TECHNICAL REVIEW OF 2021 and 2022 ENVIRONMENTAL MONITORING REPORTS FOR SAVANNAH RIVER SITE F-AREA AND H-AREA TANK FARM FACILITIES

Date: September 2023

Reviewers:

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Primary Documents Reviewed:

1. SRNS-RP-2022-00001, "Savannah River Site, Environmental Report 2021," Savannah River Nuclear Solutions, Savannah River Site: Aiken, SC. 2022.
2. WSRC-RP-2000-4134, "Scoping Summary for the General Separations Area Eastern Groundwater Operable Unit," November 2021.
3. ERD-EN-2005-0127, "Scoping Summary for the General Separations Area Western Groundwater Operable Unit (U)", Savannah River Nuclear Solutions, Savannah River Site: Aiken, SC. November 2021.
4. SRNS-RP-2022-00076, Rev. 0, "2021 Annual Groundwater Monitoring Report for the F- and H-Area Radioactive Liquid Waste Tank Farms (U)," Savannah River Nuclear Solutions, Savannah River Site: Aiken, SC. March 2022.
5. SRNL-STI-2022-00169, Rev. 0, "Colloid-Facilitated Actinide Transport in a Cementitious-Impacted SRS Groundwater, Savannah River National Laboratory, Savannah River Site: Aiken, SC. April 2022.
6. WSRC-RP-2000-4134, "Scoping Summary for the General Separations Area Eastern Groundwater Operable Unit," February 2023.
7. ERD-EN-2005-0127, "Scoping Summary for the General Separations Area Western Groundwater Operable Unit (U)", Savannah River Nuclear Solutions, Savannah River Site: Aiken, SC. February 2023.
8. SRNS-RP-2022-01106, Rev. 0, "2022 Annual Groundwater Monitoring Report for the F- and H-Area Radioactive Liquid Waste Tank Farms (U)," Savannah River Nuclear Solutions, Savannah River Site: Aiken, SC. March 2023.

[1] The Center for Nuclear Waste Regulatory Analyses (CNWRA®) is federally funded research and development center, which was established in 1987 by the U.S. Nuclear Regulatory Commission. The CNWRA is part of the Chemistry and Chemical Engineering Division of Southwest Research Institute, San Antonio, Texas 78238.

Summary and Evaluation:

This technical review report is an update to four previous reports on the same topic dated December 17, 2019, April 20, 2018, March 31, 2015, and May 14, 2021 (Agencywide Documents Access and Management System [ADAMS] Accession Nos. ML19280A059, ML18051B154, ML12272A124, and ML21119A312) with the former reports evaluating the F-Area Tank Farm Facility (FTF) and H-Area Tank Farm Facility (HTF) monitoring well networks, lysimeter and natural attenuation studies, and trends in groundwater quality parameters. This technical review is associated with Monitoring Factors (MFs) 4.1, "Natural Attenuation of Key Radionuclides," and 4.3, "Environmental Monitoring," listed in the NRC's combined FTF and HTF monitoring plan entitled "U.S. Nuclear Regulatory Commission Plan for Monitoring Disposal Actions Taken by the U.S. Department of Energy (DOE) at the Savannah River Site (SRS) F-Area and H-Area Tank Farm Facilities in Accordance with the National Defense Authorization Act for Fiscal Year 2005," issued in October 2015 and available using ADAMS Accession No. ML15238A761. MF 4.1 is focused on U.S. NRC staff review of studies that provide information on key radionuclide mobility in the natural system to provide support for key assumptions in DOE's performance assessment (PA) important to DOE's compliance demonstration for the TFFs. MF 4.3 is focused on NRC staff review of environmental monitoring data collected by DOE that also provides information about tank farm releases and provides data to assess DOE's flow and contaminant transport modeling.

This technical review report is divided into two parts. The first part is focused on NRC staff review of environmental monitoring reports prepared by DOE SRS for FTF and HTF that provide information on radionuclide mobility in the subsurface at SRS, or that provide information on SRS facility impacts on the surrounding environment. The second part is focused on review of results of studies that also provide information on the potential for colloid-facilitated transport of key radionuclides from the tank farm facilities.

Part I: Summary and Evaluation of Environmental Monitoring Results

Summary of SRS-Wide Monitoring Report

2021 SRS Environmental Report, SRNS-RP-2022-00001, Prepared by Savannah River Nuclear Solutions, LLC, SRS, Aiken, SC 29808, 2022. http://www.srs.gov/general/pubs/ERsum/index.html

A status update on SRS facilities was listed in the report and included the following:

- With regard to high-level-waste tank closure (Radioactive Liquid Waste Processing and Dispositioning), 43 tanks remain with 130,000 m^3 (34.3 Mgal) of waste and 8.4 EBq (227 MCi) of activity (8 of the tanks have been cleaned and closed).
- In 2021, the Salt Waste Processing Facility treated more than 7,600 m^3 (2 Mgal) of salt solution.
- In 2021, more than 12,000 m^3 (3.14 Mgal) of waste was processed into grout and disposed of in the Saltstone Disposal Facility, including mega-vault saltstone disposal structure (SDS)-6.
- In 2021, the Defense Waste Processing Facility filled 62 canisters with of glass waste mixture $1x10^{+05}$ kg (230,000 lbs), immobilizing 39 PBq (1.06 MCi) of high-level radioactive waste.
- In 2021, the H-Area Effluent Treatment Project processed approximately 27,400 m^3 (7.25 Mgal) of treated wastewater.

Figure 1 provides a schematic related to the processing of high-level waste in the tank farm facilities.

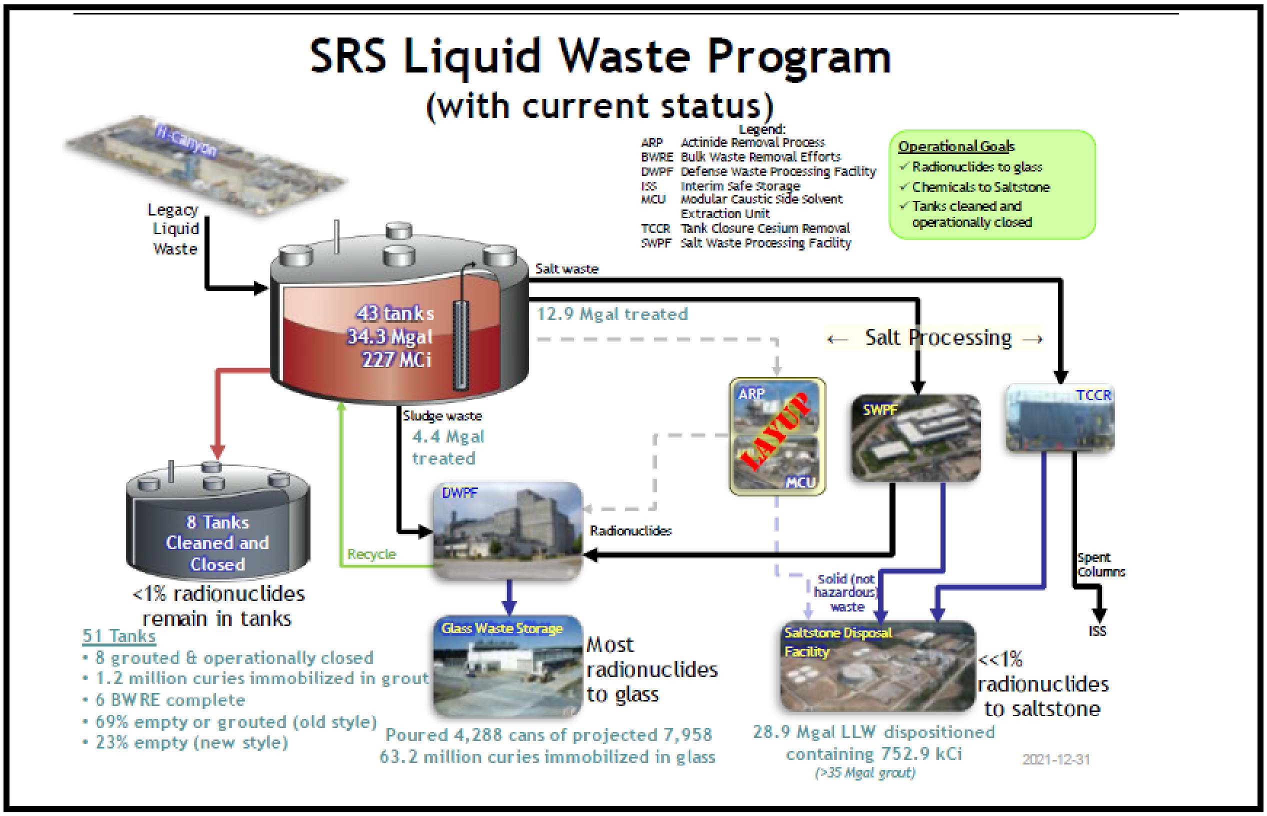


Figure 1 SRS High-Level Waste Processing Schematic and Status. Image Credit: Figure 3-3, *2021 SRS Environmental Report*.

The report included information about DOE's efforts to support NRC's monitoring role at the FTF and HTF under Section 3116 of the National Defense Authorization Act (NDAA) by providing routine documentation such as groundwater monitoring reports, and PA maintenance plans. Review of routine documentation is listed in NRC's monitoring plan found at ADAMS Accession No. ML15238A761. The report noted that NRC did not conduct any onsite observation visits for FTF and HTF in 2021. The report went on to discuss the general process of retrieving waste from the tanks including Bulk Waste Removal Efforts (BWRE) which is a multiyear engineering and waste removal process that involves installing specialized equipment that meets strict nuclear safety standards. The report indicated that no BWRE or other Federal Facility Agreement (FFA) tank closure commitments were required for 2021, and that follow-up negotiations were scheduled to be completed in 2022 for additional BWRE and tank closure milestones.

The environmental report also noted significant progress DOE SRS has made towards the first operational closures of ancillary structures in FTF and HTF. Internal grouting of F-Area Diversion Box (FDB)-5 in 2021, and internal grouting of FDB-6 was completed in 2022. SRS had an FFA commitment to operationally close these two structures by the end of 2022. For additional details, please see NRC's separate technical review report (TRR) at ADAMS Accession No. ML23262B355 on ancillary equipment closure.

