UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 17, 2019

MEMORANDUM TO: Stephen S. Koenick, Acting Chief
Low Level Waste Projects Branch
Division of Decommissioning, Uranium Recovery
and Waste Programs

THRU: Christepher McKenney, Chief
Risk and Technical Analysis Branch
Division of Decommissioning, Uranium Recovery
and Waste Programs

FROM: Cynthia Barr, Senior Risk Analyst
Risk and Technical Analysis Branch
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and Waste Programs

SUBJECT: TECHNICAL REVIEW OF ENVIRONMENTAL MONITORING REPORTS FOR F-AREA AND H-AREA TANK FARM FACILITY FACILITIES (DOCKET NO. PROJ0734)

The U.S. Nuclear Regulatory Commission (NRC) has performed a technical review of a collection of related documents prepared by the U.S. Department of Energy (DOE) that provide information about recent groundwater monitoring. This technical review report is an update to two previous reports on the same topic dated April 20, 2018 and March 31, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML12272A124 and ML18051B154) with the former reports evaluating the F-Area Tank Farm (FTF) facility and H-Area Tank Farm (HTF) facility monitoring well networks. Monitoring is performed on the General Separations Area (GSA) of the Savannah River Site in Aiken, SC. This technical review is associated with Monitoring Factors 4.1, "Natural Attenuation of Key Radionuclides," and 4.3, "Environmental Monitoring," listed in the NRC's combined F-Area and H-Area Tank Farm monitoring plan entitled "U.S. Nuclear Regulatory Commission Plan for Monitoring Disposal Actions Taken by the U.S. Department of Energy 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.

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The NRC staff has performed technical reviews of environmental monitoring reports prepared by the DOE to support FTF and HTF closure at SRS. Based upon its review of the environmental monitoring reports, the NRC staff concludes the following:

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 tank farm facilities (TFFs) and provide support for DOE Performance Assessment (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 better understand 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.
5. Additional work is needed to better understand the significance of the observed mobile fraction of Plutonium (Pu) in the natural system.
6. DOE should justify its Pu K_d averaging approach, or explicitly model the various oxidation states of key radionuclides such as Pu in future PA documentation, because explicitly modeling the more mobile fraction of Pu could lead to risk-significant dose significantly earlier in time compared to the current modeling approach.

In this report, there is no significant change to the NRC staff overall conclusions from the NRC Technical Evaluation Report (TER) for the FTF dated October 2011 (ADAMS Accession No. ML112371751) or the NRC TER for the HTF dated June 2014 (ADAMS Accession No. ML14094A496) regarding compliance of the DOE disposal actions with the requirements of the performance objectives in 10 CFR Part 61, Subpart C. NRC staff will continue to monitor DOE activities in this area under MFs 4.1, “Natural Attenuation of Key Radionuclides,” and 4.3, “Environmental Monitoring” under NRC staff’s Tank Farms Monitoring Plan (ADAMS Accession No. ML15238A761).

Enclosure:
Technical Review of Environmental Monitoring Reports for FTF and HTF

SUBJECT: TECHNICAL REVIEW OF ENVIRONMENTAL MONITORING REPORTS FOR F-AREA AND H-AREA TANK FARM FACILITY FACILITIES (DOCKET NO. PROJ0734) **DATE: December 17, 2019**

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Technical Review of Environmental Monitoring Reports for F-Area and H-Area Tank Farm Facilities

Date: December 17, 2019

Technical Reviewers:

Cynthia Barr, Senior Risk Analyst,
U.S. Nuclear Regulatory Commission

George Alexander, Risk Analyst
U.S. Nuclear Regulatory Commission

Primary Documents Reviewed:

1. ML19094B756, *2017 Annual Groundwater Monitoring Report for the F- and H-Area Radioactive Liquid Waste Tank Farms*, SRNS-RP-2018-00226, Rev. 0, March 2018.
2. ML19094B251, *2018 Annual Groundwater Monitoring Report for the F- and H-Area Radioactive Liquid Waste Tank Farms*, SRNS-RP-2019-00097, Rev. 0, March 2019.
3. ML19318F627, *Scoping Summary for the General Separations Area Western Groundwater Operable Unit*, ERD-EN-2005-0127, Rev. 0, October 2018.
4. ML19318F629, *Scoping Summary for the Eastern Separations Area Groundwater Operable Unit*, WSRC-RP-2000-4134, Rev. 0, October 2018.
5. ML19352D941, *Scoping Summary for the General Separations Area Western Groundwater Operable Unit*, ERD-EN-2005-0127, Rev. 0, October 2019.
6. ML19346D756, *Scoping Summary for the Eastern Separations Area Groundwater Operable Unit*, WSRC-RP-2000-4134, Rev. 0, October 2019.
7. ML18067A486, *Determination of Constituent Concentrations in Field Lysimeter Effluents*, SRRA021685-000008, Clemson University under contract with Savannah River Remediation, Aiken, SC, December 2017.
8. ML18067A509, *Analysis of Plutonium Soil Concentrations in Field Lysimeter Experiments*, SRRA021685-000009 Clemson University under contract with Savannah River Remediation, Aiken, SC, December 2017.
9. ML19179A062, *Analysis of Plutonium Soil Concentrations in Field Lysimeter Experiments*: Soil Pu Concentration Profile from a $NH_4Pu(V)O_2CO_3(s)$ Source, SRRA021685-000010, Clemson University under contract with Savannah River Remediation, Aiken, SC, October 2018.
10. ML19179A047, *Determination of Constituent Concentrations in Field Lysimeter Effluents*, SRRA021685-000011, Clemson University under contract with Savannah River Remediation, Aiken, SC, October 2018.

<u>Summaries</u>:

Department of Energy (DOE) collected groundwater monitoring data in 2017 and 2018 and produced reports in 2018 and 2019 detailing the results of the monitoring. The monitoring well network was based on plans approved by the United States Environmental Protection Agency (EPA) and the South Carolina Department of Health and Environmental Control (SCDHEC) in December 2012. The approved F-Area Tank Farm Groundwater Sampling and Analysis Plan and the H-Area Tank Farm Groundwater Monitoring Plan and Sampling and Analysis Plan provide specific details of the groundwater monitoring programs. During scoping for the sampling and analysis plans, gaps in the existing well coverage were identified by DOE, SC

DHEC and EPA. Subsequently, new wells were installed at agreed upon locations at both the F-Area Tank Farm Facility (FTF) and H-Area Tank Farm Facility (HTF) to address as many data gaps as possible. DOE indicates that placement of additional wells is currently limited by existing active utilities and operating facilities, and additional well installation will not be possible until closure of the FTF and HTF (SRNS-RP-2019-00097).

2017 and 2018 Tank Farm Monitoring Reports at FTF (Primary Documents 1 and 2)

During 2018, SRS recorded 72.06 inches (in.) (1.8 meters [m]) of precipitation as measured at the H-Area weather station[1]. This amount of precipitation was greater than the 30-year average (49 in/yr or 1.2 m/yr) and is considered above normal rainfall for SRS (precipitation was greatest in the 3rd and 4th quarters and is expected to be reflected in the water table elevations in the early 2019). Overall, the 2018 monitoring results show no indications of new contaminant releases to groundwater. Water level measurements and flow paths were similar to those from past years. DOE SRS would like to discuss an alternate location for the installation of an Upper Three Runs Aquifer (UTRA) Upper Aquifer Zone (UAZ) background well with SC DHEC and EPA, because this well has been dry and workers have been unable to sample the well as a result (SRNS-RP-2019-00097).

The groundwater monitoring plan for the FTF includes sampling twice per year of a network of thirteen monitoring wells, including seven wells installed in 2012. The well network is located around the downgradient perimeter of the FTF and includes wells screened in the UAZ (7) and Lower Aquifer Zone (LAZ) (4) and two background wells (UAZ and LAZ)[2]. In 2017 and 2018, SRS collected samples during the first and third quarters for 12 of 13 wells (one UAZ background well [FGB 1D] was dry) at the FTF.

As required by the sampling and analysis plan and based on prominent radionuclides and/or historical data, samples are analyzed for gross alpha, nonvolatile beta, tritium, nitrate, nitrite, cadmium, chromium, manganese, and sodium. In addition, technetium-99 was analyzed to provide information on known technetium-99 in the groundwater. Trigger levels for contingent analysis of specific radionuclides are 15 picocuries per liter (pCi/L) (0.56 Bq/L) for gross alpha and 50 pCi/L (2 Bq/L) for nonvolatile beta. Wells FTF 28 and FTF 12R exceeded a screening trigger level (nonvolatile beta) for all samples collected and contingency analyses were performed (Figure 1 shows the locations of these FTF wells).

Contingency analyses were conducted for wells FTF 28 (LAZ) and FTF 12R (UAZ) based on the results for nonvolatile beta which surpassed the trigger level of 50 pCi/L (2 Bq/L). Levels at FTF 28 ranged from 300 to 1000 pCi/L (11 to 37 Bq/L). Although lower than the values at FTF 28, in these last several years, nonvolatile beta has increased in FTF 12R. DOE associates the elevated nonvolatile beta at FTF 28 and FTF 12R, as well as other wells downgradient from

[1] During 2017, 55 inches (1.4 m) of precipitation were measured, which was also stated to be greater than the 30-year average of 47 inches (1.2 m) per year. NRC staff note that DOE contractors reported a 30-year average of 49 inches (1.2 m/yr) in the 2018 monitoring report. The groundwater elevations for the UAZ and LAZ are approximately 221 and 210 feet above mean sea level (msl) (66 and 63 m above msl) at FTF, respectively. These elevations are about 1 and 3 feet (0.2 and 0.9 m) above normal levels, respectively. At HTF, the groundwater elevations for the UAZ and LAZ are approximately 270 and 252 feet above mean sea level, which are about 1 foot above normal levels.

