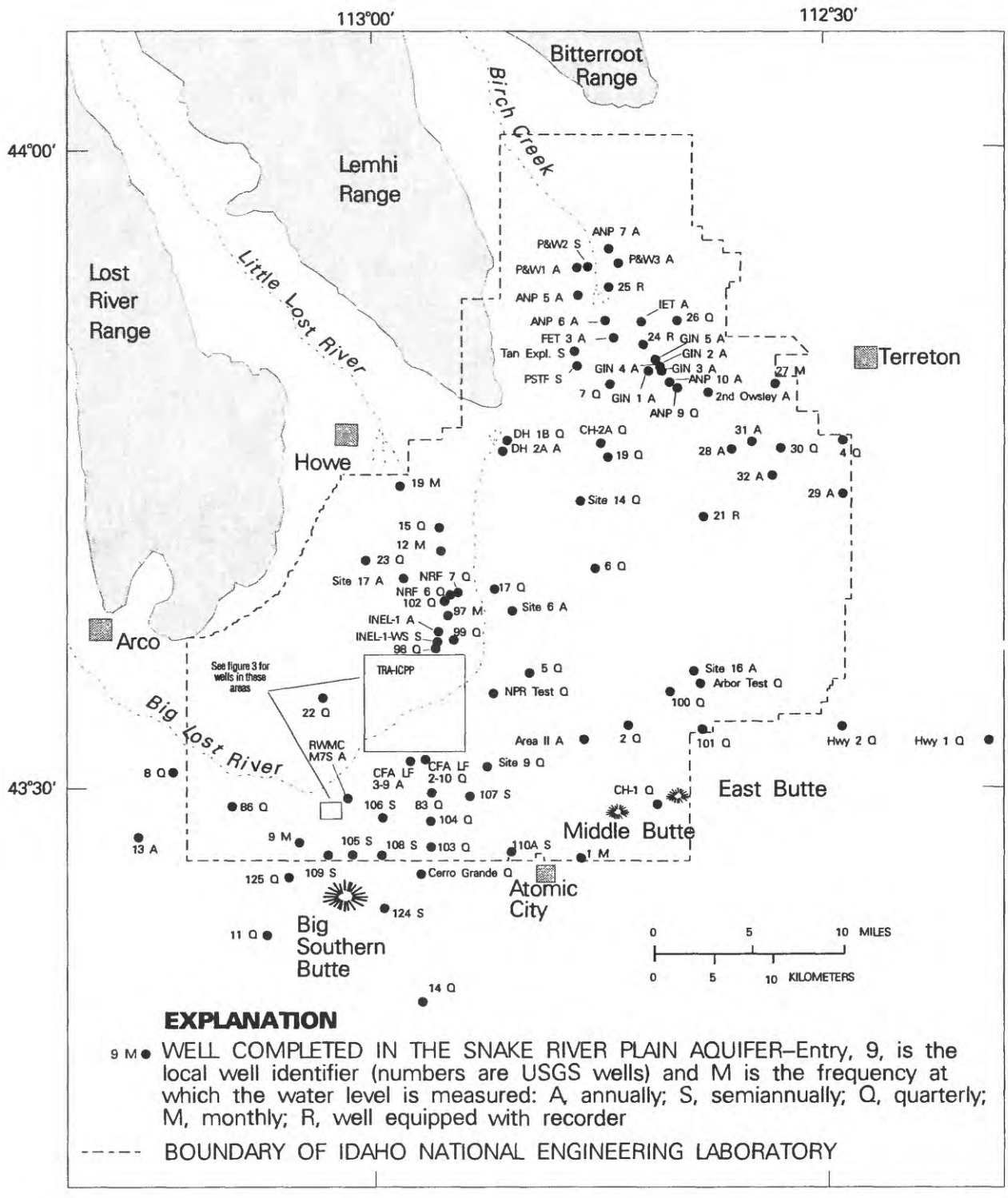
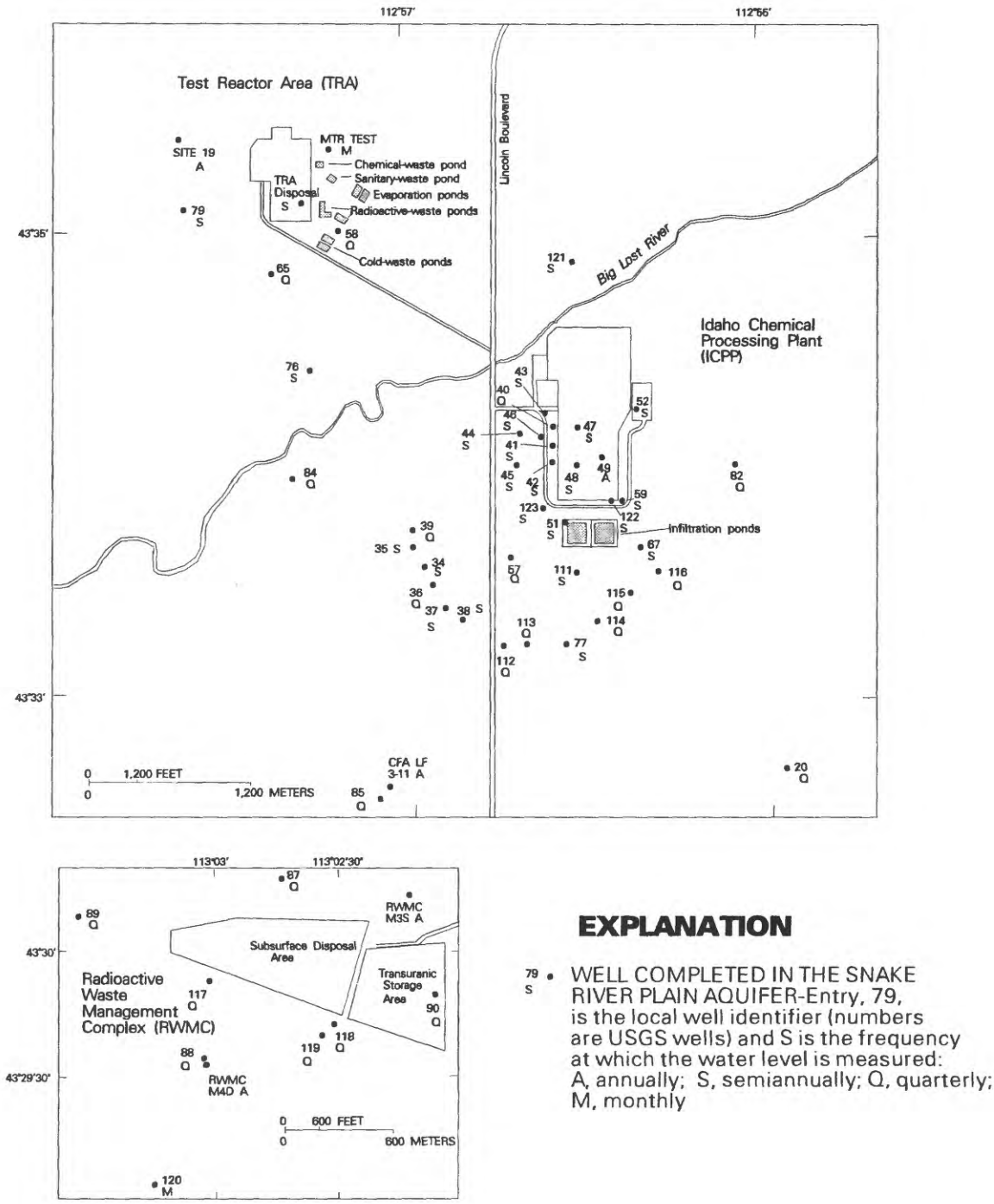


Figure 2. Location of wells and frequency of water-level measurements (as of December 1995) in the Snake River Plain aquifer, Idaho National Engineering Laboratory and vicinity.



EXPLANATION

79 S • WELL COMPLETED IN THE SNAKE RIVER PLAIN AQUIFER-Entry, 79, is the local well identifier (numbers are USGS wells) and S is the frequency at which the water level is measured: A, annually; S, semiannually; Q, quarterly; M, monthly

Figure 3. Location of wells and frequency of water-level measurements (as of December 1995) in the Snake River Plain aquifer, Test Reactor Area, Idaho Chemical Processing Plant, and Radioactive Waste Management Complex.

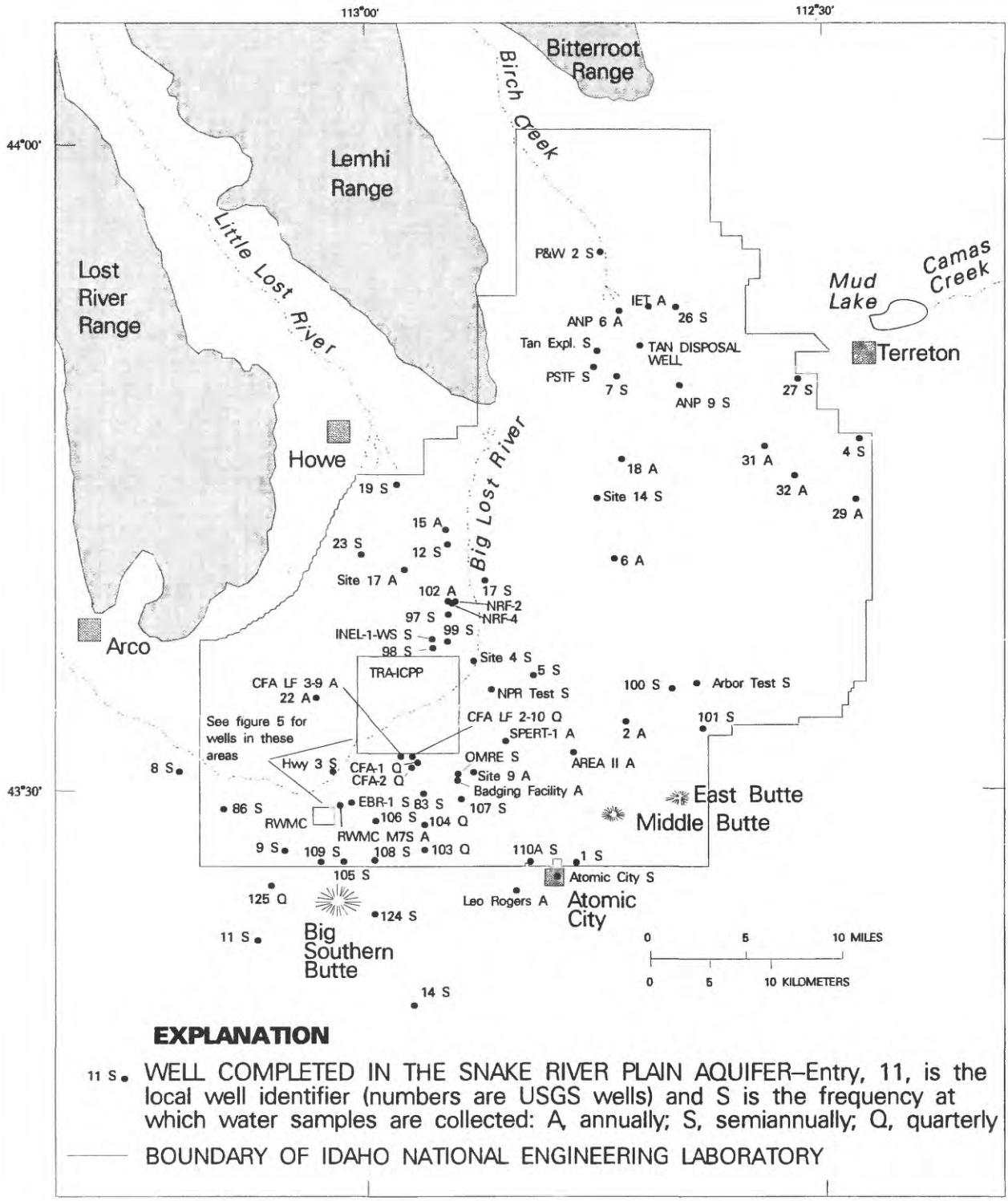


Figure 4. Location of wells and frequency of water-sample collections (as of December 1995) in the Snake River Plain aquifer, Idaho National Engineering Laboratory and vicinity.

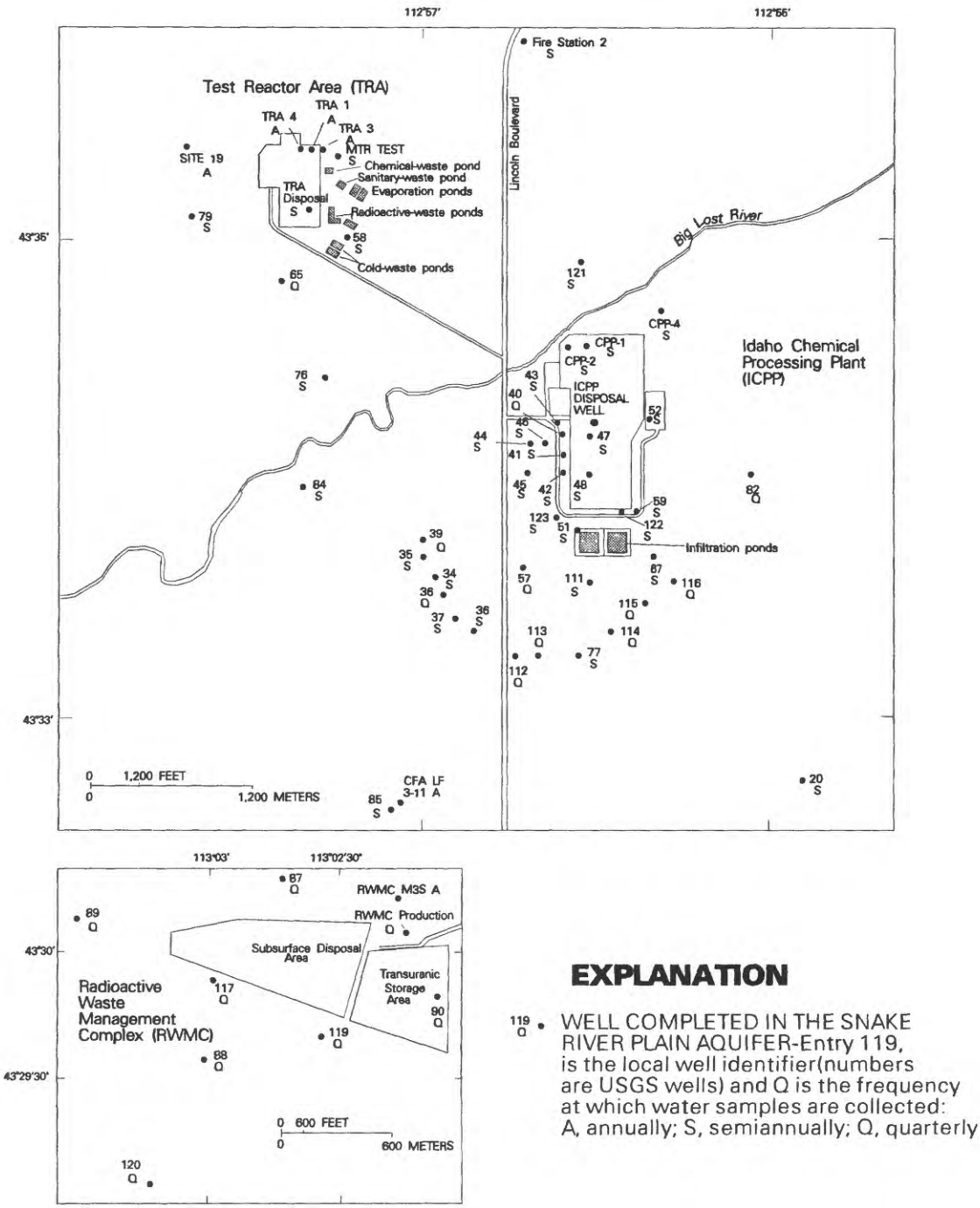


Figure 5. Location of wells and frequency of water-sample collections (as of December 1995) in the Snake River Plain aquifer, Test Reactor Area, Idaho Chemical Processing Plant, and Radioactive Waste Management Complex.

