

2017 Groundwater Mixing Zone Report for the R-Area Reactor Seepage Basins/108-4R Overflow Basin Operable Unit (U)

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EXECUTIVE SUMMARY

The selected remedy for the groundwater at the R-Area Reactor Seepage Basins/108-4R Overflow Basin Operable Unit (RRSB OU) is a groundwater mixing zone with land use controls. The remedy is described by the *R-Area Reactor Seepage Basins/108-4R Overflow Basin Operable Unit Groundwater Mixing Zone Application (U)* as approved by the U.S. Environmental Protection Agency (USEPA) and the South Carolina Department of Health and Environmental Control (SCDHEC). Groundwater at RRSB OU is monitored for strontium-90 (Sr-90), americium-241 (Am-241), and water elevation. This document summarizes groundwater monitoring well data for calendar year 2017 and compares the results to previously reported data. The new data were collected during the fourth quarter of 2017 (4Q2017).

The current distribution of contamination is consistent with previous observations in previous mixing zone reports. Specifically:

- There were no mixing zone concentration limit (MZCL) exceedances of Sr-90 in plume/intermediate wells in 4Q2017.
 - There were no maximum contaminant level (MCL) exceedances in boundary wells in 4Q2017.
 - There were no MCL exceedances in Transmissive Zone (TZ) wells in 4Q2017.
 - Strontium-90 was detected at low levels (estimated quantities) in six boundary wells, two in the A horizon and four in the TZ. The values are well below the Sr-90 MCL. Detections from these wells have always been estimated or non-detect values. The presence of Sr-90 in the laboratory blank increases the uncertainty of these results.
 - Strontium-90 concentrations in 4Q2017 were generally comparable to observed concentrations.
 - Americium-241 was not detected in auxiliary well RSE 26DL during this sampling event. Am-241 will undergo one more sampling event to determine if it should remain as an analyte for future sampling.
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- Sampling results confirm that the approved groundwater mixing zone remedy is performing as expected and is still considered an appropriate action for the RRSB OU.
 - Water elevations in 4Q2017 were generally lower than in 4Q2015 and ranged from an increase of 0.3-meters (m) [1-foot (ft)] higher to 3.2-m (10.5-ft) lower than 4Q2015 values.
 - The next sampling event of the RRSB OU GWMZ monitoring well network will occur in the fourth quarter of 2019, to be followed by a letter report submitted no later than June 30, 2020.
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LIST OF ABBREVIATIONS AND ACRONYMS

BRA	Baseline Risk Assessment
cm	centimeters
EQL	estimated quantitation limit
FFA	Federal Facility Agreement
ft	feet, foot
GAU	Gordon aquifer unit
GCU	Gordon confining unit
GWMZ	Groundwater Mixing Zone
in	inches
km	kilometers
LAZ	lower aquifer zone
m	meters
MAZ	middle aquifer zone
MCL	maximum contaminant level
MDC	minimum detectable concentration
mi	miles
MZCL	mixing zone concentration limit
NA	not applicable
NFA	no further action
NTU	nephelometric turbidity units
OU	operable unit
PTSM	principal threat source material
pCi/L	picocuries per liter
RCRA	Resource Conservation and Recovery Act
RFI/RI	RCRA Facility Investigation/Remedial Investigation
ROD	Record of Decision
RRSB	R-Area Reactor Seepage Basins
SCDHEC	South Carolina Department of Health and Environmental Control
SRNS	Savannah River Nuclear Solutions
SRS	Savannah River Site
TC	tan clay
TZ	transmissive zone
UAZ	upper aquifer zone
USEPA	U.S. Environmental Protection Agency
UTRAU	Upper Three Runs aquifer unit
WSRC	Washington (Westinghouse) Savannah River Company

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1.0 INTRODUCTION

The R-Area Reactor Seepage Basins (RRSB)/108-4R Overflow Basin Operable Unit (OU) is listed as a Resource Conservation and Recovery Act (RCRA) 3004(u) Solid Waste Management Unit/Comprehensive Environmental Response, Compensation, and Liability Act unit in Appendix C of the Federal Facilities Agreement (FFA) (1993) for the Savannah River Site (SRS). The selected remedy for the groundwater at RRSB is a groundwater mixing zone (GWMZ) with land use controls. This document summarizes biennial groundwater monitoring well data in compliance with the requirements of the *R-Area Reactor Seepage Basins/108-4R Overflow Basin Operable Unit Groundwater Mixing Zone Application (U)* (WSRC 2004a), as approved by the U.S. Environmental Protection Agency (USEPA) and the South Carolina Department of Health and Environmental Control (SCDHEC). This document reports the groundwater monitoring well data collected during the fourth quarter of 2017 (4Q2017) and compares the results to previously obtained data.

1.1 Unit Description and History

The RRSB OU RCRA Facility Investigation/Remedial Investigation (RFI/RI) Report with Baseline Risk Assessment (BRA) (WSRC 2002) provides detailed information about the unit, location, topography surface features, ecology, soil, and regional and local geologic and hydrogeologic conditions. The following paragraphs summarize the information pertinent to the groundwater monitoring information.

1.1.1 Site Description and History

R Area is located in the east-central portion of the SRS approximately 8.4-kilometers (km) [5.2-miles (mi)] from the nearest SRS boundary (Figure B-1). The RRSB OU is located to the north of the R-Reactor building and originally consisted of the following subunits: six unlined seepage basins, an abandoned process sewer line, an abandoned sanitary sewer system (sewer line and lagoon), surface water and sediment, RRSB groundwater, and the 108-4R Overflow Basin (WSRC 2002). Based on the approved Record of Decision (ROD) (WSRC 2003a), the Core Team agreed

that there was no further action (NFA) to be taken for the surface water, sediment, and 108-4R Overflow Basin subunits (WSRC 2004b). These NFA subunits will not be discussed further in this report or subsequent reports for the RRSB OU. The RRSB OU is portrayed in Figure B-2.

The six seepage basins were excavated in succession between June 1957 and March 1958 to receive low-activity level radioactive purge water from the R-Reactor disassembly building. The purge water primarily contained cesium-137, strontium-90 (Sr-90), and tritium (WSRC 2002). In November 1957, a failed calorimeter experiment resulted in the discharge of large volumes of radioactive wastewater to the R-Discharge Canal and to Basin 1. Basins 2 through 6 were subsequently excavated to accommodate the large volumes of purge water and the slow seepage rates. Basins 1 through 5 were deactivated and backfilled by 1960. Basin 6 was deactivated in 1964 and backfilled in 1977.

In 1996, an asphalt cover was placed over the seepage basins to limit bioturbation and vegetative growth. Remediation of the surface units was completed in 2007 and a Post-Construction Report (WSRC 2005) was issued in March 2008. Remediation consisted of excavation of all contaminated process and sanitary sewer lines and associated soil above principal threat source material (PTSM) levels located outside the boundary fence, placement of a concrete intruder barrier over all six basins and excavated material that was above the PTSM levels, and placement of asphalt over contaminated vegetation.

Groundwater monitoring at the RRSB OU has been performed since 1957, shortly after the failed calorimeter test. Investigative activities within the RRSB OU have shown that, to date, the extent of the groundwater contamination from all radiological constituents has not extended significantly beyond the boundaries of the RRSB OU, and Sr-90 is the predominant constituent present within the shallow groundwater aquifer beneath the RRSB OU. The GWMZ addresses the RRSB OU groundwater.

1.2 Regulatory History

SRS submitted the Revision 1.2 RFI/RI/BRA document (WSRC 2002) to USEPA and SCDHEC in February 2002. Characterization activities at the RRSB OU identified a shallow localized plume of Sr-90.

The ROD for RRSB OU (WSRC 2003a) was submitted in October 2003 and approved in March 2004. The remedial objective for the groundwater is to decrease the concentration of contaminants in groundwater to levels at or below the maximum contaminant level (MCL) for Sr-90. GWMZ with land use controls was the selected remedy for achieving this goal.

The *R-Area Reactor Seepage Basins/108-4R Overflow Basin Operable Unit Groundwater Mixing Zone Application (U)* (WSRC 2004a) was submitted in November 2004. The detailed technical analysis supporting the GWMZ Application was presented in the *R-Reactor Area Seepage Basins Strontium-90 Groundwater Transport Uncertainty Analysis and Monitoring Network Optimization (U)* (Brewer and Fogle 2004).

The first monitoring report, titled *2007 Biennial Mixing Zone Monitoring Report for the R-Area Reactor Seepage Basins/108-4R Overflow Basin Operable Unit (U)* (SRNS 2008), was submitted in August 2008.

In 2012, SRS undertook a comprehensive review of its groundwater monitoring program, including RRSB OU, and identified optimization opportunities (SRNS 2012a). The 2011 RRSB OU monitoring report formally presented several optimization proposals for future monitoring and reporting (SRNS 2013). The proposed changes were approved by SCDHEC (SCDHEC 2013) and USEPA (USEPA 2013), and are described below in Section 1.3.

1.3 Groundwater Mixing Zone Compliance

The objective of monitoring at the RRSB OU is to assess compliance with the MCL at the compliance boundary and with the mixing zone concentration limits (MZCLs) at the plume/intermediate wells as required by the GWMZ Application (WSRC 2004a). The need for

continued monitoring of the GWMZ compliance wells will be re-evaluated once the Sr-90 levels fall below the MCL and/or every five years as part of the remedy review for the ROD (SRNS 2012b). Groundwater modeling was used to determine the locations of compliance wells and the GWMZ boundary (Figure B-2) and to predict the MZCLs (Table 1) (Brewer and Fogle 2004). The approved monitoring network, established in WSRC (2004a), consisted of 4 plume/intermediate wells, one alternate plume/intermediate well, and 12 compliance boundary wells, with additional monitoring performed at 4 auxiliary wells (Figure B-2, Table 1).

