Chapter 6: Environmental Monitoring Programs – Eastern Snake River Plain Aquifer Monitoring

CHAPTER 6

One potential pathway for exposure from contaminants released at the Idaho National Laboratory (INL) Site is through the groundwater pathway. Historic waste disposal practices have produced localized areas of chemical and radiochemical contamination beneath the INL Site in the eastern Snake River Plain Aquifer. These areas are regularly monitored by the U.S. Geological Survey (USGS), and reports are published showing the extent of contamination plumes. Results for most monitoring wells within the plumes show decreasing concentrations of tritium, strontium-90, and iodine-129 over the past 20 years. The decrease is probably the result of radioactive decay, discontinued disposal, dispersion, and dilution within the aquifer.

In 2022, USGS sampled 26 groundwater monitoring wells and one perched water well at the INL Site for analysis of 61 purgeable (volatile) organic compounds. Eleven purgeable organic compounds were detected in at least one well. Most of the detected concentrations were less than the maximum contaminant levels established by the U.S. Environmental Protection Agency (EPA) for public drinking water supplies. One exception was carbon tetrachloride, detected in the production well at the Radioactive Waste Management Complex (RWMC). This compound has shown a decreasing trend since 2005 and is removed from the water prior to human consumption. Trichloroethene was detected above the maximum contaminant levels (MCLs) at a perched well at the RWMC and a well at Test Area North (TAN), where there is a known groundwater plume containing this contaminant being treated.

Groundwater surveillance monitoring required in area-specific Records of Decision under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) was performed at Waste Area Groups (WAGs) 1–4, WAG 7, and WAG 9 in 2022.

In addition to the Advanced Test Reactor (ATR) Complex and the Materials and Fuels Complex (MFC), the INL contractor also monitors groundwater at the Remote-Handled Low-Level Waste Disposal (RHLLW) Facility for the surveillance of select radiological analytes. Groundwater samples were collected from three monitoring wells at the RHLLW Disposal Facility in 2022. The 2022 results show no discernable impacts to the aquifer.

There are 11 drinking water systems on the INL Site monitored by INL and Idaho Cleanup Project (ICP) contractors. All contaminant concentrations measured in drinking water systems in 2022 were below regulatory limits.

Drinking water and springs were sampled in the vicinity of the INL Site and analyzed for gross alpha and gross beta activity and tritium. Some locations were co-sampled with the Idaho Department of Environmental Quality (DEQ) INL Oversight Program. Results were consistent with historical measurements and do not indicate any impact from historical INL Site releases.

6. ENVIRONMENTAL MONITORING PROGRAMS – EASTERN SNAKE RIVER PLAIN AQUIFER

The eastern Snake River Plain Aquifer serves as the primary source of drinking water and crop irrigation in the upper Snake River Basin. This chapter presents the results of water monitoring conducted on and off the INL Site within the eastern Snake River Plain Aquifer hydrogeologic system. This includes the collection of water from the aquifer (including drinking water wells), downgradient springs along the Snake River where the aquifer discharges water (Figure 6-1), and an ephemeral stream (the Big Lost River), which flows through the INL Site and helps to recharge the aquifer. The purpose of the monitoring is to ensure the following:

- The eastern Snake River Plain groundwater is protected from contamination from current INL Site activities.
- Areas of known underground contamination from past INL Site operations are monitored and trended.
- Drinking water consumed by workers and visitors at the INL Site and by the public downgradient of the INL Site is safe.
- The Big Lost River, which occasionally flows through the INL Site, is not contaminated by INL Site activities before entering the aquifer via channel loss and playas on the north end of the INL Site.

Analytical results are compared to applicable regulatory guidelines for compliance and informational purposes. These include the following:

- State of Idaho groundwater primary and secondary constituent standards (Ground Water Quality Rule, IDAPA 58.01.11)
- EPA health-based MCLs for drinking water (40 CFR 141)
- U.S. Department of Energy (DOE) Derived Concentration Standards for the ingestion of water (DOE 2021).

6.1 Summary of Monitoring Programs

Four organizations monitor the eastern Snake River Plain Aquifer hydrogeologic system:

- The USGS INL Project Office performs groundwater monitoring, analyses, and scientific studies to improve the understanding of the hydrogeological conditions that affect the movement of groundwater and contaminants in the eastern Snake River Plain Aquifer underlying and adjacent to the INL Site. The USGS utilizes an extensive network of strategically placed monitoring wells on the INL Site, as shown in Figure 6-2, and at locations throughout the eastern Snake River Plain.

  Table 6-1 summarizes the USGS routine groundwater surveillance program. In 2022, USGS personnel collected and analyzed more than 1,200 samples for radionuclides and inorganic constituents, including trace elements, and 26 samples for purgeable organic compounds. USGS INL Project Office personnel also published two documents and one software package covering hydrogeologic conditions and monitoring at the INL Site. The abstracts to these reports are presented in Section 6.10.

- The ICP contractor conducts groundwater monitoring at various WAGs delineated on the INL Site, which are identified in Figure 6-3, for compliance with the CERCLA. The ICP contractor also conducts drinking water monitoring at the Idaho Nuclear Technology and Engineering Center (INTEC), RWMC, and the Naval Reactors Facility (NRF). In 2022, the ICP contractor monitored groundwater at the TAN, ATR Complex, INTEC, Central Facilities Area (CFA), and RWMC (WAGs 1, 2, 3, 4, and 7, respectively). Table 6-2 summarizes the routine monitoring for the ICP contractor drinking water program.

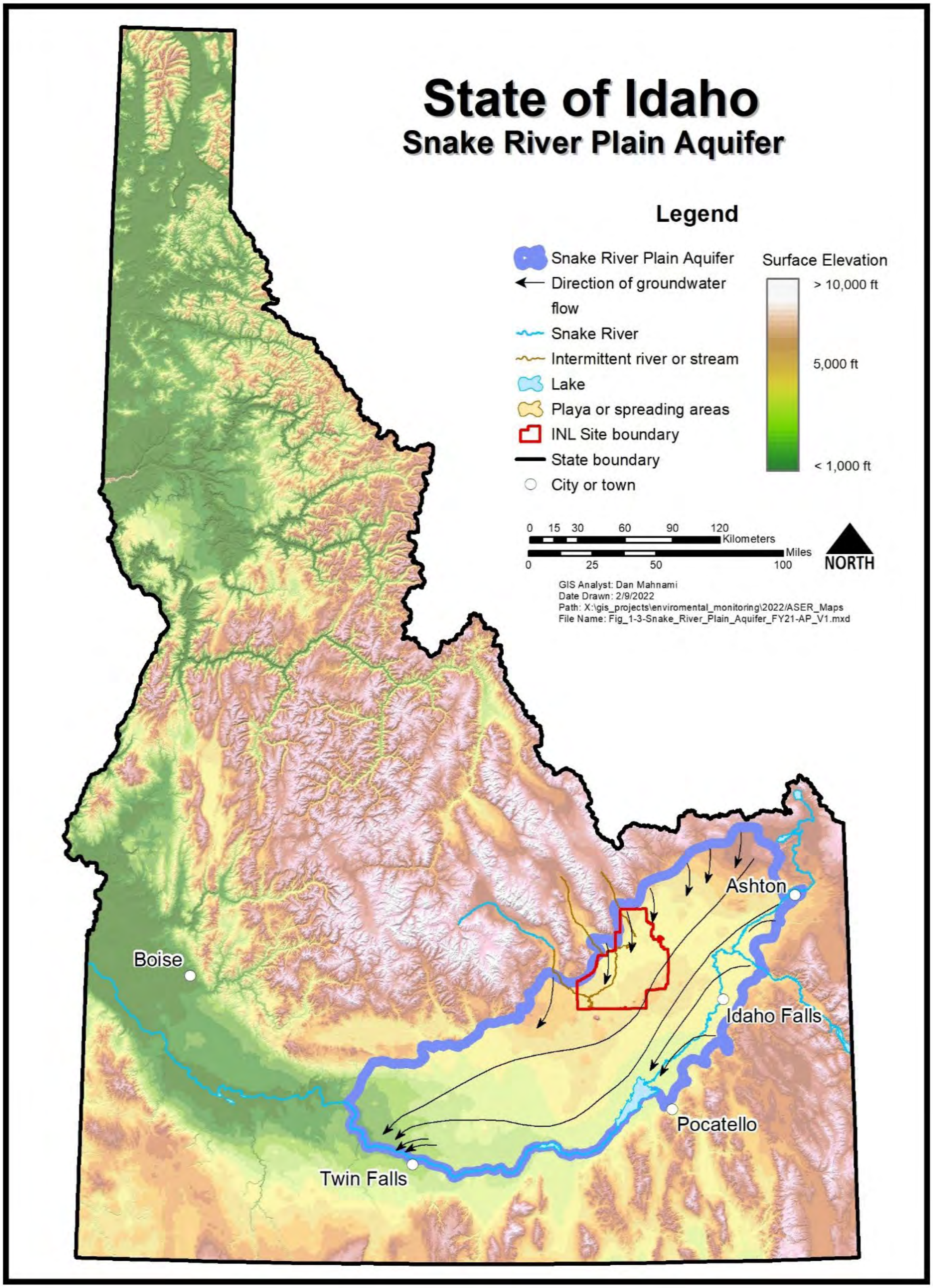

Figure 6-1. The eastern Snake River Plain Aquifer and direction of groundwater flow.

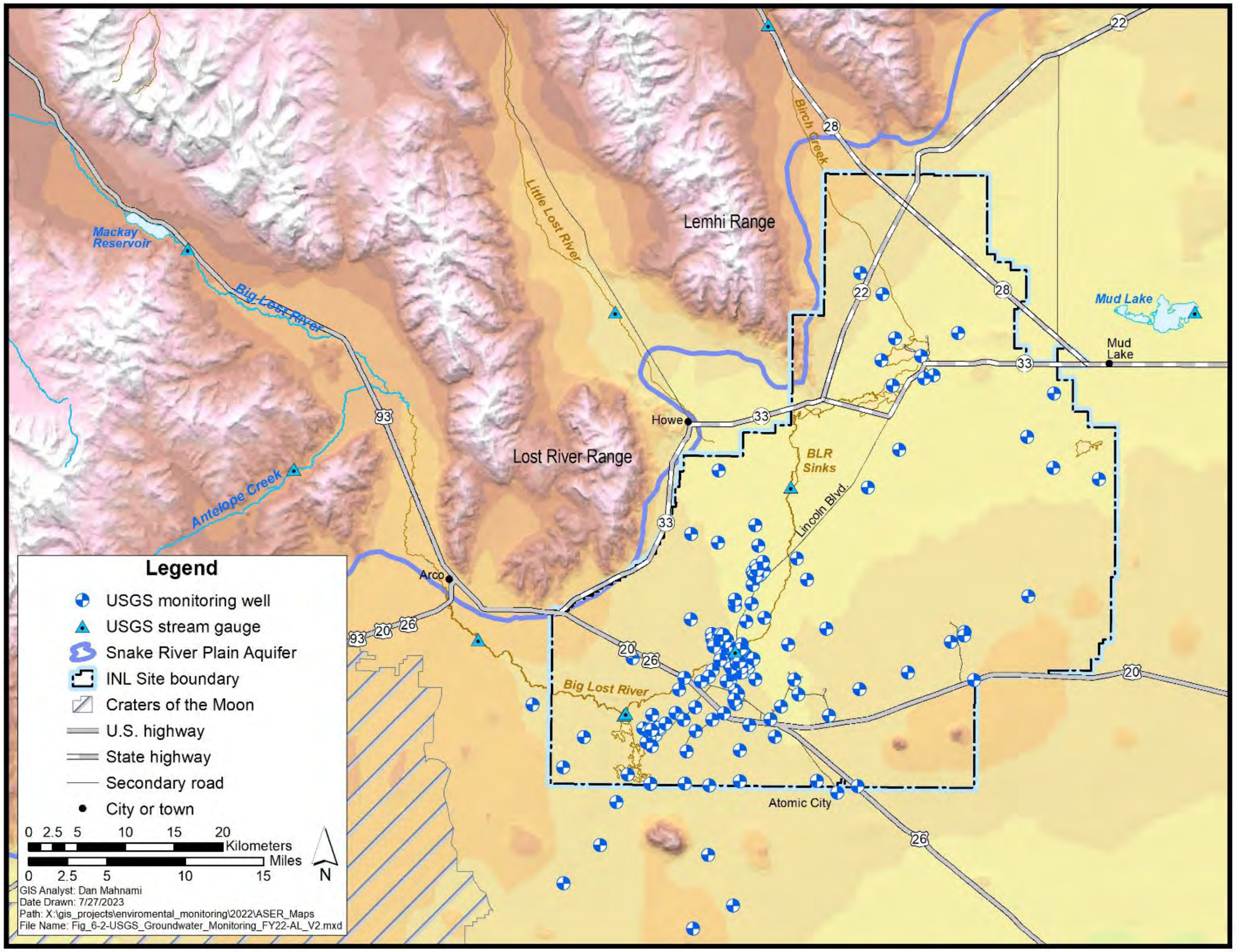

Figure 6-2. USGS groundwater monitoring locations on and off the INL Site.

Table 6-1. USGS monitoring program summary (2022).

CONSTITUENT	GROUNDWATER		SURFACE WATER		MINIMUM DETECTABLE CONCENTRATION OR ACTIVITY
	NUMBER OF SITES[a]	NUMBER OF SAMPLES	NUMBER OF SITES	NUMBER OF SAMPLES	
Gross alpha	58	66	0	0	8 pCi/L
Gross beta	58	66	0	0	3.5 pCi/L
Tritium	138	138	3	3	200 pCi/L
Gamma-ray spectroscopy	43	43	—[b]	—	—[c]
Strontium-90	64	64	—[b]	—	2 pCi/L
Americium-241	9	9	—[b]	—	0.03 pCi/L
Plutonium isotopes	9	9	—[b]	—	0.02 pCi/L
Iodine-129	30	30	—[b]	—	<1 pCi/L
Specific conductance	144	144	3	3	NA[d]
Sodium ion	135	135	—[b]	—	0.4 mg/L
Chloride ion	139	139	3	3	0.02 mg/L
Nitrates (as nitrogen)	117	117	—[b]	—	0.04 mg/L
Fluoride	4	4	—[b]	—	0.01 mg/L
Sulfate	124	124	—[b]	—	0.02 mg/L
Chromium (dissolved)	99	99	—[b]	—	1 µg/L
Purgeable organic compounds[e]	26	38	—[b]	—	Varies
Mercury	9	9	—[b]	—	0.005 µg/L
Trace elements	9	9	—[b]	—	Varies

a. Number of samples does not include 13 replicates and 4 blanks collected in 2022. The number of samples was different from the number of sites because one site for volatile organic compounds (VOCs) is sampled monthly, and three sites had pump problems or were dry, so they were not sampled. The number of sites does not include 24 zones from 10 wells sampled as part of the multi-level monitoring program.

b. No surface water samples collected for this constituent.

c. Minimum detectable concentration for gamma spectroscopic analyses varies depending on radionuclide.

d. NA = not applicable.

e. Each purgeable organic compound water sample is analyzed for 61 purgeable organic compounds.

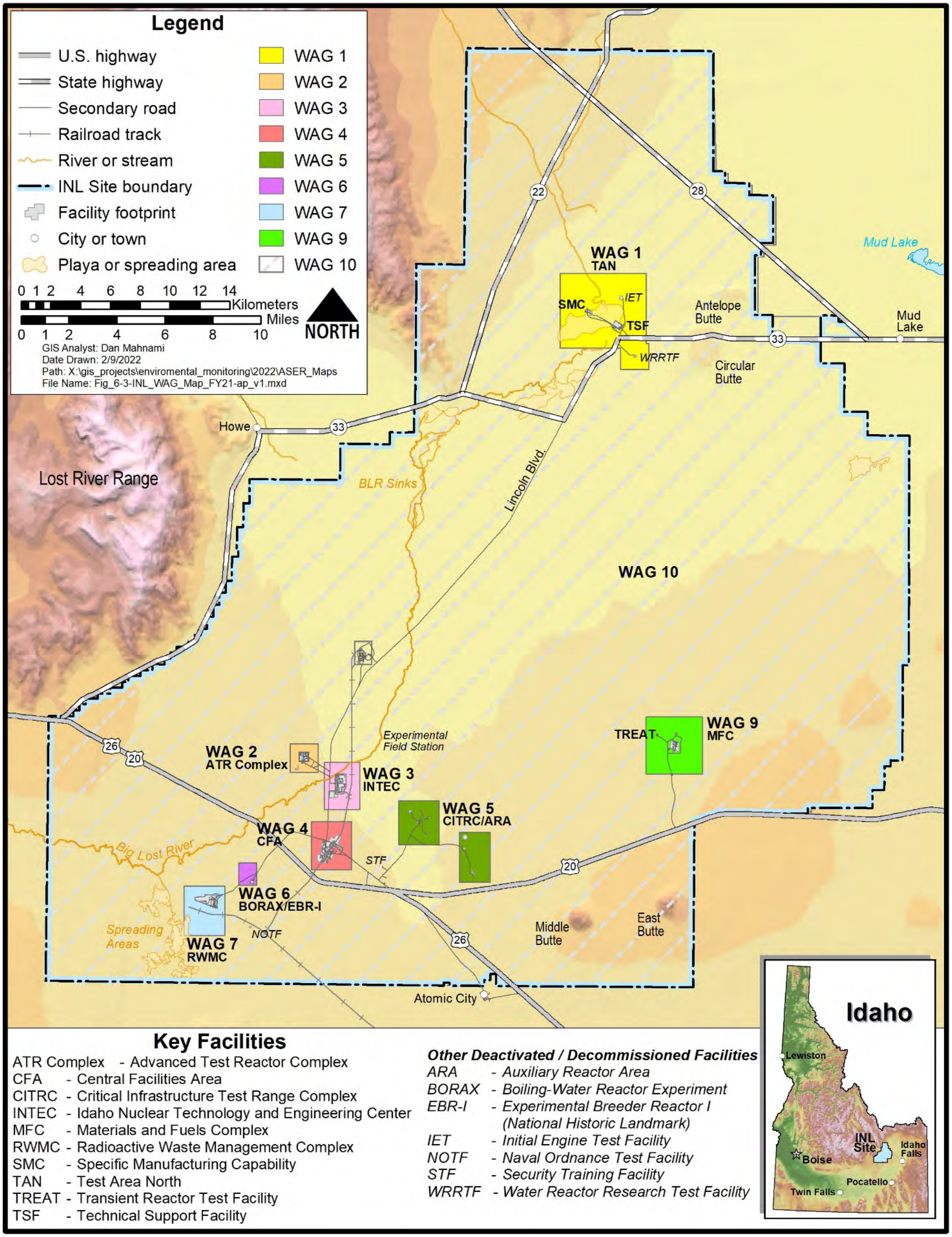

Figure 6-3. Map of the INL Site showing locations of facilities and corresponding WAGs.

Table 6-2. ICP contractor drinking water program summary (2022).

TYPE OF ANALYSIS	FREQUENCY (ONSITE)	MAXIMUM CONTAMINANT LEVEL
Gross alpha	2 semiannually	15 pCi/L
Gross beta	2 semiannually	50 pCi/L screening level or 4mrem/yr
Haloacetic acids (HAA5)[a]	2 annually	0.06 mg/L
Total coliform[b]	6 to 8 monthly	See 40 CFR 141.63(d)
E. coli[b]	6 to 8 monthly	See 40 CFR 141.63(c)
Nitrate	2 annually	10 mg/L (as nitrogen)
Radium-226/-228	2 every 9 years	5 pCi/L
Strontium-90	2 annually	8 pCi/L
Total trihalomethanes	2 annually	0.08 mg/L
Tritium	2 annually	20,000 pCi/L
Uranium	2 every 9 years	30 µg/L
VOCs	2 annually	Varies

a. Haloacetic acids = sometimes referred to as HAA5, which includes the most common haloacetic acids found in drinking water. These consist of monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid, and dibromoacetic acid.

b. Total coliform and E. coli are sampled monthly at the Naval Reactors Facility Deactivation and Decommissioning Facility.

- The INL contractor monitors groundwater at the MFC (WAG 9), the ATR Complex, and the RHLLW Disposal Facility. The INL contractor also monitors the drinking water at eight INL Site facilities: ATR Complex, CFA, the Critical Infrastructure Test Range Complex (CITRC), the Experimental Breeder Reactor-I (EBR-I), the Gun Range, the Main Gate, MFC, and TAN/Contained Test Facility (CTF). Table 6-3 summarizes the routine monitoring for the INL contractor drinking water program.
- The INL contractor collects drinking water samples from offsite locations and natural surface waters on and off the INL Site for surveillance purposes. This includes the Big Lost River, which occasionally flows through the INL Site, and springs along the Snake River that are downgradient from the INL Site. A summary of the program may be found in Table 6-4. In 2022, the INL contractor sampled and analyzed 26 surface and drinking water samples. Samples were not collected from the Big Lost River in 2022 due to water demands upstream inhibiting river flow onto the INL Site.