Table 1. Well location, construction, and sample-collection method and frequency, Snake River Plain aquifer, Idaho National Engineering Laboratory

[Status of wells as of October 1995. Well identifier: see figures 4 and 5 for well locations. Sampling method: Tap, sampled from faucet; Pump, sampled from pumping well (pumping rate in gallons per minute). Sampling frequency: A, annual; S, semiannual; Q, quarterly]

Well identifier	Location		Well construction		Water-sample collection	
	Latitude	Longitude	Diameter (inches)	Depth (feet)	Method	Frequency
ANP-6	43°53'08"	112°45'41"	12	305	Pump (40)	A
ANP-9	43°48'56"	112°40'00"	12	322	Pump (20)	S
Arbor Test	43°35'09"	112°38'48"	16	790	Pump (20)	S
AREA II	43°32'23"	112°47'02"	16	877	Pump (14)	A
Atomic City	43°26'38"	112°48'41"	8	639	Tap	S
Badging Facility	43°30'42"	112°53'51"	8	644	Pump (35)	A
CFA-1	43°32'04"	112°56'20"	16	685	Pump (1,000)	Q
CFA-2	43°31'44"	112°56'35"	20	681	Pump (1,400)	Q
CFA LF 2-10	43°32'16"	112°56'33"	6	765	Pump (6.6)	Q
CFA LF 3-9	43°32'16"	112°57'10"	4	500	Pump (5.7)	A
CFA LF 3-11	43°32'49"	112°56'55"	4	492	Pump	A
CPP-1	43°34'33"	112°56'02"	20	585	Pump (3,000)	S
CPP-2	43°34'32"	112°56'08"	16	605	Pump (3,000)	S
CPP-4	43°34'40"	112°55'44"	16	700	Pump (400)	S
EBR-1	43°30'51"	113°00'26"	12	1,075	Pump (1,000)	S
Fire Station 2	43°35'48"	112°56'23"	16	518	Pump (400)	S
Hwy 3	43°32'56"	113°00'25"	8	750	Tap	S
IET	43°51'53"	112°42'05"	20	324	Pump (40)	A
INEL-1-WS	43°37'16"	112°56'36"	8	595	Pump (30)	S
Leo Rogers	43°25'33"	112°50'49"	20	702	Pump (20)	A
MTR Test	43°35'20"	112°57'26"	8	588	Pump (26)	S
NPR Test	43°34'49"	112°52'31"	6	599	Pump (26)	S
OMRE	43°31'16"	112°53'47"	14	943	Pump (10)	S
PSTF	43°49'41"	112°45'42"	16	322	Pump (44)	S
P&W 2	43°54'19"	112°45'31"	10	386	Pump (35)	S
RWMC M3S	43°30'08"	113°02'18"	6	633	Pump (4.5)	A
RWMC M7S	43°30'23"	113°01'48"	6	638	Pump (4.5)	A
RWMC Production	43°30'02"	113°02'17"	16	683	Pump (200)	Q
Site 4	43°36'17"	112°54'20"	15	496	Pump (500)	S
Site 9	43°31'23"	112°53'01"	10	1,057	Pump (25)	A
Site 14	43°43'34"	112°46'31"	10	717	Pump (40)	S
Site 17	43°40'27"	112°57'57"	20	600	Pump (25)	A
Site 19	43°35'22"	112°58'21"	12	865	Pump (25)	A
SPERT-1	43°32'52"	112°52'03"	24	653	Pump (400)	A
TAN Expl.	43°50'38"	112°45'34"	12	550	Pump (42)	S
TRA 1	43°35'21"	112°57'38"	20	600	Pump (3,400)	A
TRA 3	43°35'22"	112°57'35"	20	602	Pump (3,800)	A
TRA 4	43°35'21"	112°57'42"	20	975	Pump (2,000)	A

Table 1. Well location, construction, and sample-collection method and frequency, Snake River Plain aquifer, Idaho National Engineering Laboratory—*continued*

Well identifier	Location		Well construction		Water-sample collection	
	Latitude	Longitude	Diameter (inches)	Depth (feet)	Method	Frequency
TRA Disposal	43°35'06"	112°57'23"	12	1,267	Pump (25)	S
USGS 1	43°27'00"	112°47'08"	6	636	Pump (16)	S
USGS 2	43°33'20"	112°43'23"	5	704	Pump (16)	A
USGS 4	43°46'57"	112°28'22"	6	553	Pump (40)	S
USGS 5	43°35'43"	112°49'38"	6	500	Pump (5)	S
USGS 6	43°40'31"	112°45'37"	6	620	Pump (25)	A
USGS 7	43°49'15"	112°44'39"	4	1,200	Pump (45)	S
USGS 8	43°31'21"	113°11'58"	6	812	Pump (16)	S
USGS 9	43°27'40"	113°04'45"	8	655	Pump (19)	S
USGS 11	43°23'36"	113°06'42"	12	704	Pump (20)	S
USGS 12	43°41'26"	112°55'07"	10	560	Pump (32)	S
USGS 14	43°20'19"	112°56'32"	6	751	Pump (16)	S
USGS 15	43°42'34"	112°55'17"	10	610	Pump (30)	A
USGS 17	43°39'37"	112°51'54"	6	498	Pump (32)	S
USGS 18	43°45'40"	112°44'09"	4	329	Pump (25)	A
USGS 19	43°44'26"	112°57'57"	6	405	Pump (33)	S
USGS 20	43°32'53"	112°54'59"	6	676	Pump (25)	S
USGS 22	43°34'22"	113°03'17"	6	657	Pump (2.5)	A
USGS 23	43°40'55"	112°59'59"	6	467	Pump (25)	S
USGS 26	43°52'12"	112°39'40"	8	266	Pump (40)	S
USGS 27	43°48'51"	112°32'18"	8	312	Pump (20)	S
USGS 29	43°44'07"	112°28'51"	6	422	Pump (32)	A
USGS 31	43°46'25"	112°34'21"	8	428	Pump (40)	A
USGS 32	43°44'44"	112°32'21"	6	392	Pump (28)	A
USGS 34	43°33'34"	112°56'55"	10	700	Pump (25)	S
USGS 35	43°33'39"	112°56'58"	7	578	Pump (25)	S
USGS 36	43°33'30"	112°56'52"	6	567	Pump (25)	Q
USGS 37	43°33'26"	112°56'48"	8	573	Pump (25)	S
USGS 38	43°33'22"	112°56'43"	8	729	Pump (6)	S
USGS 39	43°33'43"	112°57'00"	6	572	Pump (25)	Q
USGS 40	43°34'11"	112°56'11"	6	483	Pump (8)	Q
USGS 41	43°34'09"	112°56'13"	6	674	Pump (25)	S
USGS 42	43°34'04"	112°56'13"	6	678	Pump (25)	S
USGS 43	43°34'15"	112°56'15"	6	676	Pump (6)	S
USGS 44	43°34'09"	112°56'21"	6	650	Pump (24)	S
USGS 45	43°34'02"	112°56'18"	6	651	Pump (24)	S
USGS 46	43°34'07"	112°56'15"	6	651	Pump (24)	S
USGS 47	43°34'07"	112°56'03"	6	652	Pump (8)	S
USGS 48	43°34'01"	112°56'03"	6	750	Pump (24)	S
USGS 51	43°33'50"	112°56'06"	6	659	Pump (5)	S
USGS 52	43°34'14"	112°55'42"	6	650	Pump (25)	S

Table 1. Well location, construction, and sample-collection method and frequency, Snake River Plain aquifer, Idaho National Engineering Laboratory—*continued*

Well identifier	Location		Well construction		Water-sample collection	
	Latitude	Longitude	Diameter (inches)	Depth (feet)	Method	Frequency
USGS 57	43°33'44"	112°56'26"	6	732	Pump (25)	Q
USGS 58	43°35'00"	112°57'25"	6	503	Pump (25)	S
USGS 59	43°33'54"	112°55'47"	6	657	Pump (3)	S
USGS 65	43°34'47"	112°57'45"	6	498	Pump (8)	Q
USGS 67	43°33'44"	112°55'41"	6	698	Pump (8)	S
USGS 76	43°34'25"	112°57'32"	6	718	Pump (25)	S
USGS 77	43°33'15"	112°56'03"	6	610	Pump (25)	S
USGS 79	43°35'05"	112°58'19"	6	702	Pump (25)	S
USGS 82	43°34'01"	112°55'10"	8	700	Pump (25)	Q
USGS 83	43°30'23"	112°56'15"	6	752	Pump (6)	S
USGS 84	43°33'56"	112°57'42"	6	505	Pump (5)	S
USGS 85	43°32'46"	112°57'12"	6	637	Pump (23)	S
USGS 86	43°29'35"	113°08'00"	8	691	Pump (19)	S
USGS 87	43°30'13"	113°02'42"	6	673	Pump (2)	Q
USGS 88	43°29'40"	113°03'02"	6	662	Pump (1)	Q
USGS 89	43°30'05"	113°03'28"	6	646	Pump (5)	Q
USGS 90	43°29'54"	113°02'05"	6	626	Pump (4)	Q
USGS 97	43°38'07"	112°55'15"	4	510	Pump (27)	S
USGS 98	43°36'57"	112°56'36"	6	505	Pump (18)	S
USGS 99	43°37'05"	112°55'21"	6	450	Pump (25)	S
USGS 100	43°35'03"	112°40'07"	6	750	Pump (10)	S
USGS 101	43°32'55"	112°38'18"	6	865	Pump (13)	S
USGS 102	43°38'53"	112°55'16"	6	445	Pump (29)	A
USGS 103	43°27'14"	112°56'07"	8	760	Pump (21)	Q
USGS 104	43°28'56"	112°56'08"	8	700	Pump (21)	Q
USGS 105	43°27'03"	113°00'18"	8	800	Pump (19)	S
USGS 106	43°29'59"	112°59'31"	8	760	Pump (22)	S
USGS 107	43°29'42"	112°53'28"	8	690	Pump (5)	S
USGS 108	43°26'59"	112°58'26"	8	760	Pump (25)	S
USGS 109	43°27'01"	113°02'56"	6	800	Pump (16)	S
USGS 110A	43°27'17"	112°50'15"	10	644	Pump (24)	S
USGS 111	43°33'31"	112°56'05"	8	595	Pump (15)	S
USGS 112	43°33'14"	112°56'30"	8	563	Pump (25)	Q
USGS 113	43°33'14"	112°56'18"	6	564	Pump (25)	Q
USGS 114	43°33'18"	112°55'50"	6	562	Pump (10)	Q
USGS 115	43°32'20"	112°55'41"	6	581	Pump (5)	Q
USGS 116	43°33'31"	112°55'32"	6	580	Pump (20)	Q
USGS 117	43°29'55"	113°02'59"	8	655	Pump (5)	Q
USGS 119	43°29'45"	113°02'34"	8	705	Pump (3)	Q
USGS 120	43°29'19"	113°03'15"	8	705	Pump (21)	Q
USGS 121	43°34'50"	112°56'03"	8	475	Pump (8)	S

Table 1. Well location, construction, and sample-collection method and frequency, Snake River Plain aquifer, Idaho National Engineering Laboratory—*continued*

Well identifier	Location		Well construction		Water-sample collection	
	Latitude	Longitude	Diameter (inches)	Depth (feet)	Method	Frequency
USGS 122	43°33'53"	112°55'52"	4	480	Pump (0.5)	S
USGS 123	43°33'52"	112°56'14"	8	481	Pump (3)	S
USGS 124	43°23'07"	112°58'31"	4	800	Pump (18)	S
USGS 125	43°26'02"	113°05'28"	10	760	Pump (20)	Q

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, it is essential to distinguish between two key aspects of the problem of detection: (1) the instrument signal for the sample must be larger than the signal observed for the blank before the decision can be made that 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 the 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 1.6s before the qualitative decision can be made as to whether the radionuclide was detected. At 1.6s, 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 larger than or equal to 1.6s, which were concluded as being 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 1.6s has been defined, the minimum detectable concentration may be determined. Concentrations that equal 3s represent a measurement at the minimum detectable concentration. For true concentrations of 3s or larger, there is a 95-percent or larger 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 true concentrations at the minimum detectable concentration of 3s. These measurements are referred to as false negatives and are errors of the second kind in hypothesis testing.

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

The critical level and minimum detectable concentration are based on counting statistics alone and do not include systematic or random errors inherent in laboratory procedures. The values 1.6s and 3s 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 3s are considered to be below a "reporting level." The critical level, minimum detectable concentration, and reporting level aid the reader in the interpretation of analytical results and do not represent absolute concentrations of radioactivity which may or may not have been detected.

Waste-Disposal Sites at the INEL

Wastewater disposal sites at INEL facilities have been the principal sources of radioactive- and chemical-waste constituents in water from the Snake River Plain aquifer. In the past, wastewater disposal sites have included infiltration ponds and ditches, drain fields, and disposal wells. From 1992 to 1995, wastewater was discharged into infiltration and evaporation ponds and drain fields. Waste materials buried at the RWMC (fig. 1) also are a source of some constituents in ground water. Radioactive-waste-disposal data presented in this report were obtained from a series of radioactive-waste-management information reports (Litteer and others, 1993; Taylor, 1994; French and others, 1995b; and French and others, 1996b). Chemical-waste-disposal data were obtained from a series of nonradiological-waste-management information reports (Randall and Sims, 1993; Sims and Taylor, 1994; French and others, 1995a; and French and others, 1996a). The radioactive- and chemical-waste-disposal data are collected by contractors at each facility.

Test Reactor Area.—Since 1959, low-level radioactive, chemical, and sanitary wastewater has been discharged to infiltration and evaporation

ponds. 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 Disposal, fig. 3) from 1964 until March 1982, and into two cold-waste infiltration ponds from 1982 to the present. During 1992–95, about 236 million gal/yr of wastewater was discharged to infiltration and evaporation ponds at the TRA (fig. 3).

The average annual discharge to the radioactive-waste infiltration and evaporation ponds was about 125 million gal during 1960–95 (fig. 3). The volume of wastewater and the amount of tritium discharged to the radioactive-waste ponds during this period are shown in figure 6. The volume of wastewater discharged to the ponds was 28.7 million gal in 1991 and 7.4 million gal in 1995. The average annual discharge for 1992–95 was 14 million gal and was much less than the long-term average annual discharge.

In 1976, the DOE contractor at the TRA 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. The volume of radioactive wastewater discharged at the TRA decreased as a result of this program. In August 1993, two lined evaporation ponds replaced the radioactive-waste infiltration ponds (B.R. Orr, USGS, oral commun., 1996). The evaporation ponds essentially prevent radioactive wastewater from entering the aquifer.

In 1974–79, about 10 percent of the radioactivity in wastewater discharged was attributed to tritium; in 1980, about 50 percent was attributed to tritium; and in 1981–85, about 90 percent was attributed to tritium (Pittman and others, 1988, p. 22). In 1992–95, about 96 percent of the radioactivity in wastewater discharged at the TRA was attributed to tritium (fig. 6).

A chemical-waste infiltration pond has been used for disposal of chemical wastewater from an ion-exchange system at the TRA since 1962 (fig. 3). The average annual discharge to this pond was about 18.5 million gal for the period 1962–95. The average annual discharge for 1992–95 was 6.8 million gal, 37 percent of the long-term average. Sulfate and sodium were the predominant constituents in the chemical wastewater. During 1992–95, average annual amounts of about 311,000 lb of sulfate and 168,000 lb of sodium were discharged to the chemical-waste infiltration pond; average annual concentrations of sulfate and sodium in the wastewater were about 5,400 and 3,000 mg/L, respectively.

The TRA disposal well, which currently is used as an observation well, was used from 1964 to March 1982 to inject nonradioactive wastewater from cooling-tower operations at the TRA 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 230 million gal during 1964–91 and about 195 million gal during 1992–95. This wastewater contained an average annual amount of about 284,500 lb of sulfate and 43,000 lb of other chemicals during 1992–95.

About 20.5 million gal/yr of sewage effluent was discharged to a sanitary-waste infiltration pond at the TRA during 1992–95 (fig. 3). In 1989 the sewage effluent contained about 1,070 lb of chloride and 1,550 lb of hypochlorite. Chloride and hypochlorite were not part of the sewage effluent after February 1990.

Idaho Chemical Processing Plant.—From 1952 to February 1984, the ICPP discharged most of its low-level radioactive, chemical, and sanitary wastewater into the Snake River Plain aquifer through a 600-ft-deep disposal well (ICPP Disposal well, fig. 5). The average annual discharge of wastewater to the well was about 363 million gal (Pittman and others, 1988, p. 24). Two infiltration ponds currently are being used for wastewater disposal (fig. 3). The first pond was completed in February 1984 and the second pond was completed in October 1985. The volumes of wastewater discharged to the well and infiltration ponds during 1962–95 are shown in figure 7. The annual discharge to the well and ponds ranged from 260 million gal in 1963 to 665 million gal in 1993 and averaged about 430 million gal. The average

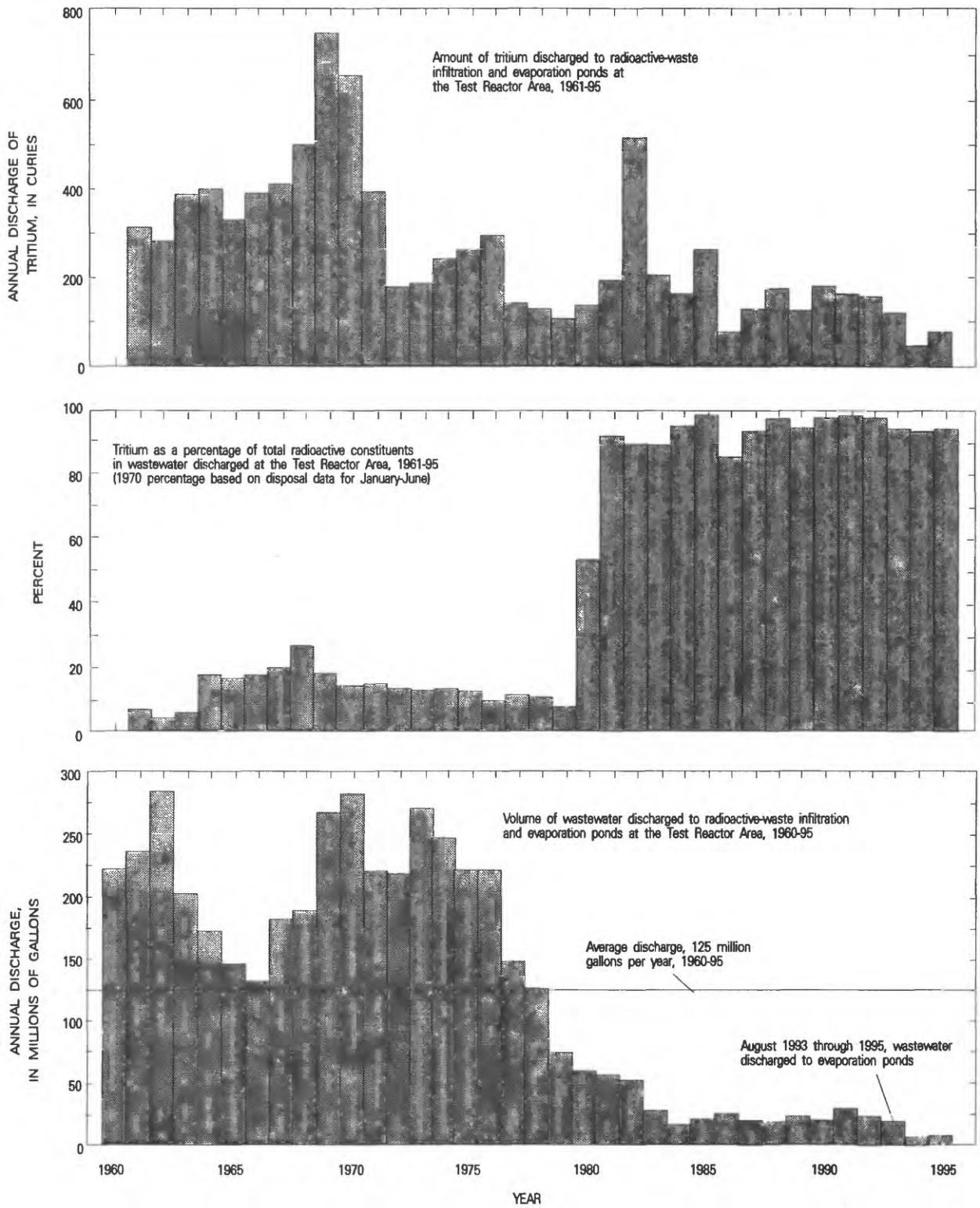


Figure 6. Amount of tritium discharged, tritium as a percentage of total radioactive constituents in wastewater discharged, and volume of wastewater discharged to the radioactive-waste infiltration and evaporation ponds at the Test Reactor Area, 1960–95.