The GWMZ Application prescribed that wells be monitored for Sr-90, Americium-241 (Am-241) and water elevation. Strontium-90 analyses are performed to demonstrate compliance with the GWMZ, while Am-241 analyses were performed for information only. Americium-241 was retained as a constituent of concern in the RFI/RI/BRA because this radionuclide was associated with historical operations at the R Reactor. However, it was only detected in 5 out of the 200 samples analyzed from 1995 through 2003. Since there is no discernible plume of Am-241, it was not considered in the groundwater model and no MZCL was established for Am-241 in the GWMZ Application.

The location of the mixing zone compliance boundary was defined by fate and transport modeling, placing it slightly beyond the farthest modeled extent of the Sr-90 plume that was greater than the MCL. The purpose of the plume/intermediate wells is to verify that the contaminants do not exceed MZCLs. If the MZCL for Sr-90 is exceeded by a result from a sampling event, the wells with the exceedances will be resampled within 60 days of receipt of a valid data report and analyzed for Sr-90 and nonvolatile beta to confirm this exceedance (WSRC 2004b). If this sample is also above the MZCL, then the well will be sampled for the next three consecutive quarters and the Core Team will be notified of this condition. If the well shows measured activity concentrations greater than the MZCL for three consecutive quarterly sampling periods, the Core Team will re-evaluate the groundwater quality conditions at the site and determine what response or corrective actions are warranted. Given the erratic nature of the observed Sr-90 activity concentrations, the activity concentrations above the MZCL must be observed and verified for three consecutive monitoring periods prior to initiation of any corrective action.

For the compliance boundary wells, if the Sr-90 MCL is exceeded by a result from a sampling event, the well will be resampled within 60 days of receipt of a valid data report and analyzed for Sr-90 and nonvolatile beta to verify the result. The Core Team will be notified within 90 days. In the event the MCL is exceeded in the validated confirmation sample(s), the Core Team will reconvene to discuss specific additional assessment, modeling, and/or remedial alternatives to address the exceedance.

The top half of Table 2 summarizes the groundwater sampling and reporting requirements, as established in WSRC (2004a), with comparison criteria for GWMZ compliance. GWMZ monitoring results from the first four quarters were summarized in the first annual report (SRNS 2008), followed by subsequent reports every two years that summarize data collected on an annual frequency. Reports summarize water-level and groundwater quality data for the current reporting period as well as previous monitoring periods and provide an assessment of compliance with the GWMZ permit requirements.

One plume/intermediate well, well RSE 10, has frequently been dry. Because of the unreliability of this well, SRS, USEPA, and SCDHEC agreed to use monitoring well RSE 10DU as an alternate plume/intermediate well, to be sampled when well RSE 10 is dry (SRNS 2010). Well RSE 10DU is co-located with well RSE 10, in the same horizon, but is screened at a lower elevation – the top of screen zone for well RSE 10DU is 0.61-m (2.0-ft) higher than the bottom of the screen zone at well RSE 10.

1.3.1 Optimization of Groundwater Monitoring

The 2011 monitoring report (SRNS 2013) established several changes to the RRSB OU groundwater monitoring and reporting program which are summarized in the bottom half of Table 2 and below.

- Remove monitoring well RSD 10 from the GWMZ network (but do not abandon the well).
 - Add five boundary wells to the GWMZ network, three wells in the A/AA horizon (RPC 4DU, RPC 5DU, RSP 4D), and two wells in the Transmissive Zone (TZ) (RPC 3DL, RPC 5DL).
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- Suspend monitoring of the six deeper wells (RSE027C, RSE028B, RSE030C, RSE031B, RSE036C, RSE038B) until such time that a TZ well shows a verified concentration of Sr-90 above the MCL.
- Conduct monitoring biennially, instead of annually.
- Discontinue analysis of Am-241.
- Submit RRSB OU reports every two years. Mixing zone reports with format and content consistent with this report will be submitted every four years (2014, 2018, etc.). In the even off-years (2016, 2020, etc.) concise letter reports will be submitted.
- Discontinue including individual hydrographs for each well in the monitoring reports, but present all water level data in a single table.

The optimization changes for sampling were implemented beginning with the fourth quarter of 2013 sampling event. Optimization changes for reporting were implemented beginning with the 2012/2013 report (SRNS 2014).

In a comment on the 2012/2013 Report, USEPA concluded that the analysis of Am-241 should continue at auxiliary well RSE 26DL (USEPA 2014). The continuation resulted from the unexpected detection of Am-241 in well RSE 26DL in the first quarter of 2013. The optimization was updated in the bottom half of Table 2 and was refined as follows:

- SRS will analyze groundwater samples from well RSE 26DL for Am-241 starting with the fourth quarter 2015 (4Q2015) sampling event. If Am-241 is detected in any sample, monitoring for Am-241 will continue at well RSE 26DL in future sampling events. If Am-241 is not detected in the next three sample events, future sampling will be for Sr-90 only.

1.4 Reporting Elements

A groundwater monitoring and reporting program began in January 2007 to demonstrate compliance with the MZCLs in plume/intermediate wells and with the MCLs at the compliance boundary, as required by the GWMZ application. This report is produced to satisfy the

requirements of the approved GWMZ application to provide a report to SCDHEC and USEPA that as a minimum includes the following:

- A unit location map (Figure B-1)
- Analytical data summary tables (Appendix A)
- Potentiometric surface maps (Figures B-4 and B-5)
- Analytical data maps of Sr-90. A map is provided for each aquifer zone where Sr-90 was greater than the MCL (Figure B-6).
- Concentration trend plots for Sr-90 at compliance wells (Appendix C)

In addition, this report provides:

- Water levels of each well (Table 4)
- Concentration trend plots for 4 auxiliary wells (Appendix C)
- Historical and recent rainfall amounts (in text, Figure B-7)
- Monitoring well network and GWMZ boundary location map (Figure B-2)

2.0 SITE HYDROGEOLOGY

2.1 Physiographic Setting

The RRSB OU lies north of and adjacent to R Reactor on an elevated divide between Mill Creek and the primary discharge canal northeast of the R-Area perimeter fence (Figure B-2). Topographic elevations in this area range between approximately 88- to 91-m (290- to 300-ft) above mean sea level. The RRSB OU is situated between drainage to Par Pond 2.7-km (1.7-mi) to the southeast (beyond the limit of Figure B-2), and the headwaters of Mill Creek located 0.40-km (0.25-mi) to the northwest. The western edge of the basin area slopes towards the west. Surface water drainage from the RRSB OU flows north and west into Mill Creek or east into the R-Discharge Canal and Pond A (Figure B-2).

2.2 Hydrogeologic Setting

A detailed description of the hydrostratigraphic units relevant to the RRSB OU can be found in the RFI/RI/BRA report (WSRC 2002), in the aquifer test plan (Hiergesell et al. 1999), and in the RI Work Plan for the RAOU (WSRC 2006). The conceptual site model (Figure B-3) shows the hydrostratigraphic units of interest for this GWMZ report.

The Floridan aquifer system is the aquifer system of concern within the RRSB OU area, and is bounded roughly by two features: Upper Three Runs Creek and the southern boundary of SRS. The Floridan aquifer system is divided into two aquifer units separated by a confining unit. From top to bottom, they are known as the Upper Three Runs aquifer unit (UTRAU), the Gordon confining unit (GCU) and the Gordon aquifer unit (GAU). Based on the results of a pumping test conducted in R Area, the GCU is a competent confining unit between GAU and the overlying UTRAU with no pressure responses observed across the GCU during pumping (Hiergesell et al. 2000).

The UTRAU occurs between the water table surface and the GCU. The UTRAU is divided into two aquifer zones by an informal aquitard referred to as the “tan clay” (TC). From top to bottom they are known as the upper aquifer zone (UAZ) of the UTRAU, the TC, and the lower aquifer zone (LAZ) of the UTRAU. The overall transmissivity of the UAZ is somewhat less than the LAZ due to the relatively large amounts of interbedded and interstitial clay within the UAZ (WSRC 2006).

The UAZ is the water table aquifer at the RRSB OU and ranges from 31.7- to 41.5-m (108- to 136-ft) in thickness (WSRC 2004b). At the RRSB OU, the UAZ can also be further subdivided (Hiergesell et al. 1999). From shallowest to the deepest, the UAZ comprises the undifferentiated soil horizon, the A horizon, the AA horizon and the TZ. The surface soils and A horizon act as a shallow semi-confining unit for the underlying coarser-grained strata of the AA horizon and TZ (WSRC 2006). Calibrated hydraulic conductivities used in modeling show average hydraulic conductivities between 0.22-m/day (0.73-ft/day) and 3.87-m/day (12.7-ft/day) in the upper

horizons of the UAZ (undifferentiated surface soils and A horizon) and 6.31-m/day (20.7-ft/day) in the underlying higher transmissivity horizon of the UAZ (AA horizon and TZ).

The aquitard below the UAZ, referred to as the TC, is from approximately 2.13- to 17.4-m (7- to 57-ft) in thickness in R Area and consists of clay lenses and interbedded sands, silty sands, clayey sands and sandy clays (Hiergesell, et al. 1999; WSRC 2006). Based on the pumping tests conducted in R Area (Hiergesell et al., 2000), the TC is locally considered an aquitard between the LAZ and UAZ with a slight response in the TZ of the UAZ due to pumping in the LAZ, and vice versa.

Within the TC there is a relatively permeable sand unit that can be mapped across the RRSB OU and other areas at SRS. Therefore, the TC is further divided into the TC confining zone, the middle aquifer zone (MAZ) of the TC, and the TC lower clay.

The LAZ of the UTRAU is approximately 20-m (67-ft) thick in R Area and consists of interbedded clayey sands, sands and carbonates (WSRC 2002). The carbonates are present in both consolidated and unconsolidated forms and have lower measured hydraulic conductivities than the clayey sands and sands.