Table 6-3. INL contractor drinking water program summary (2022).

TYPE OF ANALYSIS	FREQUENCY (ONSITE)	MAXIMUM CONTAMINANT LEVEL
Gross alpha[a]	10 to 12 semiannually	15 pCi/L
Gross beta[a]	10 to 12 semiannually	4 mrem/yr
Haloacetic acids[b]	4 annually	0.06 mg/L
Iodine-129[c]	1 semiannually	1 pCi/L
Lead/Copper[b]	35 triennially	0.015/1.3 mg/L
Nitrate[d]	10 annually	10 mg/L (as nitrogen)
Radium-226/228	4 annually	5 pCi/L
Total coliform and E. coli	12 to 14 monthly	See 40 CFR 141.63
Total trihalomethanes[b]	4 annually	0.08 mg/L
Tritium[a]	10 to 12 semiannually	20,000 pCi/L
Uranium	4 annually	30 µg/L

a. Gross alpha, beta, and tritium are sampled at all INL water systems (i.e., ATR Complex, CFA, CITRC, EBR-1, Gun Range, Main Gate, MFC, and TAN/CTF).

b. Total trihalomethanes, haloacetic acids, and lead/copper are only sampled at ATR Complex, CFA, MFC, and TAN/CTF water systems.

c. Iodine-129 is only sampled at the CFA water system.

d. Nitrate and microbes are sampled at all INL water distribution systems.

Table 6-4. INL surface water and offsite drinking water summary (2022).

MEDIUM SAMPLED	TYPE OF ANALYSIS	LOCATIONS AND FREQUENCY		MINIMUM DETECTABLE CONCENTRATION
		ONSITE	OFFSITE	
Drinking Water[a]	Gross alpha	None	9-10 semiannually	3 pCi/L
	Gross beta	None	9-10 semiannually	2 pCi/L
	Tritium	None	9-10 semiannually	100 pCi/L
Surface Water[b,c]	Gross alpha	6, when available	3-4 semiannually	3 pCi/L
	Gross beta	6, when available	3-4 semiannually	2 pCi/L
	Tritium	6, when available	3-4 semiannually	100 pCi/L

a. Samples are co-located with the DEQ-INL Oversight Program at Shoshone and Minidoka water supplies. An upgradient sample is collected at Mud Lake Well #2. The number of samples includes a duplicate sample.

b. Onsite locations are the Big Lost River (when flowing) at the public rest stop on Highway 20/26, at two locations along Lincoln Boulevard, the Experimental Field Station, and the Big Lost River Sinks. A duplicate sample is also collected on the Big Lost River. Offsite samples are co-located with the DEQ-INL Oversight Program at Alpheus Spring, Clear Springs, and a fish hatchery at Hagerman. A duplicate sample is also collected at one location.

c. One sample is also collected offsite at Birch Creek as a control for the Big Lost River when it is flowing.

Details of the aquifer, drinking water, and surface water programs may be found in the *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2021a) and *Idaho National Laboratory Groundwater Monitoring and Contingency Plan Update* (DOE-ID 2021b).

6.2 Hydrogeologic Data Management

Over time, hydrogeologic data at the INL Site have been collected by organizations, including USGS, current and past contractors, and other groups. The following data management systems are used:

- The Environmental Data Warehouse is the official long-term environmental data management and storage location for the ICP and INL programs. The Environmental Data Warehouse houses sampling and analytical data generated by site contractors and the USGS. It also stores comprehensive information pertaining to wells, including construction, location, completion zone, type, and status.
- The ICP Sample and Analysis Management Program consolidates environmental sampling activities and analytical data management. The Sample and Analysis Management Program provides a single point of contact for obtaining analytical laboratory services and managing cradle-to-grave analytical data records.
- The Hydrogeologic Data Repository houses geologic and hydrologic information compiled to support remedial investigation and feasibility study activities, Environmental Impact Statement preparation, site selection and characterization, and transport modeling in vadose and saturated zones. The information available includes (1) well construction and drill hole information, (2) maps, (3) historical data, (4) aquifer characteristics, (5) soil characterization, and (6) sediment property studies.
- The USGS Data Management Program involves putting all data in the National Water Information System, which is available online at https://waterdata.usgs.gov/id/nwis/nwis.

6.3 USGS Radiological Groundwater Monitoring at the INL Site

Historical waste disposal practices have produced localized areas of radiochemical contamination in the eastern Snake River Plain Aquifer beneath the INL Site.

Presently, strontium-90 (^{90}Sr) is the only radionuclide that continues to be detected by the ICP contractor and USGS above the primary constituent standard in some surveillance wells at TAN and between INTEC and CFA. Other radionuclides (e.g., gross alpha) have been detected above the primary constituent standard in wells monitored at individual WAGs.

Tritium – Because tritium is equivalent in chemical behavior to hydrogen—a key component of water—it has formed the largest plume of any of the radiochemical pollutants at the INL Site. The configuration and extent of the tritium contamination area, based on the most recent USGS data (2018), are shown in Figure 6-4 (Bartholomay et al. 2020). The area of contamination within the 500-pCi/L contour line decreased from about 103 km^2 (40 mi^2) in 1991 to about 52 km^2 (20 mi^2) in 1998 (Bartholomay et al. 2000). The area of elevated tritium concentrations near CFA likely represents water originating at INTEC some years earlier when larger amounts of tritium were disposed. This source is further supported by the fact that there are no known sources of tritium contamination in groundwater at CFA.

Two monitoring wells downgradient of the ATR Complex (USGS-065) and INTEC (USGS-114) have continually shown the highest tritium concentrations in the aquifer over the past 20 years, as shown in Figure 6-5. For this reason, these two wells are considered representative of maximum concentration trends in the rest of the aquifer. The concentration of tritium in USGS-065 near the ATR Complex decreased from 1,380 ± 90 pCi/L in 2021 to 400 ± 30 pCi/L in 2022; the tritium concentration in USGS-114, south of INTEC, decreased slightly from 4,280 ± 150 in 2021 to 3,970 ± 130 pCi/L in 2022.

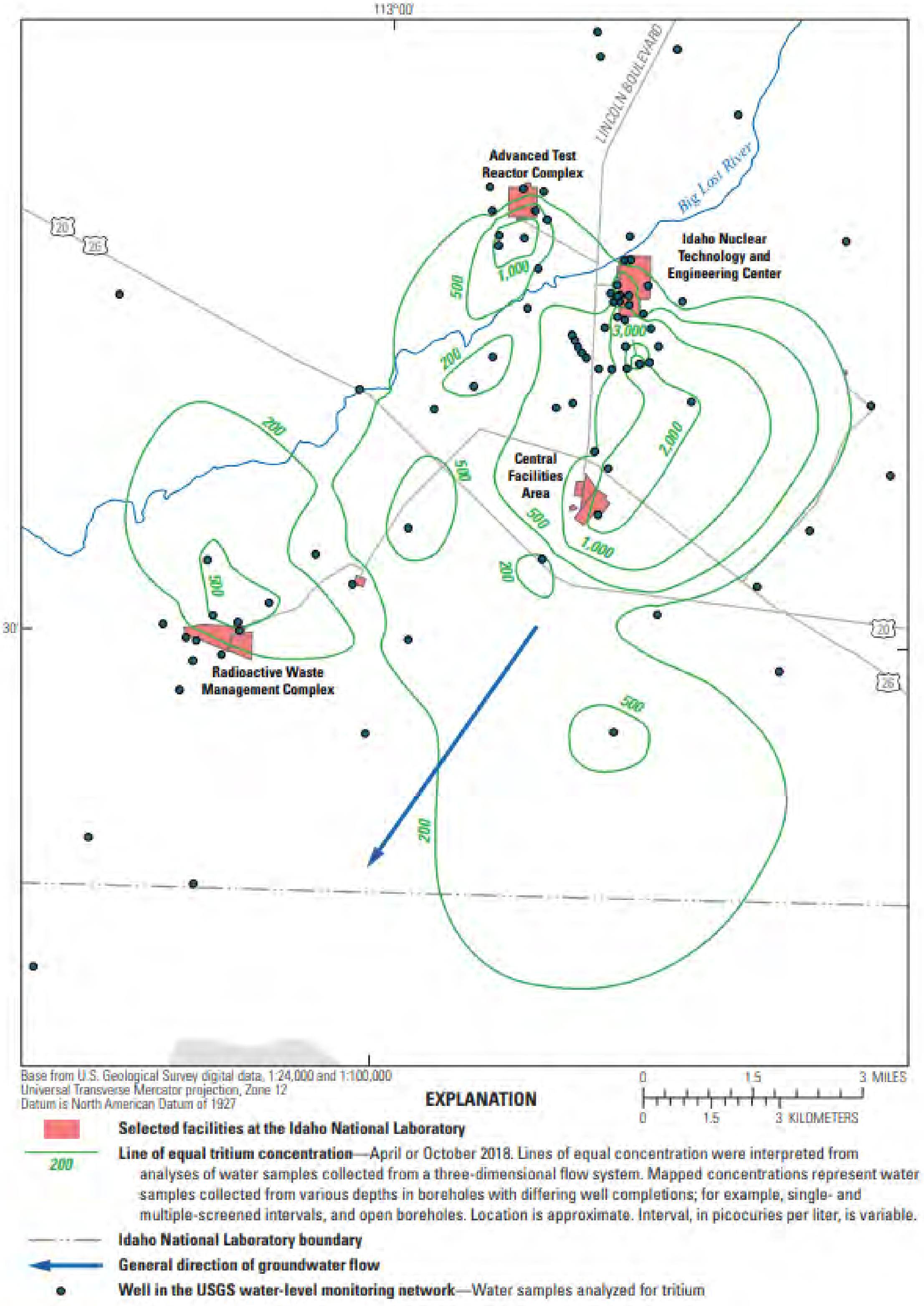

Figure 6-4. Distribution of tritium (pCi/L) in the eastern Snake River Plain Aquifer onsite in 2018 (from Bartholomay et al. 2020).

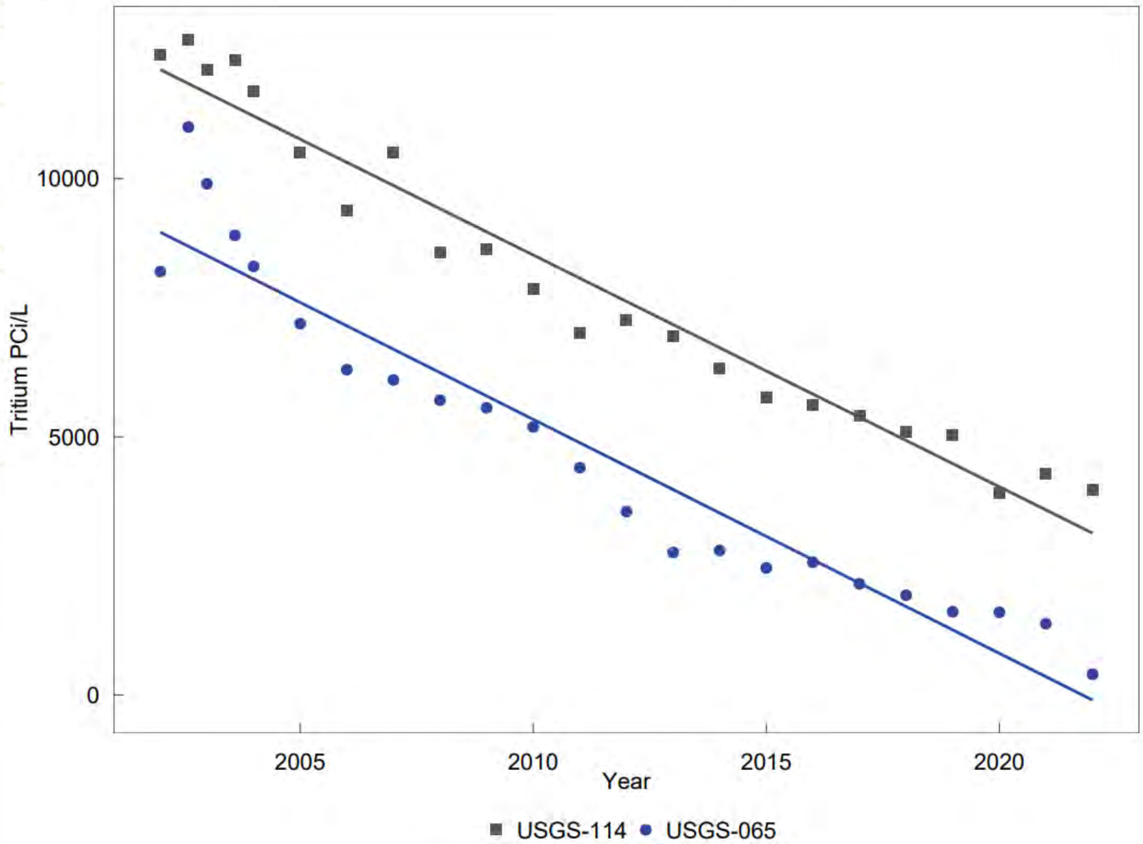

Figure 6-5. Long-term trend of tritium in wells USGS-065 and USGS-114 (2002–2022).

The Idaho primary constituent standard for tritium (20,000 pCi/L) in groundwater is the same as the EPA MCL for tritium in drinking water. The values in Wells USGS-65 and USGS-114 dropped below this limit in 1997 due to radioactive decay (tritium has a half-life of 12.33 years), ceased tritium disposal, advective dispersion, and dilution within the aquifer. A 2015 report by the USGS (Davis et al. 2015) indicated that water quality trends for tritium in all but one well at the INL Site showed decreasing or no trends, and the well that showed the increasing trend changed to a decreasing trend after an analysis of the 2018 data (Bartholomay et al. 2020, Figure 15).

Strontium-90 – The configuration and extent of ^{90}Sr in groundwater, based on the latest published USGS data, are shown in Figure 6-6 (Bartholomay et al. 2020). The contamination originates at INTEC from the historical injection of wastewater. No ^{90}Sr was detected by USGS in the eastern Snake River Plain Aquifer near the ATR Complex during 2022. All ^{90}Sr at the ATR Complex was disposed to infiltration ponds in contrast to the direct injection that occurred at INTEC. At the ATR Complex, ^{90}Sr is retained in surficial sedimentary deposits, interbeds, and perched groundwater zones. The area of ^{90}Sr contamination from INTEC is approximately the same as it was in 1991.

The ^{90}Sr trend over the past 20 years (i.e., 2002–2022) in Wells USGS-047, USGS-057, and USGS-113 is shown in Figure 6-7. Concentrations in Well USGS-047 have varied throughout time but indicate a general decrease. Concentrations in Wells USGS-057 and USGS-113 also have generally decreased during this period. The variability of concentrations in some wells was thought to be due to, in part, a lack of recharge from the Big Lost River that would dilute the ^{90}Sr. Other reasons may include increased disposal of other chemicals into the INTEC percolation ponds, which may have changed the affinity of ^{90}Sr on soil and rock surfaces, causing it to become more mobile (Bartholomay et al. 2000). A 2015 report by the USGS (Davis et al. 2015) indicated that water quality trends for ^{90}Sr in all but two perched water wells at the INL Site showed decreasing or no trends.

Summary of other USGS Radiological Groundwater Monitoring – USGS collects samples annually from select wells at the INL Site for gross alpha, gross beta, gamma spectroscopy analyses, and plutonium and americium isotopes.

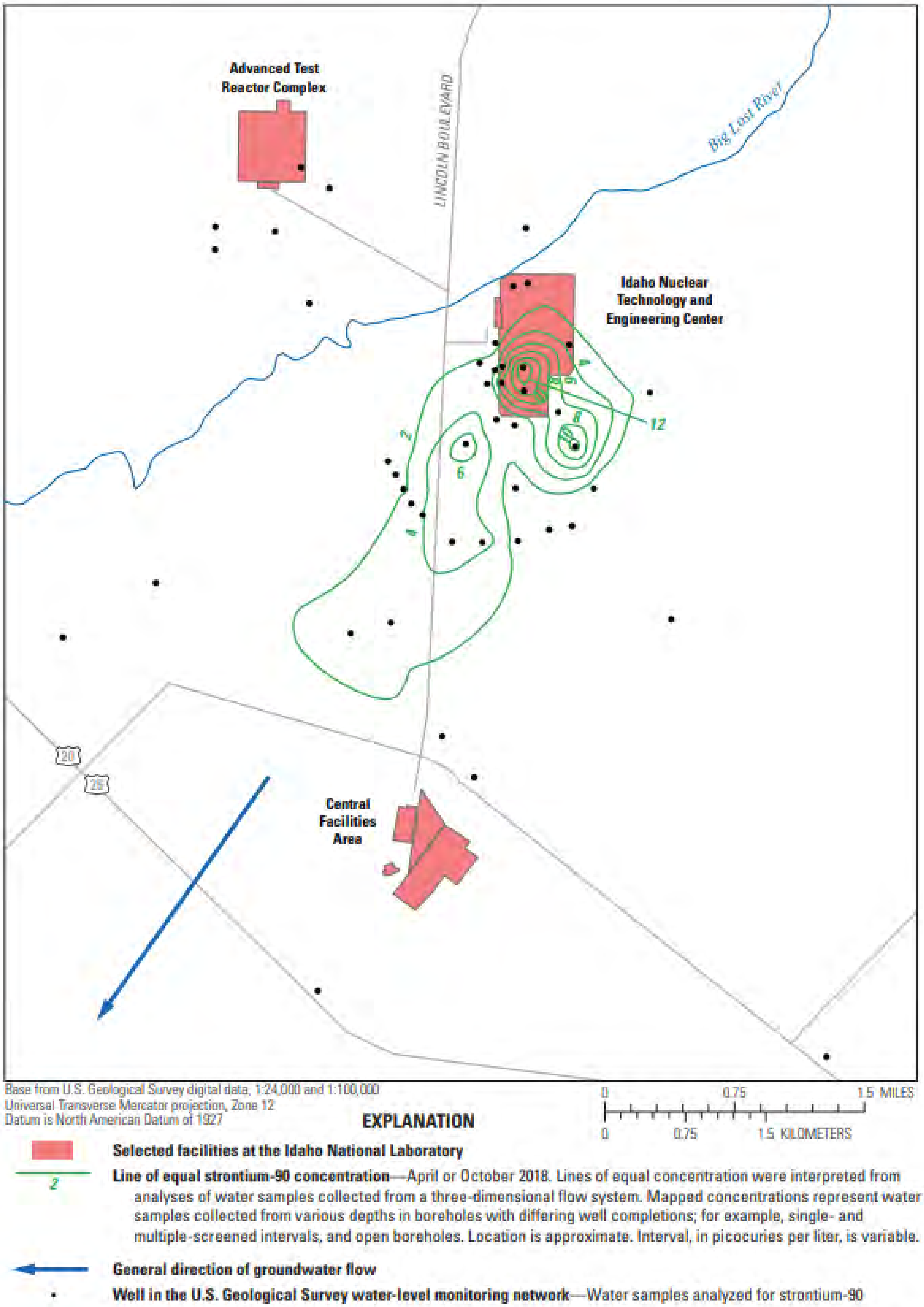

Figure 6-6. Distribution of ^{90}Sr (pCi/L) in the eastern Snake River Plain Aquifer onsite in 2018 (from Bartholomay et al. 2020).

These values are shown in Table 6-1. Results for wells sampled in 2022 are available at https://waterdata.usgs.gov/id/nwis/ (U.S. Geological Survey 2021). Monitoring results for 2016–2018 are summarized in Bartholomay et al. (2020). During 2016–2018, concentrations of cesium-137 were greater than or equal to the reporting level in one well, and concentrations of plutonium-238, plutonium-239/240, and americium-241 in all analyzed samples were less than the reporting level. In 2016–2018, reportable concentrations of gross alpha radioactivity were observed in six of the 55 wells and ranged from 6 ± 2 to 141 ± 29 pCi/L. Beta radioactivity exceeded the reporting level in most of the wells sampled, and concentrations ranged from 2.4 ± 0.8 to 1,390 ± 80 pCi/L (Bartholomay et al. 2020). Monitoring results from 2019–2021 will be published in 2023.