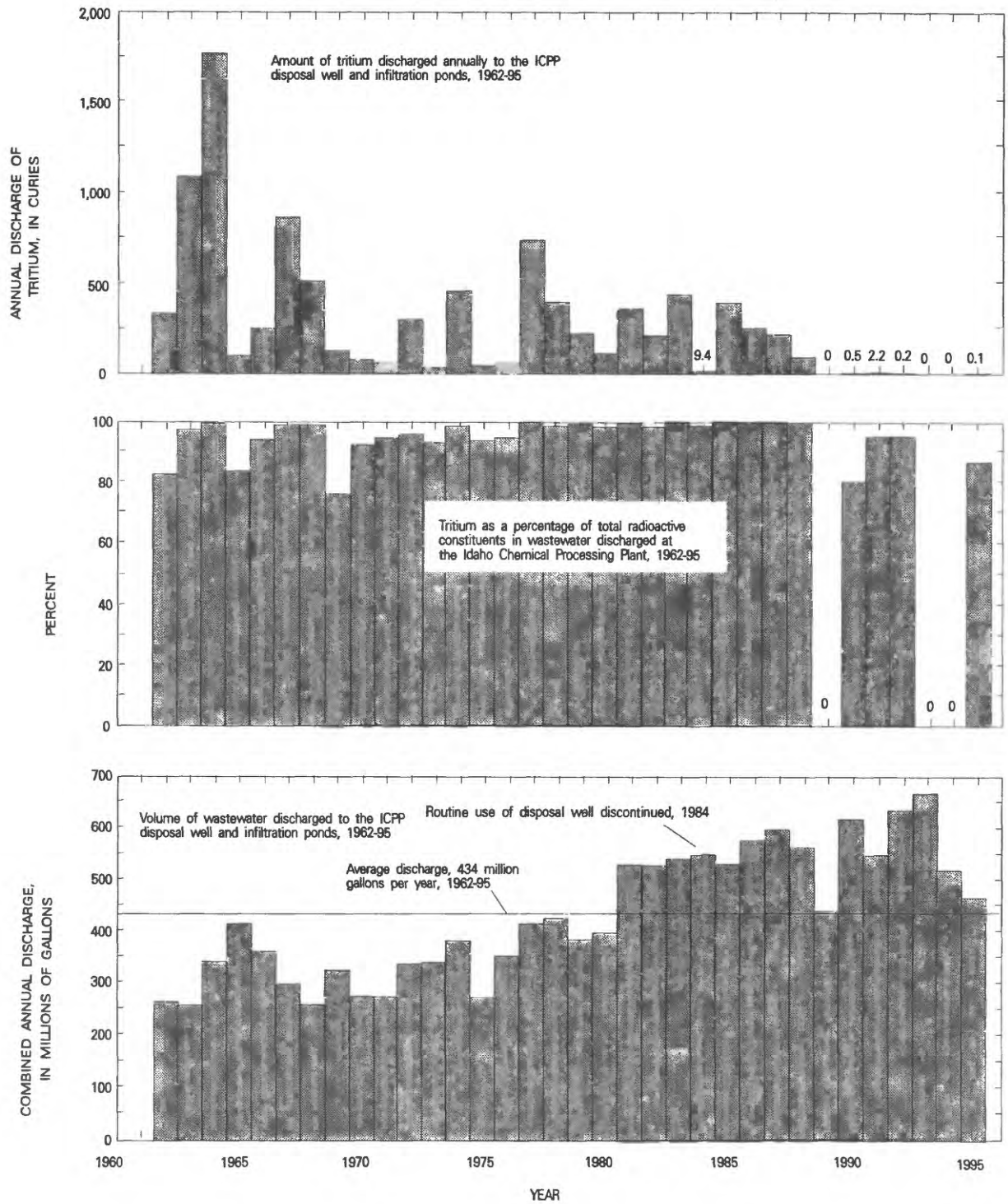


Figure 7. Amount of tritium discharged, tritium as a percentage of total radioactive constituents in wastewater discharged, and volume of wastewater discharged to the disposal well and infiltration ponds at the Idaho Chemical Processing Plant, 1962–95.

annual discharge during 1992–95 was about 570 million gal.

Most of the radioactivity in wastewater discharged to the infiltration ponds at the ICPP is attributed to tritium. Tritium has accounted for more than 90 percent of the radioactivity in wastewater discharged at the ICPP since 1970 (fig. 7). During 1986–88, a total of 556 Ci of tritium was discharged at the ICPP and the average annual amount was 185 Ci (Orr and Cecil, 1991, p. 20). During 1990–91, only 2.7 Ci of tritium was discharged and during 1992 and 1995 only about 0.3 Ci was discharged. No tritium was discharged during 1989, 1993, and 1994 (fig. 7).

During 1992–95, chloride, fluoride, nitrate, sodium, and sulfate were the predominant chemical constituents in wastewater discharged to the ICPP infiltration ponds. Average annual amounts of about 1,224,000 lb of chloride; 860 lb of fluoride; 41,100 lb of nitrate; 754,000 lb of sodium, and 124,000 lb of sulfate were in wastewater discharged at the ICPP.

Naval Reactors Facility.—Wastewater at the Naval Reactors Facility (NRF) (fig. 1) is discharged to a 3-mi-long industrial-waste ditch and to sewage ponds. During 1992–95, about 148 million gal/yr of wastewater was discharged to the industrial-waste ditch. About 15 million gal/yr of sewage effluent was discharged to the sewage ponds. The 1992–95 disposal rates represent an increase since 1989–91, when 115 million gal/yr was discharged (Bartholomay, Orr, and others, 1995, p. 25).

Chloride, sulfate, and sodium were the predominant chemical constituents in wastewater discharged to the industrial-waste ditch. About 241,000 lb of chloride, 269,000 lb of sulfate, and 134,000 lb of sodium was discharged annually during 1992–95. These amounts reflect disposal-rate increases from the average annual amounts discharged during 1989–91 (Bartholomay, Orr, and others, 1995, p. 27). The average annual amount of all other chemical constituents in the wastewater was about 4,250 lb.

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 constituents include transuranic wastes (buried in trenches until 1970), other radiochemical and inorganic chemical constituents, and organic compounds. 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 550 Ci of plutonium-238; 21,000 Ci of plutonium-239; 4,900 Ci of plutonium-240; 165,000 Ci of plutonium-241; and 51,000 Ci of americium-241 was buried in the SDA during 1954–70 (Barraclough and others, 1976, p. 11). 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, fig. 4). In 1972, the disposal well was replaced by a 35-acre infiltration pond. No records are available as to the amount of radioactivity in wastewater discharged at TAN prior to 1959. During 1959–95, about 61 Ci of radioactivity was discharged in wastewater to the disposal well and infiltration pond. Of this amount, about 20 Ci was 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).

During 1992–93, an average of about 37 million gal/yr of radioactive wastewater was discharged to the infiltration pond at TAN. The average rate of disposal of radioactivity in this wastewater during 1992–93 was about 1 Ci/yr. No wastewater discharge was recorded for 1994–95.

An average of about 12.9 million gal/yr of chemical wastewater was discharged to the infiltration pond during 1992–95. The predominant constituents were chloride and sodium. Average annual amounts of 6,400 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 3,700 lb.

Central Facilities Area.—An average annual volume of about 27 million gal of wastewater was discharged to the sewage-plant tile drain field at the CFA (fig. 1) during 1992–93. Most radioactive wastes discharged to this drain field are from pumpage of production well CFA-1 (fig. 4), which obtains water from within the ICPP contaminant plume in the Snake River Plain aquifer. Most of the radioactivity in wastewater discharged at the CFA is attributed to tritium. During 1992–93, tritium accounted for 99.7 percent of the total radioactivity in wastewater discharged at the CFA and averaged about 1.5 Ci/yr. No wastewater discharge was recorded for 1994–95.

Chloride and sodium are the predominant constituents in chemical and laundry wastewater discharged to the drain field at the CFA. During 1992–95, average annual amounts of about 22,700 lb of chloride and 15,000 lb of sodium were discharged. The average annual amount of all other chemical constituents in the wastewater was about 12,700 lb.

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 is principally from infiltration of applied irrigation water, infiltration of streamflow, and ground-water inflow from adjoining mountain drainage basins. Some recharge may be from direct infiltration of precipitation, although the small amount of annual precipitation on the plain (8 in. at the INEL), evapotranspiration, and the great depth to water (in places exceeding 900 ft) probably minimize this source of recharge.

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 Range west of the INEL (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 river's terminus. To avoid flooding at the INEL facilities, excess runoff has been diverted since 1958 to spreading areas in the southwestern part of the INEL, where much of the water rapidly infiltrates to the aquifer. Other surface drainages that provide recharge to the Snake River Plain aquifer at the INEL include Birch Creek, Little Lost River, and Camas Creek (fig. 1).

The average streamflow in the Big Lost River below Mackay Reservoir (fig. 1) for the 79-yr period of record (water years 1905, 1913–14, and 1920–95) was 222,900 acre-ft/yr (Brennan and others, 1996, p. 217). Streamflow in the Big Lost River below Mackay Reservoir (fig. 8) ranged from 125,900 acre-ft (56 percent of average flow) during the 1992 water year (Harenberg and others, 1993, p. 178) to 310,000 acre-ft (139 percent of average flow) during the 1995 water year (Brennan and others, 1996, p. 217). Streamflow recorded for the Big Lost River near Arco (fig. 1) during 1993 and 1995 was 10,610 and 84,880 acre-ft/yr, respectively. The Big Lost River below the INEL diversion near Arco (fig. 1), and the INEL diversion at its head near Arco (fig. 8) also had streamflow during 1993 and 1995. A combined rate of 7,777 acre-ft/yr was reported in 1993 (Harenberg and others, 1994, p. 210, 212) and 80,080 acre-ft/yr was reported in 1995 (Brennan and others, 1996, p. 221, 223). There was no streamflow below the Big Lost River near Arco during 1992 and 1994.

Before 1989, recharge to the Snake River Plain aquifer downstream from Arco was substantial because of infiltration of streamflow from the Big Lost River channel, diversion areas, sinks, and playas. For example, measured infiltration losses at

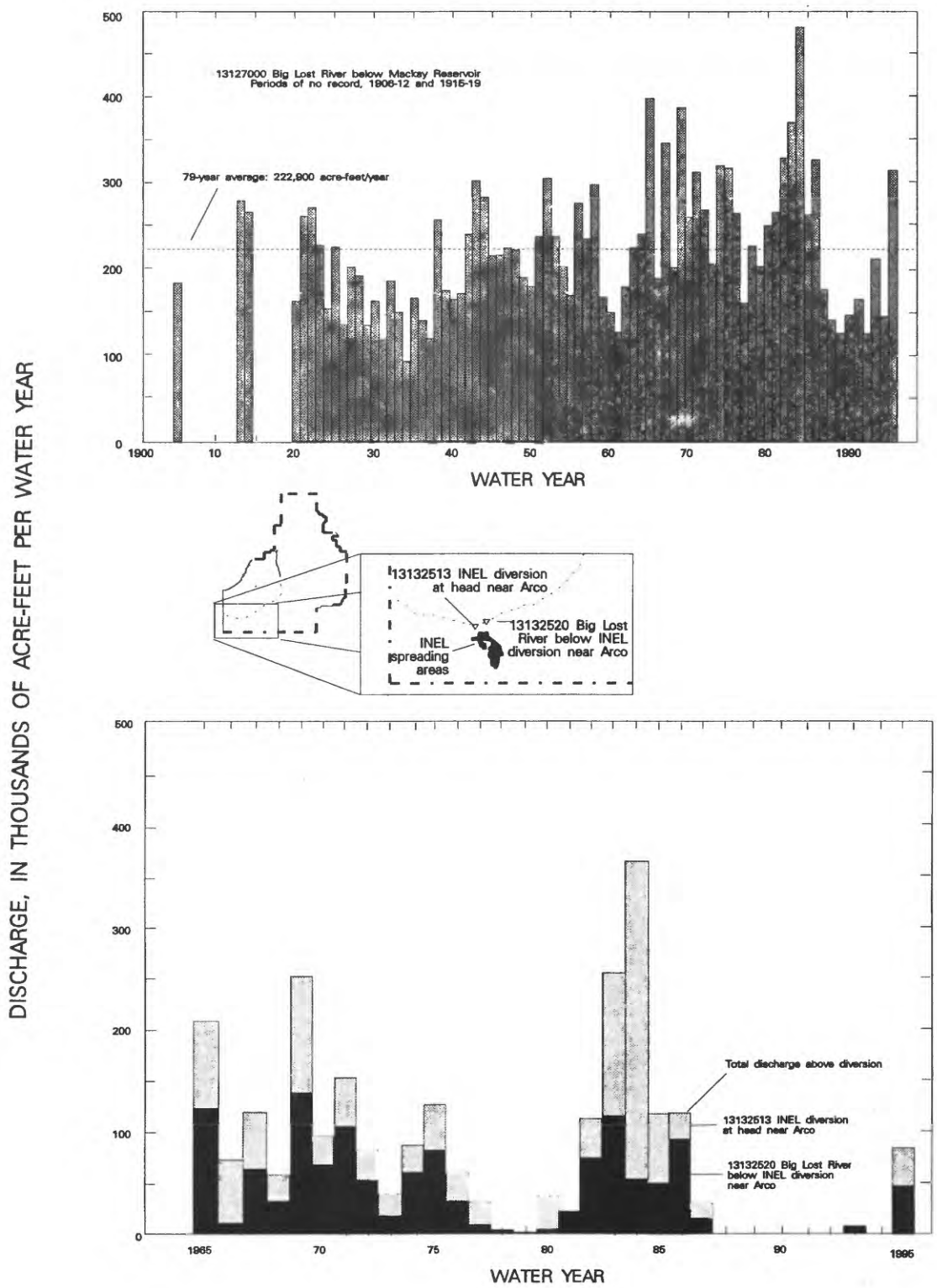


Figure 8. Discharge of the Big Lost River below Mackay Reservoir (water years 1905, 1913-14, and 1920–95), Big Lost River below the INEL diversion near Arco, and the INEL diversion at head near Arco (water years 1965–95).

various discharges ranged from 1 to 28 (ft^3/s)/mi (Bennett, 1990, p. 1).

Ground Water

Water in the Snake River Plain aquifer moves principally through fractures and interflow zones in the basalt. A significant proportion of the ground water moves through the upper 200 to 800 ft of basaltic rocks (Mann, 1986, p. 21). Ackerman (1991, p. 30) reported a range of transmissivity of basalt in the upper part of the aquifer to be from 1.1 to 760,000 ft^2/d. Since Ackerman (1991) was published, additional data have become available. Data on additional specific-capacity tests and estimates of transmissivity are presented in tables 2 and 3. These data were collected and analyzed according to the same methods reported by Ackerman (1991). The additional data fall within the range of estimated transmissivities reported by Ackerman (1991). The hydraulic conductivity of underlying rocks is 0.002 to 0.03 ft/day, several orders of magnitude smaller (Mann, 1986, p. 21). The effective base of the Snake River Plain aquifer at the INEL probably ranges from about 815 to 1,710 ft below land surface (Anderson and others, 1996, p. 23).

Depth to water in wells completed in the Snake River Plain aquifer ranges from about 200 ft in the northern part of the INEL to more than 900 ft in the southeastern part. In March-May 1995, the altitude of the water table was about 4,580 ft above sea level in the northern part of the INEL (fig. 9) and about 4,420 ft above sea level in the southwestern part. Water flowed southward and southwestward beneath the INEL (fig. 9) at an average hydraulic gradient of about 4 ft/mi. Locally, however, the hydraulic gradient ranged from about 1 to 15 ft/mi. From March-May 1991 to March-May 1995, water levels generally declined throughout the INEL because of drought conditions that began in 1987. Water-level declines ranged from about 8.5 ft in wells in the west-central part of the INEL to about 2.5 ft in wells in the southern part (fig. 10). The larger water-level decline in wells in the west-central part of the INEL is attributed to lack of recharge from the Big Lost River.

Water levels monitored in wells 12, 17, 23 (fig. 2), and 20 (fig. 3) show long-term water-level changes in the Snake River Plain aquifer at different locations at the INEL. Water levels in these wells fluctuated in response to infiltration of streamflow (fig. 11). Long-term water-level fluctuations ranged from about 11 ft in well 20 to about 27 ft in well 12. Water levels in these wells declined from 1992 to the early part of 1995 because there was only a small amount of streamflow in the Big Lost River below Arco and because of a decline in recharge to the aquifer because of drought conditions. Wells 12 and 23 indicate an upward trend in water levels at the end of 1995 (fig. 11). This upward trend probably is influenced by infiltration of flow in the Big Lost River during 1995.

Ground water moves southwestward from the INEL and eventually is discharged to springs along the Snake River downstream from Twin Falls, 100 mi southwest of the INEL. About 3.7 million acre-ft of ground water was discharged to these springs in 1995 (Berenbrock, USGS, written commun., 1996).

SELECTED RADIOCHEMICAL AND CHEMICAL CONSTITUENTS IN 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 INEL are attributed to waste-disposal practices. The areal distribution of the plumes are approximately defined from concentrations of these constituents in water samples from wells completed in the aquifer. No attempt is made to determine the vertical extent and distribution of these plumes. Radiochemical and chemical constituents detected in ground water at the INEL include tritium, strontium-90, cobalt-60, cesium-137, plutonium-238, plutonium-239,-240 (undivided), americium-241, gross alpha- and beta-particle radioactivity, dissolved and hexavalent chromium, sodium, chloride, sulfate, nitrate, fluoride, trace elements, purgeable organic compounds, and total organic carbon.