2.2.1 Groundwater Flow and Contaminant Transport

The saturated zone from the water table surface to the top of the TC interval is defined as the UAZ and is of significance with respect to RRSB OU contaminant migration (WSRC 2003a). The water table surface is in the shape of a mound, with a radial hydraulic gradient in the A/AA horizons and TZ centered beneath the southern or southwestern portion of the RRSB OU (Figures B-4 and B-5).

Groundwater flow modeling (WSRC 2003b) indicates that the dominant groundwater flow direction is vertically downward from the surface through the A and AA horizons, and obliquely downward through the TZ. Lateral flow dominates in the MAZ and LAZ, with an eastward component in most places. The hydrogeological conceptual model of RRSB OU is shown in Figure B-3.

Strontium-90 contamination in groundwater is found only in the UAZ of the UTRAU, and there has been little lateral migration beyond the RRSB OU. The extent of the plume is limited to the A horizon, AA horizon, and TZ of the UAZ (Figure B-3). The highest Sr-90 activity concentrations are contained within the footprint of the existing asphalt cover. The vertical geometry of the Sr-90 plume is typical in an aquifer with a downward vertical gradient (Figure B-3). Based on the characterization investigation, the Sr-90 contamination greater than the 8 pCi/L MCL was in the immediate vicinity of the seepage basins, with the exception of the contamination to the south and east of Basin 1. This southeastern portion of the plume is probably a result of flow through the breached sanitary sewer system and/or overflow from Basin 1 (Jones et al. 1998) rather than groundwater transport. According to groundwater modeling and uncertainty analysis results, Sr-90 contamination from the RRSB OU is not expected to discharge to any surface-water bodies (Brewer and Fogle 2004). Groundwater transport of Sr-90 is significantly attenuated by two mechanisms: 1) sorption onto mineral grains, and 2) radioactive decay with a half-life of 28.8 years. Groundwater modeling and uncertainty analysis results indicate that Sr-90 contamination is expected to travel vertically downward from the source areas and primarily stay within the vicinity of the asphalt cover (WSRC 2003b; Brewer and Fogle 2004). No significant lateral migration is predicted prior to natural attenuation of Sr-90 to concentrations below 0.01 pCi/L.

3.0 GROUNDWATER MONITORING AND REPORTING

3.1 Network Integrity and Well Changes

The implementation of the GWMZ application involved the installation of 15 new wells during March/April 2006 to augment one existing well (RSE 10), resulting in a GWMZ compliance monitoring network of 16 wells, plus four auxiliary wells (RSD 10, RSE 1A, RSE 26DL and RPC 11DU) as listed in Table 3. The table includes a correlation between the well names proposed for the new wells in the GWMZ application and the final names applied at installation. The GWMZ boundary and the well locations are presented in Figure B-2. Well RSE 10DU was added as an alternate plume/intermediate well in 2011.

Optimization changes took effect starting with the 4Q2013 sampling event. Five wells were added to the network (RPC 3DL, RPC 4DU, RPC 5DL, RPC 5DU, RSP 4D), and one well (RSD 10) was removed (Figure B-2). Furthermore, monitoring of the six deep wells (Middle and Lower Aquifer Zones) is suspended until such future time as Sr-90 is detected in the TZ. Affected wells are RSE027C, RSE028B, RSE030C, RSE031B, RSE036C, and RSE038B.

Wells are sampled using either submersible variable speed centrifugal pumps or bailing.

3.2 Monitoring Data Collection and Presentation

This report includes monitoring data from the 4Q2017. The results of the annual groundwater sampling and analyses are reported in Table A-1. The results shown in these tables were used to create the contaminant concentration and potentiometric maps. As discussed below, the laboratory may report more than one result from a particular sample. However, only one result per analyte for each sample is used for presentation in figures and time-series plots.

3.2.1 Quality Assurance/Quality Control

According to the GWMZ application, analytical results shall be generated at SCDHEC-certified laboratories. In addition, analytical methods at SRS contract laboratories are required to comply with the Department of Energy Quality Systems for Analytical Services.

The Sr-90 analytical method involves use of a resin column for separating strontium from the sample, followed by quantitation with gas flow proportional counting. Americium-241 was likewise separated with a resin column, and counted by alpha spectroscopy. Per the GWMZ application, the required minimum detectable concentrations (MDCs) are 2 pCi/L for Sr-90 and 0.3 pCi/L for Am-241. Analytical data is required to be verified and validated. Each sampling event is required to include two split samples (Table A-1).

As part of their quality assurance procedures, the laboratories duplicate certain analyses. The results of these analyses are used for inter-laboratory comparisons. The results of the original and duplicate analyses are provided in Table A-1.

The “Uncertainty and Data Usability” section of the Appendix A “Data Review Key” describes the process used to select the maximum result from the original sample and the laboratory duplicate(s) of the original sample. This result, used to create the contaminant concentration maps and time-series plots, is based on a selection process that considers the laboratory qualifier codes. The selection process was designed to select the most conservative result that has the least amount of uncertainty.

3.2.2 Purging, Sampling and Analysis Problems

Turbidity of water exceeded the recommended maximum value of 15 NTU at two wells: plume/intermediate well RSE 10 (827 NTU), and auxiliary well RPC 11DU (22.3 NTU). The Sr-90 concentration at well RSE 10 and well RPC 11DU in 4Q2017 were higher than the previous sampling event in the 4Q2015. Well RSE 10 was detected at 111 pCi/L in 2015 and 264 pCi/L in 2017. Well RPC 11DU received an estimated quantity of 2.72 pCi/L in 2015 and 8.76 pCi/L in 2017. Although these concentrations are higher, they are consistent with historical trends in both wells (Appendix C). Therefore, it is concluded that the excessive turbidity did not significantly affect data quality.

3.2.3 Errata

No corrections were made to any data reported from the laboratory during the 2017 monitoring period.

3.3 Water Elevation Measurements and Groundwater Flow Direction

Water-level data for the monitoring network are presented in Table 4, and water elevations have been used to prepare potentiometric surface maps (Figures B-4 and B-5). The maps provide information used to evaluate the groundwater flow directions as well as the effectiveness of the well network. The potentiometric surface maps were constructed for 4Q2017 data collected at the time of sampling.

Construction of potentiometric surfaces for the A/AA and TZ horizons took advantage of water level data for several wells not included in the monitoring network. Since the measurement times for these wells were not synchronous with the RRSB OU water level sampling, their water levels were not treated rigorously for the placement of contour lines, but were rather used as guides. These wells located outside the monitoring network are indicated as “other wells” in Figures B-4 and B-5.

The A/AA horizon well with the deepest screen zone is RSD002DU with the top of the screen zone 4.9-m (16-ft) deeper than the next deepest A/AA horizon well (Table 3). For this reason, the water level for well RSD002DU is not regarded as fully representative of the RRSB OU water table, and it was not used for potentiometric surface contouring in Figure B-4.

Although the spatial distribution of the current potentiometric data is limited, the primary flow and transport path/direction appear consistent with the characterization data for the contaminant plumes and the previous years. The potentiometric surface is radial in the A/AA and TZ horizons and transitions to a generally eastward dip in the deeper aquifer horizons. Potentiometric heads in the A/AA horizon are generally about 0.61- to 2.4-m (2- to 8-ft) higher than corresponding heads in the TZ (compare Figure B-4 to B-5), indicating that flow is generally downward in this groundwater recharge area.

Table 4 indicates that potentiometric heads at RRSB OU have been consistently higher in the last few sampling events when compared to 4Q2007 levels. Water elevations in 4Q2017 were generally lower than in 4Q2015 but ranged from 0.3-m (1-ft) higher to 3.2-m (10.5-ft) lower than 4Q2015 levels. All wells yielded adequate sampling volumes. Well RSE035D had a measured increase in water elevation of 10.7-m (35-ft) in 4Q2015 which was marked as a suspect value. Well RSE035D decreased 9.1-m (30-ft) in 4Q2017 which is more consistent with its historical level.

3.3.1 Recharge and Precipitation Measurements

Recharge entering the groundwater can be estimated from precipitation data. The amount of precipitation generally entering the groundwater as recharge is typically one-third of total

precipitation. Average annual precipitation at SRS is 122-centimeters (cm)/year [47.9 inches (in.)/year]. 2017 was an above-average year, with 135-cm (53.1-in). of precipitation. Precipitation in the fall months was typically less than in previous years. Changes in potentiometric surfaces at RRSB OU are consistent with the variations in monthly rainfall rates. A comparison of monthly rainfall for 2017 and the 30-year climatological reference period are shown in Figure B-7.

3.4 Groundwater Mixing Zone Monitoring Data Evaluation

All analytical data collected for the RRSB OU GWMX in 4Q2017 are presented in Appendix A, Table A-1. A historical data summary for Sr-90 since 2007 is given in Table 5. Detailed Sr-90 time-series plots for all wells are presented in Appendix C.

3.4.1 Extent of Contamination

Strontium-90 concentrations in RRSB OU groundwater during 4Q2017 were generally consistent with reported concentrations from previous years (Table 5). All concentrations are consistent with the trends shown in the time series plots in Appendix C. Strontium-90 was detected in samples collected from one plume/intermediate wells, three auxiliary wells, and six boundary wells (Table A-1).

3.4.1.1 Plume/Intermediate Wells

The well with the highest Sr-90 detection is well RSE 10 which is screened in the A horizon. Since a sample was obtained from well RSE 10, a sample was not collected from well RSE 10DU. Well RSE 10 has been the most contaminated well in the GWMZ since monitoring began in 2007. The well produced a concentration of 264 pCi/L. This result exceeds the Sr-90 MCL (8 pCi/L), but is below the MZCL (2,244 pCi/L) for this well. The 4Q2017 result is higher than the most recent previous result of 111 pCi/L, obtained in 4Q2015. The time-series plot for well RSE 10 (Appendix C) indicates that the 4Q2017 concentration is consistent with the well's history.