[2] SRS wells are set in three aquifer zones. The “A” wells are set in the GAU. The “B” and “C” wells are set in the LAZ and the “D” wells are in the UAZ of the UTRA.

these wells, with releases from the F-Area Inactive Process Sewer Line (FIPSL) partially due to what it considers elevated acidity at FTF 28, which serves as a chemical signature of releases from the FIPSL (i.e., acidic wastewater was released from the collapsed section of the FIPSL near well FTF 28). Isotopic analyses performed on samples from FTF 28 and FTF 12R identified technetium-99 as the primary source of nonvolatile beta. The 2018 maximum concentration of technetium-99 at FTF 28 was 1,510 pCi/L (56 Bq/L) and exceeded the maximum contaminant level (MCL) of 900 pCi/L[3] (33 Bq/L). DOE indicates that it is not uncommon for technetium-99 to be higher than nonvolatile beta because technetium-99 can be volatilized during the drying step in the nonvolatile beta analytical method (whereas the technetium-99 analytical method does not have the drying step).

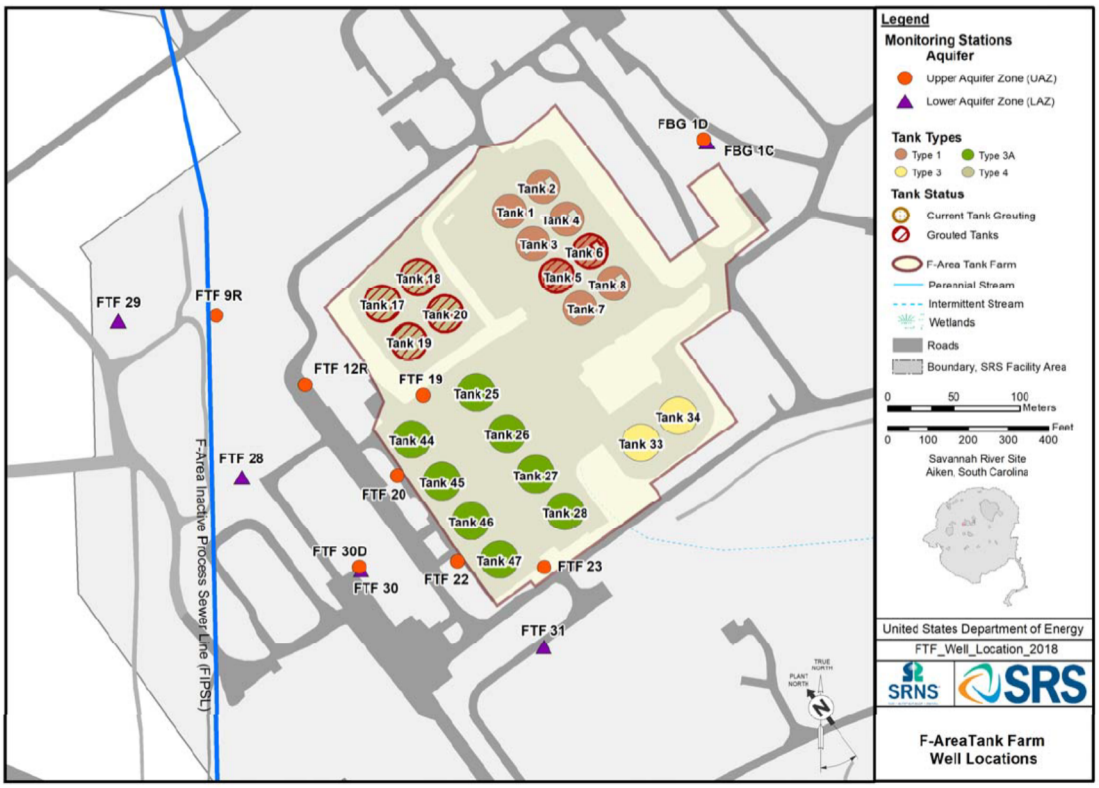

Figure 1. FTF Monitoring Well Network. Image Credit: Figure 7, SRNS-RP-2019-00097, Revision 0

Tritium had previously been detected above the MCL at FTF 30D (in 2017) at a value of 105 pCi/mL (4 Bq/mL) but was less than the MCL in 2018 at a value of 1 pCi/ml (0.037 Bq/ml). Upgradient of FTF 30D, FTF 20, FTF 22, and FTF 19 were also impacted by tritium below the MCL. No information was provided about the source of the tritium plume.

Overall, the monitoring results are similar to those from previous years. Laboratory results indicate low concentrations of nitrate-nitrite, nonvolatile beta, and tritium in most wells, consistent with past results. In addition, manganese and sodium, which are naturally occurring in aquifer sediments at SRS, were also detected in nearly every well.

[3] The maximum technetium-99 concentration in 2017 was slightly higher at 1670 pCi/L.

FY2017 Western Groundwater Operable Unit (Primary Documents 3 and 5)

Data from the Western Groundwater Operable Unit include some data from FTF monitoring wells, as well as data from other wells downgradient from FTF. NRC staff focuses on the monitoring results of the so-called "South plume" that is potentially sourced by the tank farm. During 2017 and 2018, groundwater samples were collected from 13 wells in the "South plume" of the western groundwater operable unit. The "South plume" to the southwest of FTF consists primarily of tritium and nonvolatile beta constituents (see Figures 2 and 3). Specific radionuclides that have been present above MCLs include iodine-129, strontium-90, radium-226, technetium-99, and tritium. DOE contractors think the source of the elevated radioactivity is from the FIPSL. A collapsed section of the vitrified clay FIPSL is located downgradient of the FTF. DOE contractors indicate that sampling locations near the collapsed section of the FIPSL are not accessible at this time due to interferences with power lines and active steam lines.

According to ERD-EN-2005-0127 (2018 and 2019), nonvolatile beta was the most widespread contaminant detected in 2017 and 2018. In 2017, it was present at levels exceeding 50 pCi/L (2 Bq/L) in five of the thirteen wells with concentrations ranging from 77.3 pCi/L (2.9 Bq/L) (FSL 11C) to 419 pCi/L (15.5 Bq/L) (FTF 28). In 2018, it was present at levels exceeding 50 pCi/L (2 Bq/L) in six of the thirteen wells with concentrations ranging from 50.6 pCi/L (1.9 Bq/L) (FSL 11C) to 582 pCi/L (21.5 Bq/L) (FTF 28). Historically, the elevated concentrations have been detected in the area of wells FTF 28 and FSL 5D near the FIPSL collapsed section, and also at downgradient well FGW 12C (Figure 2).

In addition to nonvolatile beta activity, ERD-EN-2005-0127 (2018 and 2019) indicates that a few wells near the FIPSL have exceeded the MCL for iodine-129, nitrate, strontium-90, radium-226, technetium-99, and tritium. In 2017, all of these analytes exceeded the MCL in at least one well with maximum concentrations as follows: iodine-129 (16.2 pCi/L or 0.6 Bq/L), nitrate (11.5 mg/L), radium-226 (5.95 pCi/L or 0.22 Bq/L), strontium-90 (53.9 pCi/L or 2 Bq/L), technetium-99 (1050 pCi/L or 39 Bq/L), and tritium (72.3 pCi/mL or 2.7 Bq/L). In 2018, all of these analytes exceeded the MCL in at least one well with maximum concentrations as follows: iodine-129 (74 pCi/L or 2.7Bq/L), nitrate (11.3 mg/L), radium-226 (5.1 pCi/L or 0.19 Bq/L), strontium-90 (40.8 pCi/L or 1.5 Bq/L), technetium-99 (1200 pCi/L or 44 Bq/L), and tritium (71 pCi/mL or 2.6 Bq/L). The maximum concentrations occurred in wells along or near the FIPSL, except for nitrate and tritium which were highest at downgradient well FGW 12C. Although I-129 was significantly elevated at FSL 6D in 2018 compared to previous results, ERD-EN-2005-0127 (2019) reports that the most recent result in 2019 is back down and similar to the 2017 result.

DOE indicates that overall, the 2017 and 2018 data indicate that the plume remains stable with respect to extent and concentrations.