Periodically, the USGS has sampled for iodine-129 (^{129}I) in the eastern Snake River Plain Aquifer. Monitoring programs from 1977, 1981, 1986, 1990, 1991, 2003, 2007, 2011, and 2012 were summarized in Mann et al. (1988), Mann and Beasley (1994), and Bartholomay (2009, 2013), Maimer and Bartholomay (2019), and (2021–2022) in preparation. The USGS sampled for ^{129}I in wells at the INL Site in the fall of 2021 and collected additional samples in the spring of 2022. Average concentrations of 15 wells sampled in 1990–1991, 2003, 2007, 2011–2012, and 2017–2018 decreased from 1.15 pCi/L in 1990–1991 to 0.168 pCi/L in 2017–2018. The maximum concentration in 2017 was 0.877 ± 0.032 pCi/L in a monitoring well southeast of INTEC—the drinking water standard for ^{129}I is 1 pCi/L. The concentration in that same well in 2021 increased to 0.968 ± 0.023 pCi/L. In general, concentrations around INTEC showed slight decreases from samples collected in previous sample periods, and the decreases are attributed to discontinued disposal as well as dilution and dispersion in the aquifer. Select wells showed a slight increase ^{129}I, which could be controlled by preferential flow from legacy contamination source locations southwest of INTEC. The configuration and extent of ^{129}I in groundwater, based on the 2017–2018 USGS data (most current published date), are shown in Figure 6-8 (Maimer and Bartholomay 2019).

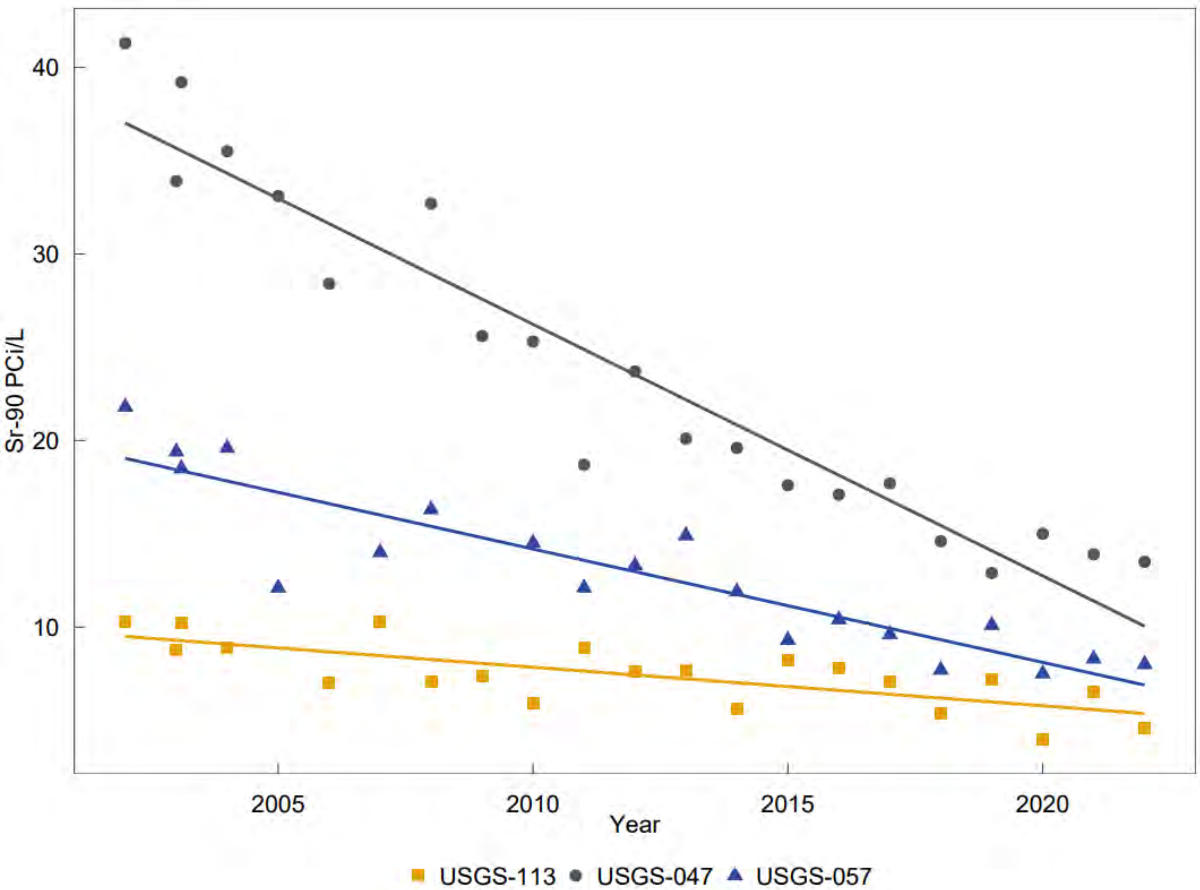

Figure 6-7. Long-term trend of ^{90}Sr in wells USGS-047, USGS-057, and USGS-113 (2002–2022).

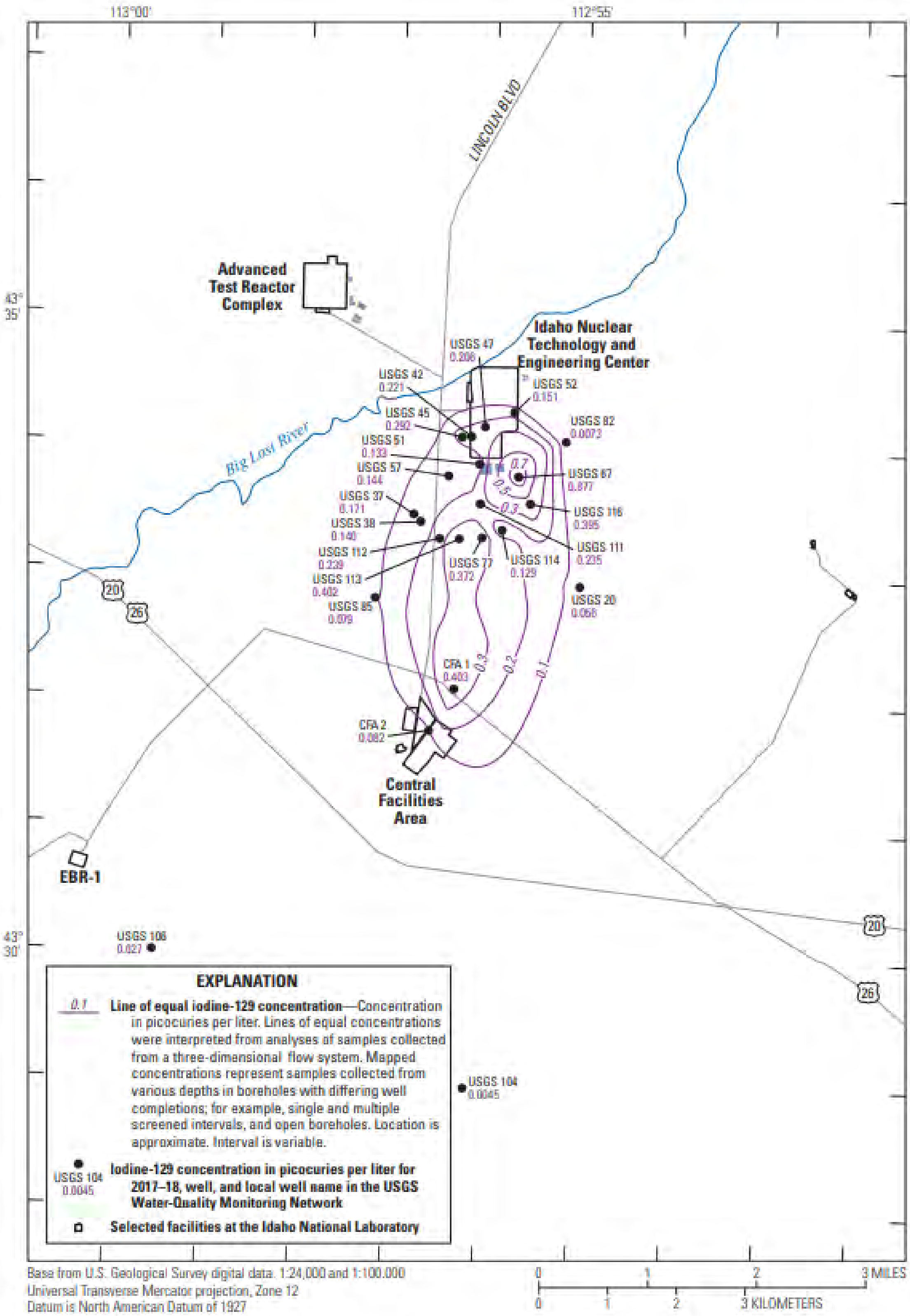

Figure 6-8. Distribution of ^{129}I in the eastern Snake River Plain Aquifer onsite in 2017–2018 (from Maimer and Bartholomay 2019).

6.4 USGS Non-radiological Groundwater Monitoring at the INL Site

USGS collects samples annually from select wells at the INL Site for chloride, sulfate, sodium, fluoride, nitrate, chromium, and other trace elements and purgeable organic compounds identified in Table 6-1. Bartholomay et al. (2020) provides a detailed discussion of results for samples collected during 2016–2018. Chromium had a concentration at the MCL of 100 µg/L in Well USGS-065 in 2009 (Fisher et al., 2021), but its concentration has since been below the MCL and was 78.8 µg/L in 2022. This well has shown a long-term decreasing trend (Fisher et al. 2021, Appendix 7).

Concentrations of chloride, nitrate, sodium, and sulfate historically have been above background concentrations in many wells at the INL Site, but concentrations were below established MCLs or secondary MCLs in all wells during 2018 (Bartholomay et al. 2020).

VOCs are present in water from the eastern Snake River Plain Aquifer because of historical waste disposal practices at the INL Site. Products containing VOCs were used for degreasing, decontamination, and other activities at INL Site facilities. The USGS sampled purgeable (volatile) organic compounds in groundwater at the INL Site during 2022. Samples from 26 groundwater monitoring wells and one perched well were collected and submitted to the USGS National Water Quality Laboratory in Lakewood, Colorado; the samples analyzed 61 purgeable organic compounds. USGS reports describe the methods used to collect the water samples and ensure sampling and analytical quality (Mann 1996; Bartholomay et al. 2003; Knobel et al. 2008; and Bartholomay et al. 2021). Eleven purgeable organic compounds were detected above the laboratory reporting level of 0.2 or 0.1 µg/L in at least one well on the INL Site identified in Table 6-5.

Historically, concentrations of VOCs in water samples from several wells at and near the RWMC exceeded the reporting levels (Bartholomay et al. 2020). However, concentrations for all VOCs except tetrachloromethane (also known as carbon tetrachloride) and trichloroethene were less than the MCL for drinking water (40 CFR 141, Subpart G). The production well at the RWMC was monitored monthly for tetrachloromethane during 2022, and concentrations exceeded the MCL of 5 µg/L during 11 of the 12 months measured, as shown in Table 6-6.

Since 1998, concentrations have routinely exceeded the MCL for tetrachloromethane in drinking water (5 µg/L) at RWMC. (Note: VOCs are removed from production well water prior to human consumption—see Section 6.7.1.10.) Trend test results for tetrachloromethane concentrations in water from the RWMC production well indicated a statistically significant increase in concentrations has occurred from 1989 through 2015; however, Bartholomay et al. (2020) indicated that more recent data through 2018 showed no trend for the entire dataset and a decreasing trend for data collected since 2005. The more recent decreasing trend indicates that engineering practices designed to reduce VOC movement to the aquifer are having a positive effect.

Concentrations of tetrachloromethane from Wells USGS-87 and USGS-120, south of RWMC, have had an increasing trend since 1987, but concentrations have decreased through time at Well USGS-88 (Davis et al. 2015; Bartholomay et al. 2020; Fisher et al. 2021).

Trichloroethylene (trichloroethene) (TCE) exceeded the MCL of 5 µg/L from one sample collected from GIN 2 at TAN, identified in Table 6-5. There is a known groundwater TCE plume being treated at TAN, as discussed in more detail in Section 6.5.1. The sample collected at a perched well, USGS-92, at RWMC also detected TCE above the MCL.

Table 6-5. Purgeable organic compounds in annual USGS groundwater well samples (2022).

CONSTITUENT	USGS-120	USGS-88	RWMC M3S	USGS-87	RWMC M7S	USGS-77	USGS-065	TAN-2312	GIN 2	TAN-2271
1,1-Dichloroethane (MCL = 7 µg/L)[a]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.308
1,1,1-Trichloroethane (MCL = 200 µg/L)[a]	<0.1	<0.1	0.160	<0.1	0.306	<0.1	<0.1	<0.1	<0.1	<0.1
cis-1,2-Dichoroethene[b] (MCL = 70 µg/L)[a]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.126	0.950
Ethylbenzene (MCL = 700 µg/L)[a]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tetrachloroethene[b] (MCL = 5 µg/L)[a]	<0.1	<0.1	0.173	0.115	0.419	<0.1	<0.1	<0.1	3.61	<0.1
Tetrachloromethane (PCS = 2 µg/L)[c]	1.092	0.797	3.65	2.80	4.32	<0.2	<0.2	<0.2	<0.2	<0.2
Trichloroethene[b] (MCL = 5 µg/L)[a]	0.220	0.513	1.05	0.738	2.43	<0.1	<0.1	0.160	10.9	1.69
Trichloromethane (MCL = 5 µg/L)[a]	0.155	0.441	0.320	0.328	0.905	<0.1	0.216	<0.1	0.138	<0.1
Toluene (MCL = 1,000 µg/L)[a]	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
trans-1,2-Dichloroethene[b] (MCL = 100 µg/L)[a]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	59.17
Vinyl chloride (MCL = 2 µg/L)[a]	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.12
1,1-Dichloroethene (MCL = 7 µg/L)[a]	<0.1	<0.1	<0.1	<0.1	<0.1	0.102	<0.1	<0.1	<0.1	<0.1
Dichlorodifluoromethane[d]	<0.2	<0.2	<0.2	0.485	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2

a. MCL = maximum contaminant level from the EPA (40 CFR 141).

b. The International Union of Pure and Applied Chemistry name for ethylene is ethene. So, for example, trichloroethene is equivalent to trichloroethylene. This is the name reported in the USGS database. This nomenclature is used in this table in case the reader wants to look up the constituent in the USGS database.

c. PCS = primary constituent standard values from IDAPA 58.01.11.

d. No MCL has been established for Dichlorodifluoromethane (40 CFR 141).

Table 6-6. Purgeable organic compounds in monthly production well samples at the RWMC (2022).

CONSTITUENT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1,1,1-Trichloroethane (MCL = 200 µg/L)[a]	0.276	0.241	0.270	0.266	0.249	0.243	0.263	0.238	0.233	0.256	0.304	0.238
Tetrachloroethene[b] (MCL = 5 µg/L)[a]	0.361	0.380	0.381	0.351	0.289	0.309	0.350	0.286	0.303	0.366	0.431	0.341
Tetrachloromethane (MCL = 5 µg/L)[a]	5.12	4.75	5.17	5.60	5.23	5.08	5.88	5.20	5.13	5.35	6.60	5.02
Trichloroethene[b] (MCL = 5 µg/L)[a]	3.48	3.84	3.64	3.38	2.78	2.93	3.27	3.01	2.96	3.24	3.47	3.60
Trichloromethane (PCS = 2 µg/L)[c]	1.93	1.69	1.66	1.78	1.49	1.57	1.70	1.51	1.57	1.73	1.97	1.76

a. MCL = maximum contaminant level values from the EPA (40 CFR 141).

b. The International Union of Pure and Applied Chemistry name for ethylene is ethene. So, for example, trichloroethene is equivalent to trichloroethylene. This is the name reported in the USGS database. This nomenclature is used in this table in case the reader wants to look up the constituent in the USGS database.

c. PCS = primary constituent standard values from IDAPA 58.01.11.

6.5 Comprehensive Environmental Response, Compensation, and Liability Act Groundwater Monitoring During 2022

CERCLA activities at the INL Site are divided into WAGs that roughly correspond to the major facilities, with the addition of the INL Site-wide WAG 10. Locations of the various WAGs are shown in Figure 6-3. The following subsections provide an overview of the groundwater sampling results. More detailed discussions of CERCLA groundwater sampling can be found in the WAG-specific monitoring reports within the CERCLA Administrative Record at Administrative Record Information Repository (ARIR) Home – ARIR (idaho-environmental.com). WAG 8 is managed by the Naval Reactors Facility and is not discussed in this report.

6.5.1 Summary of Waste Area Group 1 Groundwater Monitoring Results

Groundwater is monitored at WAG 1 (TAN) to evaluate the progress of the remedial action at TAN. The VOC groundwater plume at TAN has been divided into three zones based on the 1997 TCE concentrations with three different remedy components, which work together to remediate the entire VOC plume. The monitoring program and results are summarized by plume zone in the following paragraphs.

Hot Spot Zone (historical TCE concentrations exceeding 20,000 µg/L) – In-situ bioremediation (ISB) was used in the hot spot (near Well TSF-05) to create conditions favorable for naturally occurring anaerobic bacteria in the aquifer to break down chlorinated solvents (principally TCE). The hot spot concentration was defined using TCE data from 1997, which is identified in Figure 6-9 and is not reflective of current concentrations, as shown in Figure 6-10. With regulatory agency concurrence, an ISB rebound test began in July 2012 to determine if the residual TCE source in the aquifer had been sufficiently treated. Currently, the ISB rebound test has been split into two components: (1) an ISB rebound test for the area near the former injection Well TSF-05 and (2) ISB activities to treat the TCE source affecting Well TAN-28.

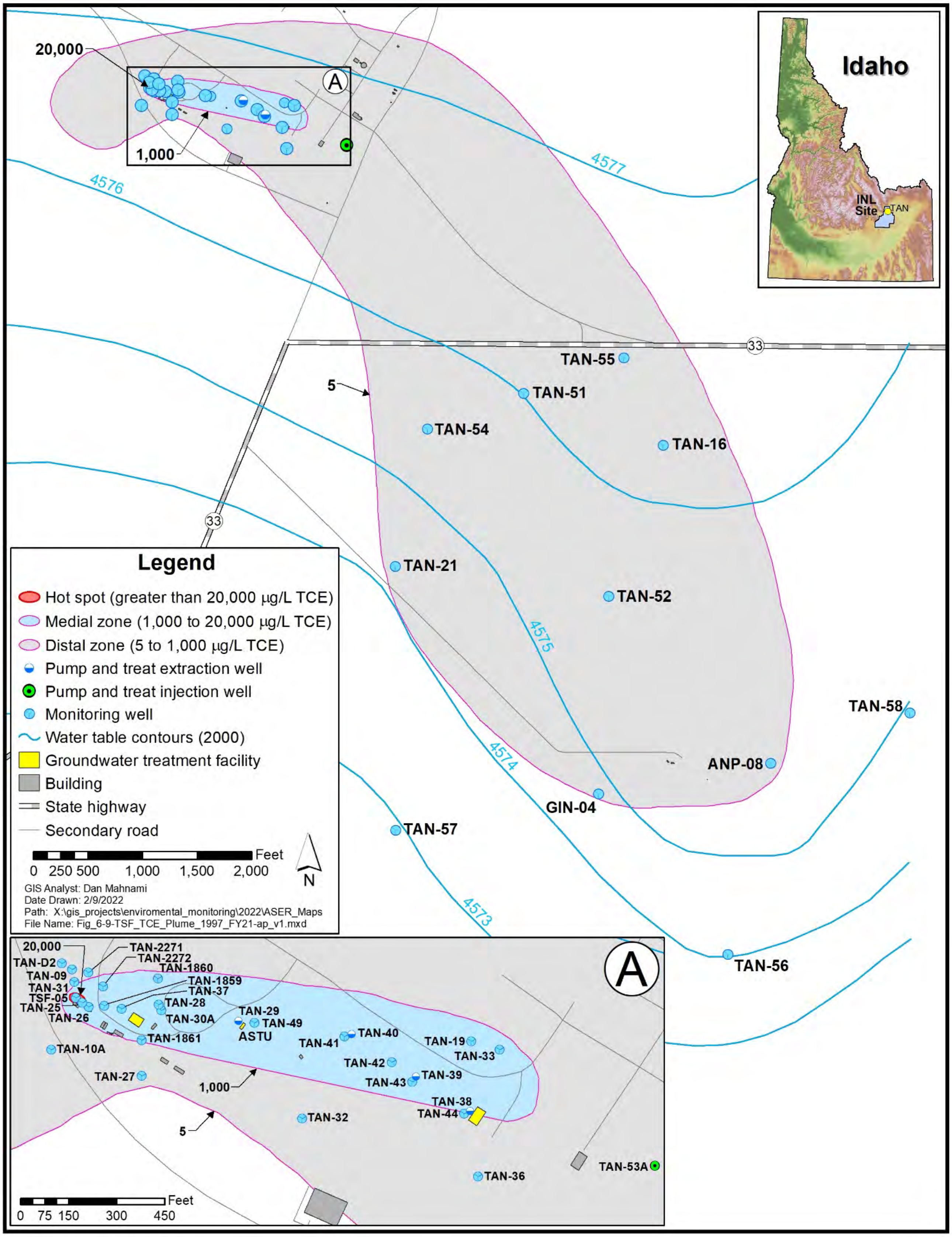

Figure 6-9. TCE plume at TAN in 1997.