Table 7-2 in the 2021 Environmental Report also listed key constituents at FTF and including tritium, nonvolatile beta and manganese with 2021 maximum concentrations reported at 0.23 Bq/mL (6.27pCi/mL) (FTF-12R), 63 Bq/L (171 pCi/L) (FTF 28) and 129 ug/L (FTF-30D), respectively. HTF also had the same key constituents with maximum concentrations of 1.3 Bq/mL (34.9 pCi/mL) (HAA-12C), 1.3 Bq/L (33.8 pCi/L) (HAA-12B), and 393 ug/L (HAA-10D), respectively.

The report notes that review of air monitoring and water monitoring data shows that radioactivity levels are below applicable permit and regulatory limits and consistent with historical levels/trends. DOE SRS also supports a wildlife surveillance program considering a sportsman scenario. The program is supported by sampling of 26 feral hogs. The radioactivity levels are stated to be below applicable standards, although no hunts were conducted in 2021 which would lead to an actual exposure. Figure 2 depicts the types of radiological sampling performed at the site.

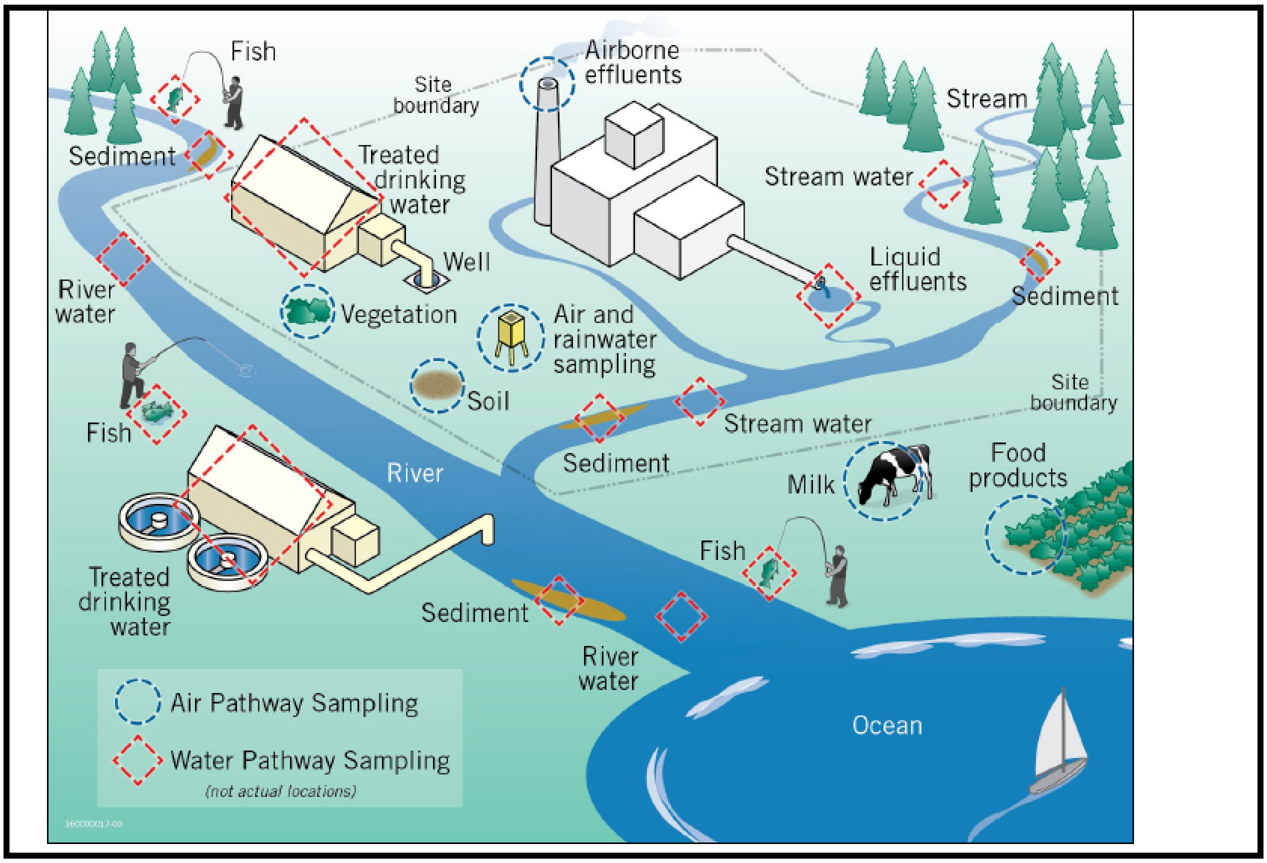


Figure 2 Types of Radiological Sampling Performed in the Environs at SRS. Image Credit: Figure 5-1 in the 2021 *SRS Environmental Report*.

With respect to offsite monitoring, the report provides results of sampling of air, river water, drinking water, soil, sediment, vegetation, milk, food products, fish, and other media from various locations, which are collected and analyzed for radioactive contaminants. Offsite monitoring assists DOE SRS with better understanding impacts of the SRS on the environment and to assess long-term trends with respect to radionuclide levels in the environment. SRS collects samples beyond the site perimeter in Georgia and in South Carolina at 40- and 160-km

(25- and 100-mi) intervals from the site. Additionally, SRS collects samples at several population centers in Georgia and South Carolina.

Doses to the “offsite representative person” are calculated by DOE to demonstrate that SRS activities complies with the DOE all-pathway dose limit of 1 mSv/yr (100 mrem/yr). SRS adds the doses from both site liquid and air releases when calculating the “offsite representative person” dose. In 2021, the dose to the “offsite representative person” was 3 μSv (0.3 mrem) from liquid releases and 0.17 μSv (0.017 mrem) from air releases. The total representative person dose was 3 μSv (0.3 mrem), which is 0.30% of the 1 mSv/yr (100 mrem/yr) DOE dose limit.

SRS conducts annual hunts to control onsite deer and wild hog populations. SRS determines the estimated potential dose from eating harvested deer or hog meat for onsite hunters. No hunts were conducted in 2021 due to the pandemic. However, SRS collected flesh samples from feral hogs that had been trapped in various onsite hunt compartments and performed radioanalytical analysis of the samples. SRS also estimated the maximum potential dose from bass fish consumption collected at the mouth of Steel Creek assuming a consumption rate of 24 kg (53 lbs) of bass caught exclusively from the mouth of Steel Creek. The dose was calculated at 4.3 μSv (0.43 mrem), which is about 0.43% of the 1 mSv/yr (100 mrem/yr) DOE dose limit.

Summary of General Separations Area (GSA) Monitoring Reports

ERD-EN-2005-0127, “Scoping Summary for the GSA Western Groundwater Operable Unit (U)”, Savannah River Nuclear Solutions, SRS: Aiken, SC. November 2021.

Key points from the report include the following:

- The Resource Conservation and Recovery Act Facility Investigation (RFI)/Remedial Investigation (RI) Phase 1 Work Plan for the GSA Western Groundwater Operable Unit (OU), Revision 1.1, was approved by the United States Environmental Protection Agency (US EPA) and by the South Carolina Department of Health and Environmental Control (SC DHEC) on September 9, 2003.
- A field start for monitoring the OU was achieved on September 20, 2004.
- The GSA Western Groundwater OU monitoring network was completed in 2007.
- The purpose of the Scoping Summary is to present results of the 2020 groundwater monitoring to the Core Team comprised of representatives from the US DOE, US EPA, and SC DHEC to determine if the monitoring well network and list of analytes remain appropriate.[2] See Table 1 for a list of monitoring wells and analytes.
- The GSA Western Groundwater OU consists of groundwater associated with the north, west and south plumes including shallow groundwater discharging to surface seeplines; and surface water. The OU does not include soil contamination which will be addressed during closure of the individual waste units and operating facilities.
- The groundwater monitoring well network consists of 33 monitoring wells, four shallow sampling points at the seepline (seepline piezometers), and four surface water sampling stations.

[2] The Core Team has determined that a Record of Decision is not appropriate until all sources of potential contamination are brought to closure, including the FTF tanks. The most appropriate action was determined to be continued groundwater monitoring to ensure that surface water resources are protected.

- Groundwater wells are sampled annually (established wells) or semi-annually (F-Area Retention Basis and new wells, until a baseline can be established).
- In the South Plume[3], all 13 wells were sampled. Maximum concentrations of nonvolatile beta were found at well FTF-28 at a value of 35 Bq/L (956 pCi/L). See Figure 3 for 2020 results for nonvolatile beta in the Upper Three Runs Aquifer (UTRA). Nonvolatile beta was also elevated at FSL-5D, and FGW-12C. The non-volatile beta plume is stated to be associated with the F-Area Inactive Process Sewer Line (FIPSL).
- In 2020, several analytes exceeded the Maximum Contaminant Level (MCL) in at least one well with maximum concentrations at the following values and wells: iodine(I)-129 (1.2 Bq/L or 33 pCi/L), nitrate (15 mg/L) radium(Ra)-226 (0.30 Bq/L or 8.09 pCi/L), Ra-228 (0.30 Bq/L or 8 pCi/L), strontium-90 (2.0 Bq/L or 54 pCi/L), technetium(Tc)-99 (1170 pCi/L or 43 Bq/L), and tritium (3.9 Bq/mL or 106 pCi/mL). The maximum concentrations occurred in wells along or near the FIPSL, except for nitrate and tritium which was highest at downgradient well FGW 12C.
- Very low detections below the MCL were observed at surface water locations FGW-23 and FGW-24.
- The groundwater plumes were stated to remain stable with respect to magnitude and extent.

South Plume	UAZ of UTRA	BRR1D, BRR6D, FSL4D, FSL5D, FSL6D, FSL7D, FSB76C, FGW012D	Nitrate, gross alpha, nonvolatile beta, tritium, iodine-129, radium-226, 228, strontium-90, technetium-99, uranium-233/234, 238
	LAZ of UTRA	BRR6C, BRR7C, FTF28, FSL11C, FGW012C	
	Seepline/ Surface Water	FGW024, FGW023	

Table 1 List of Monitoring Well Locations for the South Plume.