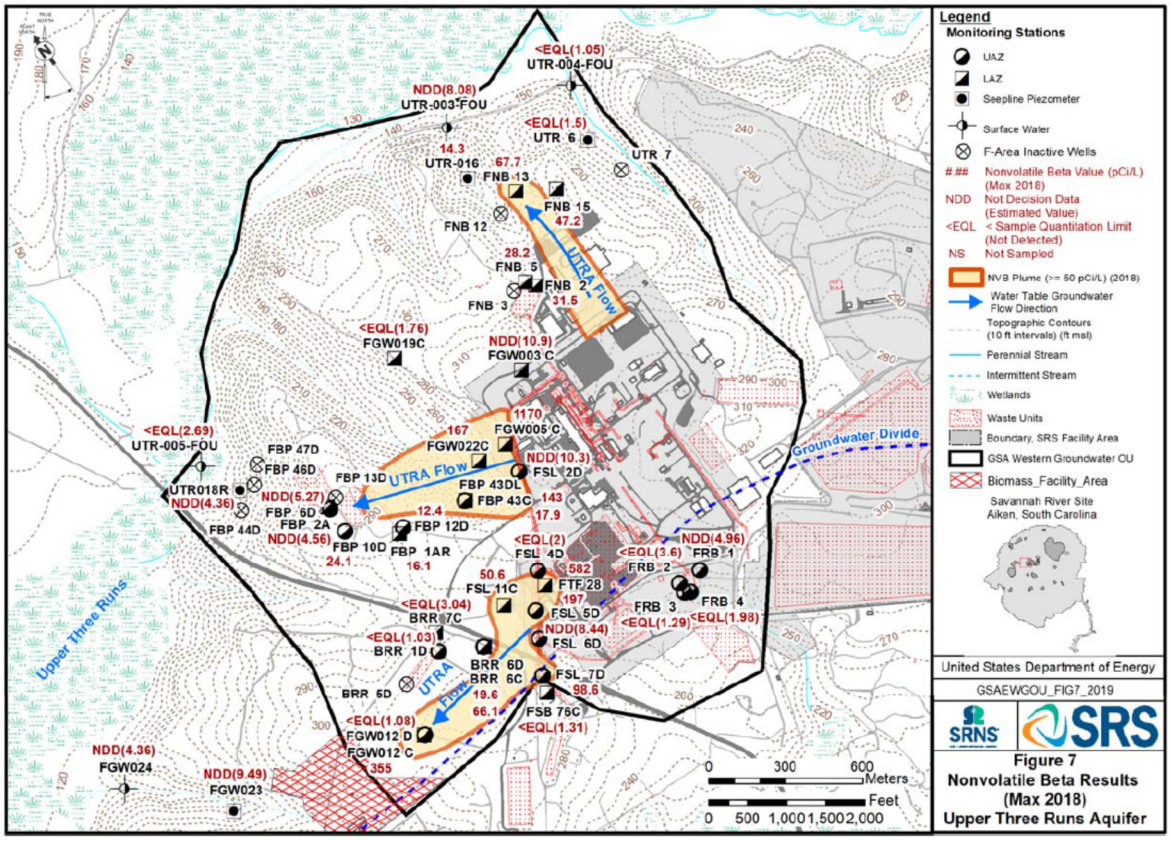

Figure 2. Nonvolatile Beta Results (pCi/L) Max in 2018 in the UTRA. Figure Credit: Figure 7 in ERDN-EN-2005-0127 (2019).
Conversion: 1 pCi/L=0.037 Bq/L.

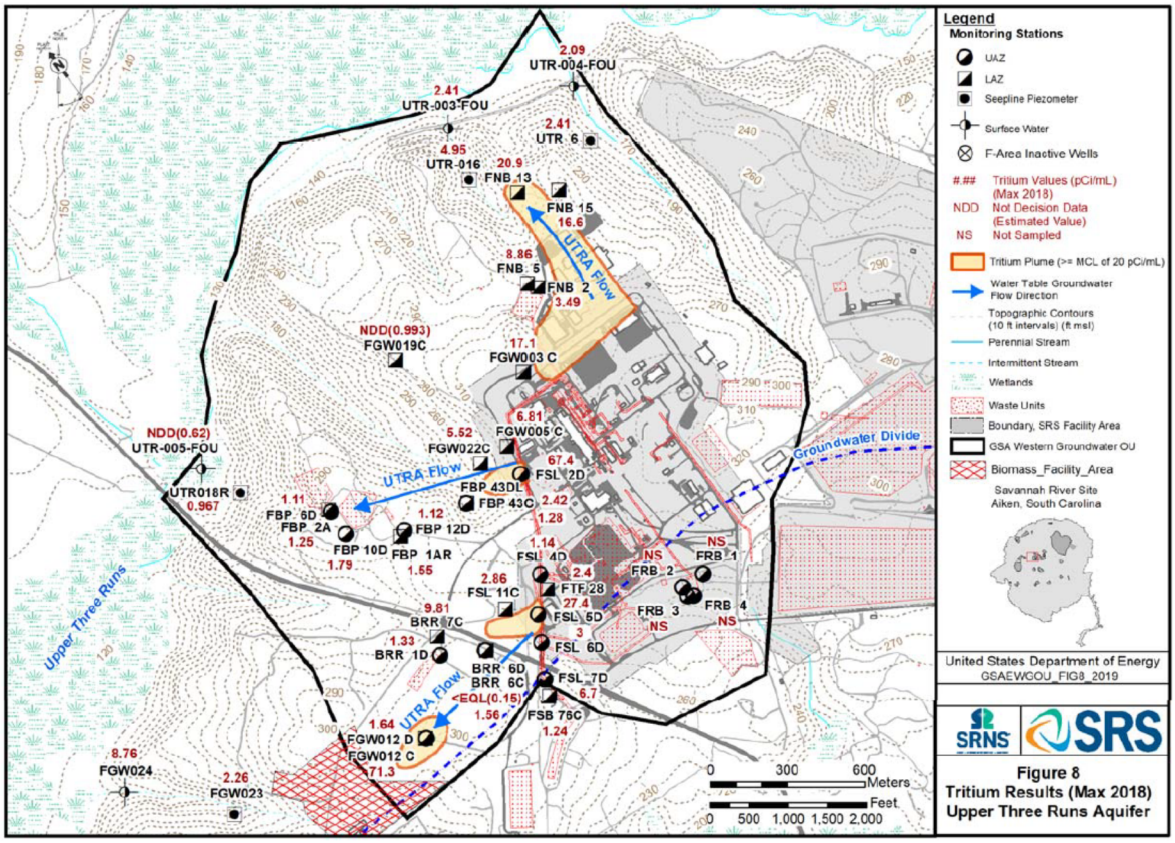

Figure 3. Tritium Results (pCi/mL) Max in 2018 UTRA. Figure Credit: Figure 8 in ERD-EN-2005-0127 (2019).
Conversion: 1 pCi/mL=0.037 Bq/mL.

2017 and 2018 Tank Farm Monitoring Reports at HTF (Primary Documents 1 and 2)

The groundwater monitoring plan for the HTF includes sampling twice per year at a network of 46 monitoring wells. The well network is located around the downgradient perimeter of the HTF and consists of wells screened in the UAZ (17), LAZ (28), and Gordon Aquifer Unit (GAU) (1) including three background wells. In 2017 and 2018, all 46 HTF monitoring wells were sampled in the first and third calendar quarters.

As required by the sampling and analysis plan, and based again on prominent radionuclides and/or historical data, samples were analyzed for the same analytes at FTF: gross alpha, nonvolatile beta, tritium, nitrate-nitrite, cadmium, chromium, manganese, and sodium. Additionally, wells were sampled for technetium-99. The same trigger levels for gross measurements (i.e., alpha and nonvolatile beta) used for FTF also apply to HTF. In 2018, no results exceeded the trigger levels at HTF.

DOE indicates that tritium has been identified as the prevalent groundwater contaminant at the HTF based on historical monitoring. A small dilute tritium plume is located north of the HTF and has been regularly monitored since 2000. The plume is located near and downgradient of the Off-Site Fuels Receiving Basin facility and the H-Area Inactive Process Sewer Line (HIPSL), both listed by DOE as potential sources of historical tritium releases. At well cluster HAA 12, tritium exceeded the MCL in both the UAZ and the LAZ wells in 2018 (and exceeded the MCL in

the LAZ in 2017). Compared to recent years, concentrations were steady at HAA 12D and decreasing at HAA 12C.

In 2018, nitrate-nitrite exceeded the MCL at one well (HAA 4D) during the first quarter but was below the MCL again in the third quarter sample. The remaining nitrate-nitrite results at the HTF were low and similar to previous years. Manganese also exceeded its regional screening level (RSL) at one well (HAA 10D) during the first quarter of 2018 but was below the RSL again in the third quarter sample.

FY2017 Eastern Groundwater Operable Unit (OU) (Primary Documents 4 and 6)

The Eastern Groundwater Operable Unit includes data on some HTF wells, as well as data from wells located downgradient of HTF. Tritium has been detected in the GSA Eastern Groundwater OU since monitoring began in 2002 (see Figures 4 and 5). In 2017, the maximum tritium concentration was 28.9 pCi/milliliter (mL) (1 Bq/mL) at well HGW 2D. In 2018, the maximum tritium concentration was 24 pCi/mL (0.90 Bq/mL) at well HGW 2D. Tritium has historically been present in relatively high concentrations in well HAA 12D, located within the center of the H-Area facilities (see Figures 4 and 5). Potential sources of the tritium are the Off-Site Fuels Receiving Basin facility (244-H), the numerous process sewer lines in the area, and/or the nearby HIPSL that transported low-level radioactive wastewater from the separations facilities to the H-Area Seepage Basins.

In 2017 and 2018, tritium was detectable in only two of the seven GAU monitoring wells. In 2017 and 2018, tritium was below the MCL in all wells in the GAU except HAA 12A in 2017 (see Figure 6). The maximum concentration was 23.1 pCi/mL(0.85 pCi/mL) at well HAA 12A in 2017 and 8.5 pCi/ml (0.31 pCi/mL) in 2018. SRS believes the presence of tritium in the GAU may be due to downward leakage along the well bore from the overlying UAZ and is working to abandon and replace HAA 12A. Tritium has been present above the MCL at wells HAA 12D and HAA 12C in the overlying aquifers. Note that well HAA 12C is monitored for the H-Area Tank Farm groundwater OU.