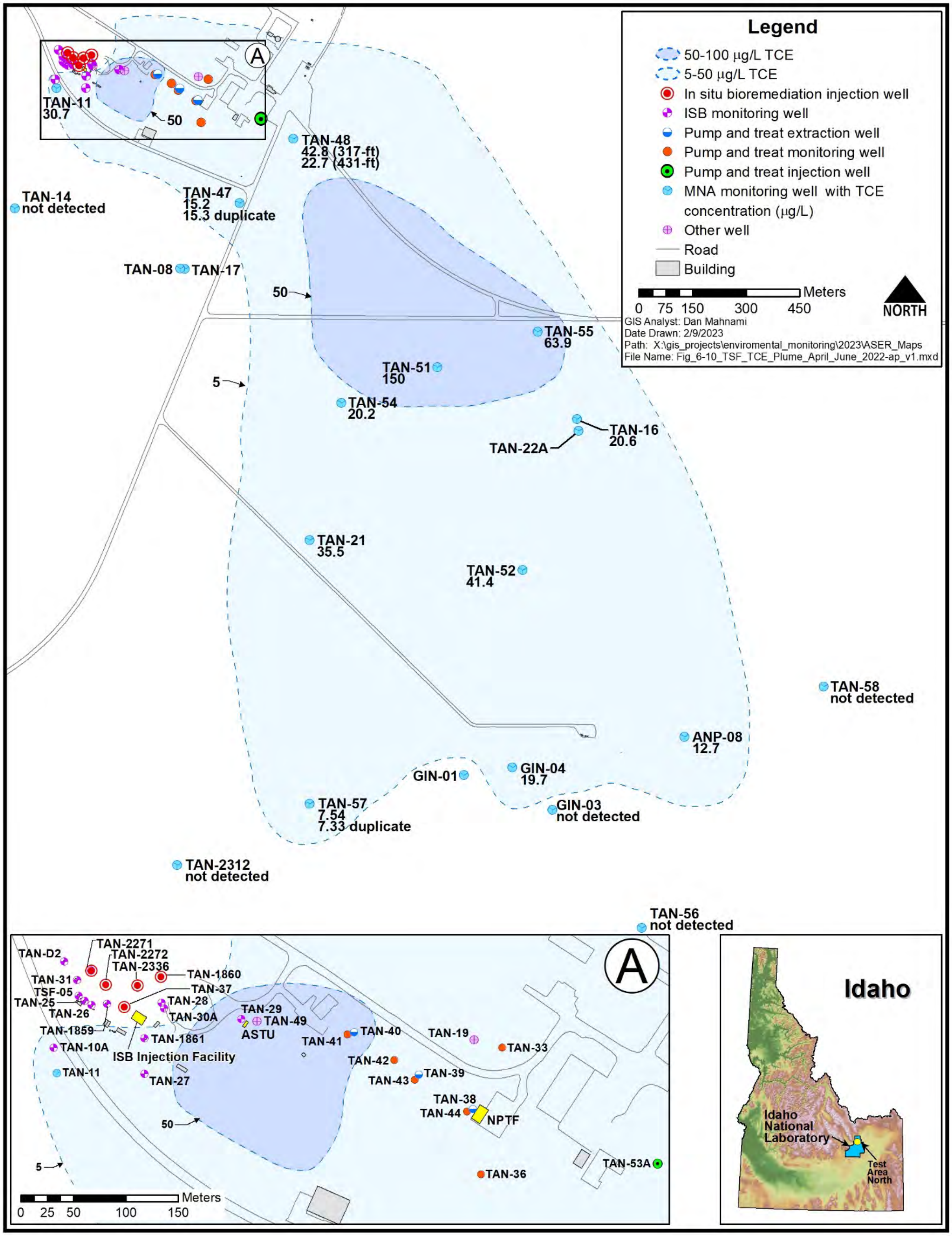

Figure 6-10. Distribution of TCE in the Snake River Plain Aquifer from April–June 2022.

In FY 2022, data collected during the ISB rebound test for the area near the former injection Well TSF-05 indicated that anaerobic conditions created by ISB were still present in the hot spot area and that TCE concentrations were near or below MCLs in the wells near the former injection Well TSF-05, as shown in Figure 6-10. After background aquifer conditions are re-established, the effectiveness of the ISB part of the remedy will be evaluated (DOE-ID 2023a).

To address the source of TCE in Well TAN-28, continued ISB injections have been made into TAN-2336. Five ISB injections were made into TAN-2336 in 2022. Despite some variations, TCE concentrations have declined in TAN-28 because of the ISB injections to treat the TAN-28 TCE source. ISB injections will continue into these wells until it can be determined that the TAN-28 TCE source has been successfully treated and a transition to a rebound test for the TAN-28 TCE source can be made.

Medial Zone (historical TCE concentrations between 1,000 and 20,000 µg/L) – A pump and treat system has been used in the medial zone. The pump and treat system extracts contaminated groundwater, circulates the groundwater through air strippers to remove VOCs like TCE, and reinjects treated groundwater into the aquifer. The New Pump and Treat Facility generally operated Monday through Thursday in 2022, except for shutdowns due to maintenance. All 2022 New Pump and Treat Facility compliance samples were below the discharge limits. TCE concentrations used to define the medial zone (1,000–20,000 µg/L) are based on data collected in 1997, which is before remedial actions began shown in Figure 6-9, and do not reflect current concentrations, as identified in Figure 6-10. In 2022, none of the wells were above the concentration of 1,000 µg/L used historically to define the medial zone. The TCE concentrations in Wells TAN-33, TAN-36, and TAN-44 near the New Pump and Treat Facility are used as indicators of TCE concentrations migrating past the New Pump and Treat Facility extraction wells into the distal zone. In FY 2022, TCE concentrations for Wells TAN-33, TAN-36, and TAN-44 ranged from 10.5 to 34.9 µg/L.

Distal Zone (historical TCE concentrations between 5 and 1,000 µg/L) – Monitored natural attenuation is the remedial action for the distal zone of the plume (Figure 6-9). Monitored natural attenuation is the sum of physical, chemical, and biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of groundwater contaminants. Institutional controls are in place to protect current and future users from health risks associated with groundwater contamination until concentrations decline through natural attenuation to below the MCL.

TCE data collected in FY 2022 from the distal zone wells indicate that all wells are consistent with the model predictions, but additional data are needed to confirm that the monitored natural attenuation part of the remedy will meet the remedial action objective of all wells below the MCL by 2095. The TCE data from the plume expansion wells suggest that plume expansion is currently within the limits allowed in the Record of Decision Amendment (DOE-ID 2001).

Radionuclide Monitoring – In addition to the VOC plume, ^{90}Sr, ^{137}Cs, tritium, and uranium-234 (^{234}U) are listed as contaminants of concern in the Record of Decision Amendment (DOE-ID 2001). Strontium-90 and ^{137}Cs are expected to naturally decline below their respective MCLs before 2095. However, wells in the source/ISB area currently show elevated ^{90}Sr and ^{137}Cs concentrations compared to levels prior to starting ISB. The elevated ^{90}Sr and ^{137}Cs concentrations are due to enhanced mobility created by elevated concentrations of competing cations (e.g., calcium, magnesium, sodium, and potassium) for adsorption sites in the aquifer. The elevated cation concentrations are due to ISB activities to treat VOCs. As competing cation concentrations decline toward background conditions, ^{90}Sr and ^{137}Cs are trending lower. The radionuclide concentrations are expected to continue to decrease, and concentration trends will continue to be evaluated to determine if the remedial action objective of declining below MCLs by 2095 will be met. All 2022 results for tritium are below the MCL of 20,000 pCi/L, with the highest tritium result of 1,510 pCi/L at Well TAN-25. Sampling will be conducted for ^{234}U after ISB conditions dissipate because ISB conditions suppress uranium concentrations.

6.5.2 Summary of Waste Area Group 2 Groundwater Monitoring Results

Groundwater samples were collected from six aquifer wells to monitor WAG 2 in the ATR Complex during 2022. All of the wells shown in Figure 6-11 were sampled except for TRA-07, which could not be sampled due to a malfunctioning pump. Aquifer samples were analyzed for ^{90}Sr, gamma-emitting radionuclides (e.g., the target analyte is cobalt-60), tritium, and chromium (filtered) in accordance with the groundwater monitoring plan (DOE-ID 2016). The data for the October 2022 sampling event will be included in the FY 2023 Annual Report for WAG 2 (DOE-ID 2023b). The October 2022 sampling data are summarized in Table 6-7.

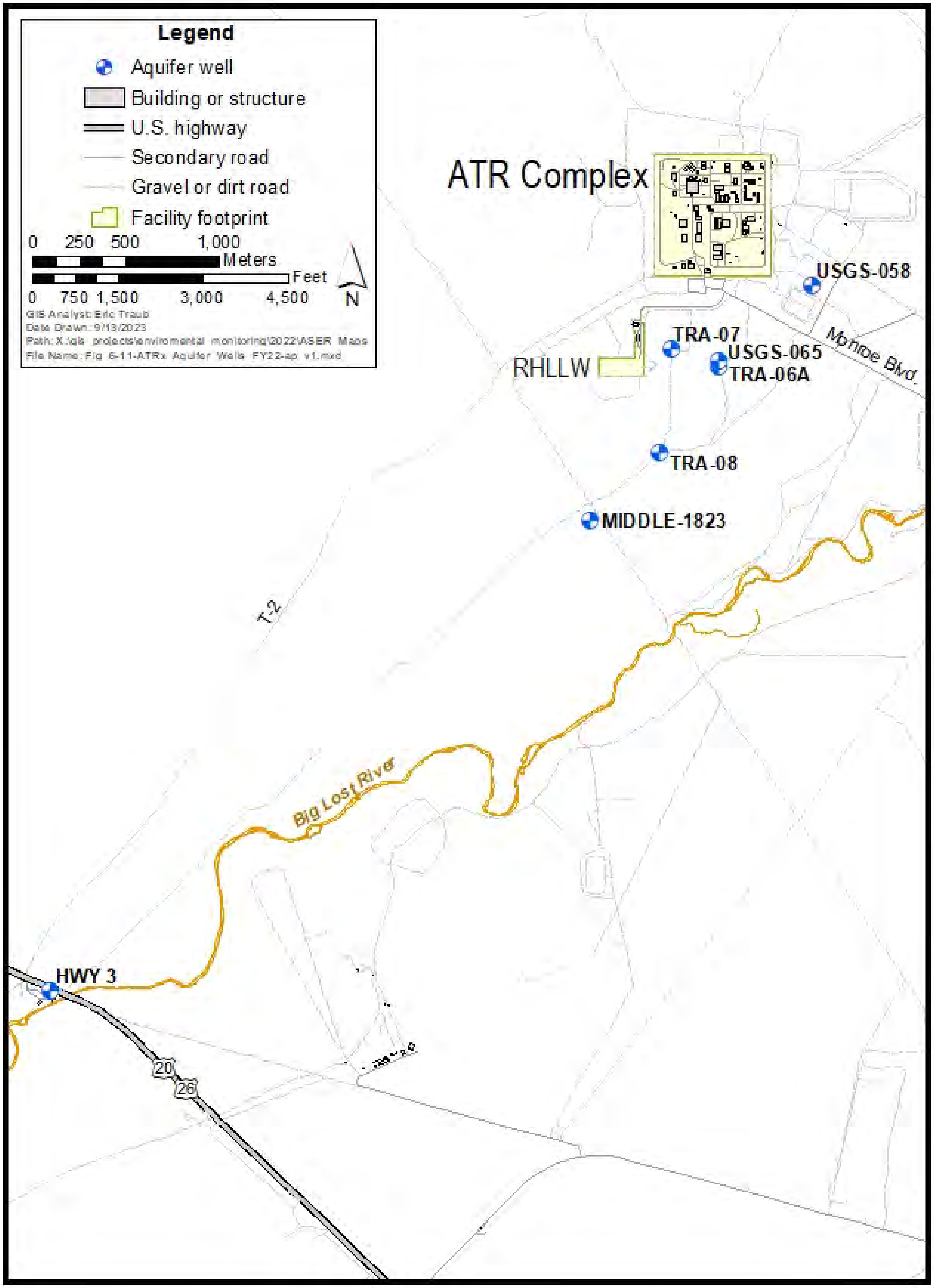

Figure 6-11. Locations of WAG 2 aquifer monitoring wells.

Table 6-7. WAG 2 aquifer groundwater quality summary (October 2022).

ANALYTE	MCL	BACKGROUND[a]	MAXIMUM	MINIMUM	NUMBER OF WELLS ABOVE MCL
Chromium (filtered) (µg/L)	100	4	82.2	2.96	0
Cobalt-60 (pCi/L)	100	0	ND[b]	ND	0
Strontium-90 (pCi/L)	8	0	ND	ND	0
Tritium (pCi/L)	20,000	34	1,160	ND	0

a. Background concentrations are for western tributary water for the eastern Snake River Plain Aquifer from Bartholomay and Hall (2016).

b. ND = not detected.

No analyte occurred above its MCL in the Snake River Plain Aquifer at WAG 2. The highest chromium concentration occurred in Well USGS-065 at 82.2 µg/L and was below the MCL of 100 µg/L. The second highest chromium concentration was in Well TRA-08 at 17.2 µg/L. The chromium concentrations in both wells have been mostly stable in recent years.

Tritium was the only radionuclide analyte detected in the aquifer and was below the MCL of 20,000 pCi/L in all the sampled wells. The highest tritium concentration was 1,160 pCi/L in Well USGS-065.

Chromium and tritium concentrations in the aquifer have declined faster than predicted by the WAG 2 models used for the Operable Unit 2-12 Record of Decision and the revised modeling performed after the first five-year review (DOE-NE-ID 2005).

The October 2022 eastern Snake River Plain Aquifer water table map prepared for the vicinity of the ATR Complex was consistent with previous maps showing general groundwater flow direction to the southwest. Aquifer water levels in the vicinity of the ATR Complex declined by approximately 1.45 ft on average from October 2021 to October 2022.

6.5.3 Summary of Waste Area Group 3 Groundwater Monitoring Results

At INTEC, groundwater samples are collected from 17 Snake River Plain Aquifer monitoring wells during odd-numbered years and 14 wells during even-numbered years. During the reporting period, 13 of the 14 required wells were sampled. Well ICPP-2020-AQ was not sampled because the sample pump was not functional (Figure 6-12). Groundwater samples were analyzed for a suite of radionuclides and inorganic constituents, and the data are summarized in the 2022 Annual Report (DOE-ID 2023c). Table 6-8 summarizes the maximum concentrations observed, along with the number of MCL exceedances reported for each constituent.

Strontium-90, Technetium-99 (^{99}Tc), and nitrates exceeded their respective drinking water MCLs in one or more of the eastern Snake River Plain Aquifer monitoring wells at or near INTEC, with ^{90}Sr exceeding its MCL by the greatest margin. Strontium-90 concentrations remained above the MCL (8 pCi/L) at five of the well locations sampled. During 2022, the highest ^{90}Sr level in eastern Snake River Plain Aquifer groundwater was at monitoring Well USGS-047 (15 ± 1.36 pCi/L), located south (downgradient) of the former INTEC injection well. All well locations showed similar or slightly lower ^{90}Sr levels compared to those reported during the previous sampling events, except for Well USGS-048 (11.1 pCi/L), which remains elevated relative to 2015–2020 reported ^{90}Sr levels.

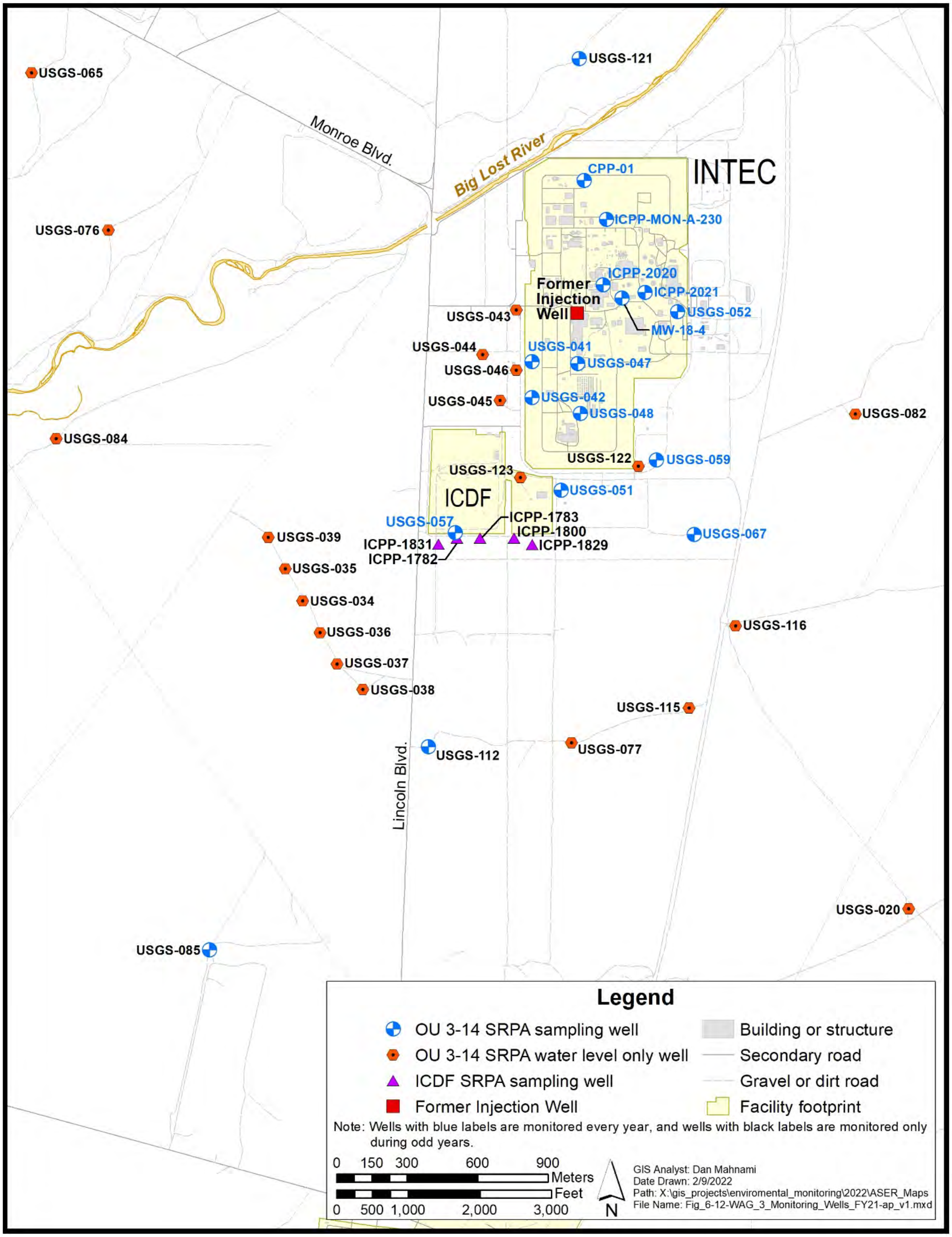

Figure 6-12. Locations of WAG 3 monitoring wells. *(Well names in blue are sampled every year; well names in black are sampled only during odd-numbered years.)*

Table 6-8. Summary of constituents detected in WAG 3 aquifer monitoring wells (FY 2022).

CONSTITUENT	EPA MCL[a]	UNITS	SNAKE RIVER PLAIN AQUIFER GROUNDWATER – APRIL 2022		
			MAXIMUM REPORTED VALUE	NUMBER OF RESULTS[a]	RESULTS > MCL[a]
Gross alpha	15	pCi/L	ND[b]	15	0
Gross beta	NA[c]	pCi/L	593 ± 6.97	15	NA[c]
Cesium-137	200	pCi/L	ND	15	0
Strontium-90	8	pCi/L	**15** ± **1.36**[d]	15	8
Technetium-99	900	pCi/L	**1,200** ± **69**	15	3
Iodine-129	1	pCi/L	0.6 ± 0.124	15	0
Tritium	20,000	pCi/L	1,930 ± 232	15	0
Plutonium-238	15	pCi/L	—[e]	—[e]	—[e]
Plutonium-239/240	15	pCi/L	—[e]	—[e]	—[e]
Uranium-233/234	NA MCL[f]	pCi/L	2.1 ± 0.315	15	NA
Uranium-235	NA MCL	pCi/L	0.146 ± 0.0655 J[b]	15	NA
Uranium-238	NA MCL	pCi/L	1.26 ± 0.223	15	NA
Bicarbonate	NA	mg/L	150	15	NA
Calcium	NA	mg/L	72.6	15	NA
Chloride	250	mg/L	142 J	15	0
Magnesium	NA	mg/L	24.7	15	NA
Nitrate/Nitrite (as N)	10	mg/L	**12.1**	15	1
Potassium	NA	mg/L	5.3	15	NA
Sodium	NA	mg/L	35.2	15	NA
Sulfate	250	mg/L	35.9	15	0
Total dissolved solids	500	mg/L	457	15	0

a. Include field duplicates.
b. Data-qualifier flags:
ND = constituent not detected in sample.
J = estimated detection.
c. NA = not applicable.
d. **Bold** values exceed MCL.
e. — = Gross alpha did not exceed 15 pCi/L; constituent not analyzed.
f. NA MCL = EPA MCL is reported in mass units (µg/L), and values listed are reported in pCi/L.