[3] Note that NRC staff are particularly interested in the South plume due to its potential association with releases from FTF. There are 13 wells and 2 surface water locations in the south plume monitoring network (see Table 1).

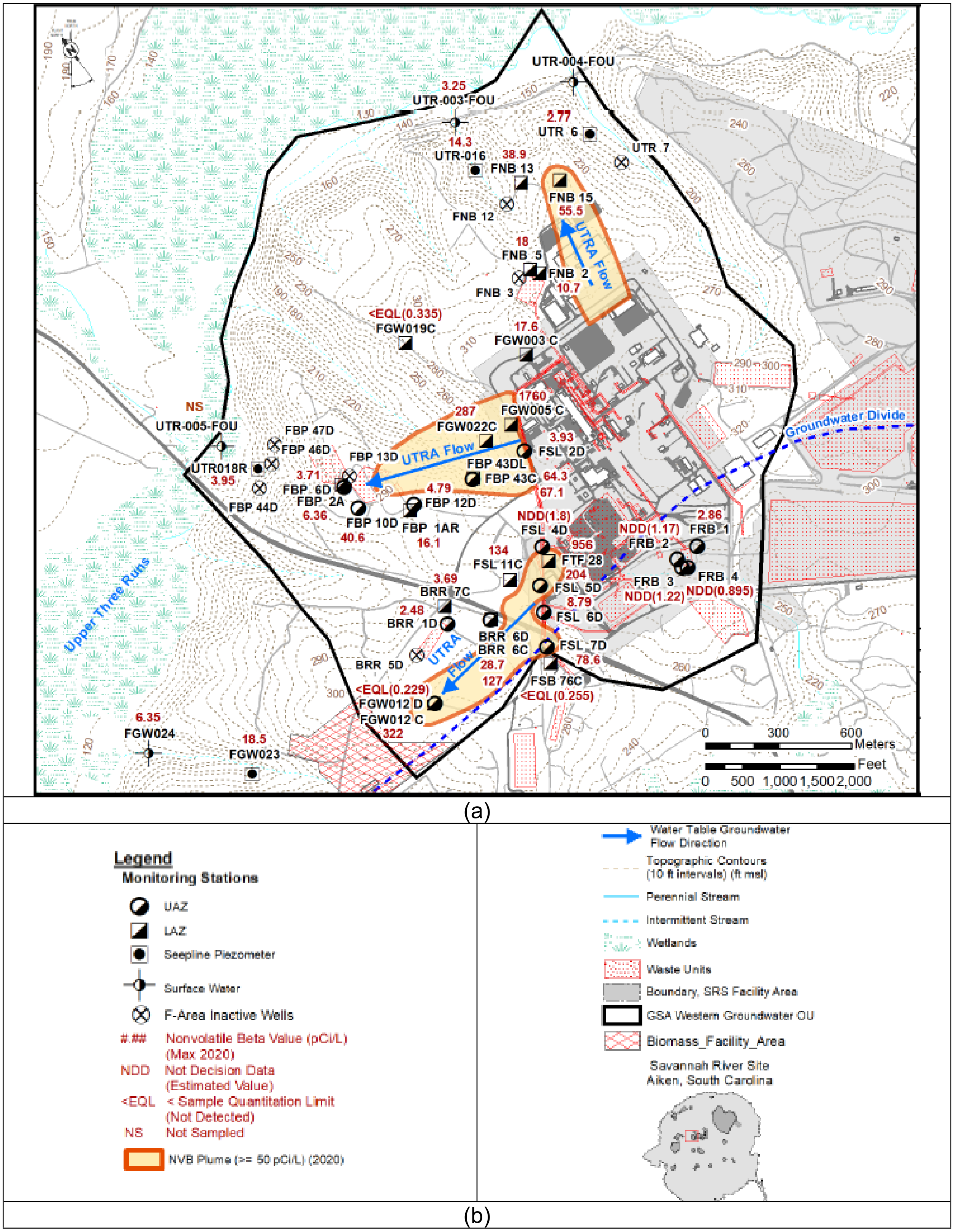


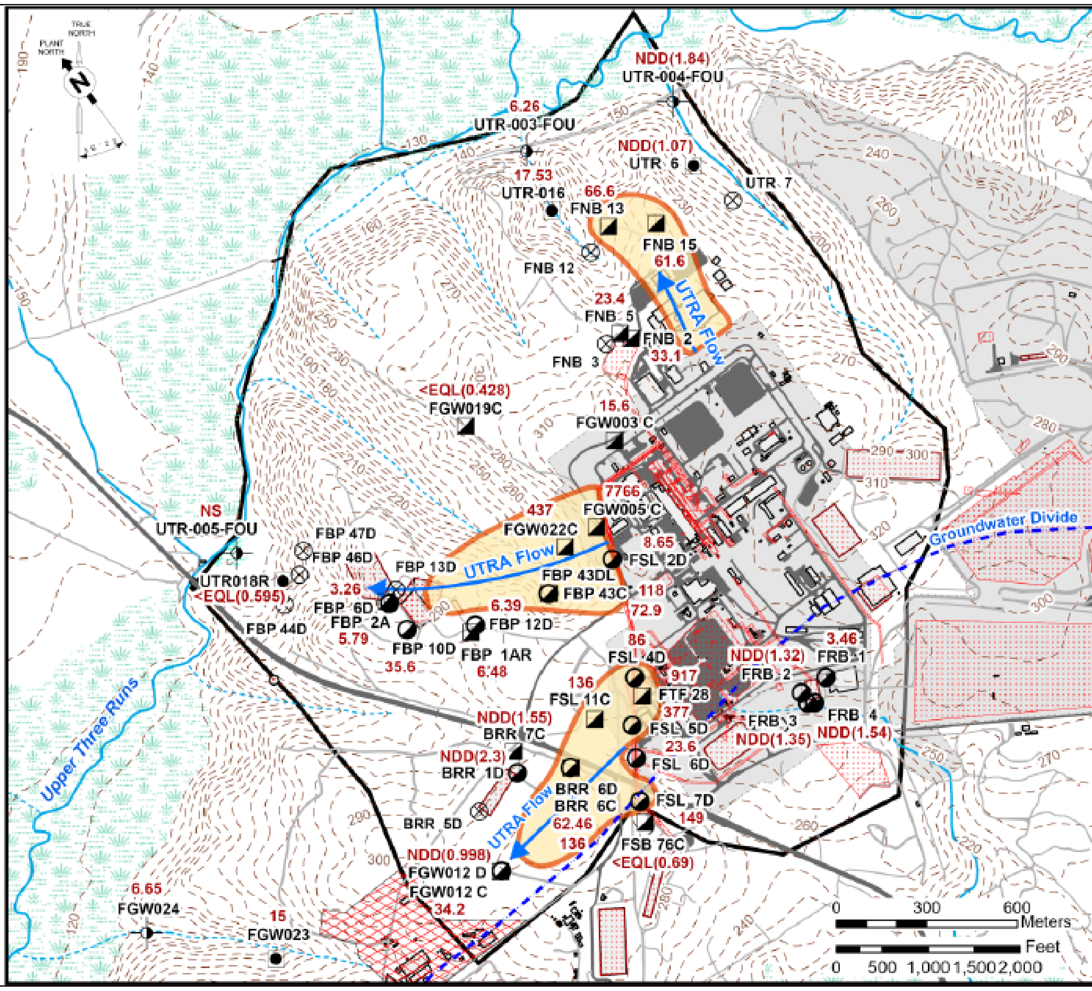
Figure 3. Nonvolatile Beta Results (Max 2020) UTRA. Image Credit: Figure 7 ERD-EN-2005-0127 (November 2021).

ERD-EN-2005-0127, “Scoping Summary for the General Separations Area Western Groundwater Operable Unit (U)”, Savannah River Nuclear Solutions, SRS: Aiken, SC. November 2023.

Key points from the report include the following[4]:

- The purpose of the Scoping Summary is to present results of the 2021 groundwater monitoring to the Core Team comprised of representatives from the US DOE, US EPA, and SCDHEC to determine if the monitoring well network and list of analytes remain appropriate.
- In the South Plume[5], all 13 wells were sampled. Maximum concentrations of nonvolatile beta were found at well FTF-28 at a value of 34 Bq/L (917 pCi/L). See Figure 4 for 2021 results for non-volatile beta in the UTRA.
- Non-volatile beta was also elevated at FSL-5D and FGW-12C.
- The non-volatile beta plume is stated to be associated with the FIPSL.
- In 2020, several analytes exceeded the MCL in at least one well with maximum concentrations at the following values and wells: I-129 (8.1 Bq/L or 219 pCi/L which was “J” qualified or an estimated value), gross alpha (1.7 Bq/L or 44.9 pCi/L), nitrate (25 mg/L), Ra-226 (0.37 Bq/L or 10 pCi/L), Ra-228 (0.5 Bq/L or 13.7 pCi/L), strontium-90 (2.4 Bq/L or 65 pCi/L), Tc-99 (49 Bq/L or 1330 pCi/L), and tritium (4 Bq/L or 109 pCi/mL).The maximum concentrations occurred in wells along or near the FIPSL, except for nitrate and tritium which was highest at downgradient well FGW 12C.
- Very low detections below the MCL were observed at surface water locations FGW-23 and FGW-24.
- The groundwater plumes were stated to remain stable with respect to magnitude and extent.
- Of note, concentrations at FGW-005C in the West Plume were four times higher compared to 2020 at 287 Bq/L (7770 pCi/L). The increase in nonvolatile beta was thought to be caused by mobilization of residual legacy contamination due to a significant increase in water level since 2013. Most notably the highest recorded monthly rainfall in 68 years occurring in February 2020 at a value of 27 cm (10.5 inches). See Figure 5 for time series data on water level and non-volatile beta concentrations.

[4] Note that key points that were made under the 2020 report published in November 2021 are not repeated.
[5] Note that NRC staff are particularly interested in the South plume due to its potential association with releases from FTF. There are 13 wells and 2 surface water locations monitoring the south plume (see Table 1).