At the seepline of Crouch Branch, a sample was collected in 2017 with a tritium concentration of 2.56 pCi/mL. Since monitoring began in 2002, the Crouch Branch piezometer has a history of very low tritium concentrations. The piezometer is less than five feet deep and has often not produced enough water for a sufficient sample. The "Core Team"[4] agreed during the October 2017 meeting to sample well HAA 16D when CBS-1 is dry. In 2018, HAA 16D was sampled (CBS-1 was dry) with a result of 7.5 pCi/mL (0.31 pCi/mL).

In 2017, nonvolatile beta was measured greater than 50 pCi/L (2 Bq/L) at wells HAA 12A, HAA 13A and HAA 15A (63.9 pCi/L [2.4 Bq/L], 51.9 pCi/L [1.9 Bq/L] and 99.1 pCi/L [3.7 Bq/L], respectively). In 2018, nonvolatile beta was also measured greater than 50 pCi/L (2 Bq/L) at wells HAA 12A, HAA 13A and HAA 15A (26.1 pCi/L [0.97 Bq/L], 65.5 pCi/L [2.4 Bq/L] and 74.7 pCi/L [2.8 Bq/L], respectively). The pH has been elevated at these three wells for many years, in some instances since installation. DOE contractors indicate that measurements of pH at these wells usually range from 10 to 13.7 and are significantly higher than normal aquifer conditions. The elevated pH along with other elevated parameters (specific conductance, calcium, and potassium), appear to be associated with intrusion of grout into the well screen zone. SRS believes these wells are no longer providing a sample that is representative of conditions in the GAU and is working to abandon and replace these wells. All other wells in the

[4] The "Core Team" consists of regulatory agencies, including SC DHEC and EPA; and DOE.

GAU are non-detect for nonvolatile beta.

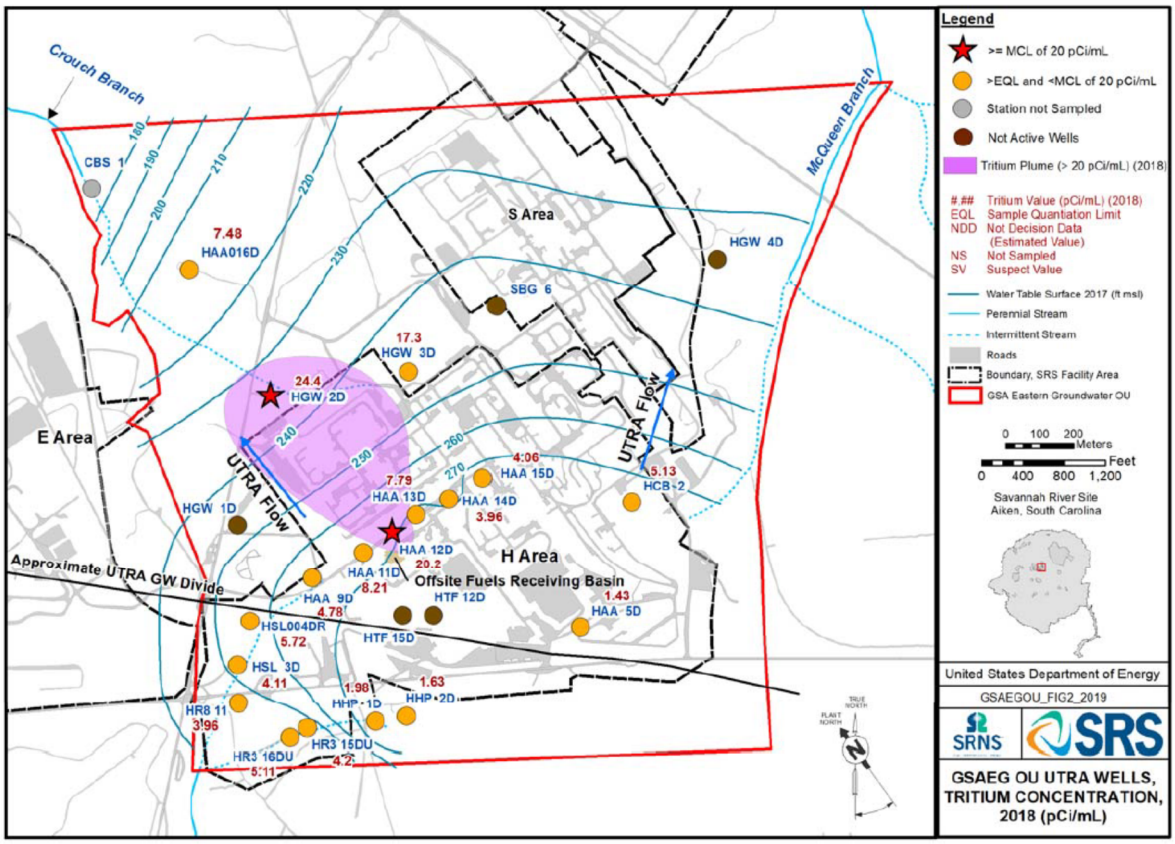

Figure 4. 2018 Tritium Concentrations pCi/mL in GSA Eastern Groundwater OU Upper Three Runs Aquifer. Image Credit: Figure 2, WSRC-RP-2000-4134 (2019). Conversion: 1 pCi/mL=0.037 Bq/mL.

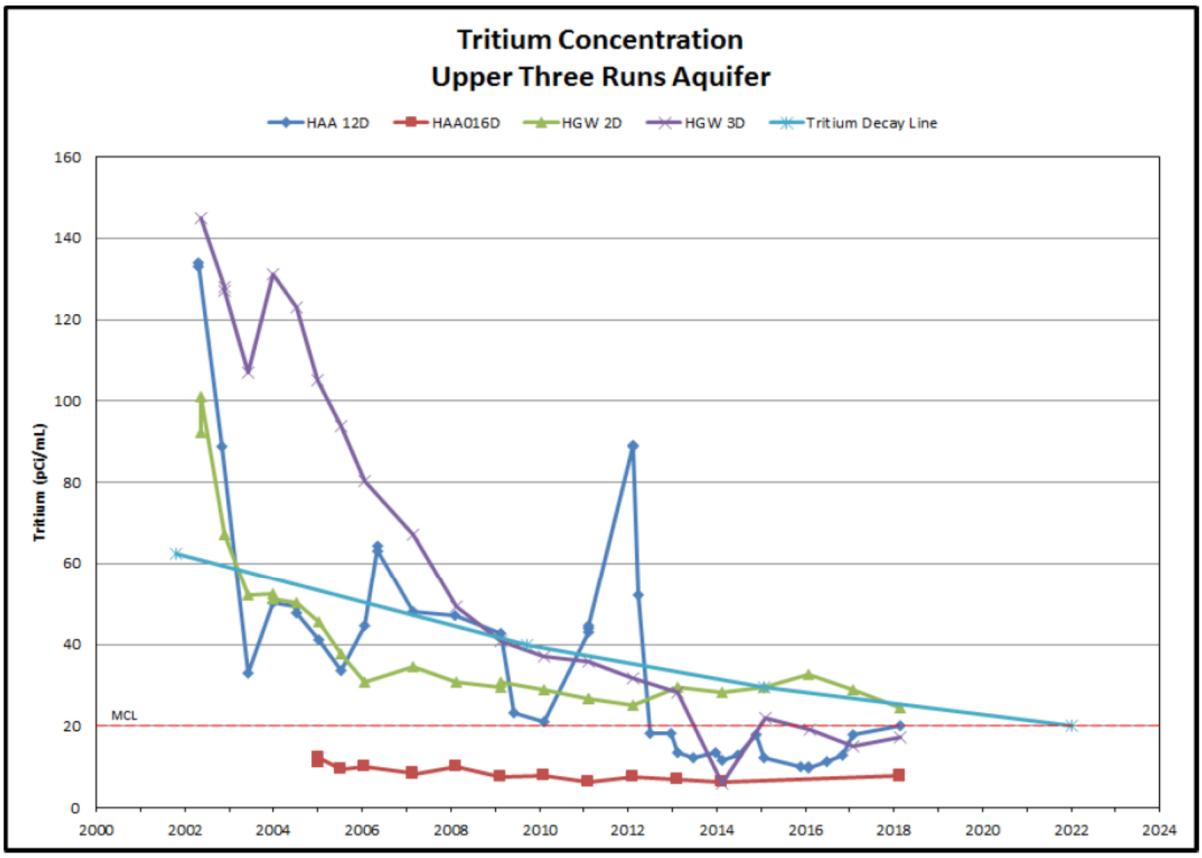

Figure 5. 2018 Tritium Concentrations pCi/mL in GSA Eastern Groundwater OU Gordon Aquifer. Image Credit: Figure 3, WSRC-RP-2000-4134 (2019).
Conversion: 1 pCi/mL=0.037 Bq/mL.