3.4.1.2 Auxiliary Wells

The three auxiliary wells with Sr-90 detections are well RPC 11DU and well RSE 1A screened in the A horizon, and well RSE 26DL screened in the TZ. Results are consistent with historical samples at these wells. Time-series plots (Appendix C) show that all three wells are continuing a trend of steady or decreasing Sr-90 concentrations.

Americium-241 was not detected in auxiliary well RSE 26DL during the 4Q2017 sampling event. Well RSE 26DL is the only well currently being analyzed for Am-241. This is the second non-detect since the most recent optimization for Am-241 has been established. If Am-241 is not detected in the next sampling event, the analysis of this constituent will be discontinued.

3.4.1.3 Boundary Wells

The six boundary wells with Sr-90 detections are well RPC 4DU and well RSE037D screened in the A horizon, and wells RPC 3DL, RPC 5DL, RSE033D, and RSE035D screened in the TZ. All detections were reported as an estimated quantity and are well below the Sr-90 MCL of 8 pCi/L. This is the first historical detection for RSE033D.

There is significant uncertainty associated with these low-level detections. The laboratory method blank associated with all boundary wells detected Sr-90 at an estimated value of 0.449 pCi/L, greater than the method detection limit of 0.263 pCi/L and less than the estimated quantifiable limit (EQL) of 0.643 pCi/L. The uncertainty associated with the estimated values is discussed below and results are shown in Table A-1.

- RPC 3DL was detected at a value of 0.907 pCi/L, higher than its EQL of 0.746 pCi/L, but is an estimated value due to the sample value being less than 10 times the concentration of the blank. The uncertainty associated with this sample is the quantity of Sr-90 present, related to the presence of Sr-90 in the blank. The reported result is likely biased high due to the presence of Sr-90 in the blank.
-

- Strontium-90 measured in well RPC 4DU and well RPC 5DL were estimated values of 1.42 pCi/L and 1.24 pCi/L, respectively. These values were above their MDL and below the EQL of 1.540 pCi/L (RPC 4DU) and 2.602 pCi/L (RPC 5DL). The sample values were less than 10 times the concentration of the blank. The uncertainty associated with these samples is both the low levels of Sr-90 measured in the sample below the EQL and the presence of Sr-90 in the blank. The reported result is likely biased high due to the presence of Sr-90 in the blank.
- Strontium-90 measured in well RSE033D (0.312 pCi/L), well RSE035D (0.456 pCi/L), and well RSE037D (0.633 pCi/L) were all detected above their method detection limit (MDL) and below the EQLs of 0.634 pCi/L, 0.728 pCi/L, and 0.693 pCi/L, respectively. These values were determined to be estimated values given that the low levels measured in the samples was below the EQL. In addition, it is uncertain whether Sr-90 is actually present in these samples based on the presence of Sr-90 in the method blank.

3.4.2 Results Greater than Groundwater Mixing Zone Compliance Limits

Monitoring results from plume/intermediate wells presented in Appendix A were compared to their respective MZCLs listed in Table 1 as defined in the approved GWMZ application. No samples from any well exceeded the MZCLs.

4.0 CONCLUSIONS FOR 2017

The following conclusions and recommendations were reached based on the 4Q2017 monitoring of RRSB OU:

- There were no MZCL exceedances of Sr-90 in plume/intermediate wells in 4Q2017.
 - There were no MCL exceedances in boundary wells in 4Q2017.
 - There were no MCL exceedances in TZ wells in 4Q2017.
-

- Strontium-90 was detected at low levels (estimated quantities) in six boundary wells, two in the A horizon and four in the TZ. The values are well below the Sr-90 MCL. These wells have always been estimated or non-detect values. The presence of Sr-90 in the laboratory blank increases the uncertainty of these results.
 - Sr-90 concentrations were generally comparable to historically observed concentrations (Appendix C).
 - Americium-241 was not detected in auxiliary well RSE 26DL during this sampling event. Sampling for Am-241 will remain for one more sampling event to determine if it should continue to be an analyte for future sampling.
 - Sampling results confirm that the approved groundwater mixing zone remedy is performing as expected and is still considered an appropriate action for the RRSB OU.
 - Water elevations in 4Q2017 were generally lower than in 4Q2015 and ranged from an increase of 0.3-m (1-ft) to a decrease of 3.2-m (10.5-ft) from 4Q2015 values.
 - The next sampling event of the RRSB OU GWMZ monitoring well network will occur in the fourth quarter of 2019, to be followed by a letter report which will be submitted no later than June 30, 2020.
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Table 1. GWMZ Compliance Limits for the Constituent of Concern

Station	Well Use	Aquifer Zone	Limit Type	Strontium-90 Concentration Limits (pCi/L) by Time Period								
				2004 to 2025	2025 to 2050	2050 to 2075	2075 to 2100	2100 to 2125	2125 to 2150	2150 to 2175	2175 to 2200	2200 to 2225
RPC 3DL	Boundary	TZ	MCL	8	8	8	8	8	8	8	8	8
RPC 4DU	Boundary	A	MCL	8	8	8	8	8	8	8	8	8
RPC 5DL	Boundary	TZ	MCL	8	8	8	8	8	8	8	8	8
RPC 5DU	Boundary	A	MCL	8	8	8	8	8	8	8	8	8
RSE027C	Boundary	MAZ	MCL	8	8	8	8	8	8	8	8	8
RSE028B	Boundary	LAZ	MCL	8	8	8	8	8	8	8	8	8
RSE029D	Boundary	TZ	MCL	8	8	8	8	8	8	8	8	8
RSE030C	Boundary	MAZ	MCL	8	8	8	8	8	8	8	8	8
RSE031B	Boundary	LAZ	MCL	8	8	8	8	8	8	8	8	8
RSE032D	Boundary	A	MCL	8	8	8	8	8	8	8	8	8
RSE033D	Boundary	TZ	MCL	8	8	8	8	8	8	8	8	8
RSE034D	Boundary	A	MCL	8	8	8	8	8	8	8	8	8
RSE035D	Boundary	TZ	MCL	8	8	8	8	8	8	8	8	8
RSE036C	Boundary	MAZ	MCL	8	8	8	8	8	8	8	8	8
RSE037D	Boundary	A	MCL	8	8	8	8	8	8	8	8	8
RSE038B	Boundary	LAZ	MCL	8	8	8	8	8	8	8	8	8
RSP 4D	Boundary	A	MCL	8	8	8	8	8	8	8	8	8
RSE 10	Plume /Intermediate	A	MZCL	2244	3064	3203	3131	2467	1662	989	536	274
RSD002DL	Plume/ Intermediate	TZ	MZCL	8	8	10	14	17	18	17	14	12
RSD002DU	Plume/ Intermediate	A	MZCL	1209	657	410	311	242	174	115	70	41
RSE 10DU	Alternate Plume/Intermediate*	A	MZCL	2244	3064	3203	3131	2467	1662	989	536	274
RSE010DL	Plume/ Intermediate	TZ	MZCL	8	8	8	8	8	8	8	8	8
RPC 11DU	Auxiliary	A	na	na	na	na	na	na	na	na	na	na
RSE 1A	Auxiliary	A	na	na	na	na	na	na	na	na	na	na
RSE 26DL	Auxiliary	TZ	na	na	na	na	na	na	na	na	na	na

- A – A horizon of the upper aquifer zone of the Upper Three Runs aquifer unit
 - TZ – Transmissive zone of the upper aquifer zone of the Upper Three Runs aquifer unit
 - MAZ – Middle aquifer zone of the tan clay
 - MCL – maximum contaminant level
 - LAZ – Lower aquifer zone of the Upper Three Runs aquifer unit
 - MZCL – mixing zone concentration limit = upper 95% confidence limit from uncertainty analysis (plume/intermediate wells)
 - na – not applicable; results from auxiliary wells are for information purposes only
- *sampled when RSE 10 is dry

5.1.1.1.1 TABLE 2. MONITORING WELL SAMPLING

Per WSRC, 2004a				
Well Identification	Measurements and Analyses	Comparison Criteria	Sample Frequency	Reporting Frequency
Plume/ Intermediate	Strontium-90 water elevation	MZCLs (see Table 1)	Quarterly for the first year, annually thereafter (subject to review every 5 years)	1 st year report, then every two years
Plume/ Intermediate	Americium-241 water elevation	No Action-Level, Information Only	Quarterly for the first year, annually thereafter (subject to review every 5 years)	1 st year report, then every two years
Compliance Boundary Wells	Strontium-90 water elevation	MCL = 8 pCi/L	Quarterly for the first year, annually thereafter (subject to review every 5 years)	1 st year report, then every two years
Compliance Boundary Wells	Americium-241 water elevation	No Action-Level, Information Only	Quarterly for the first year, annually thereafter (subject to review every 5 years)	1 st year report, then every two years
Auxiliary Wells	Strontium-90 Americium-241 water elevation	No Action-Level, Information Only	Quarterly for the first year, annually thereafter (subject to review every 5 years)	1 st year report, then every two years
Per SRNS, 2013				
Well Identification	Measurements and Analyses	Comparison Criteria	Sample Frequency	Reporting Frequency
Plume/ Intermediate	Strontium-90 water elevation	MZCLs (see Table 1)	Biennially (subject to review every 5 years)	Full report 2014, 2018, etc.; Letter report 2016, 2020, etc.
Compliance Boundary Wells (A and TZ)	Strontium-90 water elevation	MCL = 8 pCi/L	Biennially (subject to review every 5 years)	Full report 2014, 2018, etc.; Letter report 2016, 2020, etc.
Compliance Boundary Wells (MAZ and LAZ)	Strontium-90 water elevation	MCL = 8 pCi/L	Not sampled unless any TZ well verifiably exceeds 8 pCi/L	Full report 2014, 2018, etc.; Letter report 2016, 2020, etc.
Auxiliary Wells	Strontium-90 water elevation	No Action-Level, Information Only	Biennially (subject to review every 5 years)	Full report 2014, 2018, etc.; Letter report 2016, 2020, etc.
Per USEPA, 2014				
Auxiliary Well RSE 26DL	Americium-241	Detection limit	3 reporting periods, starting in 2015	N/A