(a)

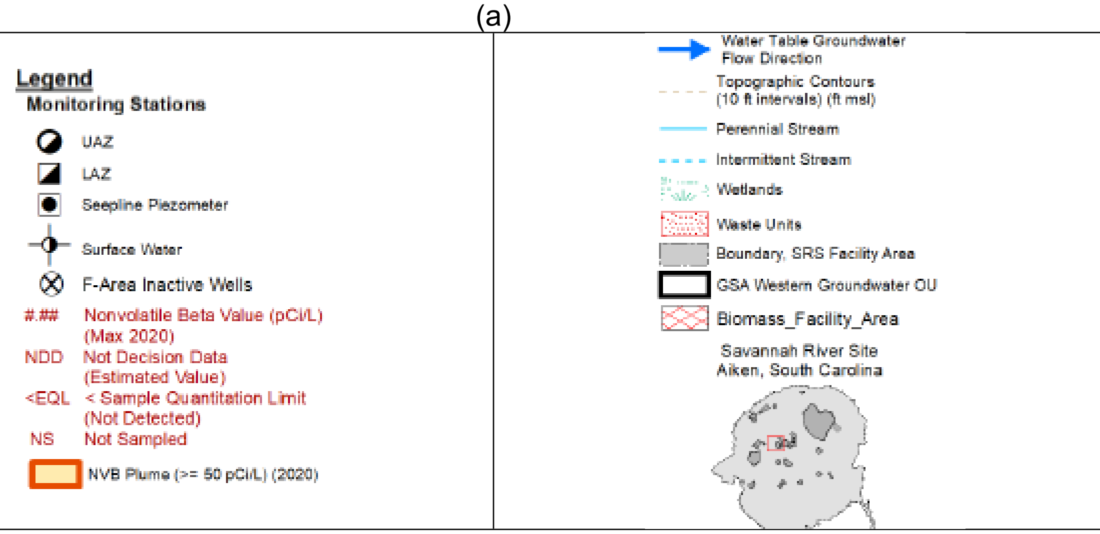


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Figure 4. Nonvolatile Beta Results (Max 2021) UTRA. Image Credit: Figure 9 ERD-EN-2005-0127 (February 2023).

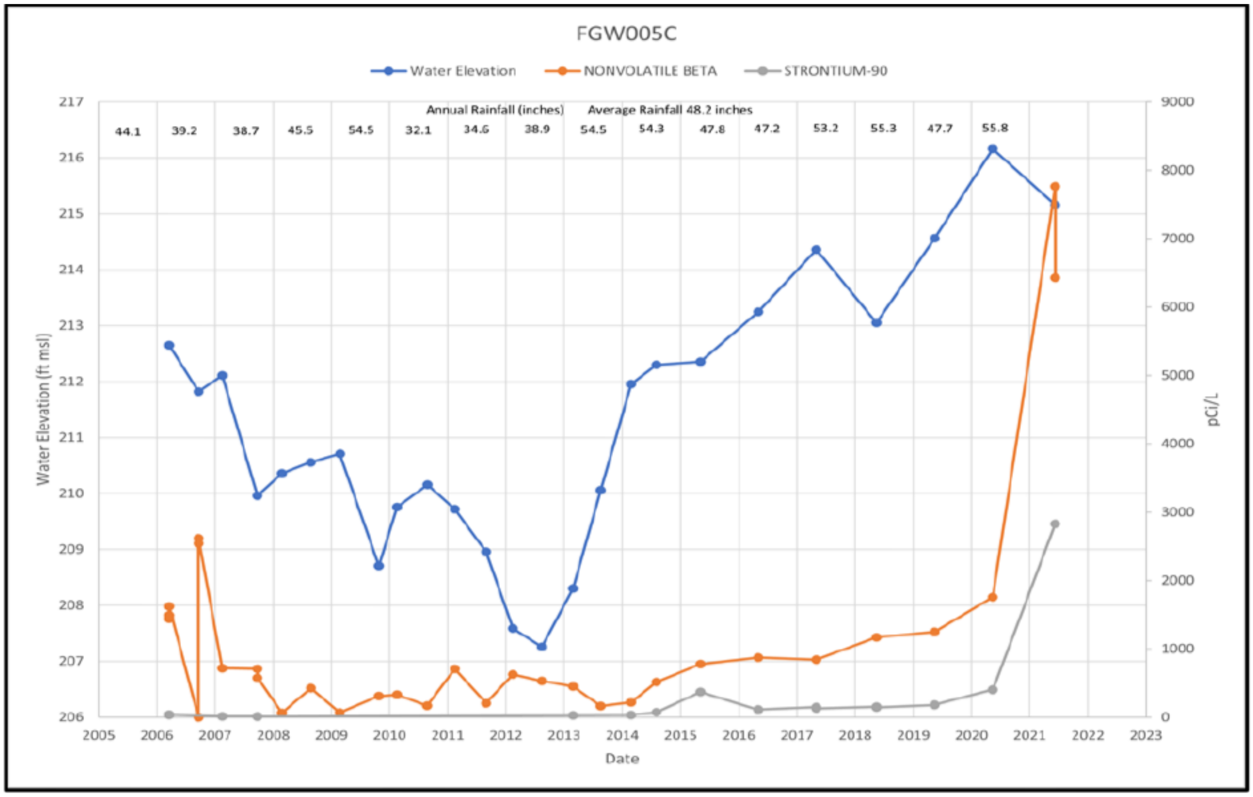

Figure 5. Nonvolatile Beta Concentrations and Water Elevations at FGW-005C. Image Credit: Figure 7 ERD-EN-2005-0127 (February 2023).

WSRC-RP-2000-4134, "Scoping Summary for the General Separations Area Eastern Groundwater Operable Unit," November 2021.

Key points from the report include the following:

- The RFI/RI Phase 1 Work Plan for the GSA Eastern Groundwater OU, Revision 1.1, was approved by the US EPA and by the SC DHEC on September 2001.
- A field start for monitoring the OU was achieved on August 16, 2001.
- The groundwater OU includes HTF facilities, except for groundwater associated with HTF which is covered in the HTF OU. The groundwater OU also includes H-Area Retention Basin, Warner's Pond, and HP52 Ponds.
- The purpose of the Scoping Summary is to present results of the 2020 groundwater monitoring to the Core Team comprised of representatives from the US DOE, US EPA, and SCDHEC to determine if the monitoring well network and list of analytes remain appropriate. See Table 2 for a listing of monitoring wells and analytes sampled near the HTF.
- The Eastern Groundwater OU is a controlled area used for industrial purposes; the UTRA and Gordon Aquifers are not used as drinking water sources at SRS.
- There are 24 monitoring wells and 1 shallow seep line sampling point in the Eastern Groundwater OU.
- Samples were collected from all monitoring locations in 2020, except for the seepline sampling point CBS-1 because it was dry. HAA 16D was sampled for tritium in place of CBS-1 as a contingency agreed to by the Core Team in 2017. See Figure 6 for results of tritium sampling in the UTRA.

- Tritium has been detected in the GSA Eastern Groundwater OU since monitoring began in 2002, with the highest concentrations in 2002 at HGW-3D and HAA-12D at a value around 5 Bq/mL (140 pCi/mL). A spike in concentration occurred in 2012 at well HAA-12D at a value of 3.3 Bq/mL (89 pCi/mL) and then rapidly trended downward as depicted in Figure 7.[6]
- In 2020, tritium exceeded the MCL at only one well, HGW-2D, at a value of 0.88 Bq/mL (23.7 pCi/mL). HGW-2D has historically been slightly above the MCL; concentrations of tritium were stated to have remained stable to slightly decreasing over the past several years.
- Potential sources of the tritium are the Off-Site Fuels Receiving Basin facility, process sewer lines in the area, and/or the nearby H-Area Inactive Process Sewer Line (HIPSL) that transported low-level radioactive wastewater from the separations facilities to the H-Area Seepage Basins.
- In 2020, concentrations of monitored constituents were stated to have remained consistent with recent past results and continued sampling of groundwater was recommended.

Well Network	Analyte List	Field Analyte List	Sampling Frequency
UAZ of UTRA: CBS-1*, HAA-5D, HAA-9D, HAA-11D, HAA-12D, HAA-13D, HAA-14D, HAA-15D, HAA-16D**, HCB-2, HGW-2D, HGW-3D **Gordon Aquifer:** HAA-4A***, HAA-9AR, HAA-11A, HAA-12A***, HAA-13A***, HAA-14A, HAA-15A****, HAA-15AR, HGW3A ** CBS-1 will be sampled for tritium and physical parameters.* *** HAA-16D per Core Team agreement will be sampled when no sample is available at seepline piezometer CBS-1.* **** HAA-12A and HAA-13A were replaced by HAA-4A which will be sampled semi-annually..* ***** HAA-15A was replaced by HAA-15AR.*	**Select Radionuclides** • tritium • non-volatile beta activity • gross alpha activity **Select VOCs** • 1,1,1-trichloroethane • 1,1-dichloroethane • carbon tetrachloride • trichloroethylene • TCL VOCs **Select Metals** • lead • cadmium	**Field Parameters** pH, specific conductivity, temperature, turbidity, and depth to water.	Annual***

Table 2. Monitoring Well Network in the Vicinity of H-Tank Farm Facilities Monitored as Part of the Eastern Groundwater OU and List of Analytes.

[6] The concentration of tritium at well HAA-12D is currently below the MCL. Additionally, well HAA-12A located in the Gordon aquifer is the only well with measured tritium. This well is thought to have been contaminated due to downward leakage in the borehole.