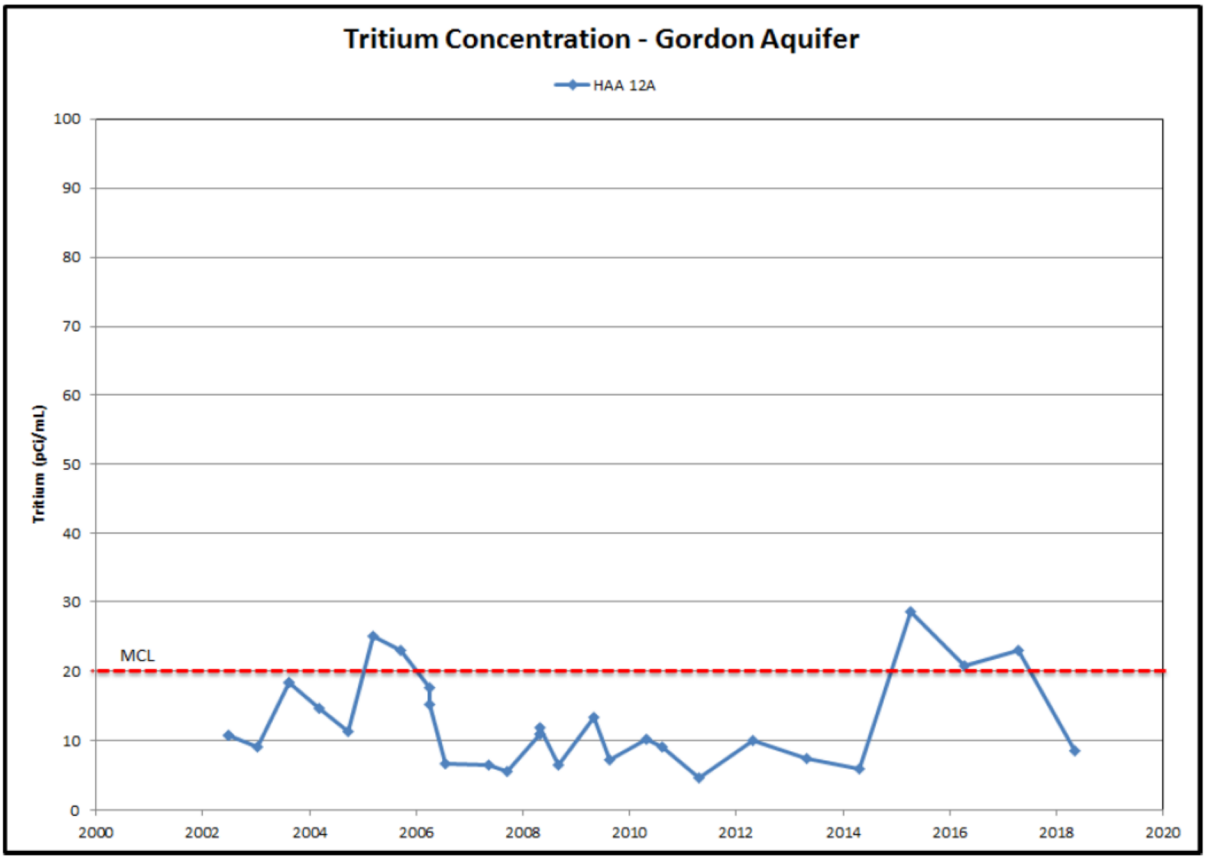

Figure 6 Time Series Tritium Concentrations in GSA Eastern Groundwater OU Gordon Aquifer Well HAA12A. Image Credit: Figure 5, WSRC-RP-2000-4134 (2019).

Lysimeter Studies (Primary Documents 7 through 10)

DOE reported effluent measurements from a series of lysimeters at the Radionuclide Field Lysimeter Experiments facility (RadFLEx) at SRS that began in May of 2012 and is anticipated to span a ten-year period (SRRA021685-000008; SRRA021685-000011). The lysimeters contained SRS vadose zone soils in addition to the source materials, which consisted of either homogeneous (oxide or solution deposited) or cementitious sources. The lysimeters are described in more detail in Tables 1.1 and 1.2 of SRRA021685-000011. The lysimeters were exposed to rainfall and field conditions and effluent was collected periodically as reported in Table 2.1 of SRRA021685-000011. The effluents were analyzed for plutonium and neptunium by inductively coupled plasma mass spectroscopy (ICP-MS). None of the 18 plutonium-containing lysimeters had plutonium concentrations above the detection limit of 1 x 10^{-12} moles (mol)/L. However, the researchers developed an ultra low-level analysis to evaluate lower concentrations of plutonium. These ultra low-level analyses were conducted for three sampling events from 13 lysimeters. Plutonium was observed for 6 lysimeters at concentrations ranging from 9 x 10^{-13} mol/L to 1 x 10^{-15} mol/L. The researchers noted that small quantities of mobile plutonium appeared to have migrated through the lysimeters. The researchers also discussed that future measurements will attempt to determine the oxidation state of the mobile plutonium phase. Lysimeters 29-32 contained neptunium (IV) or neptunium (V) with effluent concentrations of neptunium observed for lysimeters 29, 30, and 32. Neptunium concentrations in the effluent for lysimeters 29 and 30, which contained neptunium (V) corresponded to 3% and 32% of the initial source activity. Neptunium was also observed in the effluent for lysimeter 32,

which contained neptunium (IV) as NpO_2(s). The researchers noted that this implied that the neptunium (IV) is being oxidized to neptunium (V), which can then transport through the lysimeter with a relatively low K_d. Results of an analysis of the solid phase concentration of neptunium for lysimeters 29 and 31 along the column has also recently been reported.

DOE also analyzed the cores from lysimeters 41 and 44, which were 2- and 3.4-years old containing Pu(V)$NH_4(CO_3)$(s) and PuO_2(s) sources, respectively, from SRS, RadFLEx facility (SRRA021685-000009; SRRA021685-000010). The cores were segmented into either 50 or 60 sections of approximately 1 cm thick. The concentration of Pu was then determined for each section by ICP-MS. The researchers observed both upward and downward Pu migration in the lysimeters. The upward migration in both of these lysimeters was less than previous experiments that had been conducted for a longer period of time. The downward migration of plutonium was greater for both of these lysimeters compared to previous experiments conducted with $PuCl_3$, $Pu(NO_3)_4$, and $Pu(C_2O_4)_2$. The researchers hypothesized that differences in initial chemical and physical states of the Pu source materials resulted in differences in solubility and therefore migration behavior. The researchers also conducted Pu-desorption experiments on the soils and observed distribution coefficients with log K values of 3.2 +/- 0.2 mL/g for the lysimeter containing Pu(V)$NH_4(CO_3)$(s) and 4.4 +/- 0.3 mL/g for the lysimeter containing PuO_2(s). The authors concluded that there were either no colloids present in the samples or that the colloids were strongly sorbing to the soil as there was no apparent difference between unfiltered and filtered samples.

NRC Staff Evaluation:

FTF Monitoring

NRC staff had previously evaluated the tank farms annual monitoring report and concluded that the source of interpreted groundwater plumes (i.e., technetium-99 plume emanating from FTF 12R and FTF 28 downgradient towards Upper Three Runs Creek) at FTF and HTF were uncertain. The source of the technetium-99 plume present at FTF 12R and FTF 28 was originally thought by DOE contractors to be associated with a release of high-level waste from Tank 8 at FTF but was later thought to be associated with collapse of a section of process piping from F Canyon (the F-Area Inactive Process Sewer Line or FIPSL) based on proximity to the FIPSL and the relatively low pH of water samples extracted from FTF 28[5]. Given the close lateral distance of FTF 28 to the FIPSL and upgradient distance to FTF 12R (and relatively high pH at FTF 12R) it was unclear to NRC staff that the FIPSL was the source of the technetium-99 in these wells. In fact, FTF 28 is screened at an elevation of about 152 ft (46 m), while the water table surface is about 221 ft (66 m). The technetium-99 would have had to travel approximately 70 ft (21 m) vertically to reach the FTF 28 well screen, while the FTF 28 well location is only approximately 80 ft (25 m) upgradient from the FIPSL. The technetium-99 plume downgradient of FTF is also associated with well FTF 12R screened about 200 ft (60 m) above mean sea level, while the water table is also about 221 ft (66 m) at that location. Although FTF 12R is located in the UAZ and is closer to the water table surface, FTF 12R is approximately 250 ft (75 m) upgradient of the FIPSL. While leakage from the collapsed FIPSL could have spread laterally in the vadose zone prior to flow and transport following the saturated zone gradient, the conceptual model for flow and transport of contamination from the FIPSL to FTF 28 (and FTF 12R) could be more fully developed and supported by both monitoring data and contaminant fate and transport modeling.

[5] NRC would note that although FTF 12R was also associated with the FIPSL release, the pH at FTF 12R is significantly higher than the pH at FTF 28 and other FTF wells.

As stated in previous staff technical review reports (ADAMS Accession Nos. ML12272A124 and ML18051B154), backwards particle tracking could be informative with respect to identifying the most likely source of tank farm plumes, as well as providing useful information on the ability of the GSA PORFLOW models to detect releases from the tank farm facilities. NRC staff repeated its recommendation for DOE to conduct backwards particle tracking to evaluate the source of the technetium-99 plume at FTF 28 and FTF 12R and/or perform forward particle tracking from locations of known residual radioactivity in the vadose zone from the FIPSL collapse to support assumptions regarding the nature and extent of the technetium-99 plume (ADAMS Accession Nos. ML18311A184 and ML19143A084). Following the March 2019 OOV, DOE provided forwards particle tracking from the FIPSL and Tank 8, as well as backwards particle tracking from FTF 28 and FTF 12R. The results of the particle tracking are provided in Figure 7. Figure 7 illustrates that particle tracks released from the vicinity of the FIPSL travel through the UAZ and TCCZ for quite some distance downgradient of the FIPSL prior to transport into the LAZ and do not come close to intersecting the FTF 28 well screen located upgradient of the FIPSL and deep in the UTRA. Radioactivity from the FIPSL could have been spread laterally upgradient of the FIPSL in the vadose and traveled deeper in the aquifer than depicted in Figure 7 and dispersion could have also led to increased vertical spreading of the plume. However, it appears unlikely that radioactivity from the FIPSL could have migrated to FTF 28 through natural groundwater flow and transport based on particle tracking simulations produced from the current GSA 2018 flow model. Furthermore, Figure 7 shows that releases from Tank 8 would eventually intersect the top of the FTF 28 well screen.