Technetium-99 was detected above the MCL (900 pCi/L) at two monitoring wells. During 2022, the highest ^{99}Tc level in eastern Snake River Plain Aquifer groundwater was at Well ICPP-MON-A-230 (1,200 ± 69 pCi/L), located north of the INTEC Tank Farm. All wells sampled showed stable or declining trends from the previous reporting period.

Nitrate was detected in all wells sampled during this reporting period. The highest concentration was reported at Well ICPP-2021-AQ (12.1 mg/L as N). This was the only location where the nitrate concentration exceeded the MCL (10 mg/L as N). This well is located relatively close to the Tank Farm and shows groundwater quality impacts attributed to past releases of Tank Farm liquid waste. Nitrate concentrations were similar or slightly lower than observed in previous years.

Tritium was detected at most of the wells sampled, but none of the groundwater samples exceeded the tritium MCL (20,000 pCi/L). The highest tritium concentrations in groundwater were reported at Well USGS-051, southeast of INTEC (1,930 ± 232 pCi/L). Tritium concentrations have declined at nearly all locations over the past few years.

During the reporting period, no plutonium isotope analyses were performed because the current monitoring plan identifies the contingency for plutonium analysis if gross alpha exceeds 15 pCi/L. Uranium-238 (^{238}U) was detected at all eastern Snake River Plain Aquifer well locations, with the highest concentration at Well ICPP-MON-A-230 (1.26 ± 0.223 pCi/L). Uranium-234 was also detected in all groundwater samples, with the greatest concentrations of 2.1 ± 0.315 pCi/L at Well USGS-047. Uranium-234 is the daughter product (from alpha decay) of the long-lived, naturally occurring ^{238}U. All uranium results for the other wells are consistent with background concentrations reported for Snake River Plain Aquifer groundwater. The $^{234}U/^{238}U$ ratio for all samples fell within the background range of 1.5 to 3.1 except for the sample from Well ICPP-MON-A-230. A slightly elevated ^{234}U result for this well may be attributed to sediment within the sample, as noted for some previous samples (Roback et al. 2001).

Uranium-235 (^{235}U) was detected at one monitoring well, USGS-042, with a level of 0.146 pCi/L. An evaluation of uranium in groundwater near RWMC indicates that eastern Snake River Plain Aquifer background ^{235}U activities are generally less than 0.15 pCi/L (95% upper tolerance limit).

6.5.4 Summary of Waste Area Group 4 Groundwater Monitoring Results

The WAG 4 groundwater monitoring consists of two different components: (1) monitoring the CFA landfill and (2) monitoring of a nitrate plume south of CFA. The wells at the CFA landfills are monitored to determine potential impacts from the landfills, while the nitrate plume south of CFA is monitored to evaluate nitrate trends. Groundwater monitoring for the CFA landfills consisted of sampling seven wells for metals (filtered), VOCs, and anions (nitrate, chloride, and sulfate) and two wells for VOCs only, in accordance with the long-term monitoring plan (DOE-ID 2018). Four wells south of CFA were sampled for nitrate, sulfate, and chloride to monitor the CFA nitrate plume. The CFA landfill and nitrate plume monitoring well locations are shown on Figure 6-13.

Analytes detected in groundwater are compared to regulatory levels identified in Table 6-9. In 2022, no metals exceeded an EPA MCL or secondary maximum containment level (SMCL); however, three wells exceeded a pH SMCL. The elevated pH in the three wells was due to grout placed beneath the well screens during well construction. A complete list of the groundwater sampling results will be included in the FY 2022 Annual Report for WAG 4 (DOE-ID 2023d).

In the CFA nitrate plume monitoring wells south of CFA, one well—CFA-MON-A-002—continued to exceed the nitrate groundwater MCL of 10 mg/L-N. The nitrate concentration in Well CFA-MON-A-002 remained stable with a concentration of 14.5 mg/L-N in 2021 and 14.0 mg/L-N in 2022, but the concentration is still consistent with a declining trend starting in 2006. The nitrate concentration of 7.91 mg/L-N in Well CFA-MON-A-003 is below the MCL and shows a slight downtrend.

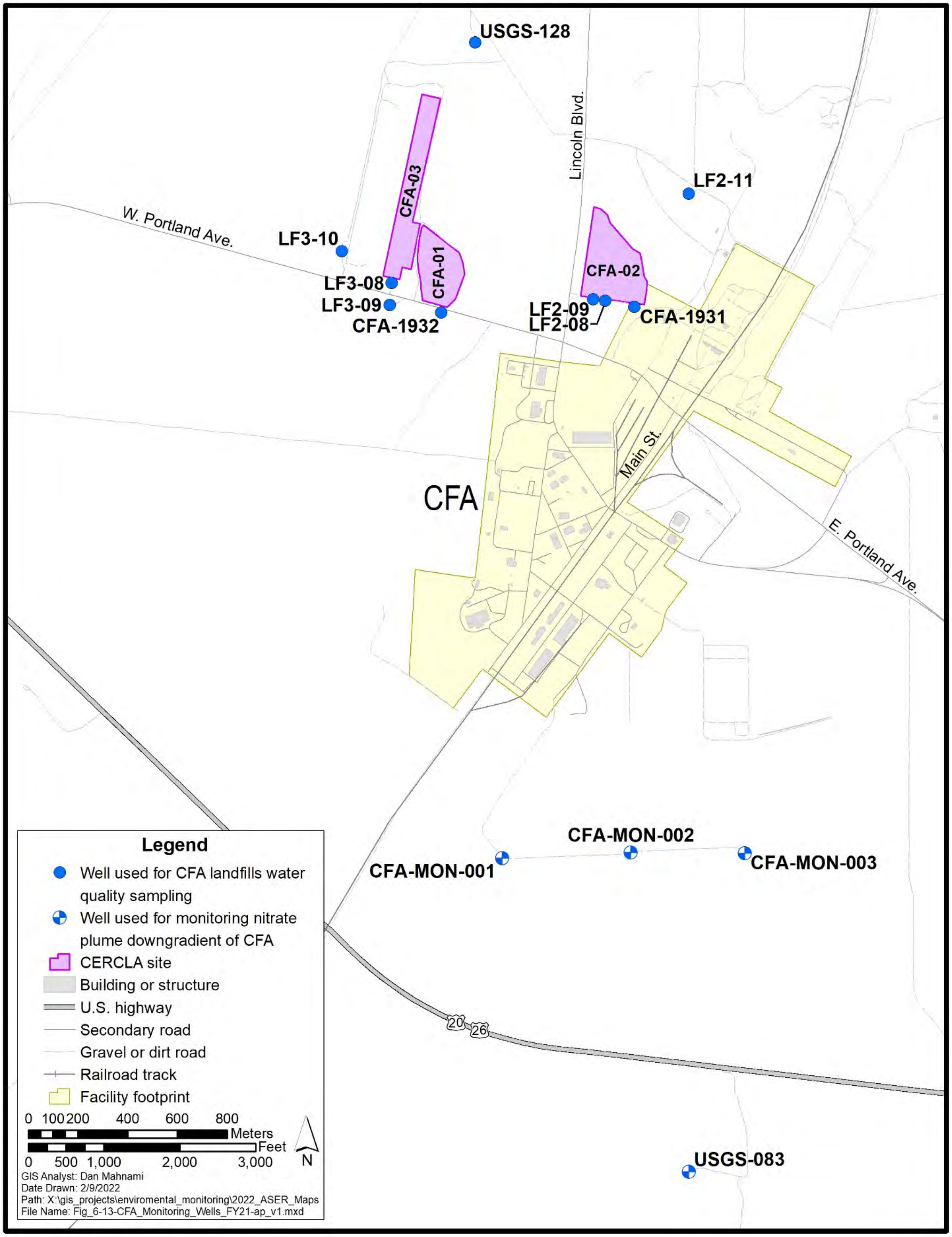

Figure 6-13. Locations of WAG 4/CFA monitoring wells.

Table 6-9. Comparison of CFA landfill groundwater sampling results to regulatory levels (August 2022).

COMPOUND	MCL OR SMCL	MAXIMUM DETECTED VALUE	NUMBER OF WELLS ABOVE MCL OR SMCL
CENTRAL FACILITIES AREA NITRATE PLUME WELLS			
Chloride (mg/L)	*250*[a]	72.9	0
Sulfate (mg/L)	*250*	33.2	0
Nitrate/nitrite (mg-N/L)	10	**14.0**[b]	0
CENTRAL FACILITIES AREA LANDFILL WELLS			
ANIONS			
Chloride (mg/L)	*250*	52.9	0
Sulfate (mg/L)	*250*	41.9	0
Nitrate/nitrite (mg-N/L)	10	2.32	0
COMMON CATIONS			
Calcium (µg/L)	None	51,700	NA[c]
Magnesium (µg/L)	None	22,900	NA
Potassium (µg/L)	None	6,480	NA
Sodium (µg/L)	None	28,200	NA
INORGANIC ANALYTES			
Antimony (µg/L)	6	ND[d]	0
Aluminum (µg/L)	*50–200*	ND	0
Arsenic (µg/L)	10	ND	0
Barium (µg/L)	2,000	92.4	0
Beryllium (µg/L)	4	ND	0
Cadmium (µg/L)	5	ND	0
Chromium (µg/L)	100	30.5	0
Copper (µg/L)	*1,300/1,000*	1.39	0
Iron (µg/L)	*300*	102	2
Lead (µg/L)	15	ND	0
Manganese (µg/L)	50	18.4	0
Mercury (µg/L)	2	ND	0
Nickel (µg/L)	None	93.5	NA
Selenium (µg/L)	50	2.12	0
Silver (µg/L)	100	ND	0
Thallium (µg/L)	2	ND	0

Table 6-9. continued.

COMPOUND	MCL[a] OR SMCL[b]	MAXIMUM DETECTED VALUE	NUMBER OF WELLS ABOVE MCL OR SMCL
Vanadium (µg/L)	None	6.50	NA
Zinc (µg/L)	*5,000*	20.4	0
DETECTED VOLATILE ORGANIC COMPOUNDS			
Chloroform (µg/L)	80	0.90	0

a. Numbers in *italic* text are for the secondary MCL.
b. **Bold** values exceed an MCL or SMCL.
c. NA = not applicable.
d. ND = not detected.

Water level measurements taken in the CFA area decreased an average of 1.29 ft from August 2021 to August 2022. A water level contour map based on August 2022 water levels showed groundwater gradients and flow directions consistent with previous maps (DOE-ID 2023d).

6.5.5 Summary of Waste Area Group 7 Groundwater Monitoring Results

Groundwater samples collected from 12 monitoring wells near and downgradient of RWMC in May 2022 were analyzed for radionuclides, inorganic constituents, and VOCs. Of the 92 aquifer analytical results (excluding field blanks), 22 met reportable criteria established in the *Field Sampling Plan for Operable Unit 7-13/14 Aquifer Monitoring* (DOE-ID 2021c). Table 6-10 summarizes the reportable contaminants of concern in 2022, and a discussion of those results follows. Figure 6-14 depicts the WAG 7 aquifer well monitoring network.

- *Carbon tetrachloride* – Carbon tetrachloride was reportable at seven monitoring locations in May 2022, one of which was detected above the MCL at Well M15S. The carbon tetrachloride concentrations increased slightly in most wells nearby, as shown in Figures 6-15 and 6-16.

Table 6-10. Summary of WAG 7 aquifer analyses for May 2022 sampling.

ANALYTE	NUMBER OF WELLS SAMPLED	NUMBER OF SAMPLES ANALYZED[a]	NUMBER OF REPORTABLE DETECTIONS[a,b]	CONCENTRATION MAXIMUM[a]	LOCATION OF MAXIMUM CONCENTRATION	NUMBER OF DETECTIONS GREATER THAN MCL[c]	MCL[c]
Carbon tetrachloride	12	14	8	6.00 µg/L	M15S	1	5 µg/L
Trichloro-ethylene	12	14	6	3.69 µg/L	M15S	0	5 µg/L
Nitrate (as nitrogen)	12	14	8	2.64 mg/L	M6S	0	10 mg/L

a. Includes field duplicate samples collected for quality control purposes and samples collected from wells with multiple ports.
b. Results that exceeded reporting criteria as established in the Operable Unit 7-13/14 Field Sampling Plan (DOE-ID 2021c).
c. MCLs are from “National Primary Drinking Water Regulations” (40 CFR 141).

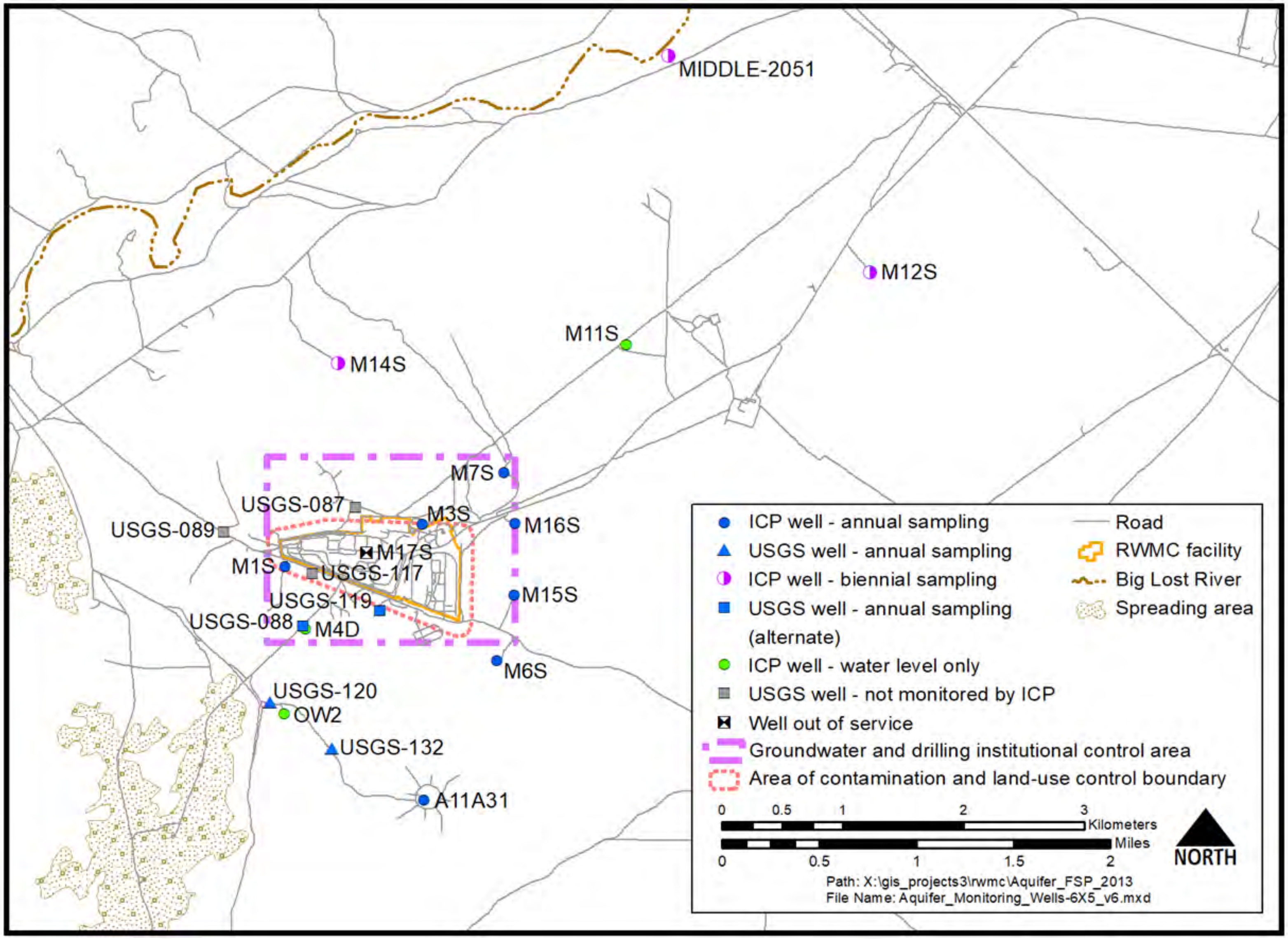

Figure 6-14. The WAG 7 aquifer well monitoring network at the RWMC (DOE-ID 2021c).

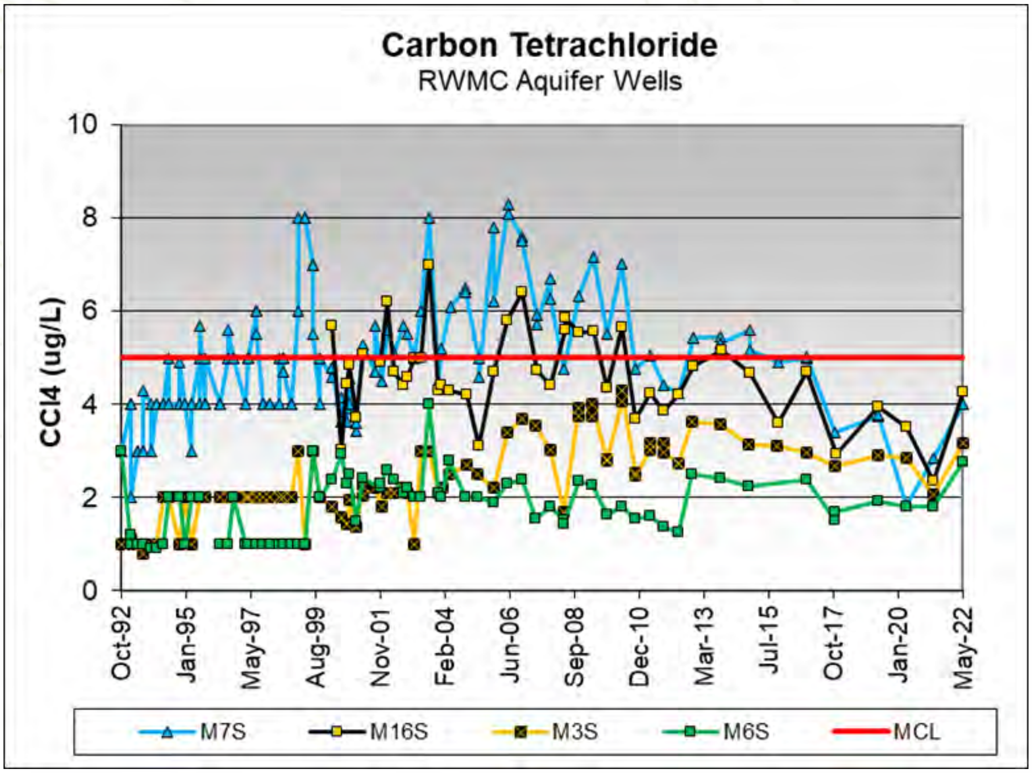

Figure 6-15. Carbon tetrachloride (CCl4) concentration trends in RWMC aquifer Wells M7S, M16S, M3S, and M6S.

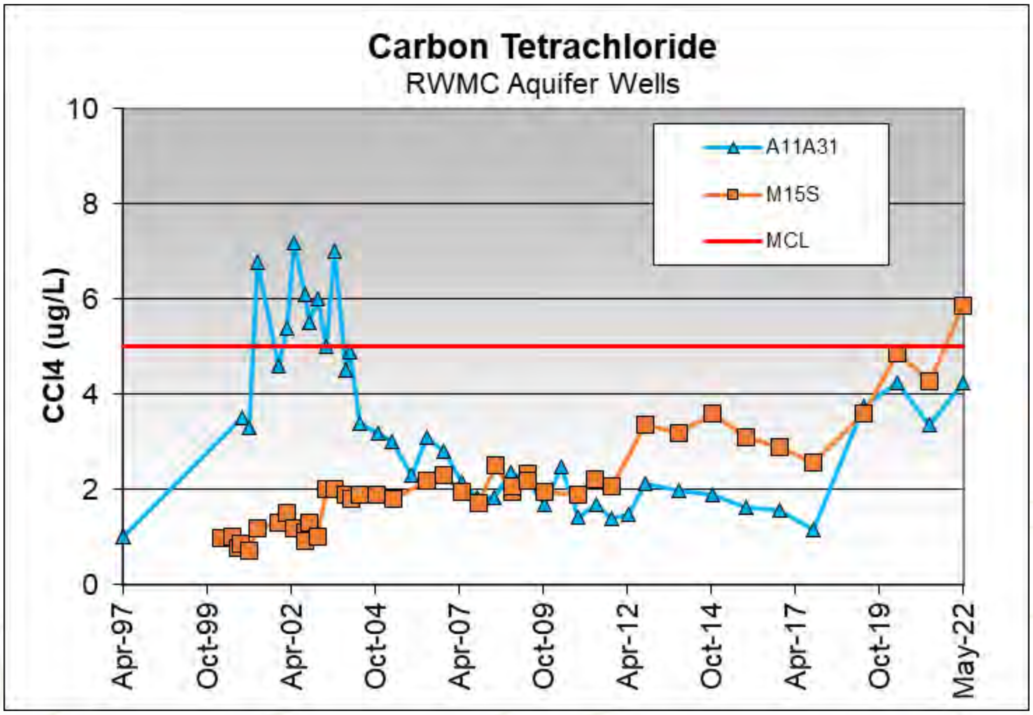

Figure 6-16. Carbon tetrachloride (CCl4) concentration trends in RWMC aquifer Wells A11A31 and M15S.