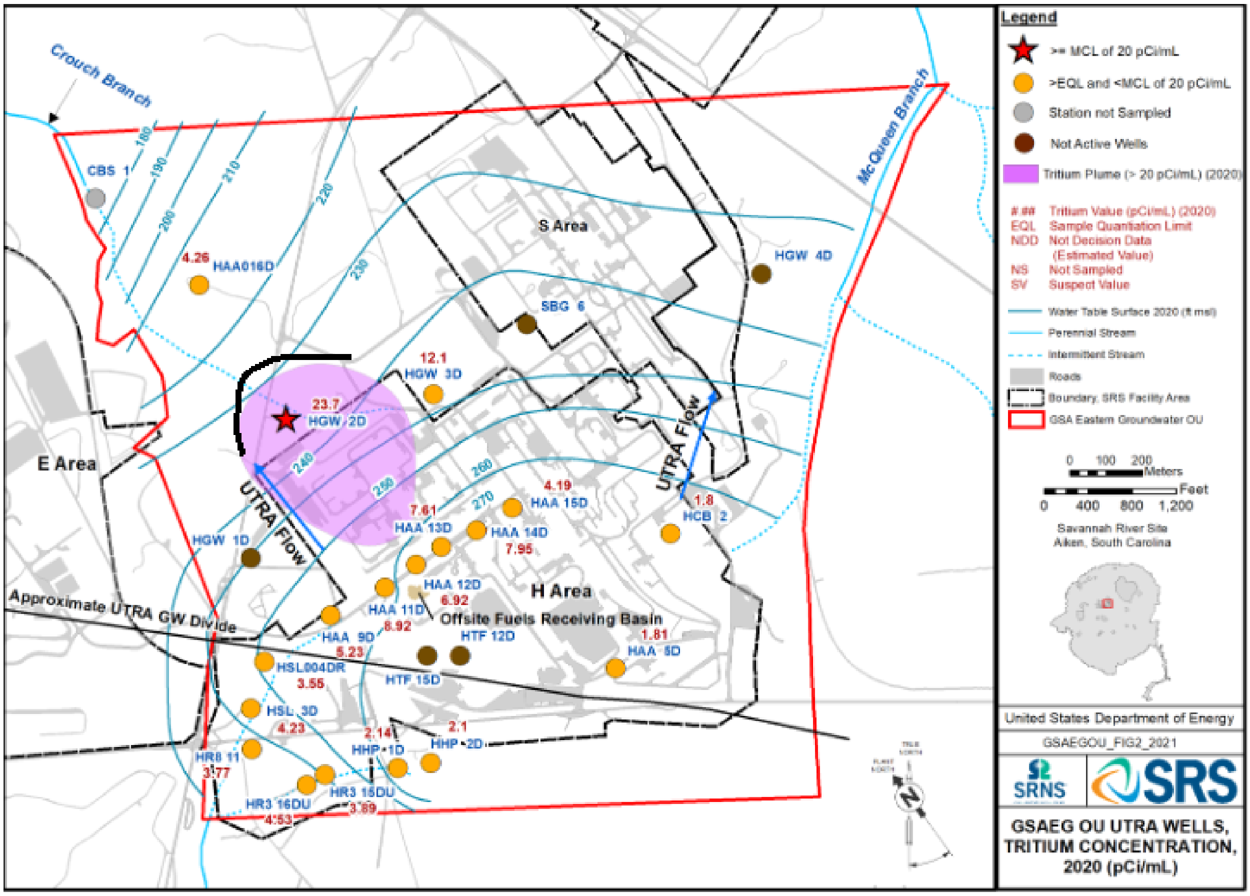

Figure 6. 2020 Tritium Concentrations in the Eastern Groundwater OU (UTRA Aquifer). Image Credit: Figure 2 in WSRC-RP-2000-4134 (November 2021).

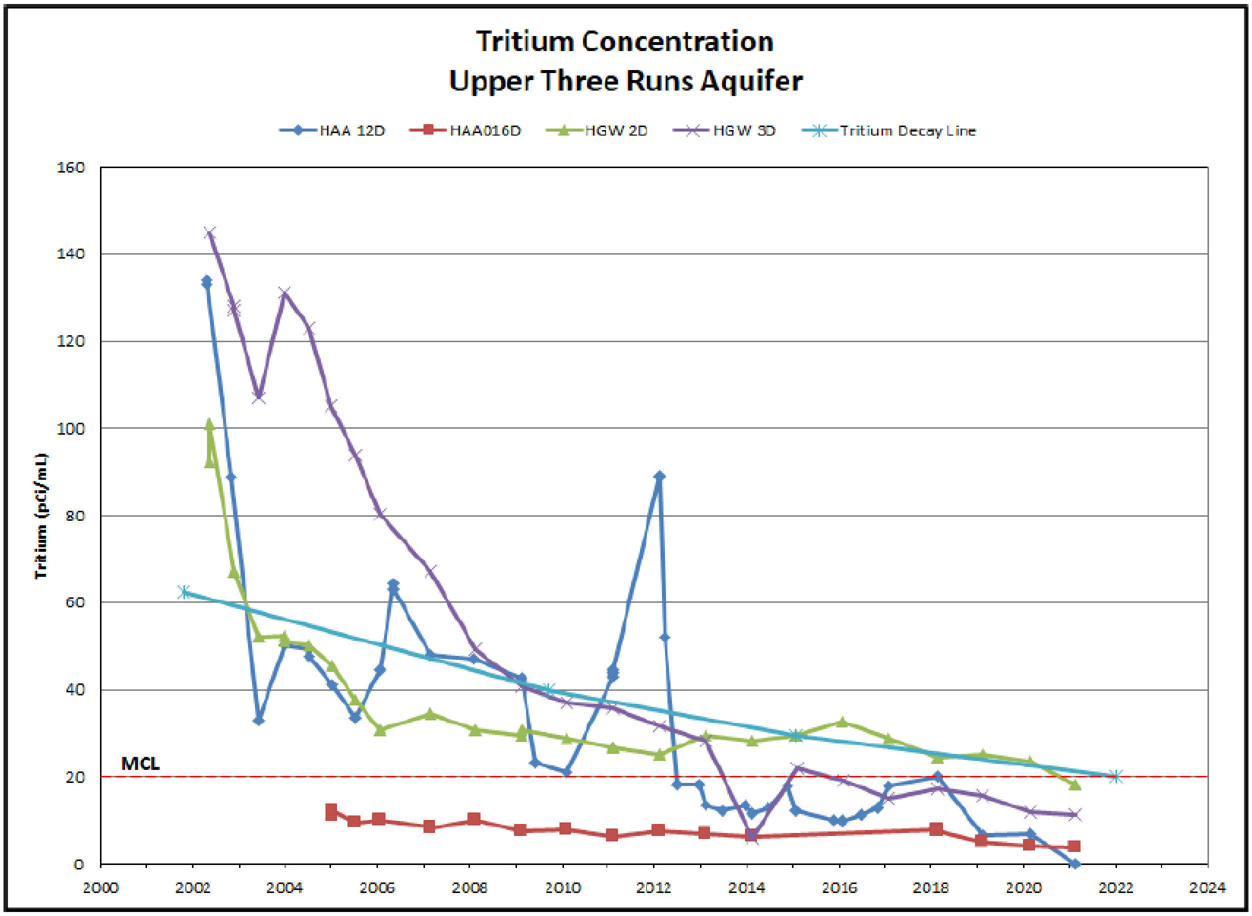

Figure 7. Tritium Trend Data for Eastern Groundwater OU Wells Screened in the UTRA. Image Credit: Figure 3 in WSRC-RP-2000-4134 (2022).

WSRC-RP-2000-4134, "Scoping Summary for the General Separations Area Eastern Groundwater Operable Unit," February 2023.

Key points from the report include the following[7]:

- Seepline sampling point CBS-1 was dry and was not sampled; HAA-16D was sampled instead (see Figure 8).
- Gordon Aquifer wells HAA-4A replaced HAA-12A and HAA-13A, and HAA-15AR replaced HAA-15; however, these wells were not sampled until the second quarter of 2022.
- Tritium has been detected in the GSA Eastern Groundwater OU since monitoring began in 2002. However, tritium was below the MCL in all wells sampled in 2021 for the first time.
- The maximum tritium concentration was 0.68 Bq/mL (18.3 pCi/mL) at well HGW-2D. See Figure 8 for results of tritium sampling in the UTRA.
- Gordon Aquifer wells have been non-detect since 1999 except for HAA-11A in 2000. The report states that HAA-11A is below detection limits in 2021 making the 2020 detection appear anomalous.

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[7] Note that key points that were made under the 2020 report published in November 2021 are not repeated.

- Detections of gross alpha and non-volatile beta below the MCLs were also measured.
- In 2021, concentrations of monitored constituents were stated to have remained consistent with recent past results and continued sampling of groundwater was recommended.