Table 2. Data on specific-capacity tests of selected wells at or near the Idaho National Engineering Laboratory

[Location of wells shown on figures 2, 3, 4, and 5. Date, month-day-year of beginning of test; gal/min, gallon per minute; gal/min/ft, gallon per minute per foot; R, regression analysis; s, drawdown measurable but less than 0.1 foot; f, airline measurement of drawdown; N, Neuman type-curve analysis; m, discharge estimated from pump rating curve; h, large barometric change; d, decrease in saturated thickness greater than 10 percent; k, water levels oscillating. Symbol: <, less than; >, greater than]

Well identifier	Test number	Date	Length of test (minutes)	Discharge (gal/min)	Drawdown (feet)	Specific capacity (gal/min/ft)	Remarks
ANP 10	1	7-17-59	90	380	15.86	2.4×10^{1}	R
AREA II	3	8-18-90	100	15	.01	1.5×10^{3}	R, s
CFA-1	1	1-20-49	60	590	21	2.8×10^{1}	R, f
MTR Test	3	11-30-49	2,881	90	<.1	$>9.0\times10^{2}$	R, s
TAN Expl.	1	8-22-90	210	44.1	25.2	1.8×10^{0}	N
PSTF Test	2	8-21-90	100	46.4	.11	4.2×10^{2}	R
Site 9	1	9-27-91	304	23	<.01	$>2.3\times10^{3}$	R, m, s
Site 17	1	9-06-90	7	26	.19	1.4×10^{2}	R, m
USGS 1	1	7-03-90	5	14	.04	3.5×10^{2}	R, m
USGS 1	2	6-25-93	40	20	<.01	$>2.0\times10^{3}$	R, h
USGS 2	1	8-02-90	130	15.7	.05	3.1×10^{2}	R, s
USGS 4	1	7-31-90	5	28	.01	2.8×10^{3}	R, m
USGS 5	1	9-25-90	120	4.6	13.6	3.4×10^{-1}	R, d
USGS 6	1	9-06-90	120	25.2	3.6	7.0×10^{0}	R
USGS 7	1	8-31-90	130	44.6	1.1	4.1×10^{1}	R, k
USGS 8	1	10-25-90	60	15.8	.08	2.0×10^{2}	R, s
USGS 12	2	5-15-90	120	31.5	.43	7.3×10^{1}	R
USGS 15	1	5-14-90	120	31.7	.05	6.3×10^{2}	R, s
USGS 18	1	8-29-90	5	32	.09	3.6×10^{2}	R, m
USGS 19	1	10-12-90	170	33.1	.06	5.5×10^{2}	R, s
USGS 20	1	10-02-91	56	23	3.5	6.6×10^{0}	R, m
USGS 22	1	10-04-91	83	<3	30.1	$<1.0\times10^{-1}$	R, m, d
USGS 23	1	8-30-90	3	26	.04	6.5×10^{2}	R, m
USGS 26	1	7-31-90	3	43	.01	4.3×10^{3}	R, m
USGS 27	1	10-04-91	55	20	3.39	5.9×10^{0}	R, m
USGS 29	1	8-30-90	120	32.3	.05	6.5×10^{2}	R, s
USGS 31	2	8-24-90	5	29	.26	1.1×10^{2}	R, m
USGS 32	1	8-24-90	8	31	.01	3.1×10^{3}	R, m
USGS 34	1	10-08-91	165	23	<.01	$>2.3\times10^{3}$	R, m, s
USGS 35	1	10-07-91	51	23	<.01	$>2.3\times10^{3}$	R, m, s
USGS 36	1	10-08-91	42	23	.01	2.3×10^{3}	R, m, s
USGS 37	1	10-21-93	63	25.7	.20	1.3×10^{2}	R
USGS 38	1	10-03-91	375	3.5	22.1	1.6×10^{-1}	R
USGS 39	1	10-07-91	43	23	.01	2.3×10^{3}	R, m, s
USGS 41	1	10-11-91	55	23	<.01	$>2.3\times10^{3}$	R, m, s
USGS 42	1	10-11-91	57	23	<.01	$>2.3\times10^{3}$	R, m, s
USGS 44	1	9-11-90	100	24.1	.01	2.4×10^{3}	R, s
USGS 45	1	9-11-90	99	24.5	.25	9.8×10^{1}	R
USGS 46	1	8-07-90	140	28.1	<.01	$>2.8\times10^{3}$	R, s

Table 2. Data on specific-capacity tests of selected wells at or near the Idaho National Engineering Laboratory—*continued*

Well identifier	Test number	Date	Length of test (minutes)	Discharge (gal/min)	Drawdown (feet)	Specific capacity (gal/min/ft)	Remarks
USGS 48	1	9-13-90	120	24	.01	2.4×10^{3}	R, s
USGS 52	1	10-11-91	58	24	<.01	$>2.4\times10^{3}$	R, m, s
USGS 65	1	11-13-90	120	7	.07	1.0×10^{2}	R, s
USGS 77	1	10-09-91	47	23	1.32	1.7×10^{1}	R, m
USGS 79	1	10-02-91	60	23	.68	3.4×10^{1}	R, m
USGS 82	3	10-19-93	72	25	.03	8.3×10^{2}	R, s
USGS 84	1	10-21-93	411	5	<.01	$>5.0\times10^{2}$	R, s
USGS 85	1	9-12-90	100	22.7	.01	2.3×10^{3}	R, s
USGS 88	3	10-17-89	230	1.5	7.26	2.1×10^{-1}	R, d
USGS 102	1	5-16-90	100	31.5	.18	1.8×10^{2}	R
USGS 125	1	4-27-95	36	20	.05	4.0×10^{2}	R

Table 3. Estimates of transmissivity from tests of selected wells at or near the Idaho National Engineering Laboratory

[Location of wells shown on figures 2, 3, 4, and 5. ft^2/d, feet squared per day, Relative uncertainty in orders of magnitude. Well depth, below land surface. Water level, at beginning of test below land surface. Penetration, below water table. Perforated or open interval, below land surface. Symbol: >, greater than]

Well identifier	Transmissivity (ft^2/d)	Relative uncertainty	Test number	Well depth (feet)	Water level (feet)	Penetration (feet)	Perforated or open interval (feet)
ANP 10	1.8×10^3	0.4	1	677	220	457	577-677
CFA-1	2.1×10^3	.4	1	639	468	171	444-639
TAN Expl.	9.0×10^1	.1	1	550	204	346	267-550
Site 9	$>3.9\times10^5$	>.5	1	1,057	473	584	684-1,057
Site 17	1.4×10^4	.5	1	600	394	206	15-600
USGS 1	$>3.3\times10^5$	>.5	2	636	590	46	600-630
USGS 2	3.7×10^4	.4	1	704	657	47	675-696
USGS 4	5.0×10^5	.5	1	553	262	291	285-553
USGS 5	1.1×10^1	.4	1	500	466	34	475-497
USGS 6	4.1×10^2	.4	1	620	413	207	532-620
USGS 7	3.3×10^3	.4	1	1,200	209	991	760-1,200
USGS 8	2.1×10^4	.4	1	812	766	46	782-812
USGS 15	8.5×10^4	.4	1	610	316	294	540-610
USGS 18	4.3×10^4	.5	1	329	269	60	298-322
USGS 19	7.2×10^4	.4	1	399	272	127	285-306
USGS 20	3.8×10^2	.4	1	676	461	215	467-477, 515-553
USGS 22	$<2.6\times10^0$	>.5	1	657	611	46	619-634, 644-657
USGS 23	8.8×10^4	.5	1	463	397	66	410-430
USGS 26	8.2×10^5	.5	1	266	206	60	232-266
USGS 27	3.3×10^2	.4	1	312	226	86	250-260, 298-308
USGS 29	8.7×10^4	.4	1	426	355	71	363-425
USGS 32	5.6×10^5	.5	1	392	290	102	306-392
USGS 34	$>3.9\times10^5$	>.5	1	700	473	227	499-700
USGS 35	$>3.9\times10^5$	>.5	1	578	473	105	145-578
USGS 36	3.9×10^5	.5	1	567	473	94	430-567
USGS 38	4.6×10^0	.4	1	729	472	257	678-729
USGS 39	3.9×10^5	.4	1	572	475	97	47-572
USGS 41	$>3.9\times10^5$	>.5	1	674	459	215	428-674
USGS 42	$>3.9\times10^5$	>.5	1	678	460	218	453-678
USGS 44	4.1×10^5	.4	1	650	459	191	461-650
USGS 45	9.3×10^3	.4	1	651	460	191	461-651
USGS 46	$>5.0\times10^5$	>.5	1	651	458	193	461-651
USGS 48	4.1×10^5	.4	1	750	459	291	462-750
USGS 52	$>4.1\times10^5$	>.5	1	650	452	198	450-650
USGS 65	9.5×10^3	.4	1	498	464	34	456-498
USGS 77	1.2×10^3	.4	1	610	466	144	470-610
USGS 79	2.6×10^3	.4	1	702	473	229	281-702
USGS 82	1.2×10^5	.4	3	700	453	247	470-570, 593-700
USGS 84	$>6.4\times10^4$	>.5	1	505	484	21	420-505
USGS 85	3.9×10^5	.4	1	637	482	155	522-637
USGS 102	1.9×10^4	.4	1	445	368	77	359-445
USGS 125	4.9×10^4	.4	1	774	631	143	633-774

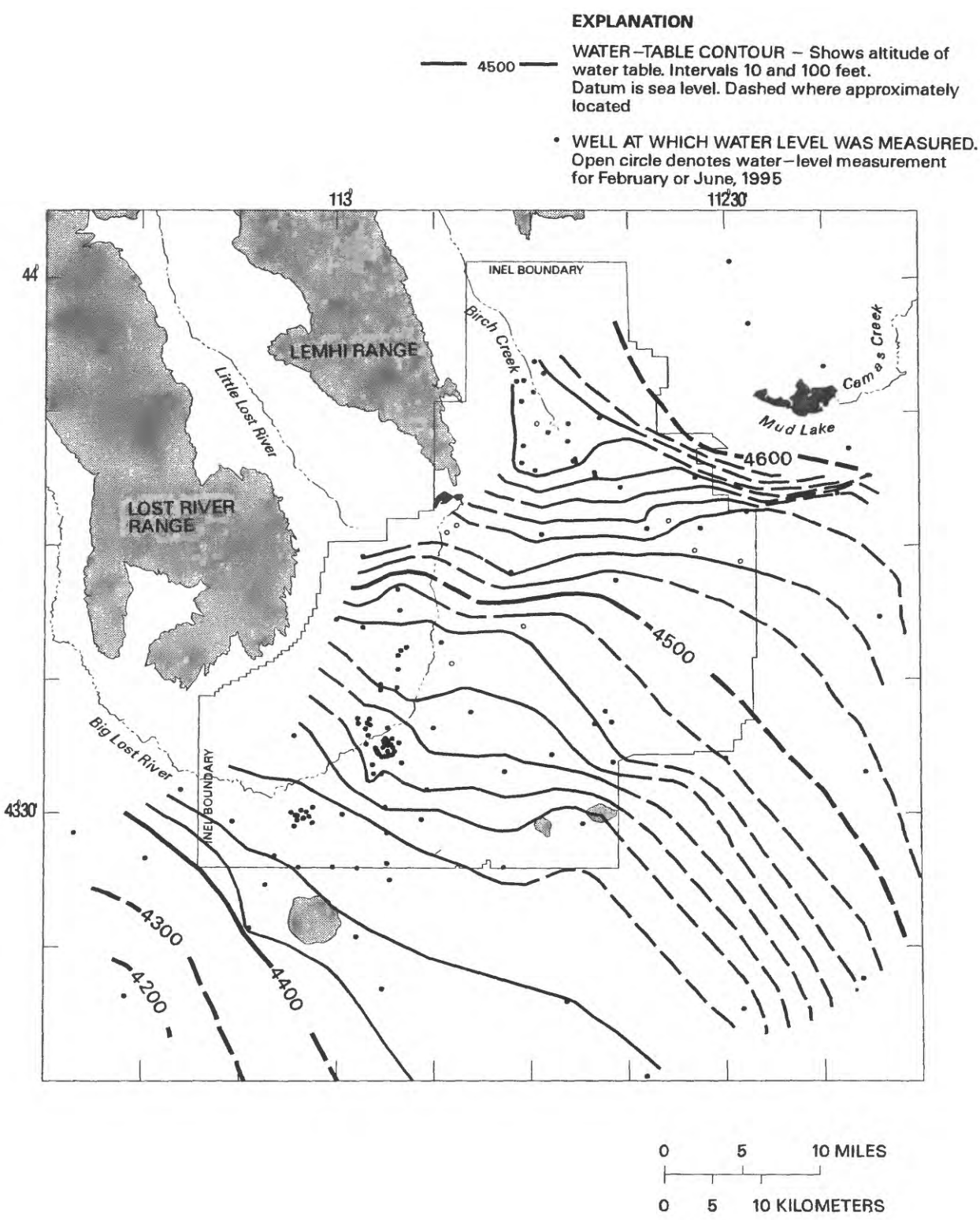


Figure 9. Altitude of the water table in the Snake River Plain aquifer in the vicinity of the Idaho National Engineering Laboratory, March-May 1995.

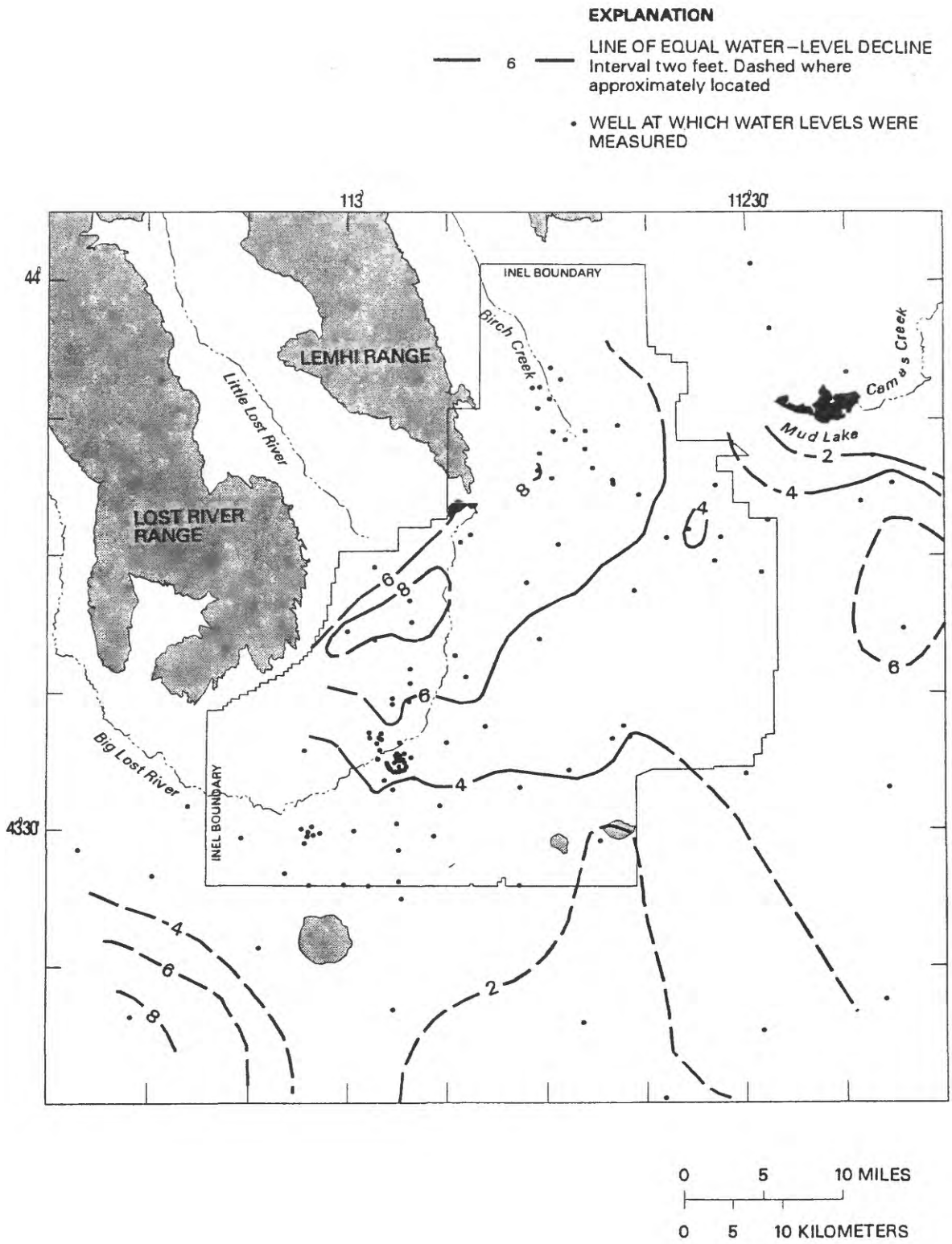


Figure 10. Generalized decline in ground-water levels in the Snake River Plain aquifer in the vicinity of the Idaho National Engineering Laboratory, March-May 1991 to March-May 1995.

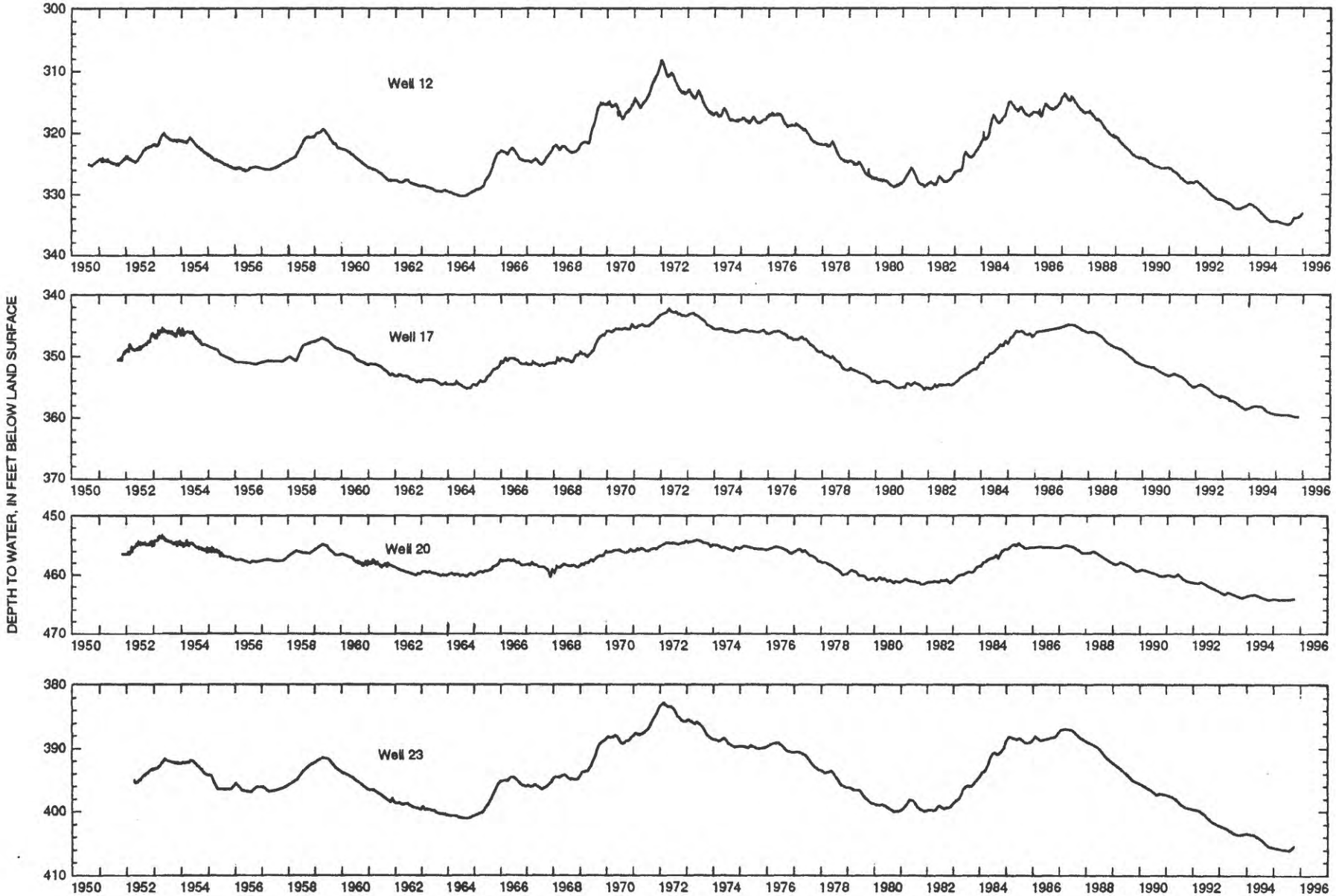


Figure 11. Water levels in four wells in the southwestern part of the Idaho National Engineering Laboratory, 1950-95.