As stated above, the conceptual model for flow and contaminant transport from the FIPSL to saturated groundwater is unclear making it difficult to interpret monitoring well data from the Western Groundwater OU. For example, Figure 2 depicts data associated with the non-volatile beta plume in the Western Groundwater OU. The shape of the “southern plume” suggests the possibility of two plumes sourced from two different locations. Because FSL 6D, BRR 1D, and BRR 5D had no detectable concentration of non-volatile beta, the plume is drawn around these wells to accommodate the monitoring result leading to a jog in the plume trajectory. Similarly, Figure 3 shows tritium results for the Western Groundwater OU. Two plumes are depicted near the FIPSL collapse (and wells FTF 28, FTF 12R, and FSL 6D) and then downgradient of the FIPSL collapse (near wells FGW 012D and FGW 12C) with no contamination depicted between the two sets of wells. Furthermore, the highest concentrations are associated with the downgradient wells for the tritium plume, while the highest concentrations are associated with wells closer to the FIPSL for the non-volatile beta/technetium-99 plume. Sorption of technetium-99 in the saturated zone is minimal and therefore, transport rates for technetium-99 should be similar to transport rates for tritium. Information about travel times could also be assessed based on a review of the data for these mobile constituents, if a complete time history and coherent conceptual model for contaminant release and transport were available.

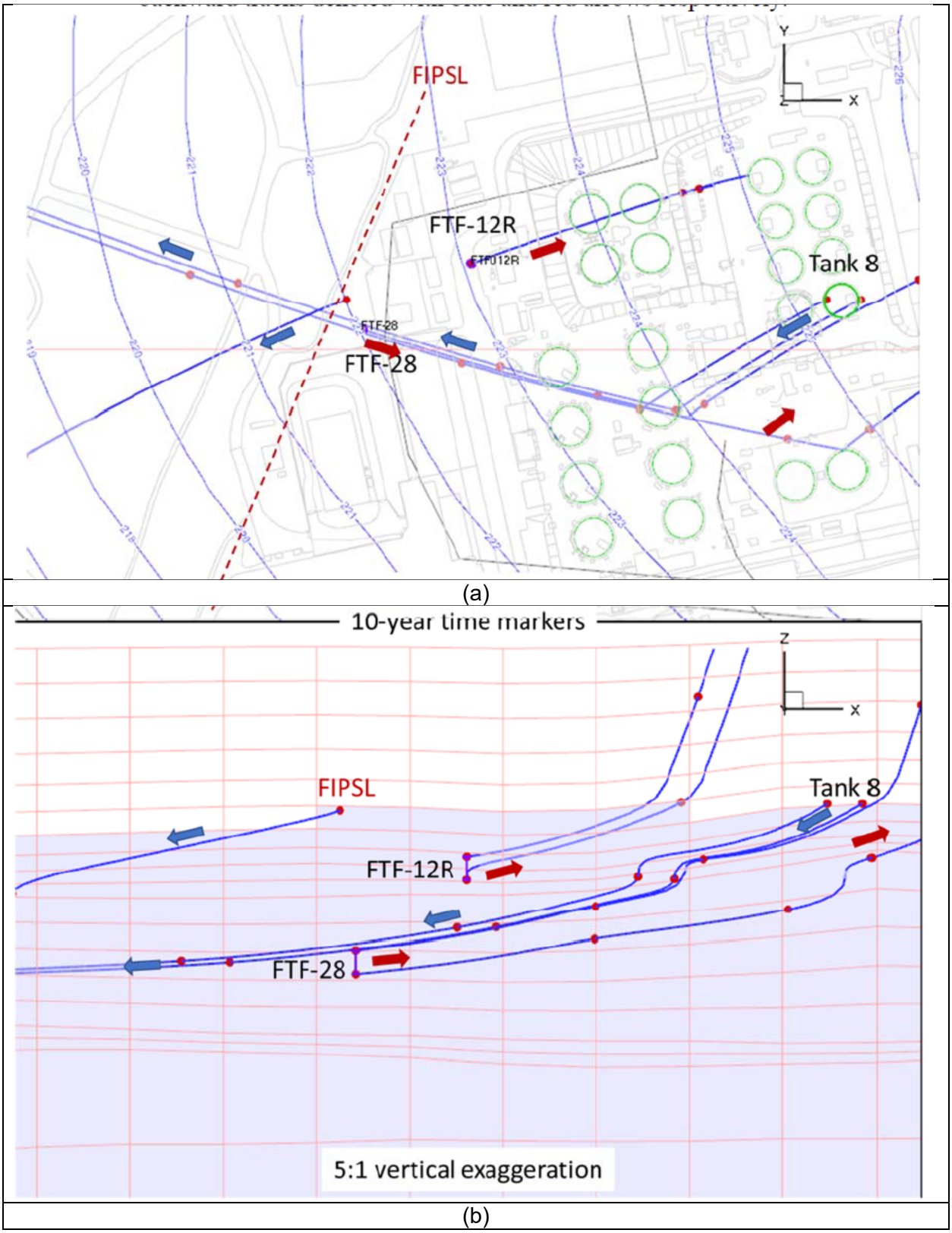

Figure 7. Forward Particle Tracking (denoted with blue arrows) from Tank 8 and FIPSL. Backward Particle Tracking (denoted with red arrows) from Wells FTF 28 and FTF 12R in Plan View (a) and Cross-Section (b).

Nonetheless, to assess the potential for non-volatile beta in FTF 28 to be associated with the low pH waste release from the FIPSL, NRC staff evaluated pH data in FTF wells including FTF 28 through FTF 31 and background well FBG01C (see Figure 1). The pH data between FTF wells screened in the LAZ is variable with well FTF 29 having significantly higher pH compared to other LAZ wells and UAZ wells at FTF (see Figures 8 and 9). Because the time period of data collection from FTF 28 is longer than other wells, only paired data from the March 2014 time period and after were used in the analysis. While pH data from FTF 28 is lower than pH data from FTF 30, the average pH for well FTF 31 is actually lower than the average pH for FTF 28 (FTF 31 is not associated with the nonvolatile beta/technetium-99 plume). The pH data, which represent a log transform on hydrogen ion concentration, was considered, and the pH data was also converted to hydrogen ion concentrations. Analysis of variance (ANOVA) tests were conducted to determine if there are statistically significant differences in the means of FTF wells, excluding well FTF 29 which was significantly higher than all other LAZ wells, and t-tests were conducted to determine if the mean pH (and hydrogen ion) concentrations at FTF 28 and FTF 31 are statistically different. ANOVA testing shows that the mean pH (and hydrogen ion concentration) of the FTF wells is statistically different. The results of the analysis also show that the mean pH (and hydrogen ion concentration) from FTF 28 is statistically different than FTF 31 at the 5 percent confidence level. The cause of the variability in pH at FTF wells, including the relatively high pH at FTF 29, should be investigated further to better understand subsurface geochemistry which may affect contaminant transport at FTF. NRC staff will continue to monitor geochemical data (e.g., pH, specific conductance, carbonate concentrations) at the FTF as it relates to (i) identifying the source of contaminant plumes, (ii) potential dissolution of carbonate materials in the subsurface signified by high pH and carbonate concentrations, and (iii) to assess impacts to contaminant fate and transport at the FTF.