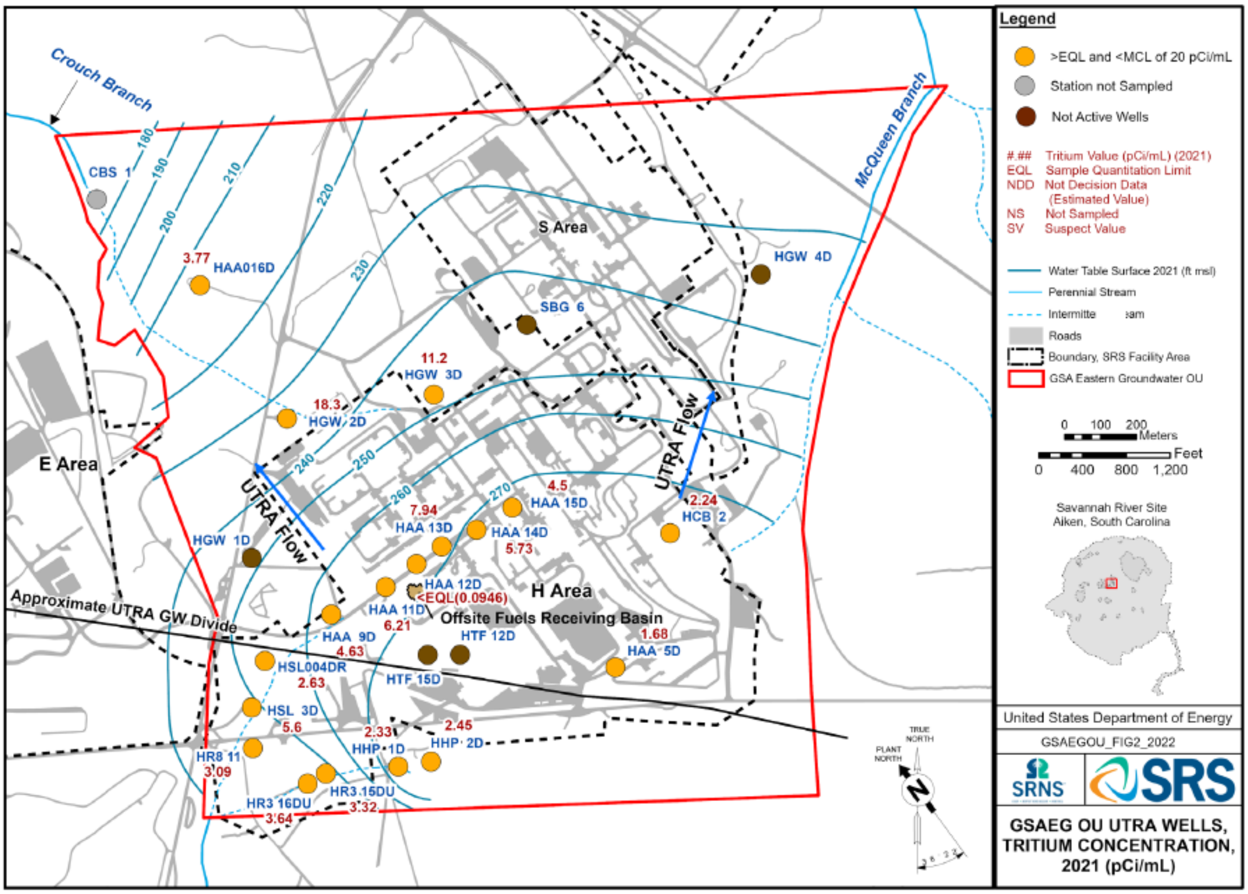

Figure 8. 2020 Tritium Concentrations (pCi/mL) in the Eastern Groundwater OU (UTRA Aquifer). Note: 1 pCi/L = 0.037 Bq/L. Image Credit: Figure 2 in WSRC-RP-2000-4134 (February 2023).

Summary of Tank Farm Monitoring Reports

2021 Annual Groundwater Monitoring Report for the F- and H-Area Radioactive Liquid Waste Tank Farms (U) SRNS-RP-2022-00076, Rev. 0, March 2022

Key points from the report include the following:

- Results from 2021 groundwater monitoring are presented in this report.
- US EPA and SC DHEC approved groundwater sampling and analysis plans for FTF and HTF in 2012.
- Precipitation rates in 2021 of 120 cm (47.43 inches) were close to the 30-year average of 123 cm (48.25 inches).
- In 2021, samples were collected in the first quarter and the third quarter of 2021 from 12 of 13 wells at FTF and 46 wells at HTF.
- The report indicated that results were similar to previous years and that there were no new releases to groundwater. Furthermore, groundwater levels and flow paths were also similar to previous years.

Results specific to FTF:

- There are 7 wells screened in the Upper Aquifer Zone (UAZ), 4 wells screened in the Lower Aquifer Zone (LAZ) and two background wells at FTF.
- In 2022, DOE installed a new well FBG-002D to monitor background conditions in the UAZ at FTF. The first sampling event was scheduled for 1Q 2022.
- The water levels were about 0.6 and 0.9 m (2 and 3 ft) above average levels for the UAZ and LAZ, respectively.
- Samples were analyzed for gross alpha, nonvolatile beta, tritium, nitrate-nitrite, cadmium, chromium, manganese, and sodium. In addition, Tc-99 was analyzed to provide information on known Tc-99 in the groundwater.
- Contingent analyses are performed if the gross beta is higher than 1.85 Bq/L (50 pCi/L) or the gross alpha is higher than 0.56 Bq/L (15 pCi/L).
- Wells FTF-28, FTF-12R, and FTF-19 exceeded the screening level for non-volatile beta. The report indicates that most of the nonvolatile beta is from Tc-99 due to the volatilization of Radon(Rn)-222 during sample preparation. Rn-222 is the parent of Bismuth(Bi)-214 and Lead(Pb)-214, which were both detected in significant concentrations during contingency analyses. Because the Tc-99 analytical method does not involve a drying step, it is common for Tc-99 results to be higher than the nonvolatile beta results.
- The report indicates that the plume extends from FTF-28 to the southwest through well FSL-11C[8] and attributes the plume to the FIPSL, although the report also acknowledges that the plume is potentially sourced by past releases from the FTF.
- A correlation is drawn between pH and nonvolatile beta concentrations in the report. For example, the pH at well FTF-28 is slightly lower than the average pH in LAZ wells (5.13 versus 5.54).
- In addition to Tc-99 being above the MCL at FTF-28 at value of 54 Bq/L (1,450 pCi/L), wells FTF-12R and FTF-19 also had Tc-99 levels above the trigger level in 2022.

[8] FSL-11C is monitored as part of the Western Groundwater OU described in the section above and is not part of the FTF monitoring well network but was included in the report for context.

- Placement of additional future wells to accurately identify the source of the nonvolatile beta/Tc-99 plume is stated to be limited by existing active utilities and operating facilities. The report goes on to state that additional well installation is not practical until closure of the FTF (including closure of the FTF HLW tanks). If contamination in the groundwater is thought to represent a threat to surface water resources, the Core Team will reconvene to determine if early response actions are required.
- Nitrate-nitrite was detected at every well at the FTF below the MCL of 10 mg/L.
- Tritium was detected at every well at the FTF below the MCL of 0.74 Bq/L (20 pCi/mL).
- Gross alpha was low (maximum was below trigger level) and consistent with previous results.

Results specific to HTF:

- There are 17 wells screened in the UAZ, 28 wells screened in the LAZ, 1 Gordon Aquifer well, and 3 background wells at HTF.
- In 2021, HTF UAZ groundwater elevations were about 0.3 m (1 ft) above average levels and LAZ wells were near average levels.
- All 46 wells were sampled in the first and third quarters of 2021, including gross alpha, nonvolatile beta, Tc-99, tritium, nitrate-nitrite, cadmium, chromium, manganese and sodium.
- No samples exceeded the gross alpha and non-volatile beta trigger levels for contingent analyses.
- Nitrate-nitrite was below the MCL of 10 mg/L in all but one sample (HAA-7B) in the third quarter at a value of 47.8 mg/L, although this value appears to be anomalous with the first quarter value being 0.08 mg/L and with concentrations historically being less than 1 mg/L at HAA-7B.
- Tritium was detected in most samples at HTF but only one well was above the MCL at a value of 1.3 Bq/mL (35 pCi/mL). Tritium has been historically elevated at the HAA-12 well cluster as described in the Eastern Groundwater OU section above. The source of the HAA-12 tritium plume is thought to be the Off-Site Fuels Receiving Basin facility, the numerous process sewer lines, and the HIPSL that transported low-level radioactive wastewater from the separations facilities to the H-Area Seepage Basins.
- In 2021, gross alpha and nonvolatile beta were below the screening level in every sample.

2022 Annual Groundwater Monitoring Report for the F- and H-Area Radioactive Liquid Waste Tank Farms (U) SRNS-RP-2022-01106, Rev. 0, March 2023

Key points from the report include the following[9]:

- Precipitation rates in 2022 of 106 cm (41.63 inches) were close to the 30-year average at HTF of 119 cm (46.73 inches), but below average precipitation rates for SRS.
- In 2022, samples were collected in the first quarter and the third quarter of 2022 from 12 of 13 wells at FTF and 46 wells at HTF.
- The report indicated that results were similar to previous years and that there were no new releases to groundwater. Furthermore, groundwater levels and flow paths were also similar to previous years.

[9] Note that key points that were made under the 2021 report published in March 2022 are not repeated.

Results specific to FTF:

- The report indicates that although there was an increasing water level in the 2012 to 2020 timeframe and water levels were near average levels in 2022, in the area of background well FBG-001D, the water table was thin.
- FBG-002D was installed in the first quarter of 2022 and was sampled in the third quarter; FBG-002D is located on the south side of the groundwater divide where water flows to Fourmile Branch and the water table exists in the UAZ. In contrast, the water table surface quickly dips below the tan clay into the LAZ as groundwater flows away from the groundwater divide.
- The FTF groundwater elevation is at 67 m (221 ft) msl (UAZ) and 64 m (211 ft) msl (LAZ) on average. In 2022, FTF groundwater levels were within 0.3 m (1 ft) of average levels (and LAZ elevations were 0.3 m (1 ft) above average levels).
- In 2022, FTF-28 and FTF-19 exceeded the screening level for non-volatile beta. Because well FTF-12R has historically been above the screening level, FTF-12R samples were also analyzed for Tc-99 in the first quarter of 2022, although nonvolatile beta concentrations were below the screening level. See Figure 9 for a figure depicting the non-volatile beta plume at FTF.
- Nitrate/nitrite was detected at every well at the FTF below the MCL. The maximum nitrate concentration was 6.41 mg/L at LAZ background well FBG-001C.
- Tritium was detected at every well at the FTF, but below the MCL. The maximum tritium concentration was 65 Bq/L (1750 pCi/L) at well FTF-28.
- The maximum gross alpha occurred at well FTF-23 at a value of 0.34 Bq/L (9.21 pCi/L), which is below the screening level for contingent analysis.
- A nonvolatile beta plume continues to be associated with the FIPSL and wells FTF-28 near the FTF and FSL-11C further downgradient of FTF.
- The basis for the association of the FIPSL with the nonvolatile beta plume at FTF-28 is the relatively low pH of 5.05 at this well versus the average pH of 5.61 for LAZ wells at FTF.
- Another possible source of the nonvolatile beta plume is from historical releases at FTF.
- The report indicates that placement of new wells to identify the source of the plume is limited by existing active utilities, ongoing operations, and tank closure activities.
- The report indicates that new well locations are not practical until tank farm closure activities are complete, unless there is a threat to surface water in which case the Core Team will reconvene to determine follow-up activities.
- Contingency analyses were performed for FTF-28, FTF-19, and FTF-12R. The only constituents detected above the SQL (sample quantitation limit) were Bi-214, Pb-214, Ra-226, and Tc-99. However, the daughter products of Rn-222, Bi-214 and Pb-214, would not be present in the non-volatile beta due to volatilization of the Rn-222 during the processing of the sample. Therefore, the non-volatile beta is thought to be a result of Tc-99.
- Tc-99 has previously been greater than the MCL in well FTF-28. In 2022, Tc-99 levels were similar to 2021 with a maximum of 51 Bq/L (1,380 pCi/L) at FTF-28. Concentration trends for Tc-99 and nonvolatile beta in well FTF-28 are provided in Figure 12 of the report, which show a slowly increasing trend over the last 11 years.
- The maximum Tc-99 concentrations at wells FTF-19 and FTF-12R were 12.5 Bq/L (339 pCi/L), which was “J qualified” or estimated, and 1.6 Bq/L (43.4 pCi/L), respectively. Tc-99 was also measured at FTF-30 but was not detected.
- In 2022, I-129 was detected at FTF 12R. I-129 has been detected at FTF-12R in the past, however the 2022 result (0.03 Bq/L or 0.827 pCi/L) was “J” qualified because it

was below the SQL. I-129 has previously been detected at three wells (FTF-19, FTF-28, and FTF-12R) but is predominantly below detection limits. Detection level is near the MCL of 0.037 Bq/g (1 pCi/g). Historically, I-129 is sometimes just above or just below the detection limit.