Tritium

A tritium plume has developed in the Snake River Plain aquifer from disposal of wastewater at the INEL since the 1950's. The principal sources of tritium in the aquifer have been the injection of wastewater through the ICPP disposal well and the discharge of wastewater to the infiltration ponds at the ICPP and TRA (fig. 5). About 31,750 Ci of tritium has been discharged to the well and ponds since 1952. Routine use of the disposal well ended in February 1984; subsequently, most radioactive wastewater has been discharged to the infiltration ponds. During 1992–95, only about 0.3 Ci of tritium was discharged to the ponds at the ICPP and about 430 Ci was discharged to the ponds at the TRA. Tritium has a half-life of 12.3 years (Walker and others, 1989, p. 20).

In October 1995, concentrations of tritium in water greater than the reporting level ranged from 0.6±0.2 to 25.1±1.0 pCi/mL and the tritium plume extended southwestward in the general direction of ground-water flow (fig. 12). The area of the plume in which tritium concentrations exceeded 0.5 pCi/mL decreased from about 45 mi^2 in October 1988 to about 40 mi^2 in October 1991 (Bartholomay, Orr, and others, 1995). In October 1995, the area remained about the same as in 1991 (fig. 12). The area of the plume in which tritium concentrations exceeded the maximum contaminant level (MCL) of 20 pCi/mL (U.S. Environmental Protection Agency, 1995, p. 913) was 2.4 mi^2 in 1991. In 1995, concentrations in water from five wells sampled by the USGS exceeded the MCL, but the wells were not all in the same area, so no plume was discernible.

Tritium concentrations in water from wells in the Snake River Plain aquifer decreased by as much as 16.6 pCi/mL during 1992–95. Tritium concentrations in water from well 65 (fig. 5), near the TRA, decreased from 37.8±0.8 pCi/mL in 1991 to 21.2±0.9 pCi/mL in 1995. Tritium concentrations in water from well 77, south of the ICPP (fig. 5), decreased from 41.7±0.9 pCi/mL in 1991 to 25.1±1.0 pCi/mL in 1995 (table 4). Tritium concentrations in water from wells 103, 105, and 108, near the southern boundary of the INEL (fig. 4), exceeded the reporting level during 1983–85 (Pittman and others, 1988, p. 51; Mann and Cecil, 1990, p. 27). Since 1985, tritium concentrations in water from these wells have been less than the reporting level.

Tritium concentrations in water from wells 83 and EBR-1 (fig. 4) within the tritium plume (fig 12) were below the reporting level. Well 83 penetrates about 250 ft of the Snake River Plain aquifer and 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 83 and EBR-1 were below the reporting level probably because of dilution by water from deeper zones (Mann and Cecil, 1990, p. 18).

Tritium concentrations in water from wells south of the ICPP disposal well generally decreased during 1980–95 (table 4) in response to a decreased rate of tritium disposal from the ICPP. Tritium concentrations in water from well 59 near the ICPP infiltration ponds (fig. 5) generally have decreased since 1980, but were unusually large in October 1983, 1985, 1991, and 1995 (table 4). The larger concentrations in 1983 and 1985 correlate with higher tritium discharge rates (fig. 7). In 1986, the well was modified because perched water was detected outside the casing. A video log of well 59 after modifications in 1986 showed that some water from the perched zone was still seeping into the well. The larger concentrations in 1991 and 1995 may be attributed to seepage from a perched zone. The increased concentrations in 1991 and 1995 correlated with the use of the east infiltration pond (fig. 5).

Long-term radioactive-decay processes and an overall decrease in tritium disposal rates have contributed to decreased concentrations of tritium and the decreased area of the tritium plume at the INEL in 1992–95. Of the total of 31,750 Ci of tritium discharged to the aquifer from 1952 to 1995, only about 7,500 Ci remained after radioactive decay. The average combined rate of tritium disposal at the TRA and ICPP during 1952–95 was 722 Ci/yr. The average combined rate was 222 Ci/yr (31 percent of the long-term average) during 1984–95 and 107 Ci/yr (15 percent of the long-term average) during 1992–95. Also, the

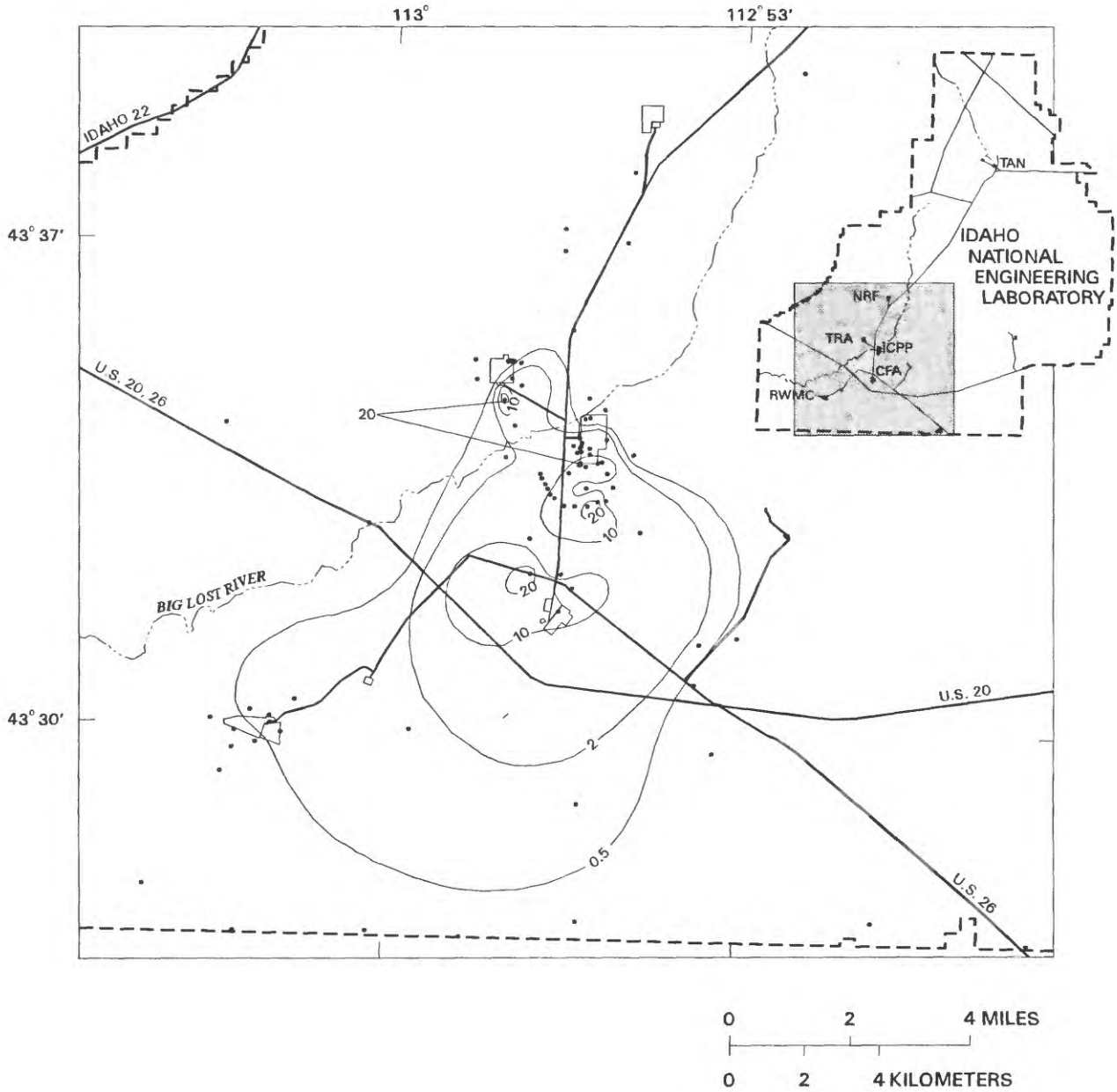


Figure 12. Distribution of tritium in water from the Snake River Plain aquifer at the Idaho National Engineering Laboratory, October 1995.

Table 4. Tritium concentrations in water from selected wells at the Idaho National Engineering Laboratory, 1980-95

[Location of wells shown on figures 4 and 5. Concentrations and associated uncertainties in picocuries per milliliter. Analytical uncertainties are reported as 1 times the sample standard deviation. NS, not sampled ; --, no data, well drilled in 1984]

Well CFA-1		Well 38		Well 47	
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
10/13/81	35.6±0.6	10/08/81	77.5±0.8	10/29/81	27.9±0.6
10/11/82	33.1±0.6	10/07/82	74.1±0.8	10/07/82	15.3±4.0
10/06/83	31.5±0.6	10/13/83	70.9±0.9	10/17/83	73.0±0.9
10/12/84	33.8±0.7	10/09/84	66.7±0.9	10/23/84	14.0±0.5
10/25/85	32.4±0.8	10/28/85	55.8±1.2	10/29/85	12.0±0.5
10/31/86	34.8±0.9	11/18/86	59.5±0.9	10/29/86	5.8±0.4
10/15/87	32.1±0.8	10/16/87	65.9±1.3	10/26/87	3.5±0.4
10/28/88	27.3±0.6	11/07/88	45.0±5.0	9/30/88	3.5±0.2
10/26/89	22.0±0.6	10/31/89	40.2±0.8	10/19/89	5.0±0.3
10/15/90	17.2±0.5	10/05/90	31.9±0.7	10/31/90	7.5±0.4
10/10/91	21.1±0.6	10/03/91	26.3±0.7	10/24/91	6.2±0.3
10/08/92	16.4±0.5	10/14/92	21.3±0.6	10/21/92	10.8±0.4
10/93	NS	10/23/93	16.2±0.7	10/26/93	6.0±0.4
10/94	NS	10/14/94	15.1±0.7	10/19/94	9.9±0.5
10/11/95	13.4±0.6	10/12/95	13.0±0.6	10/16/95	7.6±0.4

Well 59		Well 77		Well 111	
Date	Concentration	Date	Concentration	Date	Concentration
10/24/80	31.5±0.6	10/13/80	93.0±1.0		--
10/06/81	29.7±0.6	10/05/81	79.9±0.8		--
10/06/82	25.2±0.4	9/30/82	81.5±0.8		--
10/13/83	59.7±0.9	10/04/83	63.5±0.9		--
10/10/84	14.1±0.5	10/09/84	70.5±0.9		--
10/30/85	42.0±1.3	10/22/85	46.3±1.0	11/05/85	29.5±0.8
11/14/86	16.7±0.7	11/13/86	70.0±0.9	10/27/86	49.2±1.1
10/06/87	3.6±0.4	10/20/87	60.2±1.2	9/25/87	57.5±1.2
10/21/88	3.3±0.3	11/06/88	50.5±0.9	10/04/88	37.6±0.8
10/23/89	2.4±0.2	10/30/89	41.2±0.8	10/04/89	29.4±0.7
10/12/90	6.7±0.3	10/25/90	40.7±0.8	9/24/90	32.9±0.7
10/21/91	19.3±0.6	10/09/91	41.7±0.9	10/25/91	18.3±0.5
10/23/92	5.6±0.3	10/09/92	36.8±0.9	10/09/92	16.0±0.5
10/25/93	3.4±0.3	10/23/93	31.5±1.2	10/21/93	13.0±0.6
11/01/94	3.5±0.3	10/07/94	28.7±1.1	10/13/94	10.5±0.5
10/23/95	13.0±0.6	10/24/95	25.1±1.0	10/26/95	7.0±0.4

distribution of tritium concentrations in ground water probably has been affected by the shutdown of the ICPP disposal well in 1984 and the subsequent discharge of wastewater to infiltration ponds.

Strontium-90

A strontium-90 plume has developed in the Snake River Plain aquifer from the disposal of wastewater at the INEL. During 1962–63, more than 33 Ci of strontium-90 in wastewater was discharged into a pit at the ICPP (Robertson and others, 1974, p. 117). In addition, during 1952–95, about 24 Ci of strontium-90 was in wastewater injected directly into the aquifer through the ICPP disposal well and discharged to infiltration ponds at the ICPP (L.M. Williams, USGS, written commun., 1997). About 93 Ci of strontium-90 was discharged to radioactive-waste infiltration and evaporation ponds at the TRA during 1952-95. During 1992–95, about 0.32 Ci of strontium-90 was discharged to infiltration ponds at the INEL; most of this was discharged to the TRA infiltration and evaporation ponds. Strontium-90 has a half-life of 29.1 years (Walker and others, 1989, p. 29).

In October 1995, water from 19 wells had concentrations of strontium-90 greater than the reporting level. Concentrations ranged from 2.6±0.7 to 76±3 pCi/L and the plume extended southwestward in the general direction of groundwater flow (fig. 13). Concentrations of strontium-90 in water samples from most wells have remained relatively constant since 1989 (table 5). The concentrations in water from wells 37 and 45 have been quite variable. Concentrations in water from well 37 were above the reporting level through 1990 and during 1992–94, but were below the reporting level in 1991 and 1995 (table 5). Concentrations in water from well 45 were below the reporting level in 1984–89, 1992, 1994, and 1995, but were above the reporting level in 1990, 1991, 1993, and in a replicate sample collected in 1995 (table 5). The October 1995 concentration of 76±3 pCi/L in water from well 47 was larger than concentrations in previous samples, but the quality-assurance replicate concentration of 47±2 pCi/L was consistent with concentrations in previous samples. The MCL for strontium-90 in drinking water is 8 pCi/L (U.S. Environmental Protection Agency, 1995, p. 913).

Before 1989, strontium-90 concentrations had been decreasing because of changes in disposal practices and processes of radioactive decay, diffusion, dispersion, 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 may be due, in part, to a lack of recharge from the Big Lost River. Also, an increase in disposal of other chemical constituents into the infiltration ponds may have affected the exchange capacity of strontium-90 in the unsaturated zone. The absence of a strontium-90 plume at the TRA probably can be attributed to discharge of radioactive wastewater only to TRA infiltration ponds in the past and to evaporation ponds since August 1993. Also, sorption processes in the unsaturated zone and perched ground-water zones prevent migration of strontium-90 to the aquifer.

Cobalt-60

During 1952–95, about 438 Ci of cobalt-60 in wastewater was discharged to the TRA radioactive-waste infiltration and evaporation 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 1992–95, 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 65 (fig. 5), south of the TRA, exceeded the reporting level through 1985 (Orr and Cecil, 1991, p. 35), but have not been detected since 1985. The decrease in discharge of cobalt-60 to the TRA radioactive-waste infiltration ponds, radioactive decay, and sorption processes in the unsaturated and perched ground-water zones may all have contributed to the absence of detectable concentrations of cobalt-60 in ground water near the TRA since 1985.