Table 3. Construction Details of Plume/Intermediate, Boundary, and Auxiliary Wells

Current Station Name	Name Used in GWMZ Application	Well Use	Aquifer Abbreviation	Ground Elevation	Top of Screen Elevation	Bottom of Screen Elevation
RPC 11DU	RPC 11DU	Auxiliary	A	291.21	286.21	271.22
RSD 10 (r)	RSD 10	Auxiliary	A	290.50	272.50	262.50
RSE 1A	RSE 1A	Auxiliary	A	302.30	294.80	274.80
RSE 26DL	RSE 26DL	Auxiliary	TZ	306.20	203.69	193.64
RPC 3DL (a)	not used	Boundary	TZ	305.88	191.23	181.24
RPC 4DU (a)	not used	Boundary	A	302.29	284.86	269.86
RPC 5DL (a)	not used	Boundary	TZ	304.60	197.34	187.34
RPC 5DU (a)	not used	Boundary	A	304.60	277.30	262.30
RSE027C (s)	MCL08	Boundary	MAZ	305.94	178.94	168.94
RSE028B (s)	MCL12	Boundary	LAZ	297.04	152.04	142.04
RSE029D	MCL06	Boundary	TZ	288.21	204.21	194.21
RSE030C (s)	MCL09	Boundary	MAZ	295.68	170.68	160.68
RSE031B (s)	MCL11	Boundary	LAZ	298.59	133.59	123.59
RSE032D	MCL01	Boundary	A	299.59	262.59	252.59
RSE033D	MCL04	Boundary	TZ	300.06	221.06	211.06
RSE034D	MCL02	Boundary	A	303.25	261.50	251.50
RSE035D	MCL05	Boundary	TZ	305.18	219.23	209.23
RSE036C (s)	MCL07	Boundary	MAZ	285.98	162.48	152.48
RSE037D	MCL03	Boundary	A	291.39	261.39	251.39
RSE038B (s)	MCL10	Boundary	LAZ	300.63	170.63	160.63
RSP 4D (a)	not used	Boundary	A	298.20	285.20	265.20
RSD002DL	P-1-TZ	Plume/Intermediate	TZ	302.95	197.95	187.95
RSD002DU	P-1-A	Plume/Intermediate	A	302.95	244.95	234.95
RSE 10	RSE 10	Plume/Intermediate	A	303.20	290.50	270.70
RSE010DL	RSE010DL	Plume/Intermediate	TZ	305.16	181.16	171.16
RSE 10DU	not used	Alternate Plume/Intermediate*	A	305.10	273.10	253.00

A – A horizon of the upper aquifer zone of the Upper Three Runs aquifer unit

TZ – Transmissive zone of the upper aquifer zone of the Upper Three Runs aquifer unit

MAZ – Middle aquifer zone of the tan clay (TC)

LAZ – Lower aquifer zone of the Upper Three Runs aquifer unit

(r) removed from network beginning 4Q13

(a) added to network beginning 4Q13

(s) suspended from network beginning 4Q13

*sampled when RSE 10 is dry

Table 4. Water Levels in RRSB OU Mixing Zone Wells

Station	Well Use	Aquifer Zone	1Q2007	2Q2007	3Q2007	4Q2007	4Q2008	4Q2009	4Q2010	4Q2011	1Q2013	4Q2013	4Q2015	4Q2017
RPC 11DU	auxiliary	A	284.0	285.0	281.4	279.8	279.9	284.6	283.1	282.2	289.3	283.4	290.0	284.4
RSD 10	auxiliary	A	282.9	282.2	279.6	277.1	279.4	282.7	281.8	282.9	288.7			
RSE 1A	auxiliary	A	286.3	275.0	dry	dry	dry	282.3	281.2	281.2	286.2	283.5	289.1	278.5
RPC 4DU	Boundary MCL	A						275.3				278.4	285.0	277.7
RPC 5DU	Boundary MCL	A						268.6				271.4	273.5	270.2
RSE032D	Boundary MCL	A	273.2	272.6	271.5	269.7	270.0	271.1	273.6	269.5	268.2	273.4	275.7	276.1
RSE034D	Boundary MCL	A	270.8	270.8	270.8	268.1	268.7	269.6	271.7	267.9	266.6	272.3	272.7	273.1
RSE037D	Boundary MCL	A	266.9	266.7	265.2	263.8	265.0	266.2	267.0	263.7	264.0	268.1	269.3	267.6
RSP 4D	Boundary MCL	A						282.8				280.4	287.7	281.1
RSD002DU	Plume/Intermediate	A	275.6	274.1	272.6	270.2	271.9	273.6	271.6	271.4	271.7	275.6	278.9	276.9
RSE 10	Plume/Intermediate	A	271.4	270.8	269.7	dry	268.7	dry	272.6	dry	dry	277.1	277.2	276.5
RSE 10DU*	Plume/Intermediate	A					270.9	272.5		269.6	269.2	276.7	275.7	276.8
RSE 26DL	auxiliary	TZ	273.5	271.4	271.5	268.2	267.8	271.2	277.5	272.0	271.4	278.7	280.8	278.9
RPC 3DL	Boundary MCL	TZ						264.7			263.2	266.9	268.7	266.7
RPC 5DL	Boundary MCL	TZ						265.4			263.5	266.9	268.7	267.1
RSE029D	Boundary MCL	TZ	265.0	dry	262.5	262.3	261.9	263.2	264.5	261.6	263.1	264.2	267.4	265.0
RSE033D	Boundary MCL	TZ	273.1	272.5	269.4	269.5	269.9	271.0	273.5	269.5	268.2	273.3	275.6	275.9
RSE035D	Boundary MCL	TZ	267.5	267.4	266.4	264.9	266.5	266.6	268.2	264.8	264.1	264.1	**299.5	269.3
RSD002DL	Plume/Intermediate	TZ	272.5	271.5	270.2	268.2	269.2	270.5	272.1	268.6	268.2	272.8	275.3	274.4
RSE010DL	Plume/Intermediate	TZ	269.6	269.1	267.9	266.0	267.1	268.3	271.7	266.1	264.5	271.0	271.9	271.3
RSE027C	Boundary MCL	MAZ	260.0	259.6	258.4	257.3	257.8	260.6	261.1	257.3	257.8	261.5		
RSE030C	Boundary MCL	MAZ	257.1	256.2	255.0	254.2	253.8	255.7	257.7	253.8	254.4			
RSE036C	Boundary MCL	MAZ	259.9	259.4	258.3	257.0	257.8	258.8	259.9	257.0	257.2			
RSE028B	Boundary MCL	LAZ	226.2	225.7	224.9	224.0	224.2	224.8	226.4	223.8	223.4			
RSE031B	Boundary MCL	LAZ	248.3	dry	246.4	245.8	245.6	246.6	248.9	245.1	245.1			
RSE038B	Boundary MCL	LAZ	254.5	254.0	252.8	251.5	252.9	252.8	255.8	251.5	251.0			

high water level since 4Q2007
low water level since 4Q2007
not sampled

*Added to well network in 2008, to be sampled when RSE 10 is dry.

**Suspect value

Table 5. Strontium-90 Concentration Summary

	Aquifer	1Q2007	2Q2007	3Q2007	4Q2007	4Q2008	4Q2009	4Q2010	4Q2011	1Q2013	4Q2013	4Q2015	4Q2017
RPC 11DU	A	80.5	147.0	72.5	20.7	38.6	24.3	25.4	26.9	7.3	18.7	2.72	8.8
RSD 10	A	46.8	18.6	18.0	ND	28.8	26.9	16.2	16.7	38.4			
RSD002DU	A	ND		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RSE 1A	A	9.6					ND	2.6	6.2	5.4	6.1	2.82	5.7
RSE 10	A	274.0	464.0	4170.0		155.0		224.0			213.0	111	264
RSE 10DU	A					ND	ND		ND	0.4	0.5		
RSE032D	A	ND	ND	ND	ND	ND	ND	ND	ND	0.3	ND	ND	ND
RSE034D	A	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RSE037D	A	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.4	ND	0.6
RPC 4DU	A											0.4	1.42
RPC 5DU	A										0.0	ND	ND
RSP 4D	A										0.0	ND	ND
RSD002DL	TZ	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RSE 26DL	TZ	2.6	ND	ND	ND	2.7	ND	ND	ND	1.4	1.0	0.8	0.9
RSE010DL	TZ	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RSE029D	TZ	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RSE033D	TZ	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.3
RSE035D	TZ	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.3	0.5
RPC 3DL	TZ									0.2	ND	ND	0.9
RPC 5DL	TZ									ND	0.4	ND	1.24
RSE027C	MAZ	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
RSE030C	MAZ	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
RSE036C	MAZ	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
RSE028B	LAZ	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
RSE031B	LAZ	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
RSE038B	LAZ	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		

	not sampled
ND	not detected
	detected, < 1 pCi/L
	1 to 8 pCi/L
	> 8 pCi/L

APPENDIX A

Groundwater Monitoring Results Tables and Data Review Key

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Key to Reading the Tables

The following abbreviations may appear in the data tables:

Laboratories Available for Use During 4Q17

EBL	Environmental Bioassay Lab
GEL	General Engineering Lab
LVL	Lionville Laboratory Incorporated
STL	Severn Trent Lab
TAL	TestAmerica Lab

Nomenclature

A	A horizon
LAZ	lower aquifer zone
MAZ	middle aquifer zone
TC	tan clay
TZ	transmissive zone
UAZ	upper aquifer zone
UTRAU	Upper Three Runs aquifer unit

Units

deg. C	degrees Celsius
gal	gallons
ft	feet
mg/L	milligrams per liter
msl	mean sea level
NTU	nephelometric turbidity unit
pCi/L	picocuries per liter
pH	pH unit
μ S/cm	microsiemens per centimeter