- *Trichloroethylene* – In May 2022, the concentrations of reportable TCE either increased or remained steady in wells near and downgradient of RWMC, as shown in Figure 6-17. No TCE concentrations were detected above the MCL of 5 µg/L.
- *Radiological analytes* – Radiological analytes were not detected above reporting thresholds in groundwater samples collected from the WAG 7 monitoring network in 2022.
- *Inorganic analytes* – Nitrate (as nitrogen) was the only inorganic analyte detected above its reporting threshold (background concentration of 1.05 mg/L) in 2022, which was calculated based on maximum concentrations in upgradient background wells (DOE-ID 2021c). All detections were below the MCL of 10 mg/L.

As in previous years, groundwater-level measurements in RWMC-area monitoring wells were taken prior to the sample collection for the May 2022 event. The groundwater-level contour map for the 2022 sampling indicates groundwater flow toward the south-southwest beneath the RWMC, as shown in Figure 6-18.

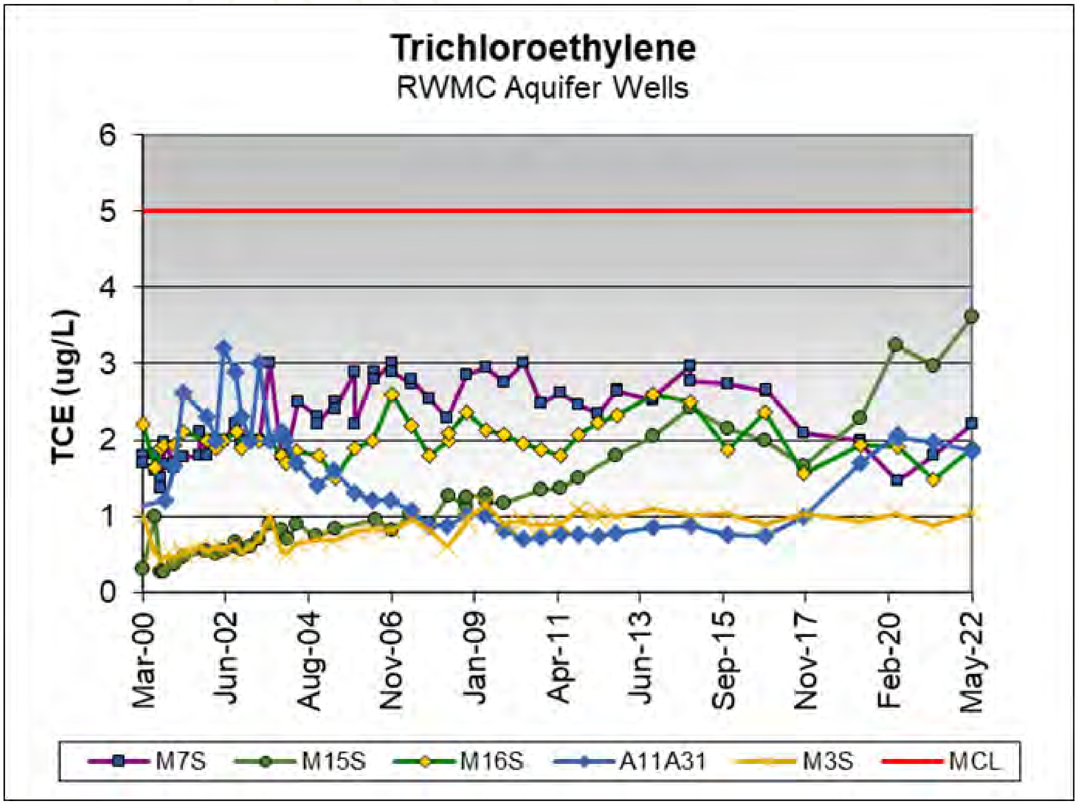

Figure 6-17. Concentration history of TCE in aquifer Wells M7S, M15S, M16S, A11A31, and M3S.

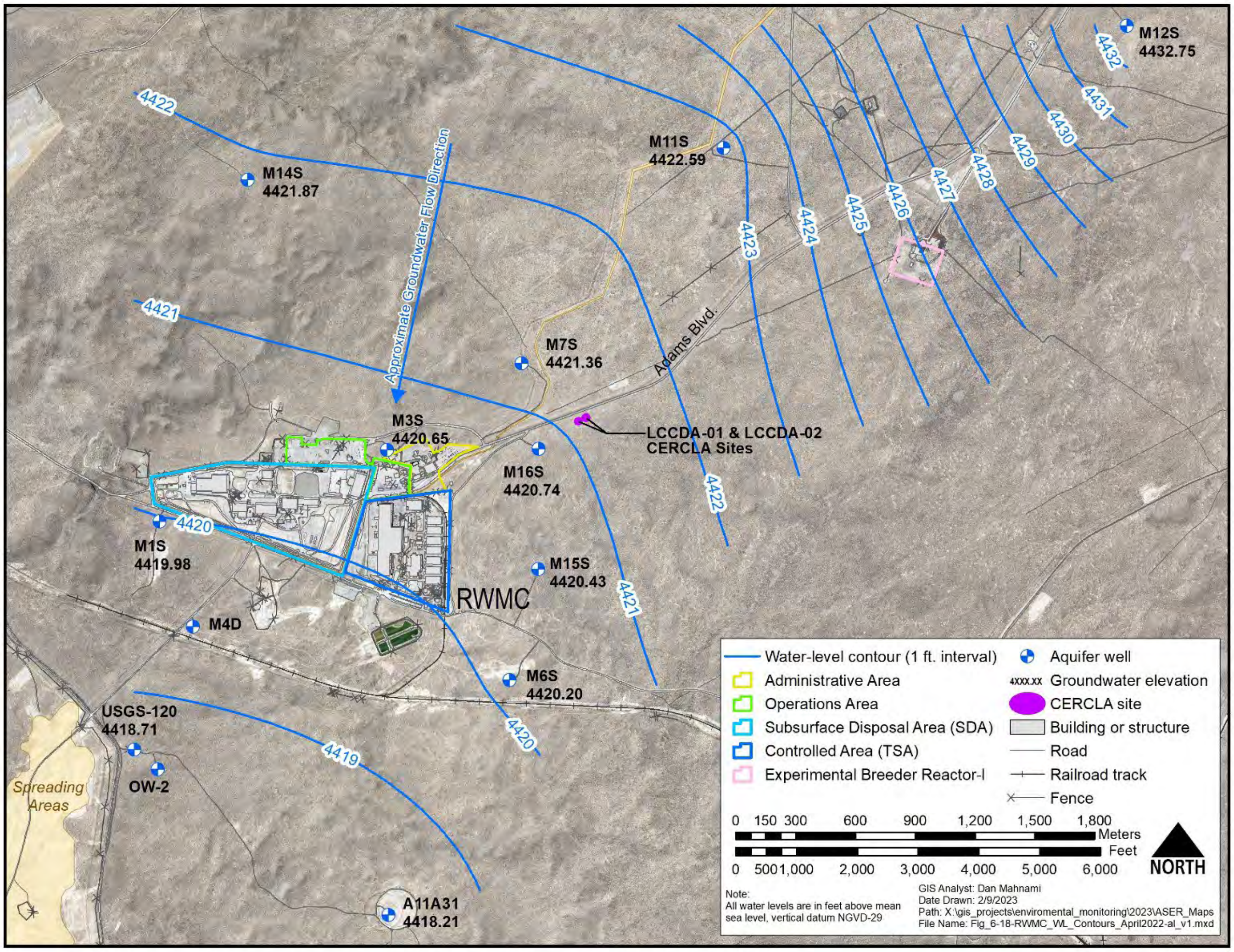

Figure 6-18. Groundwater-level contours in the aquifer near the RWMC based on 2022 measurements.

6.5.6 Summary of Waste Area Group 9 Groundwater Monitoring Results

Five wells (four monitoring and one production) at the MFC were sampled twice in 2022 by the INL contractor for selected radionuclides, metals, anions, cations, and other water quality parameters, as surveillance monitoring under the WAG 9 Record of Decision (Figure 6-19; ANL-W 1998). The 2022 results are summarized in Table 6-11. Overall, the data show no discernable impacts from activities at the MFC.

Groundwater monitoring performed to meet the CERCLA requirements of the WAG 9 Record of Decision began in 1998 and was discontinued at the end of 2022. The *Operable Unit 9-04 Operations and Maintenance Report for Fiscal Years 2008–2014* (DOE-ID 2015) indicates the groundwater monitoring data:

- Demonstrate that concentrations of organic, inorganic, and radionuclide constituents have never exceeded groundwater or drinking water standards at WAG 9
- Show the remedies have achieved their expected outcomes
- Show no discernible impact from previous or current activities at MFC.

Termination of CERCLA semiannual groundwater monitoring in 2022 was formalized in the *Five-Year Review of CERCLA Response Actions at the Idaho National Laboratory Site – Fiscal Years 2015 – 2019* (DOE-ID 2021e). While CERCLA-specific groundwater monitoring ended in 2022, groundwater monitoring for certain metals, inorganics, and radionuclides will continue at MFC monitoring Wells ANL-MON-A-012, ANL-MON-A-013, and ANL-MON-A-014 to meet the MFC reuse permit and DOE environmental surveillance monitoring requirements.

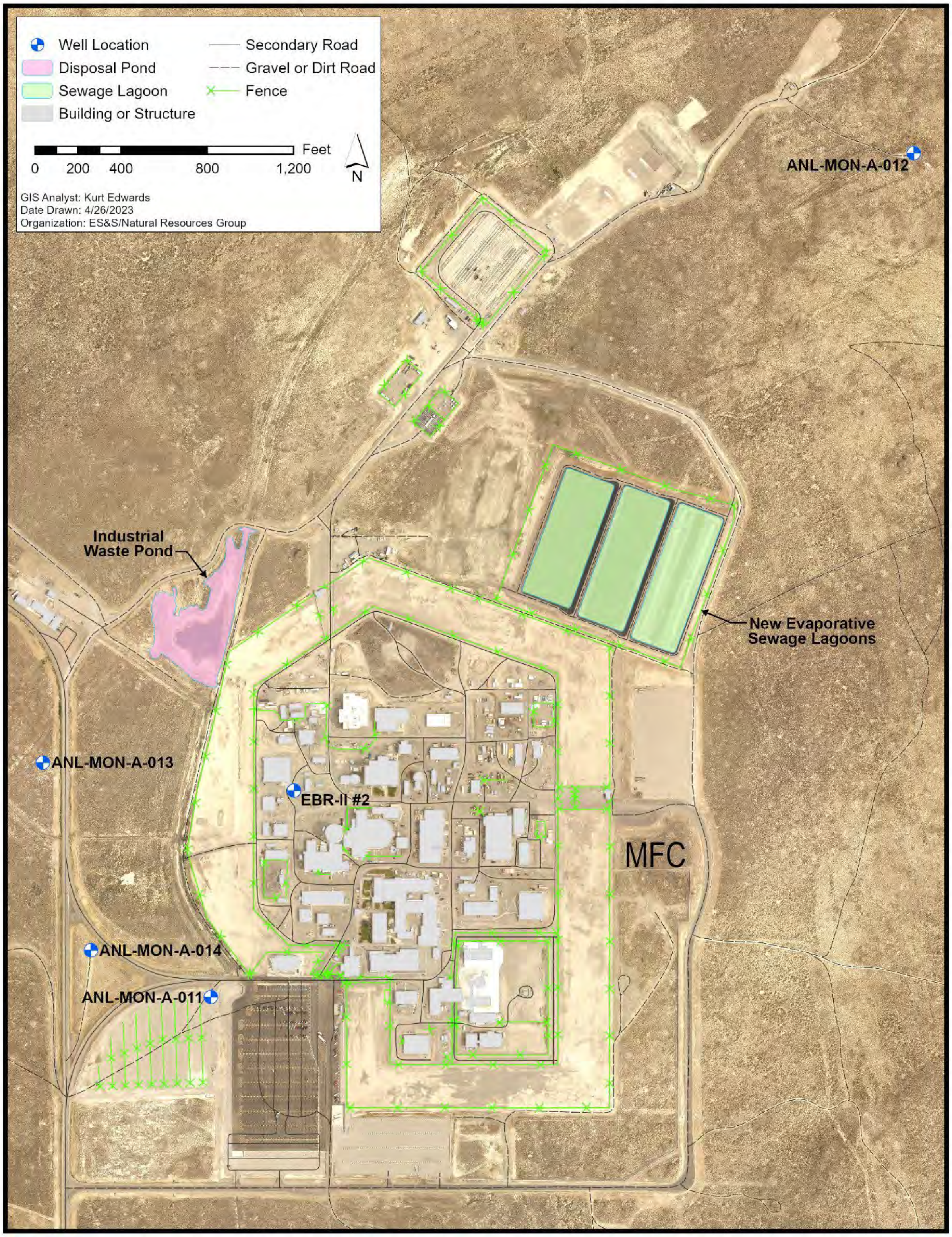

Figure 6-19. Locations of WAG 9 wells sampled in 2022.

Table 6-11. Comparisons of detected analytes to groundwater standards at WAG 9 monitoring wells (2022).

WELL:	ANL-MON-A-011		ANL-MON-A-012		ANL-MON-A-013		ANL-MON-A-014		EBR-II[a] NO. 2		PCS/SCS[b]
SAMPLE DATE:	5/3/2022	9/20/2022	4/28/2022	9/19/2022	4/28/2022	9/19/2022	5/03/2022	9/19/2022	5/04/2022	9/20/2022	
RADIONUCLIDES[c]											
Gross alpha (pCi/L)	ND[d]	ND	2.07 ± 0.492 (2.07 ± 0.545)[e]	ND	ND	ND	3.64 ± 0.687	1.70 ± 0.337	ND	1.04 ± 0.329	15 pCi/L
Gross beta (pCi/L)	4.11 ± 0.516	3.51 ± 0.259	2.33 ± 0.498 (2.50 ± 0.351)	4.03 ± 0.265	3.86 ± 0.597	2.43 ± 0.237	3.29 ± 0.426	2.74 ± 0.286	2.12 ± 0.419	2.89 ± 0.286	4 mrem/yr[f]
Cesium-137 (pCi/L)	ND	ND	1.87 ± 0.471 (ND)	ND	ND	ND	ND	ND	ND	ND	NA[g]
Uranium-233/234 (pCi/L)	1.24 ± 0.202	1.05 ± 0.150	1.39 ± 0.219 (1.13 ± 0.174)	1.28 ± 0.222	1.22 ± 0.184	1.25 ± 0.181	1.25 ± 0.199	1.28 ± 0.201	1.39 ± 0.222	1.60 ± 0.226	186,000 pCi/L (30 µg/L)
Uranium-238 (pCi/L)	0.886 ± 0.161	0.623 ± 0.110	0.537 ± 0.126 (0.692 ± 0.129)	0.488 ± 0.128	0.788 ± 0.138	0.511 ± 0.108	0.487 ± 0.115	0.587 ± 0.128	0.690 ± 0.146	0.581 ± 0.124	9.9 pCi/L (30 µg/L)
Uranium-235 (pCi/L)	ND	ND	ND (ND)	ND	ND	ND	ND	ND	ND	ND	NA
METALS[h]											
Arsenic (mg/L)	0.00227	0.00202	0.00201 (0.002U)	0.00208	0.00245	0.00202	0.00228	0.002U[d]	0.00213	0.00207	0.05
Barium (mg/L)	0.0383	0.0373	0.0370 (0.0370)	0.0391	0.0367	0.0363	0.0390	0.0364	0.0383	0.0372	2
Calcium (mg/L)	38.6	37.2	37.3 (38.0)	35.4	36.5	34.0	39.5	34.7	42.0	38.2	NA
Chromium (mg/L)	0.003U	0.003U	0.003U (0.003U)	0.003U	0.00373	0.00325	0.00408	0.003U	0.003U	0.003U	0.1
Copper (mg/L)	0.000335	0.000638	0.000314 (0.000300)	0.000335	0.000646	0.000613	0.000432	0.000467	0.0125	0.00371	1.3
Iron (mg/L)	0.0826	0.283J[d]	0.03U (0.03U)	0.03U	0.03U	0.0364	0.03U	0.03U	0.03U	0.03UJ[d]	0.3

Table 6-11. continued.

WELL:	ANL-MON-A-011		ANL-MON-A-012		ANL-MON-A-013		ANL-MON-A-014		EBR-II[a] NO. 2		PCS/SCS[b]
SAMPLE DATE:	5/3/2022	9/20/2022	4/28/2022	9/19/2022	4/28/2022	9/19/2022	5/03/2022	9/19/2022	5/04/2022	9/20/2022	
Lead (mg/L)	0.0005U	0.0005U	0.0005U (0.0005U)	0.0005U	0.0005U	0.0005U	0.0005U	0.0005U	0.00299U	0.00103	0.015
Magnesium (mg/L)	12.4	12.5	11.6 (11.8)	11.5	12.2	11.7	12.9	11.5	13.2	12.6	NA
Manganese (mg/L)	0.001U	0.001U	0.001U (0.001U)	0.001U	0.001U	0.00202	0.001U	0.001U	0.001U	0.001U	0.05
Nickel (mg/L)	0.000664	0.000617	0.0006U (0.0006U)	0.0006U	0.000685	0.00104	0.0006U	0.0006U	0.00743	0.00445	NA
Potassium (mg/L)	3.48	3.30	3.49 (3.46)	3.42	3.42	3.24	3.41	3.30	3.58	3.36	NA
Sodium (mg/L)	18.4	17.8	16.8 (17.1)	17.3	19.7	18.1	19.3	17.3	19.1	18.2	NA
Vanadium (mg/L)	0.00529	0.00486	0.00572 (0.00557)	0.00492	0.00930	0.00639	0.00516	0.00503	0.00531	0.00494	NA
Zinc (mg/L)	0.0033U	0.0033U	0.0033U (0.0033U)	0.0033U	0.0033U	0.0033U	0.0033U	0.0033U	0.0389	0.0210	5
ANIONS											
Chloride (mg/L)	17.3J	16.9J	15.8J (15.6J)	15.8J	18.8	16.9J	17.1J	15.9J	17.5	16.5J	250
Nitrate-as nitrogen (mg/L)	2.37J	2.44	2.40J (2.37J)	2.39J	2.44J	2.39J	2.36	2.45J	2.59	2.44	10
Phosphorus (mg/L)	0.0375U	0.0146U	0.0877J (0.0696J)	0.099	0.0934J	0.106	0.0354U	0.0678	0.0508UJ	0.0213J	NA
Sulfate (mg/L)	18.1	19.0	18.2J (18.3J)	17.7	21.7J	19.6	18.8	19.3	19.6	18.2	250

Table 6-11. continued.

WELL:	ANL-MON-A-011		ANL-MON-A-012		ANL-MON-A-013		ANL-MON-A-014		EBR-II[a] NO. 2		PCS/SCS[b]
SAMPLE DATE:	5/3/2022	9/20/2022	4/28/2022	9/19/2022	4/28/2022	9/19/2022	5/03/2022	9/19/2022	5/04/2022	9/20/2022	
WATER QUALITY PARAMETERS											
Alkalinity (mg/L)	134	136	136 (91.8)	147	152	145	135	139	133	136	NA
Bicarbonate alkalinity (mg/L)	134	135	136 (91.8)	147	152	145	135	139	133	135	NA
Total dissolved solids (mg/L)	206	227	227 (226)	212	244	221	223	224	249	216	500

a. EBR-II = Experimental Breeder Reactor II. Also known as ANL 2.

b. PCS = primary constituent standard; SCS = secondary constituent standard, as specified in the Idaho Ground Water Quality Rule, IDAPA 58.01.11.

c. Result ± 1σ uncertainty. Only analytes with at least one statistically positive result greater than 3σ uncertainty are shown. Samples were analyzed for gross alpha; gross beta; tritium; gamma-emitting radionuclides including americium-241, antimony-125, cerium-144, cesium-134, cesium-137, cobalt-58, cobalt-60, europium-152, europium-154, europium-155, manganese-54, niobium-95, potassium-40, radium-226, ruthenium-103, ruthenium-106, silver-108m, silver-110m, uranium-235, zinc-65, and zirconium-95; and alpha-emitting radionuclides including americium-241, uranium-233/234, uranium-235, and uranium-238.

d. ND = not detected; J = associated value is an estimate and may be inaccurate or imprecise; U = the analyte was not detected above the instrument detection limit or the analyte was detected at or above the applicable detection limit, but the value is not more than five times the highest positive amount in any laboratory blank; UJ = the sample was analyzed for but was not detected. The associated value is an estimate and may be inaccurate or imprecise.

e. Results for field duplicate samples shown in parentheses.

f. The Ground Water Quality Rule, IDAPA 58.01.11, specifies a PCS for combined beta/photon emitters of 4 millirems/yr effective dose equivalent. Speciation of the individual radionuclides present would be necessary to determine the equivalent PCS in units of pCi/L. For comparison purposes, the EPA also specifies a MCL of 4 mrem/yr for public drinking water systems and uses a screening level of 50 pCi/L. Public drinking water samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

g. NA = not applicable. A primary or secondary constituent standard has not been established for this constituent in the Idaho Ground Water Quality Rule, IDAPA 58.01.11.

h. Metals reported as non-filtered unless noted.