Table 5. Strontium-90 concentrations in water from selected wells at the Idaho National Engineering Laboratory, 1981–95

[Location of wells shown on figure 5. Concentrations and associated uncertainties in picocuries per liter. Analytical uncertainties are reported as 1 times the sample standard deviation. QA, quality assurance replicate; --, no data, well drilled in 1984]

Well 36		Well 37		Well 38		Well 45	
Date	Concentration	Date	Concentration	Date	Concentration	Date	Concentration
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	76±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	9/29/89	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±2	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
						10/11/95	12±2 (QA)

Table 5. Strontium-90 concentrations in water from selected wells at the Idaho National Engineering Laboratory, 1981–95—*continued*

Well 47		Well 57		Well 113	
Date	**Concentration**	**Date**	**Concentration**	**Date**	**Concentration**
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±6		--
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±2
10/26/87	54±3	10/09/87	49±3	10/02/87	28±3
9/30/88	48±3	10/05/88	41±3	9/27/88	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)				

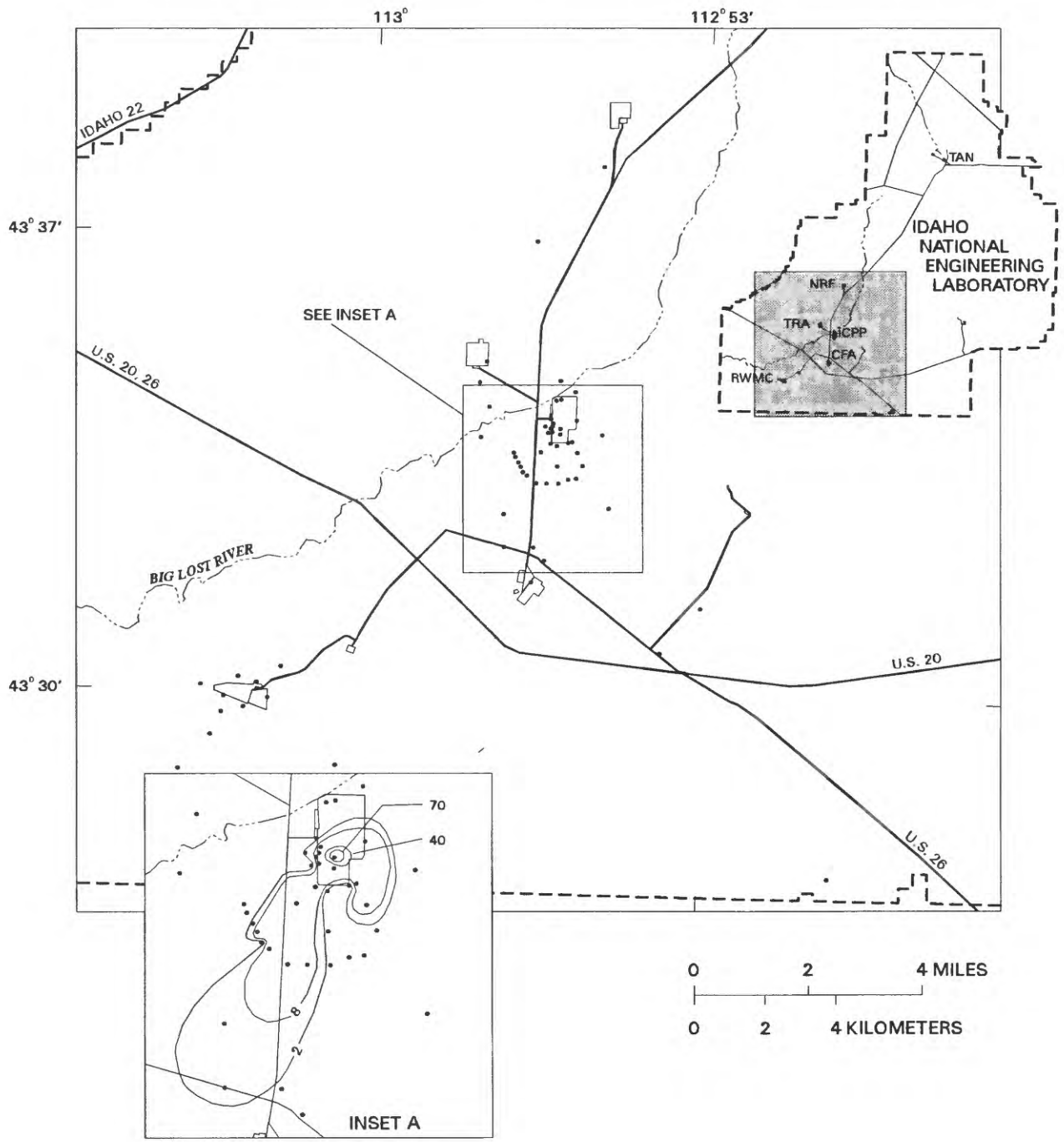


Figure 13. Distribution of strontium-90 in water from the Snake River Plain aquifer at the Idaho National Engineering Laboratory, October 1995.

Cobalt-60 concentrations in water from the TAN disposal well (fig. 4) exceeded the reporting level as a result of the discharge of radioactive wastewater to the well before 1972. The TAN disposal well was turned over to a DOE contractor in 1988 as part of the Environmental Restoration Program. Samples were collected by the USGS in 1989 for special studies, but have not been collected since 1989. Water from the TAN disposal well contained 170±40 pCi/L of cobalt-60 in December 1989. During 1992–95, cobalt-60 concentrations in water from all wells sampled by the USGS at the INEL were below the reporting level.

Cesium-137

From 1952 to 1995, about 138 Ci of cesium-137 in wastewater was discharged to the TRA radioactive-waste infiltration and evaporation ponds and about 23 Ci was discharged to the ICPP disposal well and infiltration ponds. During 1992–95, about 0.29 Ci was discharged to the TRA radioactive-waste infiltration and evaporation ponds and 0.005 Ci was discharged to the ICPP infiltration ponds. The half-life of cesium-137 is 30.17 years (Walker and others, 1989, p. 34).

Concentrations of cesium-137 in water from wells 40 and 47 (fig. 5) exceeded the reporting levels through 1985 (Orr and Cecil, 1991, p. 35), but have been below the reporting level since 1985. The absence of detectable concentrations of cesium-137 is attributed to the discontinuation of wastewater discharge to the ICPP 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. 4) exceeded the reporting level as a result of the discharge of wastewater to the well before 1972. In December 1989, the concentration was 4,370±140 pCi/L (Bartholomay, Orr, and others, 1995). The TAN disposal well has not been sampled since December 1989. During 1992–95, concentrations of cesium-137 in water from all wells sampled by the USGS at the INEL were below the reporting level.

Plutonium

Monitoring of plutonium-238 and plutonium-239, -240 (undivided) in wastewater discharged to the Snake River Plain aquifer through the ICPP disposal well (fig. 5) began in 1974. Before that time, alpha radioactivity from disintegration of plutonium was not separable from the monitored, undifferentiated alpha radioactivity. During 1974–91, about 0.26 Ci of plutonium was discharged to the disposal well and infiltration ponds at the ICPP (Bartholomay, Orr, and others, 1995). During 1992–95, about 0.0001 Ci of plutonium was discharged to infiltration ponds at the ICPP. 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). As a result of disposal of radioactive wastewater in the ICPP disposal well, concentrations of plutonium isotopes in some samples from wells 40 and 47 (fig. 5) through January 1987 exceeded the reporting level (Orr and Cecil, 1991, p. 37). Concentrations in samples collected from these wells since 1987 have been below the reporting level.

Plutonium isotopes in water from the TAN disposal well (fig. 4) exceeded the reporting level as a result of disposal of radioactive wastewater prior to 1972. In December 1989, the concentration of plutonium-238 in the TAN disposal well was 0.26±0.04 pCi/L and the concentration of plutonium-239, -240 (undivided) was 0.71±0.06 pCi/L (Bartholomay, Orr, and others, 1995). The TAN disposal well has not been sampled since December 1989. During 1992–95, concentrations in water from all wells sampled by the USGS at the INEL were below the reporting level.

Americium-241

Americium-241 is a decay product of plutonium-241. Plutonium isotopes have been detected in wastewater discharged to the Snake River Plain aquifer at the INEL 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 87, 88, 89, and 90 at the

RWMC (fig. 5), and in water samples collected through 1988 from the TAN disposal well (fig. 4), exceeded the reporting level (Orr and Cecil, 1991, p. 38–39). During 1992–95, two wells had one sample each with a concentration of americium-241 at the reporting level: the concentration in water from well 37 was 0.09±0.03 pCi/L on October 2, 1992; and the concentration in water from well 120 was 0.06±0.02 pCi/L on April 20, 1993. During 1992–95, concentrations in all other samples were below 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 general indicator of ground-water contamination. Before 1994, gross alpha- and beta-particle radioactivity in water from three wells west and south of the INEL (wells 8, 11, and 14 (fig. 4)) and four surface-water sites along the Big Lost River (fig. 1) was sampled. As part of the INEL ground-water monitoring program adopted in 1994 (Sehlke and Bickford, 1993), the USGS expanded the number of wells at the INEL used for sampling gross alpha- and gross beta-particle radioactivity.

During 1995, water in 43 wells and 4 surface water sites were sampled for gross alpha- and gross-beta particle radioactivity. Concentrations of gross alpha-particle radioactivity were below the reporting level in all but one sample. The Big Lost River at the Experimental Dairy Farm near Howe (fig. 1) had a concentration of 4.8±1.5 pCi/L in July 1995. Gross beta-particle radioactivity also was detected in the Big Lost River at the Experimental Dairy Farm at a concentration of 15±3 pCi/L. Concentrations of gross beta-particle radioactivity in water from 13 of the 43 wells sampled in 1995 were greater than the reporting level and ranged from 6±2 to 43±4 pCi/L.

Chromium

Wastewater from TRA cooling-tower operations contained an estimated 24,000 lb of chromium that was discharged to an infiltration pond during 1952–64 and an estimated 31,000 lb that was discharged to an injection well during 1965–72 (Mann and Knobel, 1988, p. 7–10). In October 1972, chromium that was used as a corrosion inhibitor in cooling-tower operations was replaced by a polyphosphate. During 1971–83, about 265 lb of chromium was discharged to the ICPP disposal well and 720 lb of chromate was discharged in wastewater at the Power Burst Facility (fig. 1) (Cassidy, 1984, p. 3). About 86 lbs of chromium was discharged to the ICPP infiltration ponds during 1992–95.

The MCL of 100 µg/L (U.S. Environmental Protection Agency, 1995, p. 912) for total chromium in drinking water was exceeded in water from one well. Concentrations of dissolved chromium and dissolved hexavalent chromium in water from well 65, south of TRA (fig. 5), were 170 and 180 µg/L, respectively during October 1995. Other water samples contained from less than 5 to 20 µg/L of dissolved chromium and from less than 1 to 19 µg/L of hexavalent chromium during October 1995. Background concentrations of dissolved chromium in the Snake River Plain aquifer range from 2 to 3 µg/L (Orr and others, 1991, p. 41).

Sodium

During 1989–91, an estimated 1.5 million lb/yr of sodium in wastewater was discharged at the INEL (Bartholomay, Orr, and others, 1995). During 1992–95, an estimated 1.1 million lb/yr of sodium was discharged. About 754,000 lb/yr of sodium was discharged to the ICPP infiltration ponds; about 168,000 lb/yr to the TRA chemical-waste infiltration pond; about 134,000 lb/yr to the NRF industrial-waste ditch; and about 15,000 lb/yr was discharged at the CFA (fig. 1).

The background sodium concentration in water from the Snake River Plain aquifer near the INEL generally is less than 10 mg/L (Robertson and others, 1974, p. 155). In October 1995, concentra-

tions in water from most of the wells in the southern part of the INEL were greater than 10 mg/L. Concentrations of dissolved sodium in water from wells in the vicinity of the ICPP have slightly increased or remained constant since disposal practices were changed in 1984 (table 6). Estimated discharge rates also have slightly increased at the ICPP since 1984, so the increase in concentrations in some wells may be attributed to this increase in discharge rates. Concentration increases may also be attributed to a lack of recharge from the Big Lost River since 1987. During 1995, the largest concentration in water samples from wells at the INEL was 79 mg/L in a sample from well 113 (table 6). In 1995, sodium concentrations in water from wells 88 and 120 (fig. 5), near the RWMC, contained 44 and 26 mg/L of sodium, respectively. Water from one well, MTR Test, at the TRA (fig. 5), contained a sodium concentration of 33 mg/L.

Chloride

About 1.5 million lb/yr of chloride was discharged to infiltration ponds at the INEL during 1992–95, which is a decrease from the estimated 1.77 million lb/yr discharged during 1989–91 (Bartholomay, Orr, and others, 1995, p. 31). Of the 1.5 million lb/yr discharged during 1992–95, about 1.22 million lb/yr was discharged to the ICPP infiltration ponds (fig. 3), which is about the same amount discharged during 1986–91 (Orr and Cecil, 1991, p. 40; Bartholomay, Orr, and others, 1995, p. 31).

The background chloride concentration in water from the Snake River Plain aquifer at the INEL is generally about 15 mg/L (Robertson and others, 1974, p. 150); the background chloride concentration near the ICPP is about 10 mg/L and near the CFA, about 20 mg/L. In 1995, concentrations of dissolved chloride in most water samples from the ICPP and NRF (fig. 14) exceeded 20 mg/L. Chloride concentrations in water from wells near the ICPP have increased or remained constant since disposal practices were changed in 1984 (table 7). Concentrations in water from wells downgradient from the infiltration ponds correlate with discharge rates into the ponds. For example, chloride concentrations in water from wells 57 and 37 were smallest in 1985, the year during which the smallest amount of chloride was discharged into the ponds (fig. 15). Concentrations in the two wells increased as discharge rates increased through 1993; concentrations then decreased through 1995 (fig. 15). Chloride concentrations in water from well 59, near the ICPP infiltration ponds, generally remained constant during 1984–95, but were unusually large in October 1991 and 1995 (table 7). The larger concentrations probably were due to seepage down the well from the perched ground-water zone, which contained chloride concentrations of about 270 mg/L in 1991 and 1995 (B.J. Tucker, USGS, written commun., 1997). October 1995 chloride concentrations in water from wells 113 (fig. 5) and CFA-1 (fig. 4) were 190 and 100 mg/L, respectively (table 7).

At the TRA, the chloride concentration in water from well 65 was 19 mg/L. Chloride concentrations in water from all other wells completed in the Snake River Plain aquifer at the TRA were less than 15 mg/L. At the RWMC, chloride concentrations in water from wells 88, 89, and 120 were 82, 37, and 20 mg/L, respectively. Chloride concentrations in water from wells near the NRF slightly exceeded 20 mg/L, except for the concentrations in well NRF-6 (fig. 2), which was 220 mg/L. This large concentration is attributed to proximity of the well to the NRF industrial-waste ditch. The secondary MCL for chloride in drinking water is 250 mg/L (U.S. Environmental Protection Agency, 1995, p. 1,055).

Sulfate

About 1.05 million lb/yr of sulfate in wastewater was discharged at the INEL during 1992–95, which is a decrease from the 1.38 million lb/yr discharged during 1989–91 (Bartholomay, Orr, and others, 1995). Of the 1.05 million lb/yr discharged during 1992–95, about 600,000 lb/yr was discharged to infiltration ponds at the TRA; 120,000 lb/yr was discharged to infiltration ponds at the ICPP; and 270,000 lb/yr was discharged to the NRF industrial-waste ditch. The background concentrations of sulfate in the Snake River Plain aquifer in the south-central part of the INEL range

Table 6. Sodium concentrations in water from selected wells at the Idaho National Engineering Laboratory, 1982–95
[Location of wells shown on figures 4 and 5. Concentrations are in milligrams per liter. NS, not sampled; --, no data, well drilled in 1984]

Well CFA-1		Well 37		Well 40		Well 47	
Date	Concentration	Date	Concentration	Date	Concentration	Date	Concentration
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	18
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	9/30/88	12
10/26/89	26	10/89	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
10/93	NS	10/21/93	45	10/08/93	16	10/26/93	15
10/94	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

Well 57		Well 59		Well 111		Well 113	
Date	Concentration	Date	Concentration	Date	Concentration	Date	Concentration
10/06/82	51	10/06/82	17		--		--
10/13/83	24	10/13/83	28		--		--
10/10/84	47	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	9/25/87	27	10/02/87	49
10/05/88	27	10/21/88	5	10/04/88	28	9/27/88	41
10/22/89	29	10/23/89	12	10/89	NS	10/89	NS
10/29/90	38	10/12/90	21	9/24/90	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

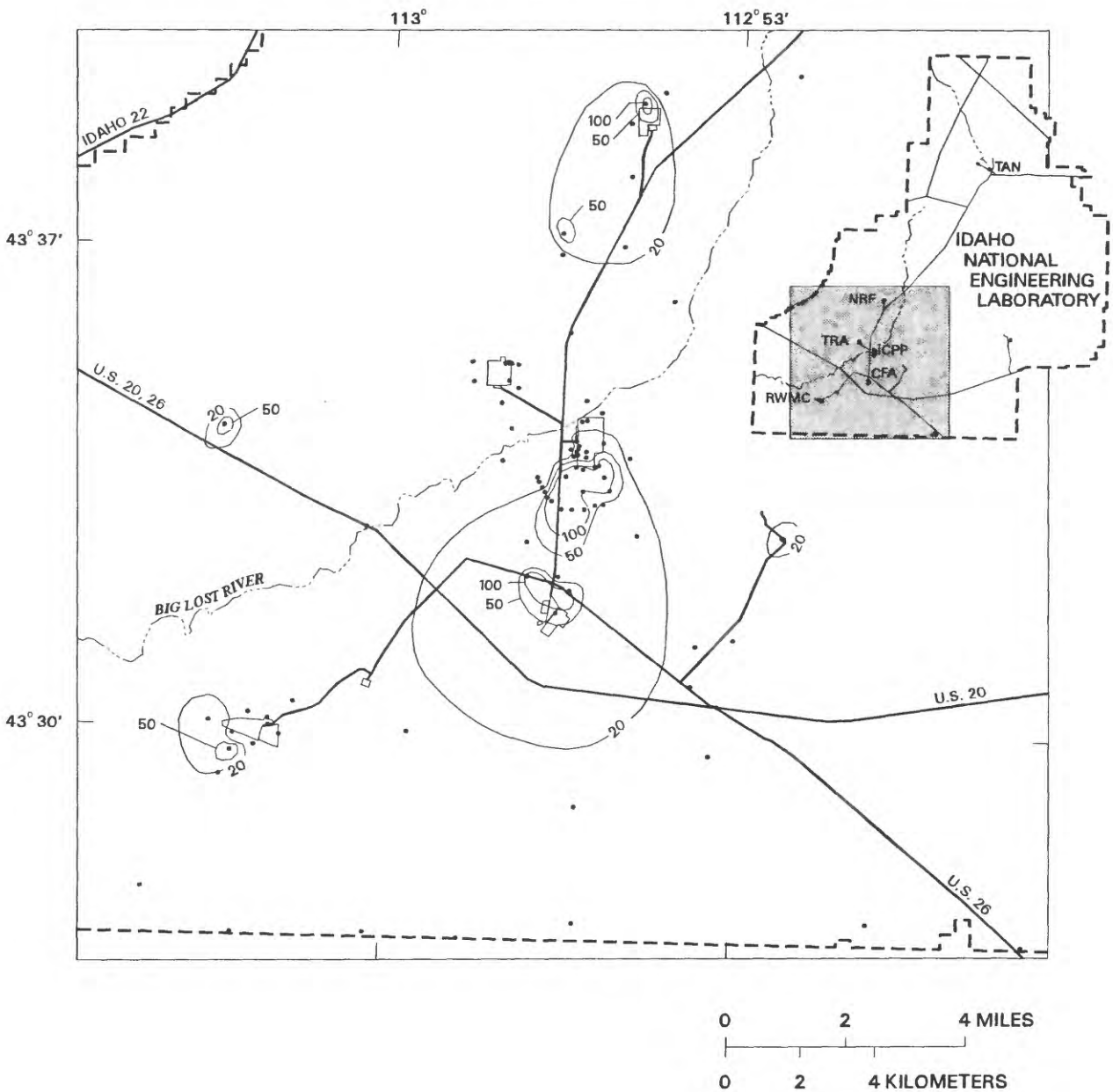


Figure 14. Distribution of chloride in water from the Snake River Plain aquifer at the Idaho National Engineering Laboratory, October 1995.