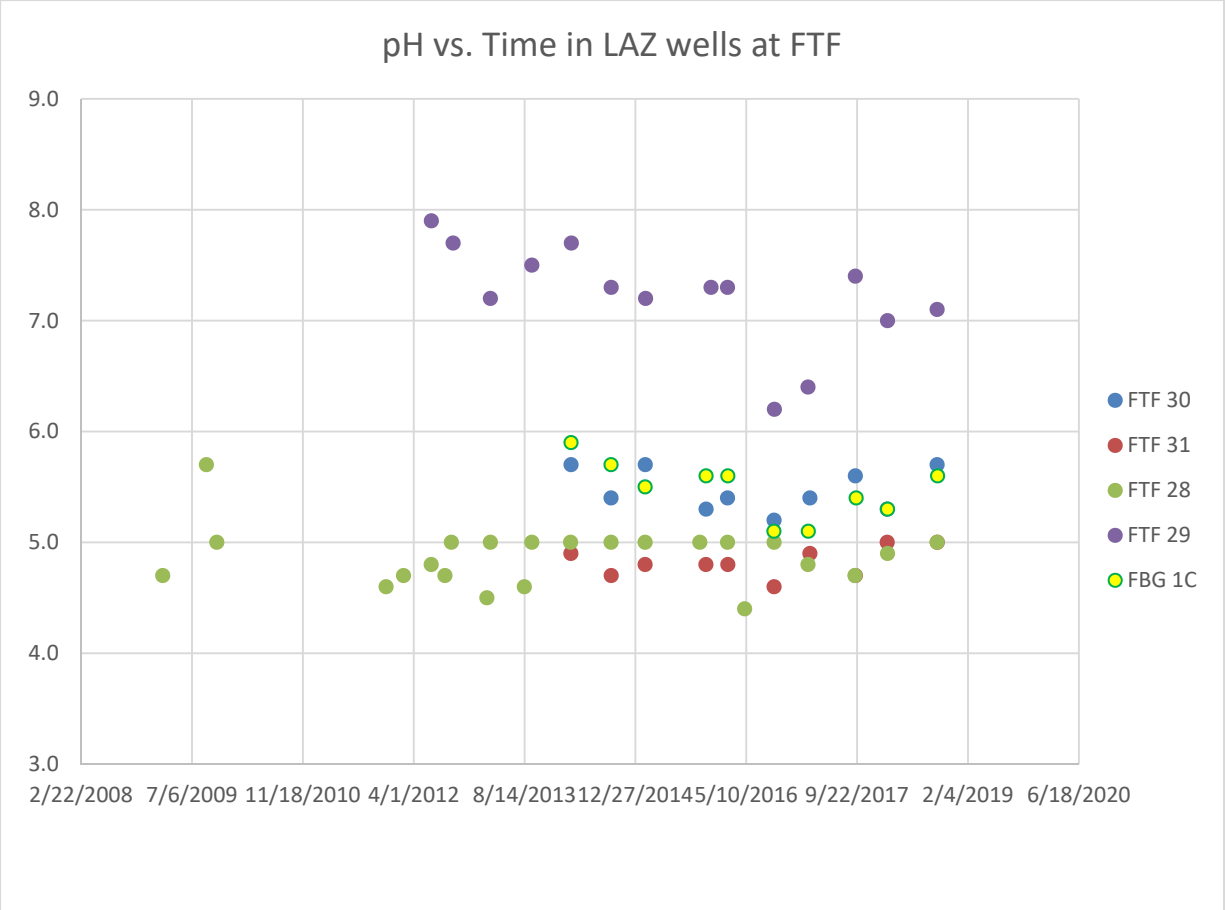

Figure 8. Time Series Data (pH v Time) for FTF Wells Screened in the LAZ

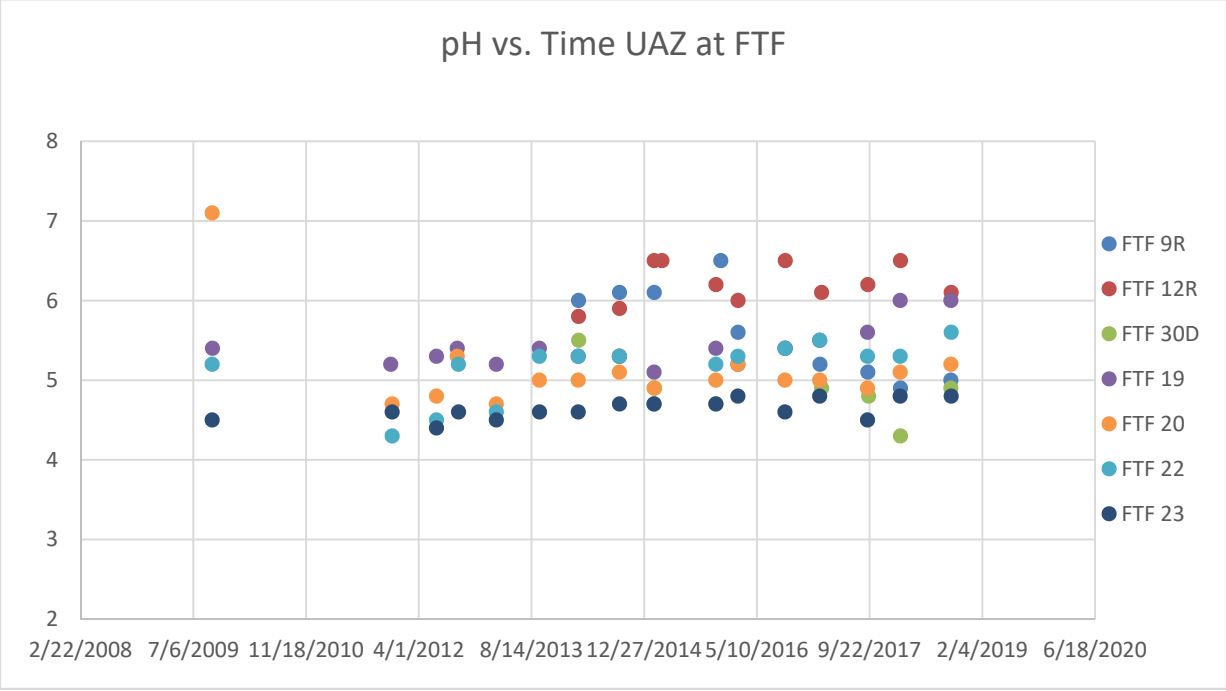

Figure 9. Time Series Data (pH v. Time) for FTF Wells Screened in the UAZ

Tritium had previously been detected above the MCL at FTF 30D (in 2017) at a value of 105 pCi/mL (4 Bq/mL) but was less than the MCL in 2018 at a value of 1 pCi/mL (0.04 Bq/mL). Upgradient of FTF 30D, FTF 20, FTF 22, and FTF 19 were also impacted by tritium but below the MCL (see Figure 1 for locations). The concentrations at FTF 30D have been quite variable over time (see Figure 10 below). Although concentrations were stated to be low at wells upgradient of FTF 30D, no information was provided about the source of the tritium plume at FTF 30D. Further, investigation of the source of the tritium plume should be conducted using backwards particle tracking. NRC staff will continue to monitor DOE's efforts to identify the source of the tritium plume at FTF.

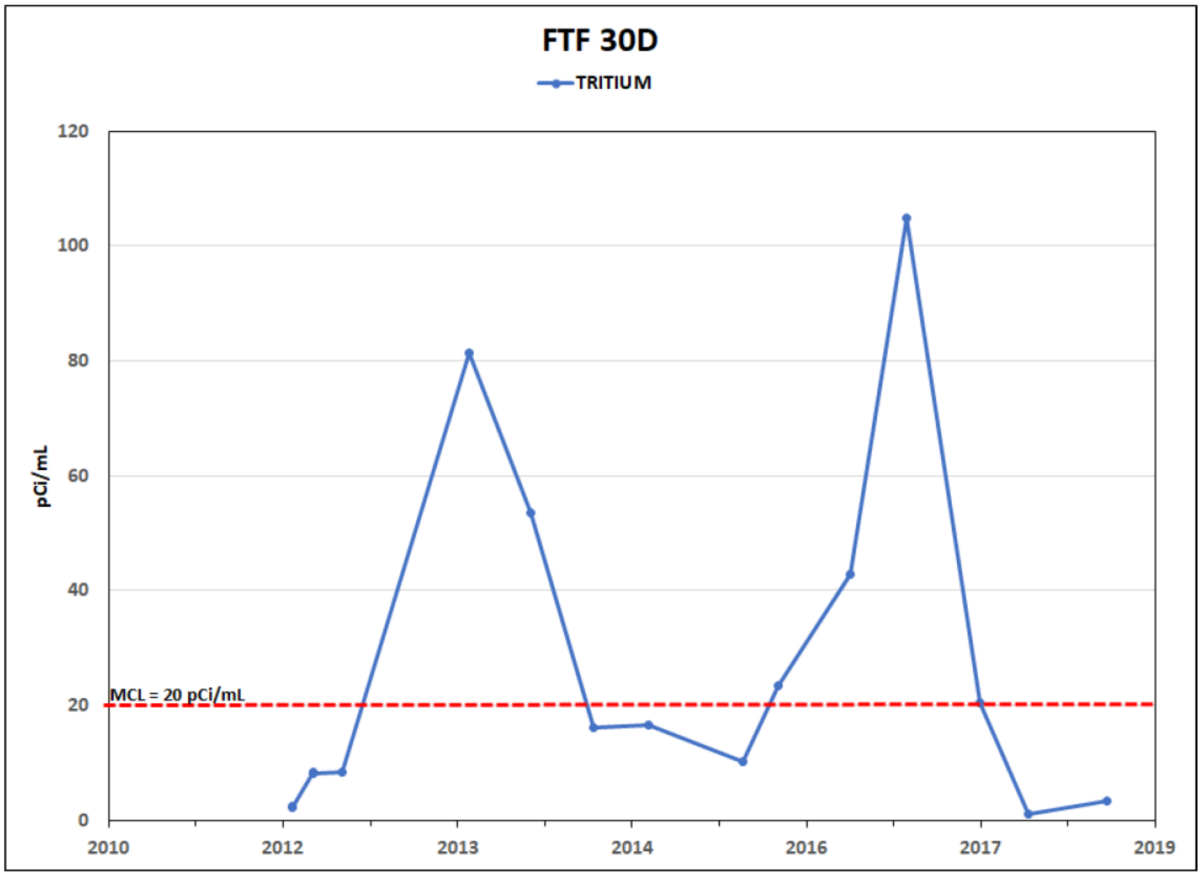

Figure 10. Tritium Concentrations in Well FTF 30D. Image Credit: Figure 8, SRNS-RP-2019-00097, Rev. 0.

HTF Monitoring

DOE contractors attribute tritium detections at HTF well HAA 12D to the Off-Site Fuels Receiving Basin facility or the HIPSL. Again, backwards particle tracking from HAA 12D could reduce uncertainty in the source of the tritium plume. Forwards particle tracking from the source to downgradient wells could also be compared to monitoring well data to help validate the updated GSA 2018 groundwater flow model.