6.5.7 Summary of Waste Area Group 10 Groundwater Monitoring Results

In accordance with the Operable Unit 10-08 monitoring plan (DOE-ID 2021d), groundwater samples are collected every two years. In 2022, groundwater samples were not collected for WAG 10. WAG 10 monitoring wells will be sampled in 2023.

6.6 Remote-Handled Low-Level Waste Disposal Facility

The INL contractor monitors groundwater at the RHLLW Disposal Facility to demonstrate compliance with DOE O 435.1, "Radioactive Waste Management," and IDAPA 58.01.11, "Ground Water Quality Rule." Samples were collected from three monitoring wells in 2022 and analyzed for gross alpha, gross beta, carbon-14 (^{14}C), ^{129}I, ^{99}Tc, and tritium in accordance with PLN-5501, "Monitoring Plan for the INL RHLLW Disposal Facility," as shown in Figure 6-20. Results for analytes with positive detections are summarized in Table 6-12. Tritium and gross beta were detected in all three wells, while gross alpha was positively detected in two of the three wells. Carbon-14, ^{129}I, and ^{99}Tc were not detected in any samples. All results are consistent with concentrations in the aquifer established prior to facility completion (INL 2017). The 2022 results show no discernable impacts to the aquifer from RHLLW Disposal Facility operations.

Table 6-12. Radioactivity detected in surveillance groundwater samples collected at the RHLLW Facility (2022).

WELL:	USGS-136		USGS-140		USGS-141		PCS/SCS[a]
SAMPLE DATE:	4/18/2022	9/16/2022	4/19/2022	9/21/2022	4/19/2022	9/21/2022	
RADIONUCLIDES[b]							
Gross alpha (pCi/L)	ND[c]	1.62 ± 0.535	ND	ND	ND (1.04 ± 0.295)[d]	ND	15 pCi/L
Gross beta (pCi/L)	1.92 ± 0.184	3.45 ± 0.556	3.80 ± 0.277	4.02 ± 0.552	1.59 ± 0.270 (2.96 ± 0.264)	2.54 ± 0.489	4 mrem/yr[e]
Tritium (pCi/L)	1,110 ± 171	535 ± 145	992 ± 161	842 ± 182	877 ± 154 (773 ± 145)	874 ± 186	20,000 pCi/L

a. PCS = primary constituent standard, SCS = secondary constituent standard, as specified in the Idaho Ground Water Quality Rule, IDAPA 58.01.11.

b. Result ± 1σ. Only analytes with at least one statistically positive result greater than 3σ uncertainty are shown. Samples were analyzed for gross alpha, gross beta, carbon-14, iodine-129, technecium-99, and tritium.

c. ND = not detected.

d. Duplicate sample results are shown in parentheses.

e. The Ground Water Quality Rule, IDAPA 58.01.11, specifies a PCS for combined beta/photon emitters of 4 millirems/yr effective dose equivalent. Speciation of the individual radionuclides present would be necessary to determine the equivalent PCS in units of pCi/L. For comparison purposes only, the EPA also specifies MCL of 4 mrem/yr for public drinking water systems and uses a screening level of 50 pCi/L. Public drinking water samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

In addition to compliance monitoring of groundwater at the RHLLW Disposal Facility, facility performance is monitored by collecting and analyzing soil-pore water samples, where sufficient water is present, from vadose-zone lysimeters installed in native materials adjacent to and below the base of the vault arrays. Development of the baseline for the soil-pore water samples was intended to include the 2019–2021 samples; however, due to the persistent lack of soil-pore water volume available for sampling at some locations in 2019–2021, the 2022 data will also be included in the development of the baseline. Additional baseline data collection may continue in 2023 and beyond to address data gaps at locations where insufficient soil-pore water for sampling persists. Future soil-pore water sample results will be compared to the baseline measurements, where established, and used as early indicators of facility operations and key assumptions. For establishment of the baseline, soil-pore water samples are analyzed for the same target and indicator analytes as the aquifer compliance samples (e.g., gross alpha, gross beta, tritium, ^{14}C, ^{129}I, and ^{99}Tc).

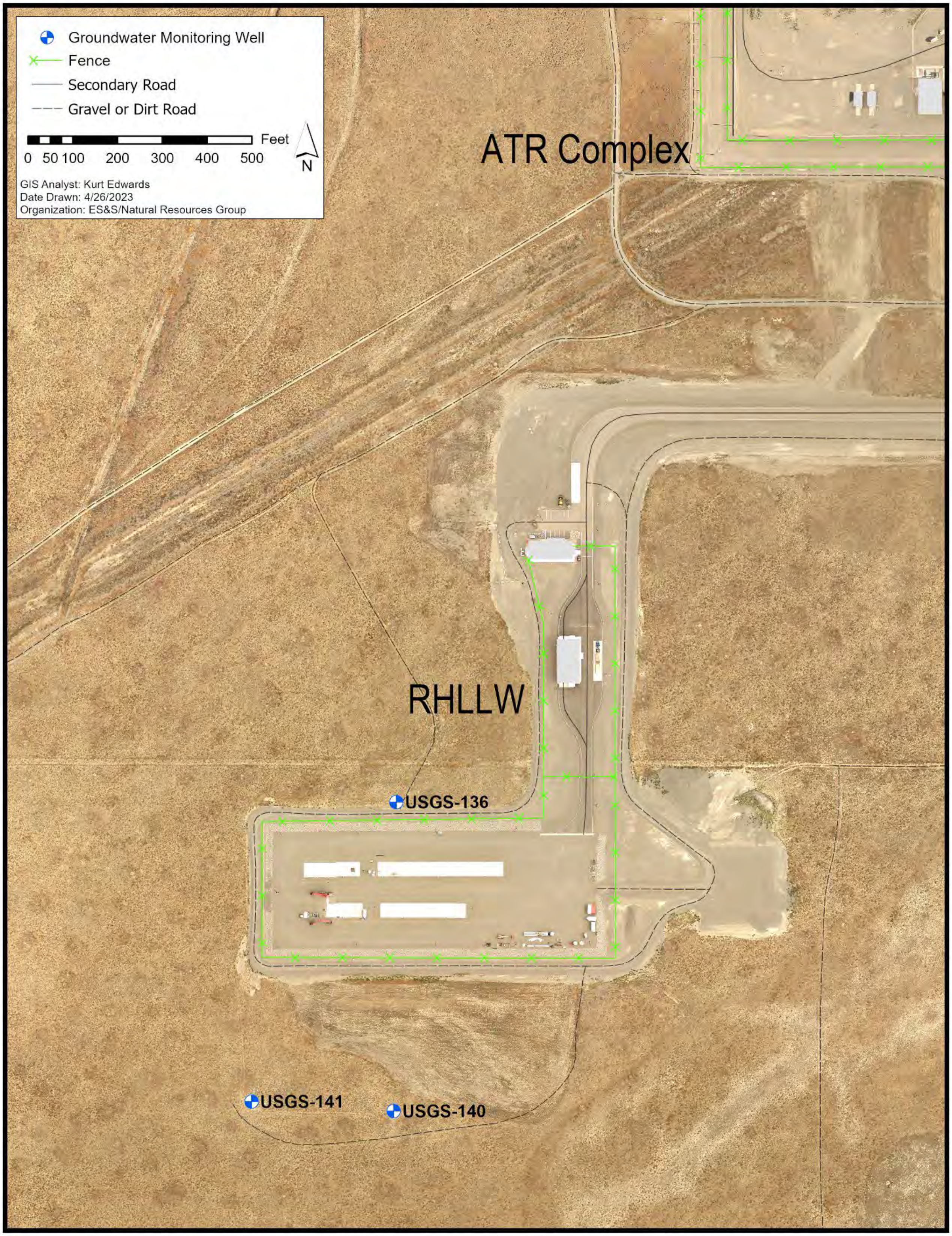

Figure 6-20. Well locations sampled for RHLLW Facility.

6.7 Onsite Drinking Water Sampling

The INL and ICP contractors monitor drinking water to ensure that it is safe for consumption and to demonstrate that it meets federal and state regulations. Drinking water parameters are regulated by the state of Idaho under authority of the Safe Drinking Water Act (40 CFR 141, 142). Parameters are sampled according to a 9-year monitoring cycle, which identifies the frequency and the specific classes of contaminates to monitor at each drinking water source (https://www2.deq.idaho.gov/water/monitoringschedulereport). Parameters with primary MCLs must be monitored at least once every three years. Parameters with SMCLs are monitored every three years based on a recommendation by the EPA (40 CFR 143). Many parameters require more frequent sampling during an initial period to establish a baseline, and subsequent monitoring frequency is determined from the baseline results.

The INL Site has 11 drinking water systems that are monitored by the INL and ICP contractors. The INL contractor monitors eight of these drinking water systems, and the ICP contractor monitors three. The Naval Reactors Facility also monitors a drinking water system. The results are not included in this annual report but are addressed in the *Naval Reactors Facility Environmental Monitoring Report for Calendar Year 2022* (FMP 2022). According to the "Idaho Rules for Public Drinking Water Systems" (IDAPA 58.01.08), INL Site drinking water systems are classified as either non-transient or transient, non-community water systems. The four INL contractor transient, non-community water systems are located at the CITRC, EBR-I, Gun Range, and Main Gate. The four remaining INL contractor water systems are classified as non-transient, non-community water systems and are located at ATR Complex, CFA, MFC, and TAN/CTF. Two of the ICP contractor systems, INTEC and RWMC, are classified as non-transient, non-community and the NRF Deactivation and Decommissioning (D&D) Facility is classified as transient, non-community.

As required by the state of Idaho, INL and the ICP drinking water programs use EPA-approved (or equivalent) analytical methods to analyze drinking water in compliance with current editions of IDAPA 58.01.08 and 40 CFR Parts 141–143. State regulations also require that analytical laboratories be certified by the state or by another state whose certification is recognized by Idaho. Idaho DEQ oversees the certification program and maintains a list of approved laboratories.

The INL and ICP contractors monitor certain parameters more frequently than required by regulation because of low volume usage on weekends. For example, bacterial analyses are conducted monthly rather than quarterly at all eight INL contractor drinking water systems and at the three ICP contractor drinking water systems during months of operation. Because of known groundwater plumes near one ICP contractor drinking water well, additional sampling is conducted for carbon tetrachloride at RWMC.

6.7.1 Idaho National Laboratory Site Drinking Water Monitoring Results

During 2022, the INL contractor collected 66 routine/compliance samples and 10 quality control samples in the form of blanks from the eight INL-operated drinking water systems. Semiannual sampling was conducted at all eight water systems for gross alpha, beta, and tritium. CFA was also sampled for ^{129}I due to its location downgradient of the plume around INTEC. Table 6-13 lists results of routine/compliance and radiological surveillance monitoring. In addition to routine samples, the INL contractor collected 211 surveillance bacteriological, lead and copper, and perfluoroalkyl substances (PFAS) samples.

The ICP contractor collected 15 routine/compliance samples and five quality control samples from the ICP drinking water systems. ICP also collected 87 surveillance bacteriological, synthetic organic compounds, and VOCs samples. Two gross alpha/beta samples were collected semiannually from both ICP drinking water systems (INTEC and RWMC). One tritium sample was also collected from each drinking water system, as shown in Table 6-13.

All INL Site water systems were sampled for nitrates and all values were less than the MCL of 10 mg/L. The highest nitrate values were 2.77 mg/L at CFA and 2.19 mg/L at MFC. Samples for total trihalomethanes and haloacetic acids were collected at ATR Complex, CFA, INTEC, MFC, RWMC, and TAN/CTF, as seen in Table 6-1.3

All INL Site drinking water systems were well below regulatory limits for drinking water or there were no detections. Since all the water systems are public water systems (PWS); their data are listed on the Idaho DEQ's PWS Switchboard (www.deq.idaho.gov).

The EPA is actively researching and beginning to establish regulations for a class of very widely used and dispersed man-made-chemicals called PFAS, which are considered to be an emerging contaminant of concern and have been used in

Table 6-13. Summary of INL Site drinking water results (2022).

CONSTITUENT	MCL (units)	ATR COMPLEX 6120020	CFA 6120008	CITRC 6120019	EBR-I 6120009	GUN RANGE 6120025	INTEC PWS 6120012	MAIN GATE 6120015	MFC 6060036	NRF D&D 6120031	RWMC PWS 6120018	TAN CTF 6120013
RADIOLOGICAL SURVEILLANCE MONITORING												
Gross Alpha[a] (pCi/L)	15	ND[b]	ND	ND	ND	ND	ND	ND	ND	NA[b]	ND-2.99	ND
Gross Beta[a] (pCi/L)	50 screening or 4 mrem	ND-3.43	4.19-5.54	2.81-4.59	ND-2.88	ND	ND	ND-3.87	ND-4.34	NA	ND-3.01	ND-2.74
Tritium[a] (pCi/L)	20,000	ND	1,770-2,260	ND	ND	ND	ND	ND	ND	NA	ND	ND
Iodine-129[c] (pCi/L)	1	—[d]	ND	—	—	—	NA	—	—	NA	NA	—
Radium-226 (pCi/L) Radium-228 (pCi/L)	5 combined	0.08 0.06	0.14/ND[a] 1.63/ND[a]	— —	— —	— —	NA NA	— —	0.05 2.29	NA NA	NA NA	ND ND
Uranium (µg/L)	30	1.26	2.37/2.38[a]	—	—	—	NA	—	1.67	NA	NA	2.26
COMPLIANCE MONITORING												
Nitrate (mg/L)	10	ND	2.75/2.77[a]	ND	ND	ND	ND	ND	2.18/2.19[a]	NA	ND	ND
Total trihalomethanes (ppb)	80	ND	5.39	NA[c]	NA	NA	ND	NA	5.13	NA	10.6	3.68
Total coliform	2 or more present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
E. coli	Present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Haloacetic acids (ppb)	60	ND	ND	NA	NA	NA	ND	NA	ND	NA	ND	ND
SOCs/VOCs[e] (ppb)	SOCs varies, 5 for most VOCs	NA	NA	NA	NA	NA	ND	NA	NA	NA	ND	NA

a. Range of results (minimum – maximum) presented.
b. ND = not detected.
c. NA = not applicable based on water system classification.
d. — = not analyzed.
e. SOCs = synthetic organic compounds and VOCs = volatile organic compounds.

industry and consumer products worldwide since the 1950s in non-stick cookware, water-repellent clothing, stain resistant fabrics and carpets, some cosmetics, some firefighting foams, and products that resist grease, water, and oil. Many of the common PFAS have been phased out of production. These chemicals do not degrade in the environment. During production and use, PFAS can migrate into the soil, water, and air. Because of their widespread use and their persistence in the environment, PFAS are found in the blood of people and animals all over the world and are present at low levels in a variety of food products and the environment. Some PFAS can build up in people and animals with repeated exposure over time. Research involving humans suggests that high levels of certain PFAS may lead to numerous health impacts. A common pathway for humans to be potentially impacted by PFAS is through drinking contaminated water.

In 2022, INL sampled three wells and one manifold associated with two drinking water systems as a follow-up to a 2021 voluntary state of Idaho initiative to explore the potential for the existence of PFAS in Idaho's drinking water sources. ICP did not sample for PFAS in 2022. In 2021, ICP collected PFAS samples from two drinking water wells at INTEC and one well at RWMC. No PFAS constituents were identified at detectable concentrations in these wells.

INL and ICP will continue to monitor PFAS based on the DOE PFAS Strategic Roadmap: DOE Commitments to Action 2022–2025 (DOE 2022), the pending INL PFAS Implementation Plan, and the ICP PFAS Implementation Plan (SPR-190). CFA was the only sample location with any detections of perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), which are the two primary constituents of concern. These results have not exceeded any regulatory limits, as there are no drinking water MCLs as of 2022.

6.7.1.1 Advanced Test Reactor Complex, PWS 6120020

There are over 500 employees assigned to the ATR Complex. The water system has a continuous chlorination system to disinfect the water on a voluntary basis as an added protection. A new potable well was completed for the ATR Complex in September 2019. This gives the ATR Complex two drinking water wells. Since both are approximately 600 feet deep and less than 100 feet apart, they are designated as a wellfield. Compliance samples are collected from the wellfield at TRA-696 for most constituents. Other compliance samples are collected from the distribution system as required by the regulations. In 2022, all compliance samples were below the MCL, which includes the monthly bacteriological (i.e., total coliform and E. coli) samples. These wells can pump over 200 gpm. Water is also supplied to the RHLLW Disposal Facility, which is outside the fence of the ATR Complex.

6.7.1.2 Central Facilities Area, PWS 6120008

The CFA water system has two wells that serves over 500 people daily. The two wells are 639 and 681 feet deep, and they pump over 600 gpm. The water system is continuously disinfected on a voluntary basis as an added protection. Compliance samples are collected from the manifold at CFA-1603 for most constituents. Other compliance samples are collected from the distribution system as required by the regulations. In 2022, all constituents sampled were below the MCL, which includes the monthly bacteriological samples (i.e., total coliform and E. coli).

6.7.1.3 Critical Infrastructure Test Range Complex Facility, PWS 6120019

At present, there are no permanent employees at CITRC. The water system has a continuous chlorination system to disinfect the water. CITRC #1 well is located at PBF-602, is 653 feet deep and can pump 400 gpm. CITRC #2 well is located at PBF-614. The well is 1,217 feet deep and can pump 800 gpm. Compliance samples are collected from the manifold, located at PBF-638. In 2022, all compliance samples were below the MCL, which includes the monthly bacteriological samples (i.e., total coliform and E. coli).

6.7.1.4 Experimental Breeder Reactor-I, PWS 6120009

EBR-I has a public water system that is open to the public from Memorial Day to Labor Day with scheduled tours throughout the year. There are no personnel stationed at this facility. The well is 1,075 feet deep. EBR-I is one of four water systems at INL that does not automatically disinfect. The water system and well were constructed in 1949. In 2022, all compliance samples, including the monthly bacteriological samples (i.e., total coliform and E. coli), were below the MCL.

6.7.1.5 Gun Range Facility, PWS 6120025

There is one employee permanently stationed at the Gun Range Facility. In 2010 continuous chlorination was discontinued due to an ongoing history of no bacteria (i.e., total coliform and E. coli). The well is located at B21-607 and was completed in January 1990. The well is 626 feet deep. The well pumps 20 gpm. Compliance samples are collected from the B21-607 well for most constituents. Bacteriological (i.e., total coliform and E. coli) compliance samples are collected from the distribution system as required by the regulations. In 2022, all sampled constituents were below the MCL, which includes the monthly bacteriological samples.

6.7.1.6 Idaho Nuclear Technology and Engineering Center, PWS 6120018

Drinking water for the INTEC is supplied by two wells, CPP-04 and ICPP-POT-A-012, located north of the facility. A disinfectant residual (e.g., chlorine) is maintained throughout the distribution system. In 2022, drinking water samples were collected from the point of entry to the distribution system (CPP-614) and from various buildings throughout the distribution system.

Five compliance samples were collected from various buildings throughout the distribution system at INTEC and were analyzed for contaminants identified by the state of Idaho per the monitoring frequency. Sample results for these compliance samples are summarized in Table 6-13. All detected contaminants were below the MCL concentrations.

6.7.1.7 Main Gate Badging Facility, PWS 6120015

There are three employees permanently stationed at the Main Gate Badging Facility. The well is located at B27-605 and was completed in January 1985. The well is 644 feet deep. The well pumps 20 gpm. Compliance samples are collected from the B27-605 well for most constituents. Bacteriological (i.e., total coliform and E. coli) compliance samples are collected from the distribution system as required by the regulations. In 2022, all constituents sampled were below the MCL, which includes the monthly bacteriological samples.