Field Conditions

- A Pump is surging excessively; aerated
 - B blank sample was collected
 - C well is continuously pumping
 - D well is dry-no sample or field data collected
 - E equipment blank was collected
 - I well went dry during sampling; field data collected but insufficient water to collect all samples
 - L well went dry before sampling began; only depth to water can be determined
 - N well was not stabilized before sampling began
 - P inaccessibility or mechanical failure prevented sample collection and field analysis of the water
 - S no water in standpipe; for water level events only
 - T samples were collected, but some samples were not sent to the laboratory due to high turbidity
 - W unable to sample well because of stabilization or sampling equipment failure; water-level measurements were obtained
 - X well went dry during purging; samples collected after well recovered measurements obtained
 - 0 OK
 - 1 Pump Dry
 - 2 Sampled after recovery
 - 3 Gallons purged through sample port
 - 4 DI water taken from 772-7B
 - 5 High turbidity
 - 6 Flow meter leaking
 - 7 Pump failure
 - 8 Flow meter not operating
 - 9 # gallons added
 - 10 Well is inaccessible, well cannot be sampled
 - 11 Well abandoned
 - 12 No water to surface
 - 13 Field measurements only
 - 14 Not all samples were collected
 - 15 Equipment failure
 - 16 No water in standpipe
 - 17 Bailed well
 - 18 Water level tape not long enough
 - 19 Well not sampled, maintenance required
 - 20 Well sampled, maintenance required
 - 21 Measurement exceeded criteria
-

Other

CLP	USEPA Functional Guideline Codes
STORET	USEPA STORET result qualifiers
<MDC	Less than the minimum detectable concentration
NDD	“not decision data”
EQL	estimated quantitation limit, = $MDC + 2 * (\text{counting uncertainty})$
<EQL	less than the sample-specific estimated quantitation limit

Results Below Detection

For radiological analyses, if the analyte is not detected, the minimum detectable concentration (MDC) is entered into the result field and is reported with a less than (<) sign. The MDC is the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero, and is determined from analysis of a sample in a given matrix containing the analyte. The EQL is defined as the $MDC + 2 * (\text{counting uncertainty})$, and represents the lowest concentration that can be achieved reliably within specified limits of precision and accuracy during routine laboratory operating conditions. The sample-specific EQL is modified for sample concentration or dilution or unusual aliquot size that affects analytical sensitivity. Any substance detected at concentration greater than the MDC but less than the EQL is 99% likely to be present; however the uncertainty in the quantitated value is unknown, and the actual concentration is questionable. The determined concentration that is >MDC but <EQL is reported along with a “J” qualifier to alert data users that the result is between the MDC and the EQL. These numbers may be used with caution for compliance or regulatory calculations but require additional substantiation.

Uncertainty and Data Usability

For reporting purposes, Savannah River Site (SRS) applies a method for minimizing uncertainty in compliance decisions potentially affecting long-term monitoring or remediation. The method is applied by using a selection process that considers the quantity and the qualifier codes [the U.S. Environmental Protection Agency (USEPA) Functional Guideline Codes (USEPA 1994; USEPA 1999)] applied by the laboratories to the analytical results. The selection processes were designed to select the most conservative result that has the least amount of uncertainty. The output of the selection process populates the data tables as follows:

- 1) "Null" or “blank” – Data not remarked. The analytical result is acceptable for use as reported.

Rationale: The best result would be one without qualifiers, so the preferred choice would be the maximum result that did not have any qualifiers.

- 2) "J", "L", "N", "NJ", or "JL" – "J" identifies that the analyte was positively identified; the associated numerical value is an estimated concentration of the analyte in the sample. "L" Indicates the sample result is off scale high. "JL" Indicates an estimated quantity of a sample that is off scale high. "N" is used for all TIC (tentatively identified compounds) and indicates the presence of an analyte for which there is presumptive evidence to make a tentative identification. "NJ" means the presence of an analyte that has been tentatively identified and the associated numerical value represents its approximate concentration.

Rationale: an estimate can still provide useful information. Although there may be a range of uncertainty around the actual value, the value itself may still grossly exceed a regulatory standard. However, an estimated value is less certain than an unqualified result. Therefore, this would be labeled on figures with a "J" qualifier.

- 3) "U" - material analyzed for, but not detected. The analyte concentration is less than 99% likely to be present, with the confidence decreasing sharply the closer the value is to zero. These results are labeled as "<MDC".

Rationale: a result above the detection limit would be chosen before a result below detection so that the process is not biased toward false negatives.

- 4) "UJ" - result is not above the reported MDC, but the reported quantitation limit itself is approximate, and may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

Rationale: the additional qualifiers make this result less reliable for use than the "U" without qualifiers. These results would be labeled "<MDC."

- 5) "Rejected" – The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Rationale: the only value in providing this result in the report is to indicate that the lab attempted to analyze the sample. If there are any other results available, the result with the "R" qualifier should not be reported.

Holding Times

Standard analytical methods include a limit, called holding time, on the maximum elapsed time between sample collection and extraction or analysis by the laboratory. In the data tables, the result qualifier Q in the "EPA" column indicates that holding time was exceeded. Analyses performed beyond holding times may not yield valid results.

Data Qualification

The contract laboratories submit sample- or batch-specific quality assurance/quality control information at the same time as analytical results or in a quarterly summary. Properly defined and used, data qualifiers can be a key component in assessing data usability. The USEPA Functional Guideline Codes (USEPA 1994; USEPA 1999) used by the analytical laboratories are defined below. These modifiers appear in the data tables associated with “EPA CLP qualifier” in the drop down comment box of the results cell in the Microsoft Excel sheet for the data table. USEPA STORET codes appear in the data tables associated with the “EPA STORET qualifier” in the drop down comment box of the result cell in the Microsoft Excel sheet for the data table.

Concentrations that exceeded the MCL if they don’t have a mixing zone concentration limit (MZCL) or the MZCL and are not “estimated quantities” (i.e., do not have a USEPA Functional Guideline Code of “J”) are identified in the tables by a red background. Concentrations that exceeded the MCL but did not exceed their MZCL and are not “estimated quantities,” are identified by an orange background. Results shown in a lavender background are estimated quantities. Blue font indicates that a particular analysis is not required for a given well for the sampling event presented. An “NS” with an ivory background identifies analyses that were required but could not be completed. Results that were rejected by the laboratory are listed in the data tables as “REJ”, with a pink background.

“EPA CLP” Qualifiers - USEPA Functional Guidelines Codes (USEPA 1994 and 1999)

<i>(Blank)</i>	Data not remarked. The analytical result is acceptable for use as reported.
<i>J</i>	The analyte was positively identified; the associated numerical value is an estimated concentration of the analyte in the sample.
<i>R</i>	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence of absence of the analyte cannot be verified. Assignment of <i>R</i> requires approval by the appropriate WSRC data validation coordinator.
<i>U</i>	Material analyzed for but not detected. Analytical result reported is less than the sample quantitation limit.
<i>UJ</i>	The analyte was not detected above the reported sample quantitation limit. The reported quantitation limit is approximate, and may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

Note: These are only some of the qualifiers present in the database. All modifiers associated with the data are published in the official repository of the data.

USEPA STORET codes appear in the data tables associated with the “EPA code”. USEPA STORET codes are defined below.

“EPA STORET” Qualifiers – USEPA STORET Codes

<i>(Blank)</i>	Data not remarked
<i>C</i>	The result is calculated.
<i>I</i>	The result is less than the EQL, but equal to or greater than the MDC. Always reported with an associated USEPA functional Guideline Code qualifier of <i>J</i> .
<i>K</i>	The actual concentration is known to be less than the reported result.
<i>L</i>	The actual concentration is known to be greater than the reported result.
<i>O</i>	Sample received by laboratory, but the analysis was lost or not performed.
<i>Q</i>	Sample was held beyond normal holding time prior to analysis.
<i>V</i>	The analyte was detected in both the method blank and the sample.
<i>Y</i>	The result is from an unpreserved or incorrectly preserved sample; the data may not be accurate.

Note: These are only some of the qualifiers present in the database. All modifiers associated with the data are published in the official repository of the data.

REFERENCES

SCDHEC, 1998. *RE: Groundwater Data Reporting Change at SRS*, Letter, G. K. Taylor (SCDHEC) to J. W. Cook (EPD/WSRC); April 21, 1998

USEPA, 1994. *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, 9240.1-05-01, PB 94-963502, EPA540/R-94/013, February 1994; U.S. Environmental Protection Agency, Washington, DC

USEPA, 1999. *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, OSWER 9240.1-05A-P, PB99-963506, EPA540/R-99/008, October 1999; U.S. Environmental Protection Agency, Washington, DC

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Table A-1. RRSB Mixing Zone Monitoring Results, Fourth Quarter 2017 (4Q2017)