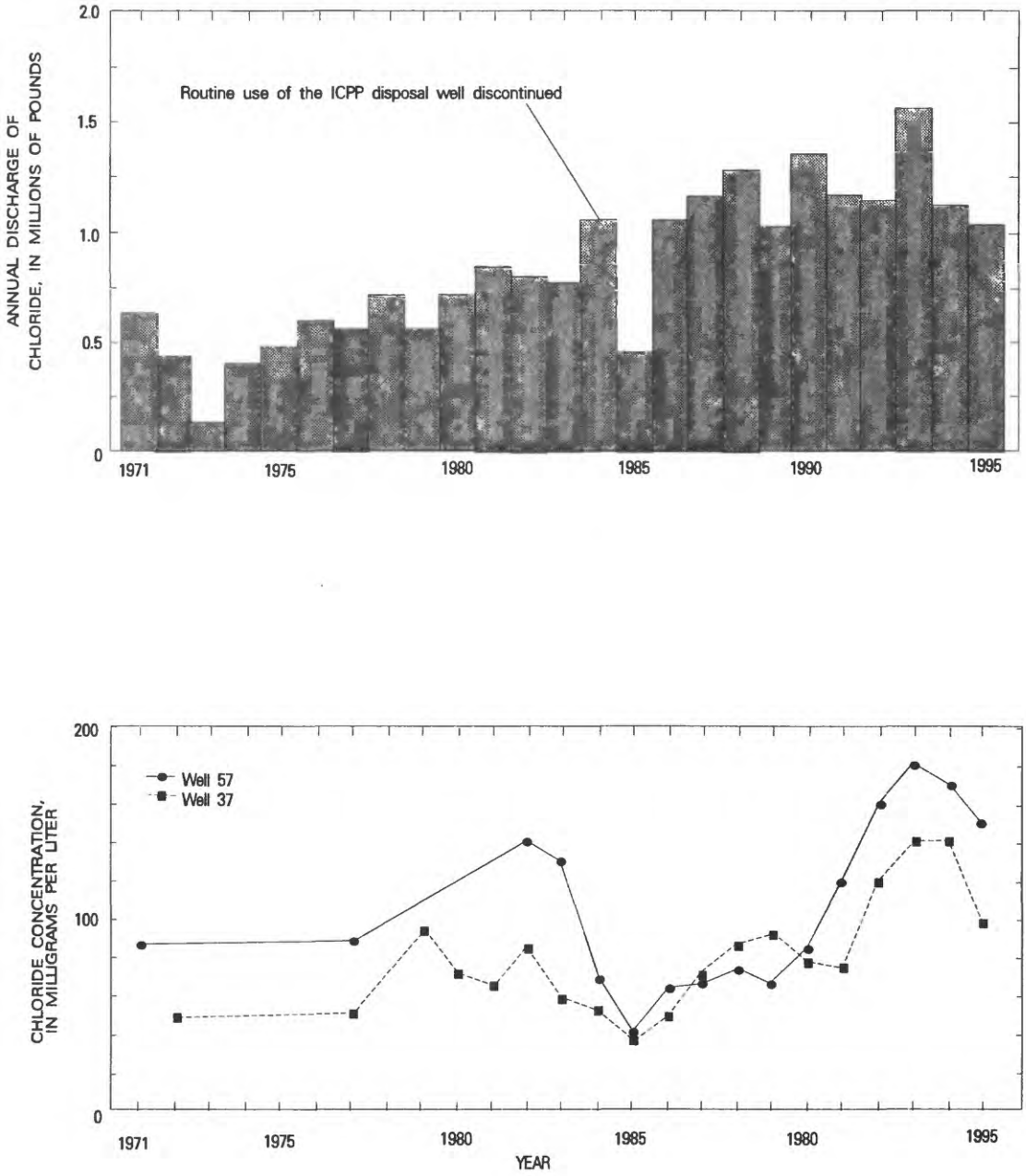


Figure 15. Amount of chloride discharged to the disposal well and the infiltration ponds, and the amount of chloride in water from two wells, Idaho Chemical Processing Plant, 1971–95.

Table 7. Chloride concentrations in water from selected wells at the Idaho National Engineering Laboratory, 1981-95
[Location of wells shown on figures 4 and 5. Concentrations are in milligrams per liter. NS, not sampled; --, no data, well drilled in 1984]

Well CFA-1		Well 37		Well 40		Well 47	
Date	Concentration	Date	Concentration	Date	Concentration	Date	Concentration
10/13/81	82	10/07/81	66	10/12/81	150	10/81	NS
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	24
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	9/30/88	23
10/26/89	93	9/29/89	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	120	11/17/92	29	10/21/92	36
10/93	NS	10/21/93	140	10/08/93	30	10/26/93	31
10/94	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

Well 57		Well 59		Well 111		Well 113	
Date	Concentration	Date	Concentration	Date	Concentration	Date	Concentration
10/81	NS	10/06/81	37		--		--
10/06/82	140	10/06/82	47		--		--
10/13/83	130	10/13/83	60		--		--
10/10/84	68	10/10/84	28		--		--
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	9/25/87	120	10/02/87	150
10/05/88	74	10/21/88	24	10/04/88	120	9/27/88	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	9/27/90	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
11/03/94	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

from about 10 to 40 mg/L (Robertson and others, 1974, p. 72).

Because of the disposal history of sulfate at the various facilities, water-sample collection for dissolved sulfate analyses at several wells was added to the water-quality monitoring network in 1995. During 1995, sulfate concentrations in water from three wells near the NRF, three wells near the TRA, and one well near the RWMC were larger than background concentrations. Water collected from wells NRF-6 (fig. 2), NRF-2, and NRF-4 (fig. 4) contained 230, 46, and 41 mg/L, respectively. The large concentration in water from NRF-6 may be attributed to proximity of the well to the NRF industrial-waste ditch. Water samples from MTR Test, well 65, and TRA Disposal (fig. 5) contained 160, 150, and 45 mg/L of sulfate, respectively. The above-background concentrations in water from these wells probably are due to sulfate disposal at the TRA infiltration ponds. The October 1995 water sample from well 88 (fig. 5), near the RWMC, contained 58 mg/L of sulfate. The above-background concentration in water from this well may be attributed to the well construction and/or waste disposal at the RWMC (Pittman and others, 1988, p. 57–58). The secondary MCL for sulfate in drinking water is 250 mg/L (U.S. Environmental Protection Agency, 1995, p. 1,055).

Nitrate

Wastewater containing nitrate was injected into the Snake River Plain aquifer through the ICPP disposal well from 1952 to February 1984 and discharged to the ICPP infiltration ponds after February 1984 (Orr and Cecil, 1991). An average of 41,000 lb of nitrate was discharged annually to the ICPP infiltration ponds during 1992–95, which is a decrease from the 56,000 lb/yr discharged during 1989–91. The 1992–95 disposal rate is about 25 percent of the disposal rate during 1986–88 and 15 percent of the rate during 1979–85. Concentrations of nitrate in ground water not affected by wastewater disposal from INEL facilities generally are less than 5 mg/L as nitrate (Robertson and others, 1974, p. 73).

Concentrations of dissolved nitrite plus nitrate reported by the NWQL as nitrogen have been converted to nitrate in this report for comparison with nitrate concentrations presented in previous reports. Because analyses indicate that almost all the nitrite plus nitrate concentration is nitrate, concentrations will be referred to as nitrate from here on. Nitrate concentrations and the area and configuration of the nitrate plume have changed in response to disposal-rate changes and to the diversion of wastewater from the ICPP disposal well to infiltration ponds in 1984. In 1981, the area of the ICPP nitrate plume in which concentrations exceeded 5 mg/L was about 10 mi^2 and the maximum concentration was 62 mg/L in water from well 43 (Lewis and Jensen, 1985). By 1984, the area had increased to about 14 mi^2 and concentrations ranged from less than 5 to 26.9 mg/L (Pittman and others, 1988, p. 61). By 1988 and 1991, the area had decreased to about 5 mi^2 (Orr and Cecil, 1991, p. 44-45; Bartholomay, Orr, and others, 1995, p. 34). In 1995, the area was about the same as in 1988 and 1991 (fig. 16). Nitrate concentrations in samples from wells 40, 43, 77, and CFA-1 (figs. 4 and 5) were 49, 42, 19, and 18 mg/L, respectively, in 1995. Nitrate concentrations remained relatively constant during 1992–95 even though disposal rates decreased. This may be attributed to lack of recharge from the Big Lost River.

In 1995, nitrate concentrations in water samples from wells 88, 89, and 119, near the RWMC, were 6.6, 7.5, and 5.3 mg/L, respectively. Historically, concentrations in water near the RWMC have slightly exceeded the regional background concentration of about 5 mg/L. At the TRA, water from wells 65, MTR Test, and TRA Disposal contained 6.6, 5.3, and 5.3 mg/L of nitrate, respectively. Water from well 97, south of the NRF, contained 9.3 mg/L. Concentrations of nitrate in water from one sample from well 40 exceeded the MCL for drinking water of 44 mg/L (as nitrate) (U.S. Environmental Protection Agency, 1995, p. 974).

Fluoride

About 3,440 lb of fluoride was discharged to infiltration ponds at the ICPP during 1992–95. About 33,000 lb of fluoride was discharged at the

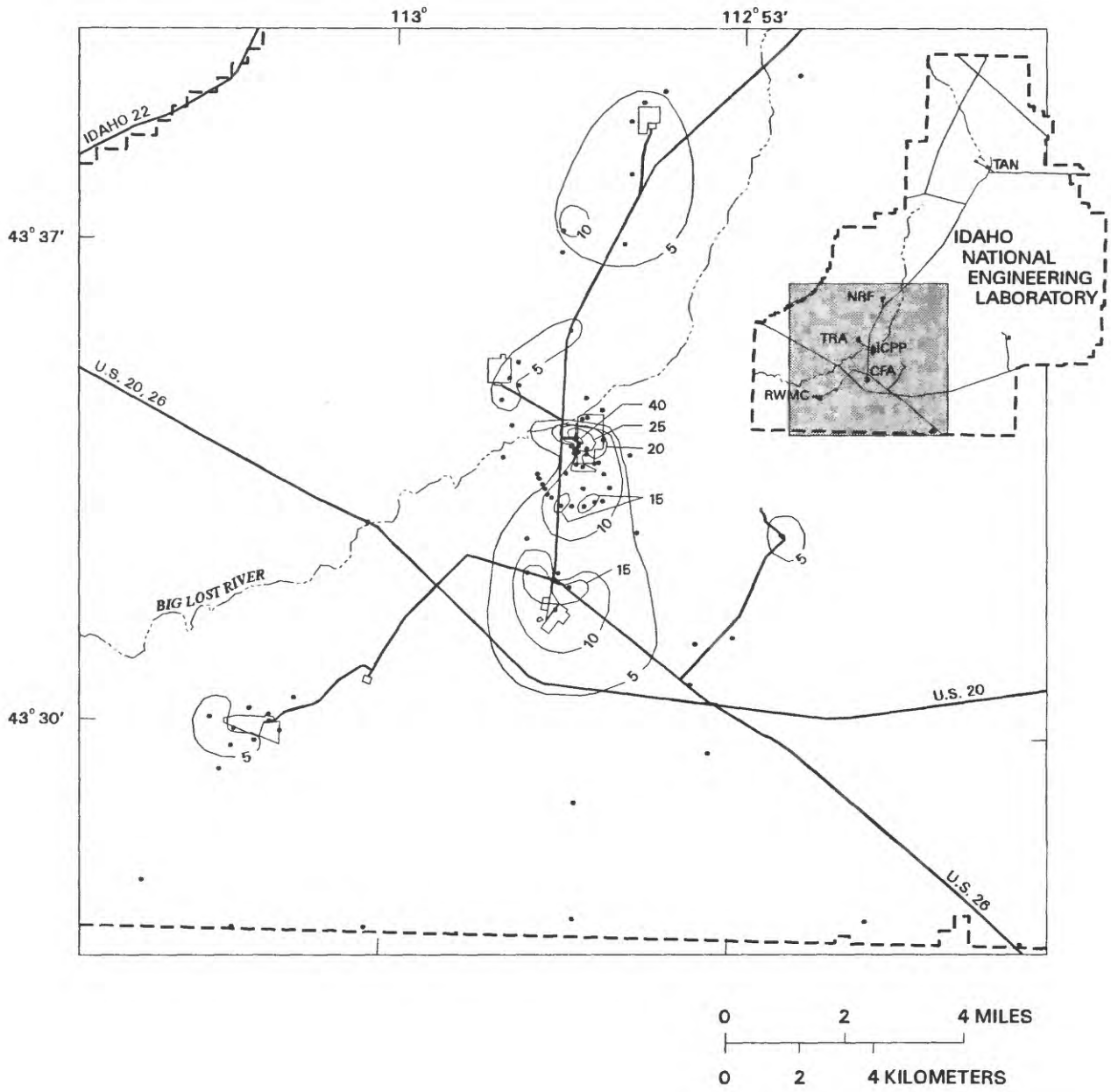


Figure 16. Distribution of nitrate in water from the Snake River Plain aquifer at the Idaho National Engineering Laboratory, October 1995.

ICPP from 1981–91. The background concentrations of dissolved fluoride in the Snake River Plain aquifer in the southwestern part of the INEL range from about 0.1 to 0.3 mg/L (Robertson and others, 1974, p. 75).

As part of the INEL ground-water monitoring program adopted in 1994, the USGS began sampling for dissolved fluoride near the ICPP because fluoride is part of the wastewater disposal at the ICPP. In addition, fluoride has been sampled at several other wells at the INEL as part of other sampling programs. During 1992–95, water samples from 28 wells completed in the Snake River Plain aquifer were analyzed for fluoride; concentrations ranged from less than 0.1 to 1.0 mg/L. Concentrations of fluoride from 11 wells near the ICPP ranged from 0.2 to 0.3 mg/L. These concentrations are consistent with background concentrations reported by Robertson and others (1974) which indicates wastewater disposal has not affected fluoride concentrations in the Snake River Plain aquifer.

Trace Elements

As part of the INEL ground-water monitoring program adopted in 1994, along with special sampling programs, several wells were sampled for a variety of dissolved trace elements during 1992–95. Trace elements sampled for during 1992–95 included aluminum, antimony, arsenic, barium, beryllium, cadmium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, uranium, vanadium, and zinc. The amount of each constituent in wastewater discharged was derived from record-to-date data from French and others (1996a, p. INEL-10 to INEL-15). Some of the elements, such as strontium and uranium, are measured in discharges as radioactive isotopes, but may not be seen or measured as stable isotopes. A summary of each trace element follows:

Aluminum.—About 71 lb of aluminum was discharged in wastewater at the ICPP during 1995. There were no other recorded discharges at the INEL during 1971–95. During 1992–95, water samples from 15 wells completed in the Snake River Plain aquifer were analyzed for aluminum; concentrations ranged from less than the minimum reporting levels of 1 or 10 µg/L to 10 µg/L. The minimum reporting level for chemical constituents is the lowest measured concentration of a constituent that may be reliably reported using a given analytical method (Timme, 1995).

Antimony.—There are no recorded discharges of antimony in wastewater at the INEL. During 1992–95, water samples from 13 wells completed in the Snake River Plain aquifer were analyzed for antimony; concentrations of all samples were less than 1 µg/L.

Arsenic.—About 7 lb of arsenic was discharged in wastewater at the INEL during 1971–95. During 1992–95, water samples from 15 wells completed in the Snake River Plain aquifer were analyzed for arsenic; concentrations ranged from less than 1 to 4 µg/L.

Barium.—About 3,313 lb of barium was discharged in wastewater at the INEL during 1971–95. During 1992–95, water samples from 24 wells completed in the Snake River Plain aquifer were analyzed for barium; concentrations ranged from 16 to 150 µg/L.

Beryllium.—Less than 1 lb of beryllium was discharged in wastewater at the INEL during 1971–95. During 1992–95, water samples from 24 wells completed in the Snake River Plain aquifer were analyzed for beryllium; concentrations ranged from less than 0.5 to 1 µg/L.

Cadmium.—About 22 lb of cadmium was discharged in wastewater at the INEL during 1971–95. During 1992–95, water samples from 24 wells completed in the Snake River Plain aquifer were analyzed for cadmium; concentrations ranged from less than 1 to 1 µg/L.

Cobalt.—There are no recorded discharges of cobalt in wastewater at the INEL. During 1992–95, water samples from 24 wells completed in the Snake River Plain aquifer were analyzed for cobalt; concentrations were less than the minimum reporting levels of 1 and 3 µg/L.

Copper.—About 33 lb of copper was discharged in wastewater at the ICPP during 1995. There were no other recorded discharges at the INEL during 1971–95. During 1992–95, water samples from 24 wells completed in the Snake River Plain aquifer were analyzed for copper; concentrations ranged from less than the minimum reporting levels of 1 or 10 µg/L to 5 µg/L.

Iron.—About 342 lb of iron was discharged in wastewater at the ICPP during 1995. There were no other recorded discharges at the INEL during 1971–95. During 1992–95, water samples from 12 wells completed in the Snake River Plain aquifer were analyzed for iron; concentrations ranged from less than 3 to 93 µg/L.

Lead.—About 547 lb of lead was discharged in wastewater at the INEL during 1971–95. During 1992-95, water samples from 24 wells completed in the Snake River Plain aquifer were analyzed for lead; concentrations ranged from less than the minimum reporting levels of 1 or 10 µg/L to 20 µg/L.

Lithium.—There are no recorded discharges of lithium in wastewater at the INEL. During 1992–95, water samples from 12 wells completed in the Snake River Plain aquifer were analyzed for lithium; concentrations ranged from less than 4 to 24 µg/L.

Manganese.—About 29 lb of manganese was discharged in wastewater at the ICPP during 1995. There were no other recorded discharges at the INEL during 1971–95. During 1992–95, water samples from 24 wells completed in the Snake River Plain aquifer were analyzed for manganese; concentrations ranged from less than 1 to 170 µg/L. Concentrations in water from two wells near the RWMC exceeded the secondary MCL of 50 µg/L (U.S. Environmental Protection Agency, 1995, p. 1,055).

Mercury.—About 141 lb of mercury was discharged in wastewater at the INEL during 1971–95. During 1992–95, water samples from 15 wells completed in the Snake River Plain aquifer were analyzed for mercury. Water samples from 13 wells contained less than 0.1 mg/L; samples from Fire Station 2 and well 65 (fig. 5) contained 0.6 and 0.1 µg/L, respectively.

Molybdenum.—There are no recorded discharges of molybdenum in wastewater at the INEL. During 1992–95, water samples from 24 wells completed in the Snake River Plain aquifer were analyzed for molybdenum; concentrations ranged from less than the minimum reporting levels of 1 or 10 µg/L to 10 µg/L.

Nickel.—There are no recorded discharges of nickel in wastewater at the INEL. During 1992–95, water samples from 24 wells completed in the Snake River Plain aquifer were analyzed for nickel; concentrations ranged from less than the minimum reporting levels of 1 or 10 µg/L to 4 µg/L.