Results specific to HTF:

- At the HTF, average groundwater elevations for the UAZ and LAZ are approximately 269 ft (82 m) and 252 ft (77 m) above mean sea level (amsl), respectively. In 2022, HTF UAZ and LAZ groundwater elevations were approximately 0.3 m (1 ft) below average levels.
- In 2022, all 46 HTF monitoring wells were sampled in the first and third calendar quarters. As required by the SAP, samples were analyzed for gross alpha, nonvolatile beta, Tc-99, tritium, nitrate-nitrite, cadmium, chromium, manganese, and sodium.
- Tritium was detectable in most of the samples from the HTF wells but was only above the MCL in one well. HAA-12C measured tritium greater than the MCL with a maximum result of 1.3 Bq/mL (35.3 pCi/mL). As reported in the HTF SAP, tritium has been detected at the HTF up to 13 Bq/mL (355 pCi/mL) at HTF-12 in 1986. Well cluster HAA-12 is downgradient of the HTF and has a history of elevated tritium.
- In 2022, nonvolatile beta was below the screening level in every sample except for one. The first quarter result of 4 Bq/L (110 pCi/L) was "J" qualified at HAA-15C and exceeded the screening level and triggered additional analysis to confirm the exceedance and analyze for specific radionuclides.
- The additional sampling was performed in May 2022 and resulted in a nonvolatile beta concentration of 0.21 Bq/L (5.75 pCi/L). The only constituents detected above the SQL in contingent analyses were naturally occurring radionuclides Bi-214 and Pb-214.
- Tc-99 was non-detect in all but 10 out of 107 samples in 2022. All of those results were low with a maximum result of 1.7 Bq/L (47 pCi/L), which is significantly below the MCL at well HAA-12B.

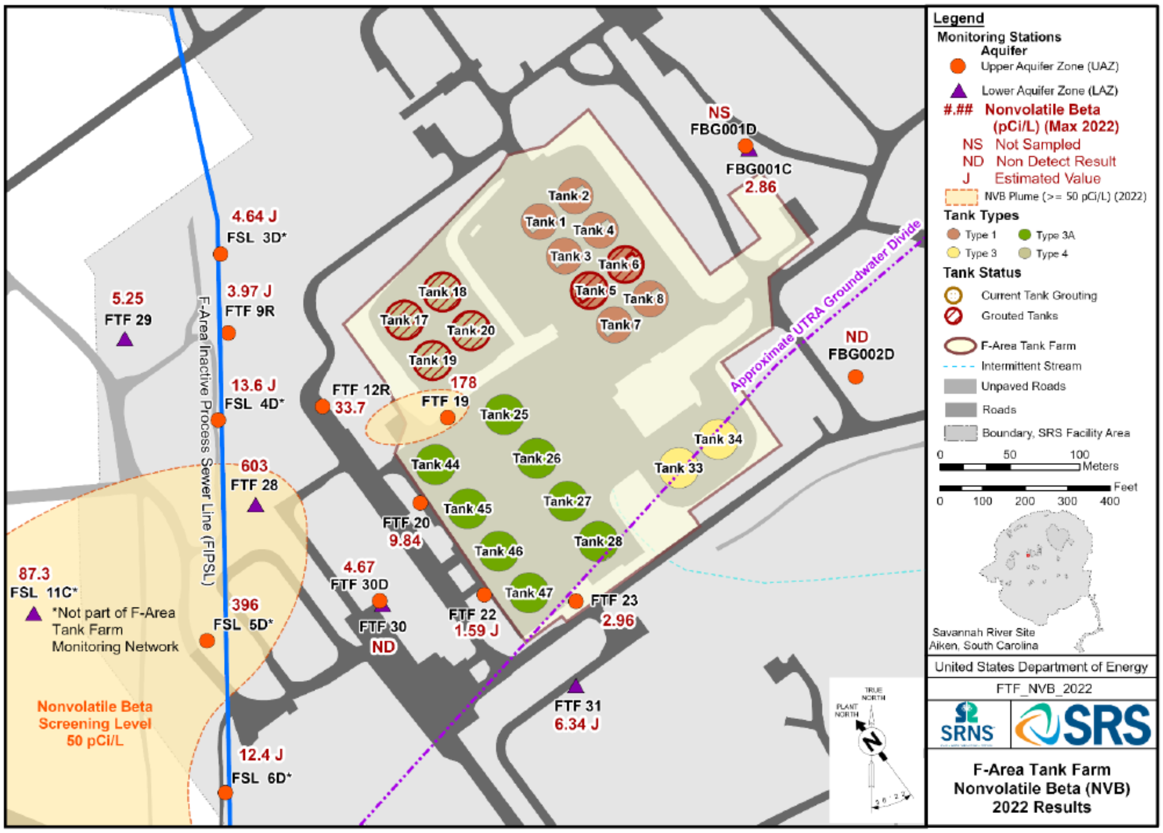

Figure 9 2022 Nonvolatile Beta Results (pCi/L) for the FTF (1 pCi/L = 0.037 Bq/L). Image Credit: Figure 10 SRNS-RP-2022-01106.

<u>Evaluation of Environmental Monitoring Reports</u>

The SRS environmental report noted that NRC did not conduct any onsite observation visits for FTF and HTF in 2021. In fact, tank farm closure activities have decreased in recent years. Due to an expected increase in tank farm activities in the coming years; however, NRC expects to increase its onsite monitoring of the SRS FTF and HTF in the coming years. With regard to air and water sampling results reported in the environmental report, the concentrations are consistent with historical trends. Furthermore, calculated doses are estimated to be less than 0.01 mSv/yr (1 mrem/yr). NRC staff thinks current doses from SRS activities, including FTF and HTF activities, are low. Nonetheless, historical releases from the tank farm facilities provide useful information that NRC staff can use to evaluate contaminant fate and transport mechanisms to support its review of DOE NDAA disposal activities at the SRS.

With regard to the FTF and HTF specific monitoring reports, the results of the 2020-2022 environmental and groundwater modeling are similar to previous results reviewed by NRC in TRRs issued on May 14, 2021, December 17, 2019, April 20, 2018, and March 31, 2015, ADAMS Accession Nos. ML21119A312, ML19280A059, ML18051B154, and ML12272A124).

NRC would note that the pH in LAZ wells at FTF appears lower in recent years. Because DOE relies on the relatively low pH at FTF-28, compared to other LAZ wells, as the basis for assuming the source of the nonvolatile beta/Tc-99 plume was from acidic releases from the FIPSL, further evaluation of the cause for the variability in pH at other LAZ wells such as background well FGB-1C and FTF-31 would be informative. Figure 10 below shows the hydrogen ion concentration at FTF-28 falls between wells FTF-31 and FGB-1C (which have relatively high hydrogen ion concentration and lower pH) and FTF-29 and FTF-30 (which have relatively low hydrogen ion concentration or higher pH). In particular, the pH at well FTF-29 appears anomalously high (or hydrogen ion concentration anomalously low). As evidenced in Figure 10, there does appear to be a strong correlation between pH and non-volatile beta (or Tc-99) concentration. A more extensive evaluation of historical trends in pH is provided in ML19280A059 and is not repeated here.

Additionally, because particle tracking results shows the potential for historic Tank 8F releases to intersect FTF-28, NRC staff continues to think that the source of the non-volatile beta plume could be from historical tank farm releases (ML19280A059)[10]. Furthermore, a non-volatile beta plume near FTF-19 (and historically at FTF-12R) are not associated with low pH and the FIPSL; however, no information is provided on the source of the elevated non-volatile beta and Tc-99 concentrations at those wells.