			R-Area Groundwater Compliance Monitoring													
			Field Data											Radionuclides		
Station	Well Use	Aquifer Zone	SAMPLE COLLECTION DATE	PH	PHENOLPHTHALEIN ALKALINITY (AS CaCO3)	SAMPLING EVENT WATER ELEVATION	SPECIFIC CONDUCTANCE	TOTAL ALKALINITY (AS CaCO3)	TURBIDITY	VOLUME PURGED	WATER TEMPERATURE	FIELD CONDITIONS	QUALIFIER	Constituent	AMERICIUM-241	STRONTIUM-90
			day-month-year	pH	mg/L	ft	uS/cm	mg/L	NTU	gal	degC			Unit	pCi/L	pCi/L
														MCL		
RPC 11DU	Auxiliary	A_UAZ_UTRAU	07-Nov-2017	4.1	0	284.39	39	0	22.3	10	24.5				NS	8.76
RSE 1A	Auxiliary	A_UAZ_UTRAU	07-Nov-2017	4	0	278.47	36	0	10.5	2	25.9				NS	5.7
			07-Nov-2017	4	0	278.47	36	0	10.5	2	25.9	SPL			NS	5.05
RSE 26DL	Auxiliary	TZ_UAZ_UTRAU	07-Nov-2017	4.8	0	278.94	25	0	1.2	2	22.9		V		<EQL (0.3122)	[0.8860]
			07-Nov-2017	4.8	0	278.94	25	0	1.2	2	22.9	SPL			<EQL (0.4630)	<EQL (3.51)
			07-Nov-2017	4.8	0	278.94	25	0	1.2	2	22.9	LD	V		<EQL (0.2978)	[0.9153]
			07-Nov-2017	4.8	0	278.94	25	0	1.2	2	22.9	LD,SPL			<EQL (0.5940)	<EQL (3.59)
RPC 3DL	Boundary MCL	TZ_UAZ_UTRAU	07-Nov-2017	5.2	0	266.71	31	0	0.4	30	19.4		V		NS	[0.907]
RPC 4DU	Boundary MCL	A_UAZ_UTRAU	07-Nov-2017	4.8	0	277.69	59	0	10.4	10	20.4		V;21		NS	[1.42]
RPC 5DL	Boundary MCL	TZ_UAZ_UTRAU	07-Nov-2017	5.7	0	267.1	30	6	2.8	30	21		V;21		NS	[1.24]
RPC 5DU	Boundary MCL	A_UAZ_UTRAU	07-Nov-2017	5	0	270.2	35	0	1.3	11	23.8		V;21		NS	<EQL (0.587)
RSE029D	Boundary MCL	TZ_UAZ_UTRAU	07-Nov-2017	4.9	0	264.97	15	2	2.7	2	19.7				NS	<EQL (0.607)
RSE032D	Boundary MCL	A_UAZ_UTRAU	07-Nov-2017	4.9	0	276.14	28	0	1.2	2	19.9				NS	<EQL (0.545)
RSE033D	Boundary MCL	TZ_UAZ_UTRAU	08-Nov-2017	4.8	0	275.86	26	0	2.1	2	19.4		21		NS	[0.312]
RSE034D	Boundary MCL	A_UAZ_UTRAU	08-Nov-2017	5	0	273.14	22	0	0.3	2	18.5				NS	<EQL (0.727)
RSE035D	Boundary MCL	TZ_UAZ_UTRAU	08-Nov-2017	5.3	0	269.32	20	0	1.4	2	18.6		21		NS	[0.456]
RSE037D	Boundary MCL	A_UAZ_UTRAU	08-Nov-2017	4.8	0	267.58	27	0	0.9	2	18.6		21		NS	[0.633]
RSP 4D	Boundary MCL	A_UAZ_UTRAU	08-Nov-2017	3.6	0	281.07	35	0	0.8	6	22.8				NS	<EQL (0.594)
RSD002DL	Plume/Intermediate	TZ_UAZ_UTRAU	07-Nov-2017	4.1	0	274.44	23	0	1.3	3	21.8				NS	<EQL (0.605)
RSD002DU	Plume/Intermediate	A_UAZ_UTRAU	07-Nov-2017	3.9	0	276.86	39	0	10.4	3	22.5				NS	<EQL (0.716)
RSE 10	Plume/Intermediate	A_UAZ_UTRAU	08-Nov-2017	5.1	0	276.53	71	0	82.7	5	21.6				NS	264
RSE 10DU	Plume/Intermediate	A_UAZ_UTRAU	12-Oct-2017	5.3	0	276.82	92	8	1.9	9	26.3				NS	NS
RSE010DL	Plume/Intermediate	TZ_UAZ_UTRAU	07-Nov-2017	5.3	0	271.3	17	3	5.2	2	21.8				NS	<EQL (0.623)

Explanation

[##]	EPA Functional Guideline Code of 'J' was applied to the result, indicating an estimated quantity.
<EQL(##)	Constituent was below detection. The sample-specific Estimated Quantitation Limit is in parentheses.
	Result exceeds applicable limit.
	For wells with MZCLs, result exceeds MCL but is below applicable MZCL.
REJ	Result Rejected
	Result is less than the applicable limit and without EPA Functional Guideline qualifiers.
NS	Requested to be sampled but was not. See section 3.4.1.1. as to why not.
Blue Text	Not a required sample analysis.
LD	Laboratory Duplicate
SPL	Split Sample

APPENDIX B

Figures

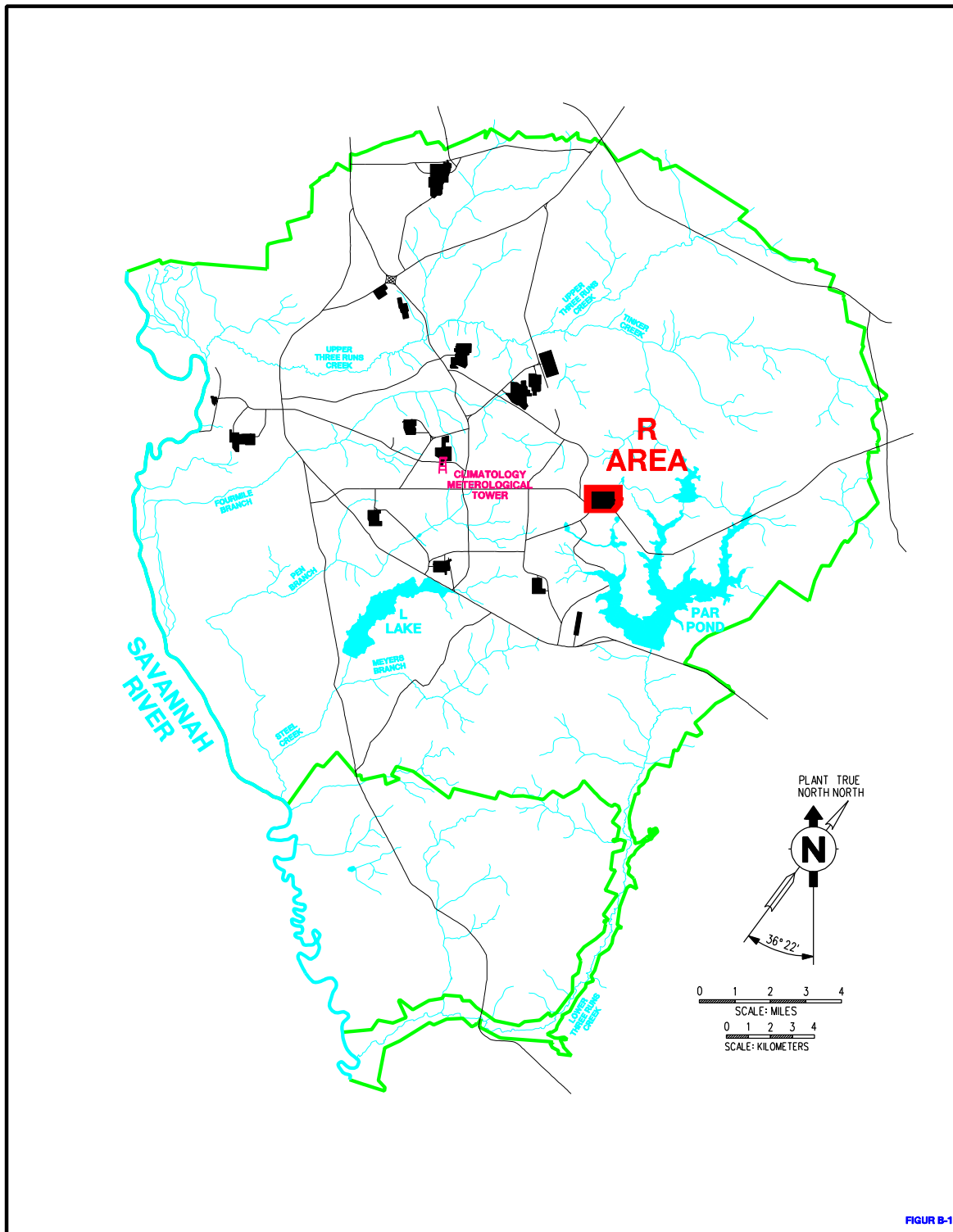


Figure B-1. Location of the R-Area Seepage Basin/108-4R Overflow Basin Operable Unit at the Savannah River Site