With regard to contamination in the GAU, in 2017 and 2018 nonvolatile beta was measured above the screening level in GAU wells HAA 12A, HAA13A, HAA 15A. In previous monitoring

reports reviewed by NRC staff (e.g., WSRC-RP-2000-4134 [2017]), DOE contractors attributed the non-volatile beta to naturally occurring radioactivity but did not explain the source of the elevated pH in these wells. In a previous TER (ADAMS Accession No. ML18051B154), NRC staff hypothesized that the elevated pH could be an indication that the groundwater has been impacted by cementitious materials (e.g., releases from the tank farm or due to poor well construction) and suggested DOE identify the source of the elevated pH (ADAMS Accession No. ML18051B154). In fact, DOE has more recently attributed the high pH of these wells to "grout intrusion" into the well screen and plans to abandon and replace these wells in the future. The "Core Team" agreed to this resolution at meeting in September 2018. NRC staff independently evaluated data from Eastern Groundwater OU reports spanning back to 2012. While the wells were constructed in 1998, data from the 1998 to 2012 timeframe were not readily available and were not assessed. As can be seen in Figure 11, pH has been extremely elevated in these wells since at least 2012. NRC staff concurs with the decision of the "Core Team" to replace these wells and collect more representative data.

In previous environmental monitoring TRRs (ADAMS Accession Nos. ML12272A124 and ML18051B154), NRC staff recommended DOE contractors use the GSA PORFLOW model to help optimize the FTF and HTF monitoring well networks. Since those TRRs were published, DOE contractors have developed a new GSA POFLOW model from which local transport models will be constructed. NRC staff continues to recommend that DOE use the updated GSA 2018 model to evaluate both the lateral and vertical placement of wells, considering uncertainty in modeled flow paths and directions. In the 2017 and 2018 tank farm monitoring reports, DOE indicates that, due to the infrastructure present at the tank farms, it would not be feasible to construct new wells to address NRC staff concerns regarding the monitoring well network at the Tank Farm facilities (ADAMS Accession Nos. ML19094B756 and ML19094B251). NRC staff understands the difficulty in constructing new wells to supplement the monitoring well network at FTF to increase the likelihood that contaminant releases would be detected. NRC staff will continue to monitor DOE's efforts in this area.

As stated in the previous environmental TRR (ADAMS Accession No. ML18051B154), DOE focuses on comparisons against MCLs in its tank farm monitoring reports, but MCLs are not relevant to providing support with respect to tank farm facility compliance with performance objectives in 10 CFR Part 61. Because the tank farm monitoring well network is being leveraged to provide early warning of potential tank farm facility releases, NRC staff will use the pathway dose conversion factors provided by DOE in previous requests for additional information to assess the significance of the monitored concentrations (i.e., equate the 0.25 mSv/yr performance objective to key radionuclide concentrations in groundwater). NRC staff will also continue to identify and evaluate chemical signatures which would signify potential tank farm facility component releases or provide information regarding performance of barriers to waste release (e.g., specific conductance, pH, Eh, analytical data on mobile radiological and chemical constituents). DOE's PA modeling is also very valuable to NRC staff with respect to optimizing the monitoring well network and evaluating the impact of near- and far-field model uncertainties on the results. NRC has requested that DOE perform particle tracking to assess potential sources of elevated concentrations identified in groundwater to assist with assessing compliance with the performance objectives. For example, results of particle tracking associated with FTF 28 were very useful in evaluating the potential source of the technetium-99 plume at that well location.

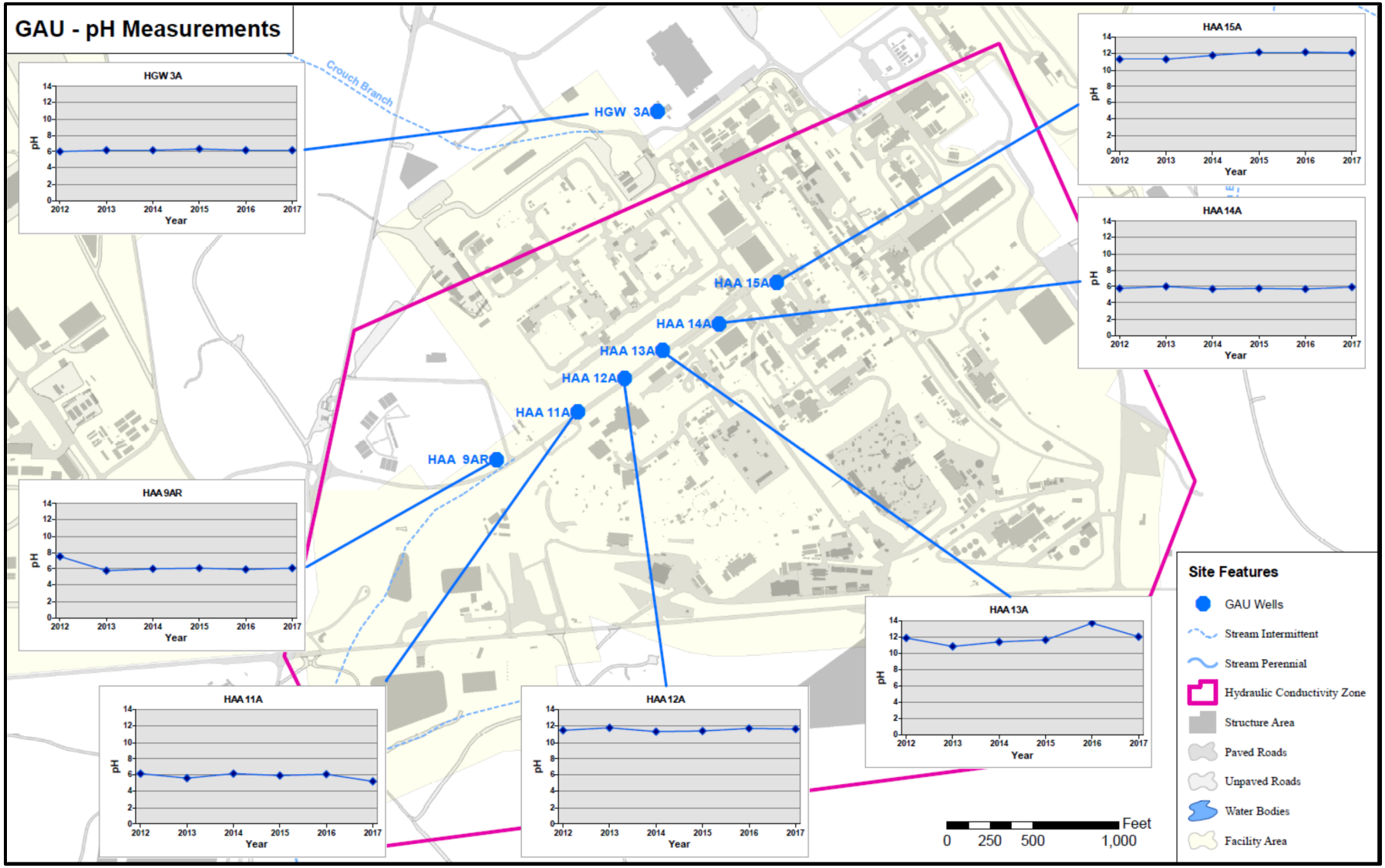

Figure 11. Time Series of pH in GAU Wells at HTF

Lysimeter Studies

As discussed in Appendix E of NRC F-Area and H-Area Monitoring Plan (ADAMS Accession No. ML15238A761), a more complex model with two sorption coefficients was required to reproduce earlier lysimeter plutonium profiles. Although researchers described desorption K_d studies in both SRRA021685-000009 and SRRA021685-000010, these studies are unlikely to capture the presence of a small mobile fraction of plutonium, which could be risk significant. A modeling analysis to determine the K_d value or values that would be required to represent the observed distribution of plutonium in the core samples reported in SRRA021685-000009 and SRRA021685-000010 and the effluents reported in SRRA021685-000011 is important to understand if there is a small mobile fraction of plutonium and to reduce uncertainty in the natural attenuation of plutonium.

As stated in NRC staff's FTF TER (ADAMS Accession No. ML112371715) and Tank Farms Monitoring Plan (ADAMS Accession No. ML15238B403), the K_d averaging approach utilized in the FTF PA can lead to non-conservative results. For K_ds that vary orders of magnitude, an average K_d approach can lead to a peak dose from Pu which occurs later in time compared to the peak dose from the more mobile fraction. Additionally, dependent on the fraction of the more mobile Pu species, the peak dose could be above the performance objective earlier in time and/or the peak dose could be under-estimated. NRC staff continues to recommend a more technically defensible model in which the multiple species of Pu are considered independently.

Teleconference or Meeting:

No teleconference or meeting was held with DOE related to this TRR.

Follow-up Actions:

NRC staff reviewed the *Impact of Cementitious Material Leachate on Iodine Partitioning*, SREL Doc. R-17-0004 (ADAMS Accession No. ML18067A444) as part of this technical review report. However, given the significance of iodine to Tank 12, the NRC will publish its findings with respect to its review of that report in a separate technical review report on the Tank 12 waste release experiments and PA impact assessment to be issued later in Fiscal Year 2020 (ML19298A092).

Open Issues:

There are no open issues resulting from this TRR.

Conclusions:

The NRC staff has performed technical reviews of environmental monitoring reports prepared by the DOE to support FTF and HTF closure at the SRS. This technical review report is related to Monitoring Factors 4.1, "National Attenuation of Key Radionuclides", and 4.3, "Environmental Monitoring," listed in NRC staff's Monitoring Plan for the TFFs (ADAMS Accession No. ML15238A761). The NRC staff concludes the following:

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.
5. Additional work is needed to better understand the significance of an observed mobile fraction of Pu in the natural system.
6. DOE should justify its Pu K_d averaging approach, or explicitly model the various oxidation states of key radionuclides such as Pu in future PA documentation, because explicitly modeling the more mobile fraction of Pu could lead to risk-significant dose significantly earlier in time compared to the current modeling approach.

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