Selenium.—About 4 lb of selenium was discharged in wastewater at the INEL during 1971–95. During 1992–95, water samples from nine wells completed in the Snake River Plain aquifer were analyzed for selenium; concentrations ranged from less than 1 to 2 µg/L.

Silver.—About 187 lb of silver was discharged in wastewater at the INEL during 1971–95. During 1992–95, water samples from 24 wells completed in the Snake River Plain aquifer were analyzed for silver; concentrations ranged from less than 1 to 2 µg/L.

Strontium.—There are no recorded discharges of strontium in wastewater at the INEL. During 1992–95, water samples from 12 wells completed in the Snake River Plain aquifer were analyzed for strontium; concentrations ranged from 85 to 240 µg/L.

Thallium.—There are no recorded discharges of thallium in wastewater at the INEL. During 1992–95, water samples from 20 wells completed in the Snake River Plain aquifer were analyzed for thallium; all concentrations were less than 1 µg/L.

Uranium.—There are no recorded discharges of uranium in wastewater at the INEL. During 1992–95, water samples from 20 wells completed in the Snake River Plain aquifer were analyzed for uranium; concentrations ranged from 1 to 2 µg/L.

Vanadium.—There are no recorded discharges of vanadium in wastewater at the INEL. During

1992–95, water samples from 12 wells completed in the Snake River Plain aquifer were analyzed for vanadium; concentrations ranged from less than 6 to 14 µg/L.

Zinc—About 5,260 lb of zinc was discharged in wastewater at the INEL during 1971–95. During 1992–95, water samples from 24 wells completed in the Snake River Plain aquifer were analyzed for zinc; concentrations ranged from less than the minimum reporting levels of 1 or 3 µg/L to 430 µg/L.

Purgeable Organic Compounds

Purgeable organic compounds (POC's) are present in the Snake River Plain aquifer as a result of waste-disposal practices at the INEL. In 1987, water samples from 81 wells completed in the Snake River Plain aquifer were analyzed for 36 POC's as part of a reconnaissance sampling program (Mann and Knobel, 1987). Analyses of samples indicated that from 1 to 12 POC's were present in samples from 45 wells at concentrations above their reporting levels. In 1988 and 1989, water samples were collected from 38 wells as a continuation of the 1987 study (Mann, 1990). Water samples from 22 wells contained concentrations above the reporting levels for 1 to 19 POC's, mainly carbon tetrachloride; 1,1,1- trichloroethane; and trichloroethylene. In 1990 and 1991, water samples were collected from 76 wells at or near the INEL for various water-quality studies (Liszewski and Mann, 1992). Water samples from 31 wells completed in the Snake River Plain aquifer contained concentrations above the reporting level for 1 to 14 POC's. During 1992–95, water samples were collected from 53 wells at or near the INEL for various water-quality studies (M.R. Greene, USGS written commun., 1996). Water samples from 23 wells completed in the Snake River Plain aquifer contained concentrations above the reporting level for 1 to 14 POC's.

A plume of 1,1,1-trichloroethane, which is a solvent used in industrial cleaning processes (Lucius and others, 1989, p. 450), has developed in the Snake River Plain aquifer near the ICPP as a result of waste-disposal practices (Bartholomay, Orr, and others, 1995). Ten of the wells near ICPP previously that had water with concentrations of 1,1,1-trichloroethane above the reporting level were sampled during 1992–95. Concentrations in water from 8 of the 10 wells still were above the reporting level. All concentrations were below the MCL for drinking water of 200 µg/L (U.S. Environmental Protection Agency, 1995, p. 972).

During 1992–95, concentrations of POC's in water samples from several wells at or near the RWMC exceeded the reporting levels. For example, in October 1995, water from the RWMC Production well contained 3.8 µg/L of carbon tetrachloride, 0.5 µg/L of chloroform, 0.5 µg/L of 1,1,1-trichloroethane, 1.7 µg/L of trichloroethylene, and 0.2 µg/L of tetrachloroethylene. These concentrations were slightly larger than the concentrations from October 1991 (Bartholomay, Orr, and others, 1995, p. 35). Water from well 87 contained concentrations above the reporting levels of carbon tetrachloride and trichloroethylene. Water from well 88 contained concentrations above the reporting levels of carbon tetrachloride; chloroform; 1,1,1- trichloroethane; and trichloroethylene. Water from well 90 contained concentrations above the reporting levels of carbon tetrachloride; chloroform; 1,1,1-trichloroethane; and trichloroethylene. Water from well 120 contained concentrations above the reporting levels of carbon tetrachloride. A July 1995 sample from well RWMC M7S contained concentrations above the reporting levels of carbon tetrachloride; chloroform; 1,1,1-trichloroethane; trichloroethylene; and tetrachloroethylene (M.R. Greene, USGS, written commun., 1996). The concentration of 5.7 µg/L of carbon tetrachloride exceeded the MCL for drinking water of 5 µg/L. The POC's are present as a result of waste-disposal practices at the RWMC.

During 1987–89, concentrations of 1 to 15 POC's in water from 10 wells near the TAN exceeded the reporting levels (Mann and Knobel, 1987; Mann, 1990). TAN wells were not sampled by the USGS for POC's during 1990–93 because the wells were not part of routine sampling. In 1994–95, six wells near the TAN were sampled as part of the INEL ground-water monitoring program (Sehlke and Bickford, 1993). One sample from the TAN Expl. well contained 1.1 µg/L of isopropylbenzene. One sample from well ANP-9

contained 11 µg/L of toluene. No other POC concentrations exceeded their reporting levels during 1994–95.

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 INEL ground-water monitoring program adopted in 1994, the USGS began sampling for TOC at several wells at the INEL. As part of another sampling program, the USGS also sampled 14 wells near the NRF for TOC. During October-November 1995, water samples from 50 wells completed in the Snake River Plain aquifer were analyzed for TOC; concentrations ranged from less than 0.1 to 6.0 µg/L.

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 INEL facilities generally have increased the specific conductance of ground water. In 1995, the specific conductance of water from 129 wells at the INEL ranged from 259 to 1,485 µS/cm; the median specific conductance was 403 µS/cm.

The increase in specific conductance attributed to wastewater discharged to the aquifer is apparent in ground water downgradient from INEL facilities. In 1995, the area near the ICPP, TRA, and NRF in which the specific conductance of water from wells exceeded 400 µS/cm was about 25 mi^2 (fig. 17), about the same as in 1991 (Bartholomay, Orr, and others, 1995, p. 38). A plume of increased specific conductance originated from the ICPP infiltration ponds and extended downgradient from the ICPP to the CFA. 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 900 µS/cm in 1995; water from well 113 (fig. 5) had a specific conductance of 999 µS/cm in 1995. Increases in specific conductance since 1985 can be attributed to the increase of chemical wastewater discharged to the ICPP infiltration ponds and to a lack of recharge from the Big Lost River.

The specific conductance of water from several wells at the TRA exceeded 400 µS/cm in 1995. Water from well 65, downgradient from infiltration ponds at the TRA, had a specific conductance of 606 µS/cm. The specific conductance of water from wells near the NRF generally exceeded 500 µS/cm. Water from well NRF-6, near the industrial-waste ditch, had a specific conductance of 1,485 µS/cm. Water from wells 88 and 120, near the RWMC, had specific conductances exceeding 400 µS/cm.

Water temperatures of 129 samples collected in 1995 ranged from 9.5°C in wells 86 and P&W 2 to 20°C in well 22. The median temperature was 13°C. The pH ranged from 7.7 in wells Leo Rogers and 124 to 8.4 in wells OMRE, 89, and 119; the median pH was 8.0.

SUMMARY

In 1995, the altitude of the water table in the Snake River Plain aquifer at the INEL was about 4,580 ft above sea level in the northern part and about 4,420 ft above sea level in the southwestern part. Locally, the hydraulic gradient ranged from about 1 to 15 ft/mi and ground-water flow was to the south and southwest. From March-May 1991 to March-May 1995, water levels in INEL wells declined; declines ranged from about 8.5 ft in wells in the west-central part of the INEL to about 2.5 ft in wells in the southern part.

During 1992–95, about 0.3 Ci of tritium was discharged to infiltration ponds at the ICPP and about 430 Ci was discharged to radioactive-waste infiltration and evaporation ponds at the TRA. A tritium plume originating from the ICPP and TRA decreased from 45 mi^2 in 1988 to about 40 mi^2 in 1995. Only five wells contained tritium concentrations in excess of 20 pCi/mL in 1995. In October 1995, tritium concentrations in wells 65 and 77

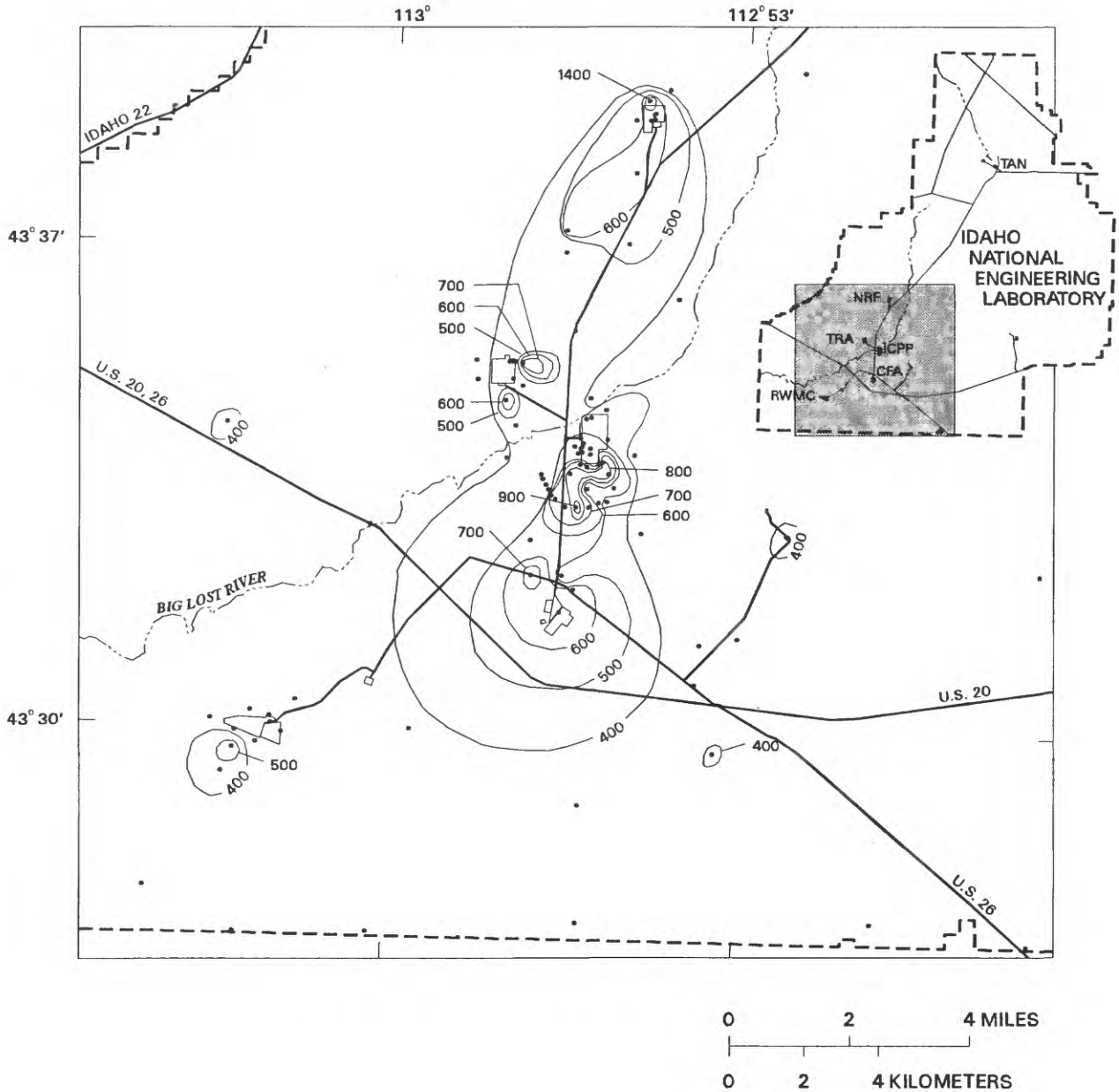


Figure 17. Distribution of specific conductance of water from the Snake River Plain aquifer at the Idaho National Engineering Laboratory, October 1995.

were 21.2±0.9 and 25.1±1.0 pCi/mL, respectively. Near the southern boundary of the INEL, tritium concentrations in water from wells 103, 105, and 108 exceeded the reporting level during 1983-85, but have been less than the reporting level since 1985. Radioactive decay, decreased tritium disposal, and discontinuation of the use of the ICPP disposal well and subsequent wastewater discharge to infiltration ponds contributed to decreased concentrations of tritium in ground water at the INEL during 1992–95.

About 0.32 Ci of strontium-90 was discharged to infiltration ponds at the INEL during 1992–95. In October 1995, strontium-90 concentrations in ground water ranged from 2.6±0.7 to 76±3 pCi/L. During 1992–95, strontium-90 concentrations remained relatively constant because of the lack of recharge from the Big Lost River and because the increased disposal of other chemical constituents to the infiltration ponds may have affected the exchange capacity of strontium-90 in the unsaturated zone. The absence of a strontium-90 plume at the TRA probably can be attributed to discharge of radioactive wastewater only to TRA infiltration ponds and to sorption processes in the unsaturated and perched ground-water zones.

During 1992–95, about 3.1 Ci of cobalt-60 was discharged to TRA radioactive-waste infiltration and evaporation ponds. In 1985, cobalt-60 was detected in water from well 65, south of the TRA, but concentrations in subsequent samples were less than the reporting level. The decrease in discharge of cobalt-60 to the TRA radioactive-waste infiltration ponds, radioactive decay, and sorption processes in the unsaturated zone may all have contributed to the absence of detectable concentrations of cobalt-60 in ground water near the TRA since 1985. Water from the TAN disposal well contained 170±40 pCi/L of cobalt-60 in December 1989. During 1992–95 cobalt-60 concentrations in water from all wells sampled by the USGS at the INEL were below the reporting level.

During 1992–95, about 0.29 Ci of cesium-137 was discharged to the TRA radioactive-waste infiltration and evaporation ponds and 0.005 Ci was discharged to the ICPP infiltration ponds. Through 1985, cesium-137 was detected in water from wells near the ICPP; since 1985, cesium-137 has not been detected. The absence of detectable concentrations of cesium-137 is attributed to changes in ICPP waste-disposal practices and to sorption processes in the unsaturated and perched ground-water zones. The concentration of cesium-137 in water from the TAN disposal well was 4,370±140 pCi/L in December 1989. During 1992–95, concentrations of cesium-137 in water from all wells sampled by the USGS at the INEL were below the reporting level.

During 1992–95, about 0.0001 Ci of plutonium was discharged to infiltration ponds at the ICPP. Concentrations of plutonium isotopes in some samples from wells 40 and 47 collected through January 1987 exceeded the reporting level; concentrations in samples collected since 1987 have been below the reporting level. In December 1989, the concentrations of plutonium-238 and plutonium-239, -240 (undivided) in water from the TAN disposal well were 0.26±0.04 and 0.71±0.06 pCi/L, respectively. Concentrations of plutonium isotopes were below the reporting level in all water samples collected from wells completed in the Snake River Plain aquifer at the INEL during 1992–95. During 1992–95, the concentrations of americium-241, a decay product of plutonium-241, in water from two wells completed in the Snake River Plain aquifer at the INEL were at the reporting level. During 1992–95, all other samples had concentrations below the reporting level.

In 1995, several wells were sampled for dissolved and hexavalent chromium. The maximum contaminant level of 100 µg/L for total chromium was exceeded in water samples from well 65, which had concentrations of 170 and 180 µg/L of dissolved and hexavalent chromium, respectively. Water samples from the other wells contained from less than 5 to 20 µg/L of dissolved chromium and from less than 1 to 19 µg/L of hexavalent chromium.

An estimated 1.1 million lb/yr of sodium in wastewater was discharged at the INEL during 1992–95, principally to the ICPP infiltration ponds. Most of the wells in the southern part of the INEL had concentrations greater than 10 mg/L in October 1995. Sodium concentrations have

increased or remained constant because of an increase in disposal rates since 1984 and a decrease in recharge. The largest sodium concentration in water from wells was 79 mg/L.

About 1.5 million lb/yr of chloride in wastewater was discharged at the INEL during 1992–95. In 1995, chloride concentrations in most water samples from the ICPP and NRF exceeded 20 mg/L. Chloride concentrations near the ICPP have increased or remained constant because of an increase in disposal rates since 1984. Chloride concentrations in water from wells 113 and CFA-1 were 190 and 100 mg/L, respectively. Chloride concentrations in water from wells near the TRA were less than 20 mg/L. Chloride concentrations in water from wells near the NRF slightly exceeded 20 mg/L, except for the concentration in water from well NRF-6, which was 220 mg/L.

About 1.05 million lb/yr of sulfate was discharged to infiltration ponds and an industrial-waste ditch at the INEL during 1992–95. During 1995, sulfate concentrations in water from three wells near the NRF, three wells near the TRA, and one well near the RWMC exceeded 40 mg/L, the estimated background concentration of sulfate in the Snake River Plain aquifer at the INEL.

An average of 41,000 lb of nitrate was discharged annually to the ICPP infiltration ponds during 1992–95. Nitrate concentrations remained relatively constant during 1992–95 even though disposal rates decreased. Nitrate concentrations in water from wells 40, 43, 77, and CFA-1 were 49, 42, 19, and 18 mg/L, respectively, in 1995.

An average of 3,440 lb of fluoride was discharged annually to the ICPP infiltration ponds during 1992–95. Concentrations of fluoride in water from wells near the ICPP ranged from 0.2 to 0.3 mg/L. These concentrations are consistent with background concentrations for that area.

During 1987–95, concentrations of 19 different purgeable organic compounds were detected in water from wells at the INEL. During 1992–95, concentrations of 1,1,1-trichloroethane were above the reporting level in eight wells near the ICPP. During 1992–95, RWMC wells contained concentrations of 1,1,1-trichloroethane, carbon tetrachloride, chloroform, trichloroethylene, and tetrachloroethylene. During 1987–89, concentrations of 15 POC's were detected in wells near TAN. Of the six wells sampled near TAN in 1994–95, only isopropylbenzene and toluene were detected.

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