6.7.1.8 Materials and Fuels Complex, PWS 6060036

There are 1,200 employees located at MFC. The water system has a continuous chlorination system to disinfect the water on a voluntary basis as an added protection. Well #1 is located at MFC-754 and Well #2 at MFC-756. Well #1 was completed in 1958 and is 747 feet deep. Well #2 was completed in 1959 and is 755 feet deep. Most compliance samples are collected from both wells. Other compliance samples, such as lead/copper, total trihalomethanes/haloacetic acids, and bacteria (i.e., total coliform and E. coli), are collected from the distribution system as required by the regulations. In 2022, all sampled constituents were below the MCL, which includes the two monthly bacteriological samples.

6.7.1.9 Naval Reactors Facility Deactivation and Decommissioning Facility, PWS 6120031

The NRF D&D Facility is made up of two comfort stations and two shower trailers that serve approximately 50 people. These trailers each have their own individual storage tanks. The source water is transported from Idaho Falls public water system and dispersed to each individual storage tank.

Four compliance samples (total coliform and E. coli) were collected from each location and analyzed for contaminants identified by the state of Idaho per the monitoring frequency. Sample results for these compliance samples are summarized in Table 6-13. All detected contaminants were below the MCL concentrations.

6.7.1.10 Radioactive Waste Management Complex, PWS 6120012

The RWMC production well is located in Building WMF-603 and is the source of drinking water for RWMC. A disinfectant residual (e.g., chlorine) is maintained throughout the distribution system. Historically, carbon tetrachloride, total xylenes, and other VOCs had been detected in samples collected at the WMF-603 production well and at the point of entry to the distribution system (WMF-603). In July 2007, a packed tower air stripping treatment system was placed into operation to remove the VOCs from the groundwater prior to human consumption.

In 2022, drinking water samples were collected from the point of entry to the distribution system (WMF-603) and from various buildings throughout the distribution system.

Six compliance samples were collected from various buildings throughout the distribution system at RWMC and analyzed for the contaminants identified by the state of Idaho per the monitoring schedule. Sample results for these compliance samples are summarized in Table 6-13. All detected contaminants were below the MCL concentrations.

6.7.1.11 Test Area North/Contained Test Facility, PWS 6060021

There are more than 300 employees located at TAN/CTF. The water system has a continuous chlorination system to disinfect the water on a voluntary basis for added protection. TAN/CTF #1 Well is located at TAN-632 and was constructed in November 1957. The well is 339 feet deep. The well can pump 1,000 gpm. TAN/CTF #2 Well is located at TAN-639 and was completed in April 1958. The well is 462 feet deep and can pump 1,000 gpm. Compliance samples are collected from the manifold at TAN-1612 for most constituents. Other compliance samples are collected from the distribution system as required by the regulations. In 2022, all sampled constituents, including the monthly bacteriological (i.e., total coliform and E. coli) samples, were below the MCL.

6.8 Offsite Drinking Water Sampling

As part of the offsite monitoring program, drinking water samples were collected off the INL Site for radiological analyses in 2022. Two locations, Shoshone and Minidoka, which are downgradient of the INL Site, were co-sampled with the state of Idaho DEQ-INL Oversight Program (DEQ-IOP) in May and November 2022. One upgradient location, Mud Lake, was also co-sampled with DEQ-IOP. Samples were also collected at Atomic City, Craters of the Moon, Howe, Idaho Falls, and the public rest area at Highway 20/26. A control sample of bottled water was also obtained. The samples were analyzed for gross alpha and gross beta activities and for tritium. The results are shown in Table 6-14. DEQ-IOP results are reported quarterly and annually and can be accessed at www.deq.idaho.gov/inl-oversight.

Table 6-14. Gross alpha, gross beta, and tritium concentrations in offsite drinking water samples collected by the INL contractor in 2022.

LOCATION	SAMPLE RESULTS (PCI/L)[a]		
GROSS ALPHA			
	SPRING	FALL	EPA MCL[b]
Atomic City	1.6 ± 0.54	1.4 ± 0.40	15 pCi/L
Control (bottled water)[c]	0.36 ± 0.16	0.12 ± 0.12	15 pCi/L
Craters of the Moon	2.2 ± 0.32	3.0 ± 0.51	15 pCi/L
Howe	1.3 ± 0.28	1.6 ± 0.38	15 pCi/L
Idaho Falls	2.5 ± 0.57	0.46 ± 0.46	15 pCi/L
Minidoka	0.64 ± 0.35	1.5 ± 0.58	15 pCi/L
Mud Lake (Well #2)	0.43 ± 0.19	0.20 ± 0.25	15 pCi/L
Rest Area (Highway 20/26)	1.2 ± 0.29	1.4 ± 0.42	15 pCi/L
Shoshone	2.0 ± 0.39	2.8 ± 0.57	15 pCi/L
GROSS BETA			
	SPRING	FALL	EPA MCL
Atomic City	4.1 ± 0.48	3.2 ± 0.48	4 mrem/yr (50 pCi/L)[d]
Control (bottled water)	0.18 ± 0.42	0.01 ± 0.31	4 mrem/yr (50 pCi/L)
Craters of the Moon	3.5 ± 0.36	2.7 ± 0.44	4 mrem/yr (50 pCi/L)
Howe	7.7 ± 0.40	2.0 ± 0.44	4 mrem/yr (50 pCi/L)

Table 6-14. continued.

LOCATION	SAMPLE RESULTS (PCI/L)[a]		
Idaho Falls	4.7 ± 0.41	3.4 ± 0.50	4 mrem/yr (50 pCi/L)
Minidoka	2.1 ± 0.41	4.7 ± 0.49	4 mrem/yr (50 pCi/L)
Mud Lake (Well #2)	4.3 ± 0.33	4.6 ± 0.43	4 mrem/yr (50 pCi/L)
Rest Area (Highway 20/26)	3.2 ± 0.35	3.0 ± 0.44	4 mrem/yr (50 pCi/L)
Shoshone	3.5 ± 0.35	4.2 ± 0.48	4 mrem/yr (50 pCi/L)
TRITIUM			
	SPRING	**FALL**	**EPA MCL**
Atomic City	-19 ± 26	-11 ± 34	20,000 pCi/L
Control (bottled water)	-13 ± 33	-19 ± 22	20,000 pCi/L
Craters of the Moon	30 ± 26	-4.9 ± 22	20,000 pCi/L
Howe	10 ± 24	-15 ± 23	20,000 pCi/L
Idaho Falls	0.80 ± 26	-49 ± 22	20,000 pCi/L
Minidoka	17 ± 34	-53 ± 21	20,000 pCi/L
Mud Lake (Well #2)	-35 ± 33	-26 ± 22	20,000 pCi/L
Rest Area (Highway 20/26)	26 ± 34	35 ± 23	20,000 pCi/L
Shoshone	17 ± 34	-26 ± 22	20,000 pCi/L

a. Result ± 1σ. Results ≥ 3σ are considered to be statistically positive.
b. EPA = Environmental Protection Agency; MCL = maximum contaminant level.
c. Water bottled in Ammon, Idaho.
d. The MCL for gross beta activity is not established. However, the EPA drinking water standard of 4 mrem/yr for public drinking water systems is applied and a screening level of 50 pCi/L is used. Samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

Gross alpha activity was detected statistically (above 3σ) in 10 of 18 samples collected in 2022. The results are below the screening level of 15 pCi/L for gross alpha activity, with a maximum of 3.0 ± 0.51 pCi/L, as measured at Craters of the Moon in November.

Gross beta activity was detected statistically in all but two drinking water samples collected during 2022. Gross beta activity was not detected in the bottled water samples (control) collected in May and November. The results are below the screening level of 50 pCi/L for gross beta activity, with a maximum of 7.7 ± 0.4 pCi/L, measured at Howe in May. If gross beta activity exceeds 50 pCi/L, an analysis of the sample must be performed to identify the major radionuclides present (40 CFR 141). Gross beta activity has been measured at these levels historically in offsite drinking water samples. For example, the maximum level reported since 2012 in past Annual Site Environmental Reports was 8.8 ± 1.0 pCi/L at Atomic City in fall of 2021.

Tritium was not statistically detected in any of the drinking water samples collected in 2022.

6.9 Surface Water Sampling

Surface water was co-sampled with DEQ-IOP in May and November 2022 at three springs located downgradient of the INL Site: Alpheus Springs near Twin Falls; Clear Springs near Buhl; and a trout farm near Hagerman shown in Figure 6-21. Results are summarized in Table 6-15.

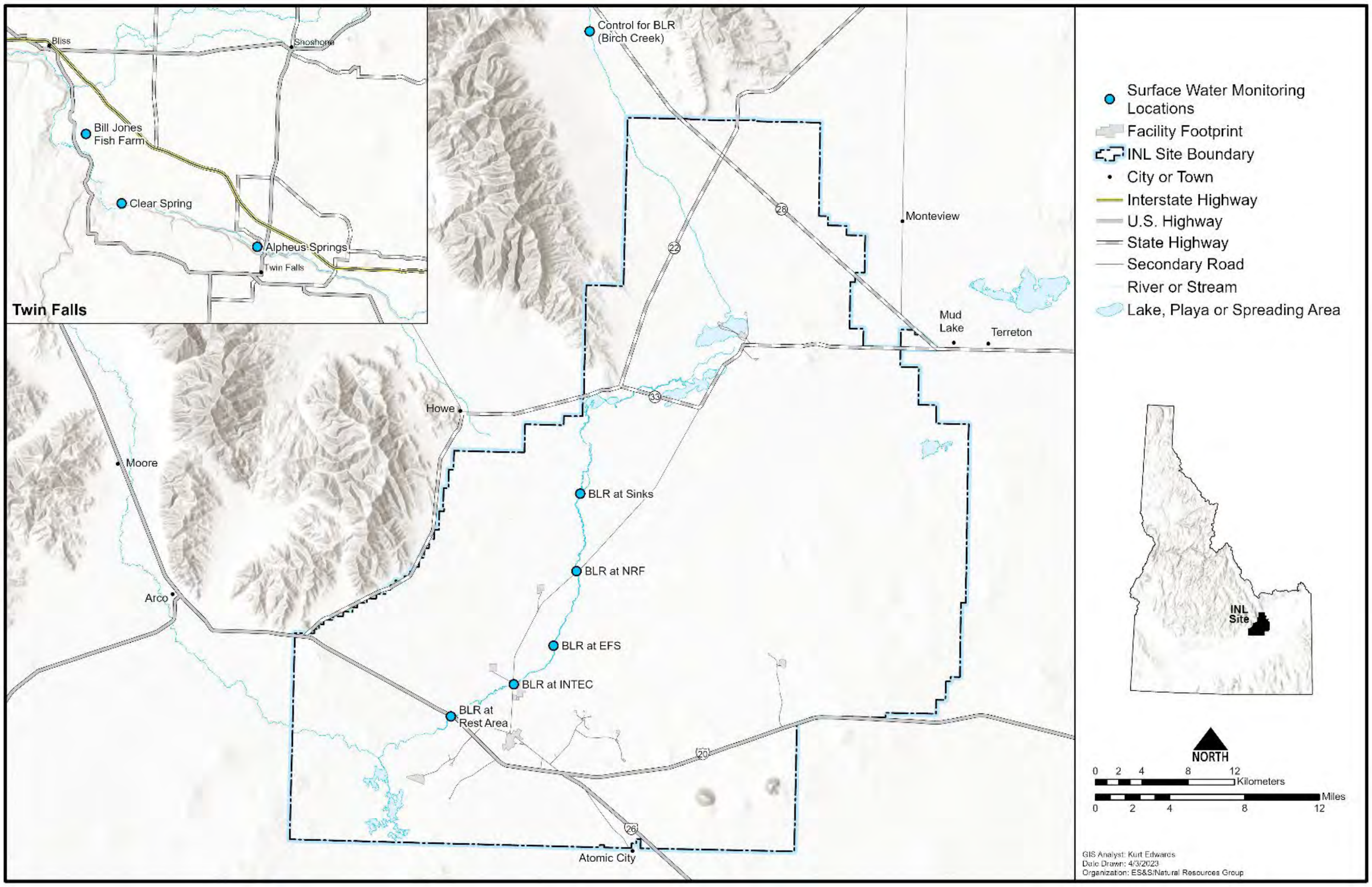

Figure 6-21. Detailed map of INL program surface water monitoring locations.

Gross alpha activity was detected in one sample collected in November for the sample collected as Alpheus Springs in May. For comparison, the maximum concentration measured since 2012 in all springs was 3.7 ± 0.68 pCi/L at Clear Springs in 2017.

Gross beta activity was detected in all surface water samples. The highest results were measured in the Clear Springs sample (4.9 ± 0.40 pCi/L) collected in May and the Alpheus Springs sample (4.9 ± 0.64 pCi/L) collected in November. The maximum result measured since 2012 was 10.6 ± 0.56 pCi/L at Alpheus Springs in 2014.

Tritium was not detected in any of the surface water samples collected in 2022.

Table 6-15. Gross alpha, gross beta, and tritium concentrations in surface water samples collected along the Big Lost River by the INL contractor in 2022.

LOCATION	SAMPLE RESULTS (PCI/L)[a]		
GROSS ALPHA			
	SPRING[b]	**FALL[b]**	**EPA MCL**
Alpheus Springs-Twin Falls	4.0 ± 0.85	1.5 ± 0.55	15 pCi/L
Clear Springs-Buhl	1.0 ± 0.35	1.6 ± 0.67	15 pCi/L
JW Bill Jones Jr Trout Farm-Hagerman	1.4 ± 0.49	1.4 ± 0.39	15 pCi/L
GROSS BETA			
	SPRING	**FALL**	**EPA MCL**
Alpheus Springs-Twin Falls	1.9 ± 0.52	4.9 ± 0.64	4 mrem/yr (50 pCi/L)[c]
Clear Springs-Buhl	4.9 ± 0.40	4.6 ± 0.52	4 mrem/yr (50 pCi/L)
JW Bill Jones Jr Trout Farm-Hagerman	4.7 ± 0.48	2.3 ± 0.45	4 mrem/yr (50 pCi/L)
TRITIUM			
	SPRING	**FALL**	**EPA MCL**
Alpheus Springs-Twin Falls	36 ± 33	-30 ± 34	20,000 pCi/L
Clear Springs-Buhl	18 ± 33	-30 ± 34	20,000 pCi/L
JW Bill Jones Jr Trout Farm-Hagerman	0.43 ± 33	-7.7 ± 33	20,000 pCi/L

a. Result ± 1σ. Results ≥ 3σ are considered to be statistically positive.
b. The springs and trout farm were sampled on May 9, 2022, and on November 14, 2022.
c. The MCL for gross beta activity is not established. However, the EPA drinking water standard of 4 mrem/yr for public drinking water systems is applied and a screening level of 50 pCi/L is used. Samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

The Big Lost River is an intermittent, ephemeral body of water that flows only during periods of high spring runoff and releases from the Mackay dam, which impounds the river upstream of the INL Site. The river flows through the INL Site and enters a depression, where the water flows into the ground, called the Big Lost River Sinks (see Figure 6-21). The river then mixes with other water in the eastern Snake River Plain Aquifer. Water in the aquifer then emerges about 160 km (100 miles) away at Thousand Springs near Hagerman and other springs downstream of Twin Falls. The INL contractor did not collect surface water samples from the Big Lost River on the INL Site because water demands upstream at the Mackay Reservoir inhibited river flow onto the INL Site from March to May 2022 and flow never went as far as the Lincoln Blvd bridge. No river samples were collected during 2022 at INL because of the lack of surface water flow in the Big Lost River.

6.10 USGS 2022 Publication Abstracts

In 1949, the USGS was asked to characterize water resources prior to the building of nuclear-reactor testing facilities at the INL Site. Since that time, USGS hydrologists and geologists have been studying the hydrology and geology of the eastern Snake River Plain and the eastern Snake River Plain Aquifer.

At the INL Site and in the surrounding area, the USGS INL Project Office:

- Monitors and maintains a network of existing wells
- Drills new research and monitoring wells, providing information about subsurface water, rock, and sediment

- Performs geophysical and video logging of new and existing wells
- Maintains the Lithologic Core Storage Library.

Data gathered from these activities are used to create and refine hydrologic and geologic models of the aquifer, to track contaminant plumes in the aquifer, and to improve understanding of the complex relationships between the rocks, sediments, and water that compose the aquifer. The USGS INL Project Office publishes reports about their studies, available through the USGS Publications Warehouse: https://usgs-r.github.io/inlpubs/articles/inl-bibliography.html. Two reports, Bartholomay (2022) and Treinen and Bartholomay (2022), and one software package (Fisher 2022) were published by the USGS INL Project Office in 2022. The abstracts of these studies and the publication information associated with each study are presented below.

6.10.1 Evaluation of Sample Preservation Methods for Analysis of Selected Volatile Organic Compounds in Groundwater at Idaho National Laboratory, Idaho (Treinen and Bartholomay 2022)

During 2020, water samples were collected from 25 wells completed in the eastern Snake River Plain Aquifer and from 1 well completed in perched groundwater above the aquifer at INL to determine the effect of different sample preservation methods on the laboratory determinations of concentrations of VOCs. Paired-sample sets were collected at each well. One sample in each set was preserved with hydrochloric acid, and one sample was preserved without it. Both samples were chilled after collection and during shipping to the laboratory for analysis. The samples were analyzed for 61 VOCs at the U.S. Geological Survey National Water Quality Laboratory in cooperation with the DOE. A comparison of the reproducibility of the analyses of co-located unpreserved and preserved samples by a relative percent difference method determined that all sample pairs were statistically equivalent. Using a normalized absolute difference method, 81 percent of the analyses were found to be statistically equivalent. This study confirms that the results of analyses of historical collected samples, which were preserved by chilling only, are statistically comparable to the analyses of samples being currently collected and preserved by both hydrochloric acid and chilling, and thus are valid for use in future geochemical evaluations.

6.10.2 Historical Development of the U.S. Geological Survey Hydrological Monitoring and Investigative Programs at Idaho National Laboratory, Idaho, 2002–2020 (Bartholomay 2022)

Long-term monitoring of water quality data collected from wells at INL have provided essential information for delineating the movement of radiochemical and chemical wastes in the eastern Idaho Snake River Plain Aquifer. In cooperation with DOE, the USGS has maintained as many as 200 wells in the INL water quality monitoring network since 1949. A network design tool, distributed as an R package, was developed to evaluate and optimize groundwater monitoring in the existing network based on water quality data collected at 153 sampling sites since January 1, 1989. The objective of the optimization design tool is to reduce well monitoring redundancy while retaining sufficient data to reliably characterize water quality conditions in the aquifer. A spatial optimization was used to identify a set of wells whose removal leads to the smallest increase in the deviation between interpolated concentration maps using the existing and reduced monitoring networks while preserving significant long-term trends and seasonal components in the data. Additionally, a temporal optimization was used to identify reductions in sampling frequencies by minimizing the redundancy in sampling events (Fisher et al. 2021).

Spatial optimization uses an islands genetic algorithm to identify near-optimal network designs removing 10, 20, 30, 40, and 50 wells from the existing monitoring network. With this method, choosing a greater number of wells to remove results in greater cost savings and decreased accuracy of the average relative difference between interpolated maps of the reduced dataset and the full dataset. The genetic search algorithm identified reduced networks that best capture the spatial patterns of the average concentration plume while preserving long-term temporal trends at individual wells. Concentration data for 10 analyte types are integrated in a single optimization so that all datasets may be evaluated simultaneously. A constituent was selected for inclusion in the spatial optimization problem when the observations were sufficient to (1) establish a two-range variability model, (2) classify at least one concentration time series as a continuous record block, and (3) make a prediction using the quantile-kriging interpolation method. The selected constituents include sodium, chloride, sulfate, nitrate, carbon tetrachloride, 1,1-dichloroethylene, 1,1,1-trichloroethane, trichloroethylene, tritium, ^{90}Sr, and plutonium-238.

In temporal optimization, an iterative-thinning method was used to find an optimal sampling frequency for each analyte-well pair. Optimal frequencies indicate that for many of the wells, samples may be collected less frequently and still be able to characterize the concentration over time. The optimization results indicated that the sample collection interval may be increased by an average of 273 days owing to temporal redundancy.

6.10.3 inlpubs—Bibliographic Information for the U.S. Geological Survey Idaho National Laboratory Project Office (Fisher 2022)

The R package (inlpubs) may be used to search and analyze 363 publications that cover the 73-year history of the USGS, Idaho Water Science Center, Idaho National Laboratory Project Office (INLPO). The INLPO publications were authored by 251 researchers trying to better understand the effects of waste disposal on water contained in the eastern Snake River Plain Aquifer and the availability of water for long-term consumptive and industrial use. Information contained within these publications is crucial to the management and use of the aquifer by the INL and the state of Idaho. USGS geohydrologic studies and monitoring, which began in 1949, were done in cooperation with the DOE Idaho Operations Office (Bartholomay 2017). Access to the inlpubs repository can be found at https://rconnect.usgs.gov/INLPO/inlpubs-main/.

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