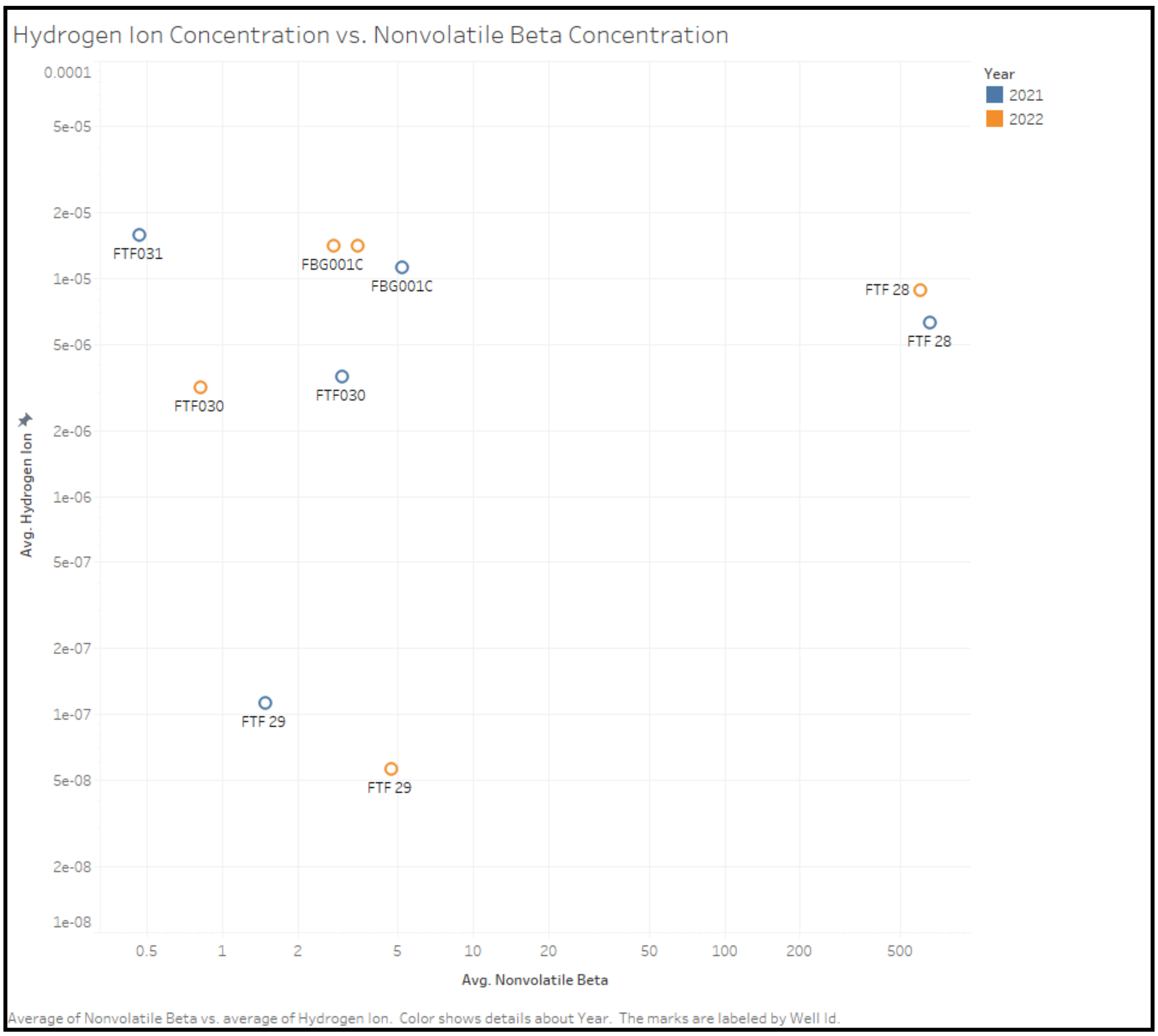

Figure 10 Hydrogen Ion Concentration Versus Non-Volatile Beta Concentration

[10] ML19280A059 also shows that releases from the FIPSL are not expected to be transported vertically into the LAZ for significant distances downgradient of the FIPSL, while FTF-28 is located slightly upgradient to the FIPSL. Therefore, the mechanism for contaminant transport of FIPSL releases to the FTF-28 LAZ well is unclear.

In previous TRRs, NRC staff also found that the vertical placement of wells at the FTF and HTF did not appear to be informed by the PA modeling (ML12272A124 and ML18051B154).Updated GSA PORFLOW modeling conducted in 2018 should be used to inform the vertical (and horizontal) placement of news wells constructed in the future, or a stronger basis provided to support the sufficiency of the monitoring well network to detect releases from the tank farm facilities.

Previous staff conclusions related to review of the environmental monitoring reports remain valid and include the following (only conclusions relevant to this TRR are listed; other conclusions in previous TRRs also remain valid such as those listed in ML21119A312):

1. DOE has performed environmental monitoring that provides useful information on the hydrogeological systems at FTF and HTF. This information can also be used to better understand contaminant flow and transport at the TFFs and provide support for DOE PA models, particularly the updated 2018 GSA PORFLOW model. Modeling and monitoring should be conducted iteratively as information is collected to help reduce hydrogeological uncertainties.
2. Significant uncertainty in the source of contaminant plumes detected via the FTF and HTF monitoring well networks exists. A better understanding of contaminant flow and transport processes at the TFFs through more extensive data analysis, modeling, and conceptual model development would provide additional confidence in modeling results. For example, geochemical data could be evaluated to develop spatial and temporal correlations, evaluate trends, and identify sources. Additional particle tracking simulations could be conducted to help identify the source of contaminant plumes and validate observed versus modeled travel times.
3. PA modeling and groundwater monitoring at the TFFs could be better integrated. PA modeling could be used to determine key constituents and the types of field monitoring data, which would provide the most useful information to evaluate performance of, and detect early releases from, the TFFs. Data from the monitoring program could be used to evaluate model performance and help develop conceptual models for contaminant flow and transport.
4. The latest GSA groundwater model should be used to establish the monitoring well network, particularly to inform vertical placement of wells when such opportunities for additions or other changes to the monitoring well network exist in the future.

Part II: Summary and Evaluation of Colloid Study

This technical review is associated with MF 4.1, "Natural Attenuation of Key Radionuclides," listed in the NRC's combined F- and H- Tank Farm Facility monitoring plan (ADAMS Accession No. ML15238A761). MF 4.1 is focused on NRC staff review of studies that provide information on key radionuclide mobility in the natural system to provide support for key assumptions in DOE's PA important to DOE's compliance demonstration for the TFFs. One report was provided on colloid-facilitated transport of actinides in cementitious material impacted groundwaters.

Summary

SRNL-STI-2022-00169, Rev. 0, "Colloid-Facilitated Actinide Transport in a Cementitious-Impacted SRS Groundwater, Savannah River National Laboratory, Savannah River Site: Aiken, SC. April 2022.

The purpose of this brief report (SRNL-STI-2022-000169) was to evaluate whether colloids could significantly affect the mobilization and transport of plutonium (Pu) in an SRS groundwater system chemically impacted by cementitious materials. The author concludes that colloidal transport enhancement is highly unlikely and that, therefore, Pu transport in such a groundwater system can be conceived as involving only a dissolved phase and an immobile sorbed phase.

The report asserts that "Pu that leaves the engineered system and resides in the subsurface environment will be in colloidal form…." Previous SRS laboratory studies on chemical effects on colloid dispersion are then cited to support the conclusion that the net effect of the higher-pH and higher-ionic strength aqueous chemical conditions imposed by cementitious materials will be to destabilize colloids.

Column studies of colloid mobility in SRS soils were then cited showing that cementitious-impacted water can mobilize soil colloids as the front moves through the soil, but that colloids do not remain stable behind the front. Colloid mobilization is essentially a transient effect at the chemical front. The results of another column study suggested that SRS soils effectively filter out organic matter colloids.

The report then listed studies in which colloid-facilitated Pu transport was observed in the field (in Nevada, Russia, and SRS), noting that Pu concentrations were well below drinking water standards and that circumstances in each case were not relevant to cementitious-impacted SRS groundwater. Next the report focused on observations of colloid-associated Pu in groundwaters (not affected by cementitious materials) impacted by the F-Area Seepage Basin at SRS going back to 1994—again at concentrations orders of magnitude below the drinking water standard. The report noted that, despite the low concentrations, the studies did point to the potential for Pu transport in the SRS subsurface environment. Also discussed were interesting observations of temporal "dynamic shifts in Pu speciation, colloid association, and transport in groundwater on both seasonal and decadal time scales and over shorter field spatial scales than commonly believed."

The report then summarized these observations to support the conclusion that colloids will not mobilize Pu in cementitious-impacted groundwater and that, therefore, Pu transport can be assumed to involve only (i) mobile dissolved and (ii) immobile solid-associated phases.

Evaluation

While the NRC staff views the lines of reasoning in the report as generally sound, we believe the conclusions may understate the potential complexity of Pu groundwater transport at SRS. One of the report's key references of SRS work on Pu colloid associations, Buesseler et al. (2009), assembles data that imply complex, variable Pu transport behavior at SRS. The authors observed temporal (possibly episodic) and spatial variations in Pu speciation and colloid association that they attributed both to changes in groundwater-imposed conditions such as pH and oxidation-reduction potential, and to source-dependent factors such as the potential importance of in situ Pu-240 generation from Cm-244 decay. The latter process, Buesseler et al. state, "accounts for 99.5% of the dissolved or colloidal Pu in groundwater away from the seepage basins." A key conclusion of Buesseler et al. (2009) is "The results show that Pu geochemistry is more dynamic and less kinetically hindered than commonly believed" and that reactive transport models that include these factors may be necessary to fully understand Pu groundwater behavior.

It is acknowledged that Buesseler et al. (2009) and other SRS studies that observed relatively distant colloidal Pu transport did not involve groundwater systems impacted by cementitious material degradation. The colloid destabilizing effect of high-ionic strength solutions is well established. Nevertheless, evaluations of colloidal Pu mobility in such systems need to consider the spatial and temporal persistence of cementitious influence on groundwater, as well as the potential for source-dependent effects such as Cm-244 decay generation—which, for example could affect Pu at distances at which cementitious material impacts are muted.

The NRC staff also acknowledge that SRS observations of Pu transport to date have involved concentrations well below drinking water standards. Nevertheless, projecting Pu behavior in the post-tank closure setting needs to consider the complexity of Pu geochemical behavior, including a potential mobile oxidized Pu fraction that may not be captured in batch sorption experiments, as has been discussed in previous NRC reports (e.g., ML21119A317 and ML21231A204).

Key findings include the following:

- The complexity of Pu geochemical behavior and groundwater transport leads to uncertainty in PA modeling predictions. Colloid associations and redox behavior of Pu can be transient and episodic along groundwater transport pathways.
- Evidence of more mobile, oxidized forms of Pu in the subsurface exists and should be further evaluated in PA models and the potential risk assessed.

Other References

Buesseler, K.O., D.I. Kaplan, M. Dai, and S. Pike. “Source-dependent and Source-independent Controls on Plutonium Oxidation State and Colloid Associations in Groundwater.” *Environmental Science and Technology* Vol. 43, pp 1322-1328. 2009.

ML12272A124. Barr, C.S. et al., “Technical Review of Environmental Monitoring Reports Prepared by DOE for Tank Farms.” U.S. NRC: Rockville, Maryland. March 2015.

ML18051B154. “Technical Review of Environmental Monitoring Reports for F-Area and H-Area Tank Farm Facilities.” U.S. NRC: Rockville, Maryland. April 2018.

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ML21231A204. Barr, C.S. et al. “Technical Review of Documents Related to Type I and II Tanks Special Analysis at the H-Area Tank Farm at Savannah River Site.” Rockville, U.S. NRC: Rockville, Maryland. August 2021.

Technical Review of Environmental Monitoring Reports F and H Tank Farm Facilities at Savannah River Site DATE September 27, 2023

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