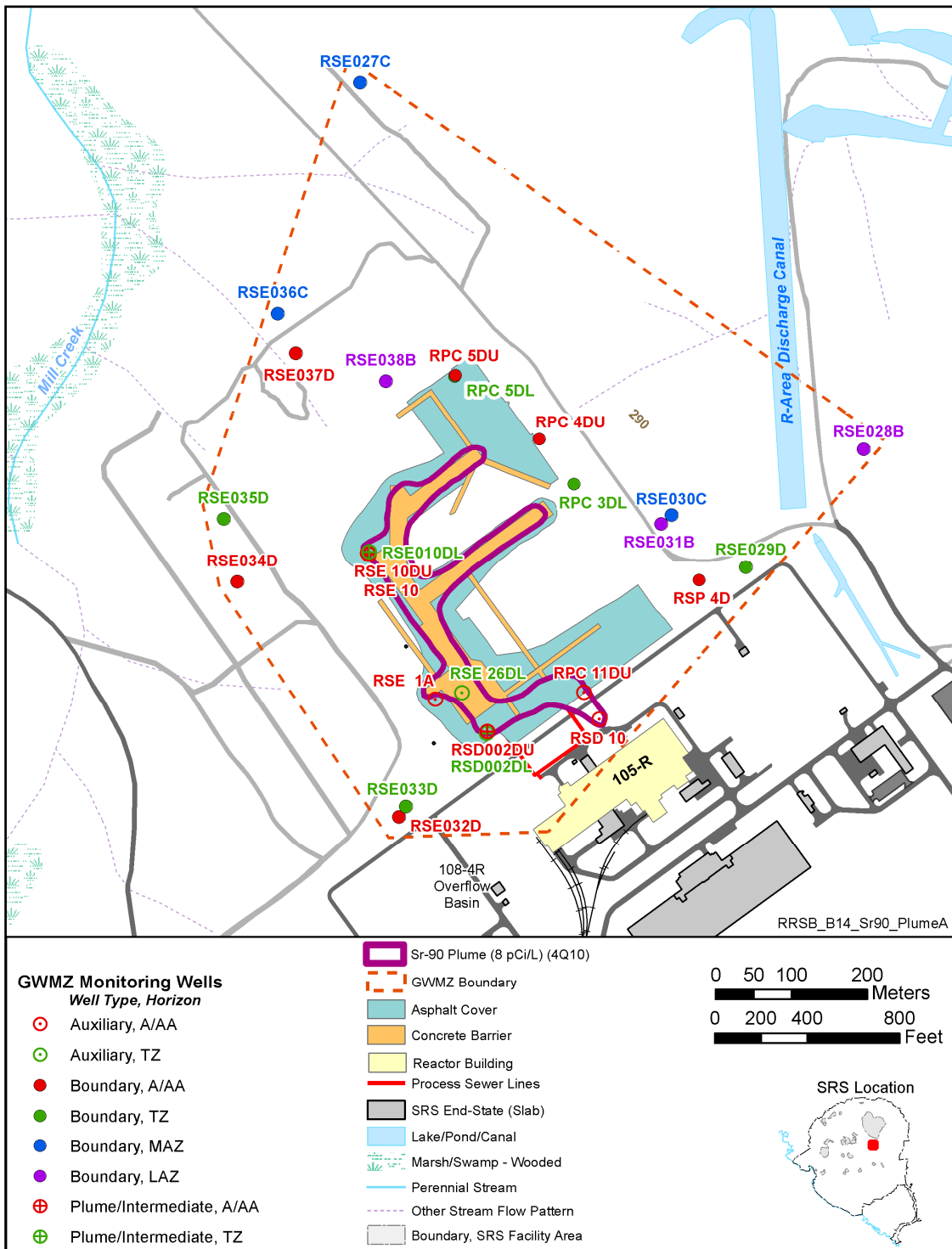


Figure B-2. Groundwater Mixing Zone Boundary and Monitoring Well Network

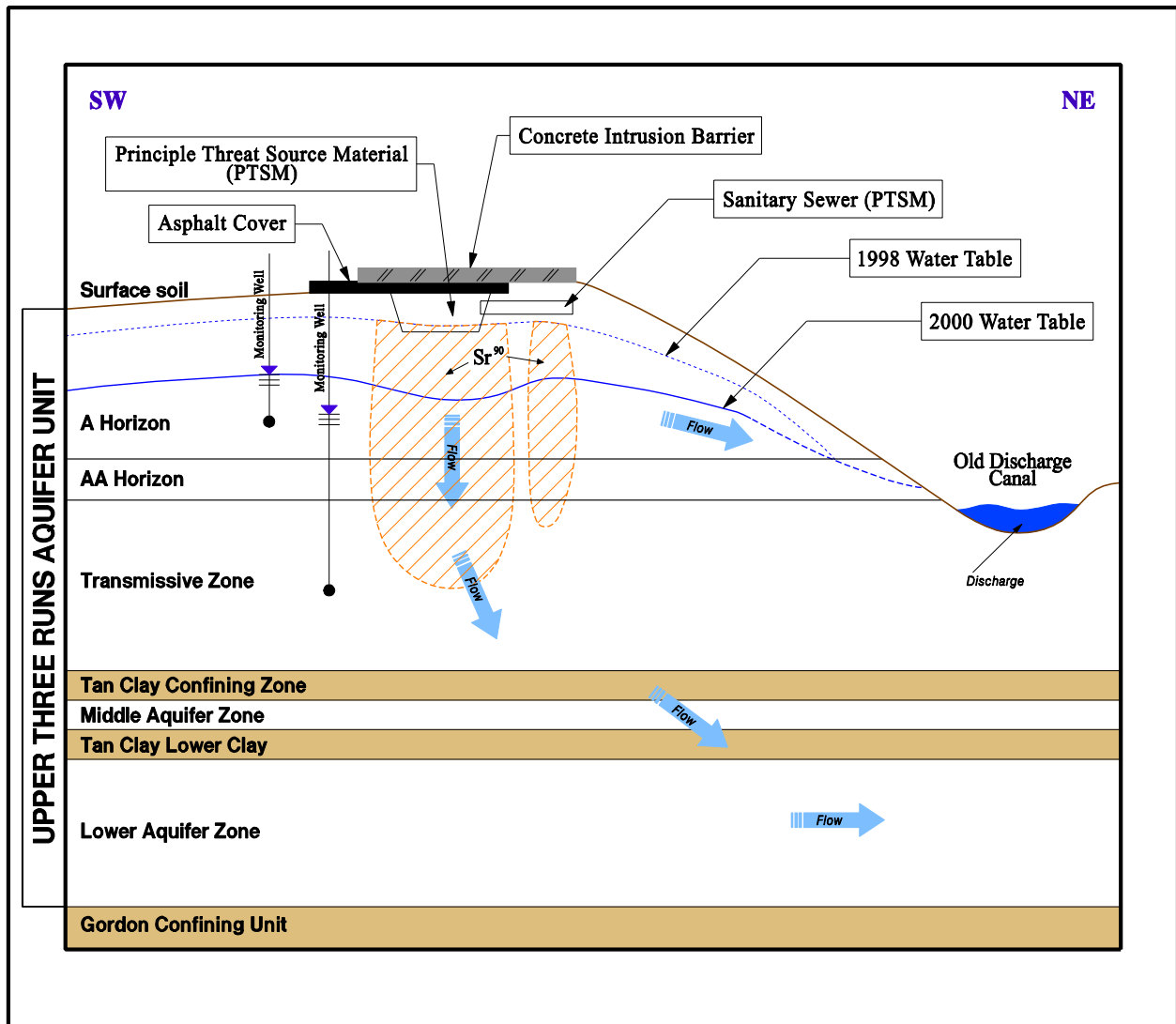


Figure B-3. RRSB OU Hydrogeological Conceptual Model

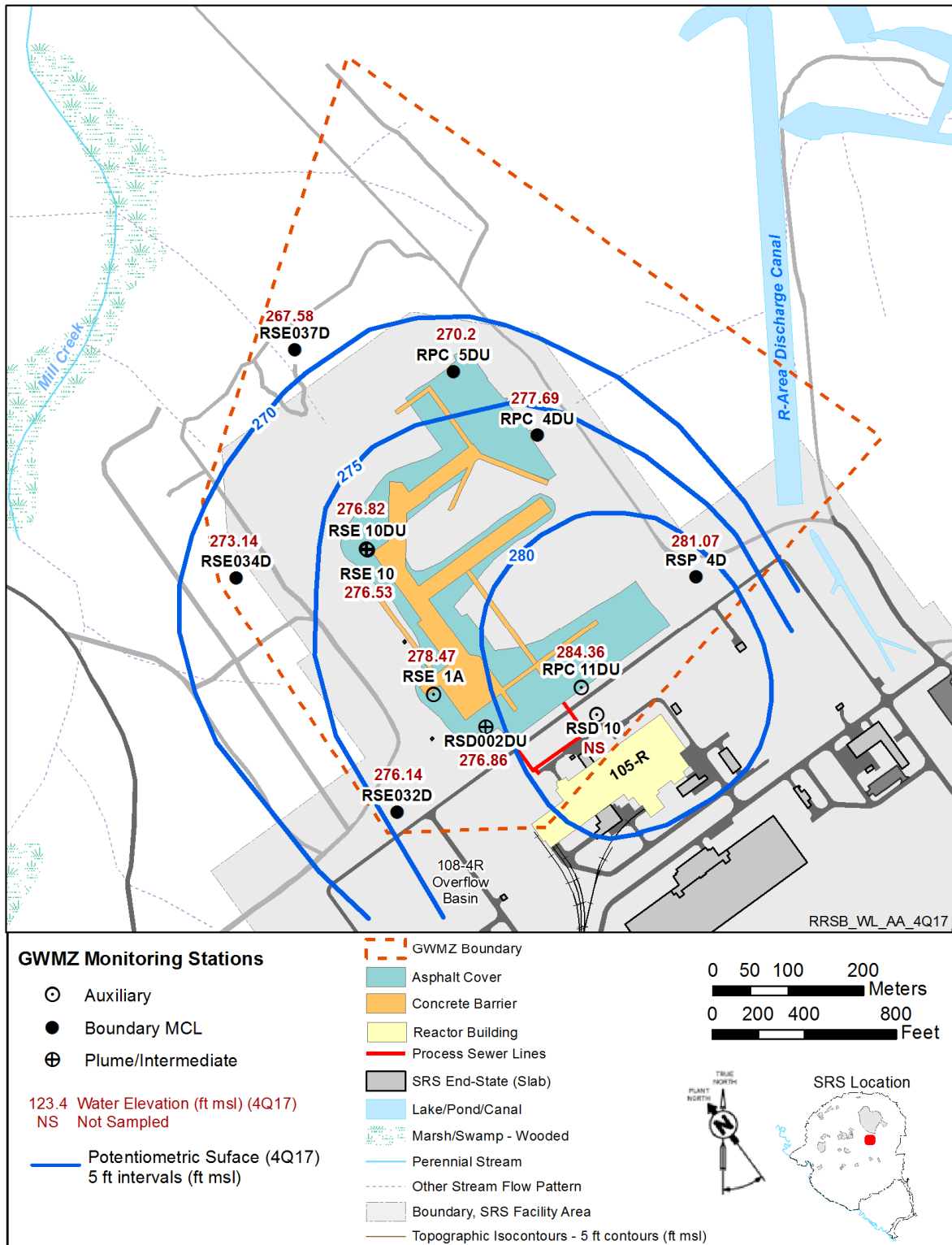


Figure B-4. Potentiometric Surface in A/AA Horizons (4Q2017)

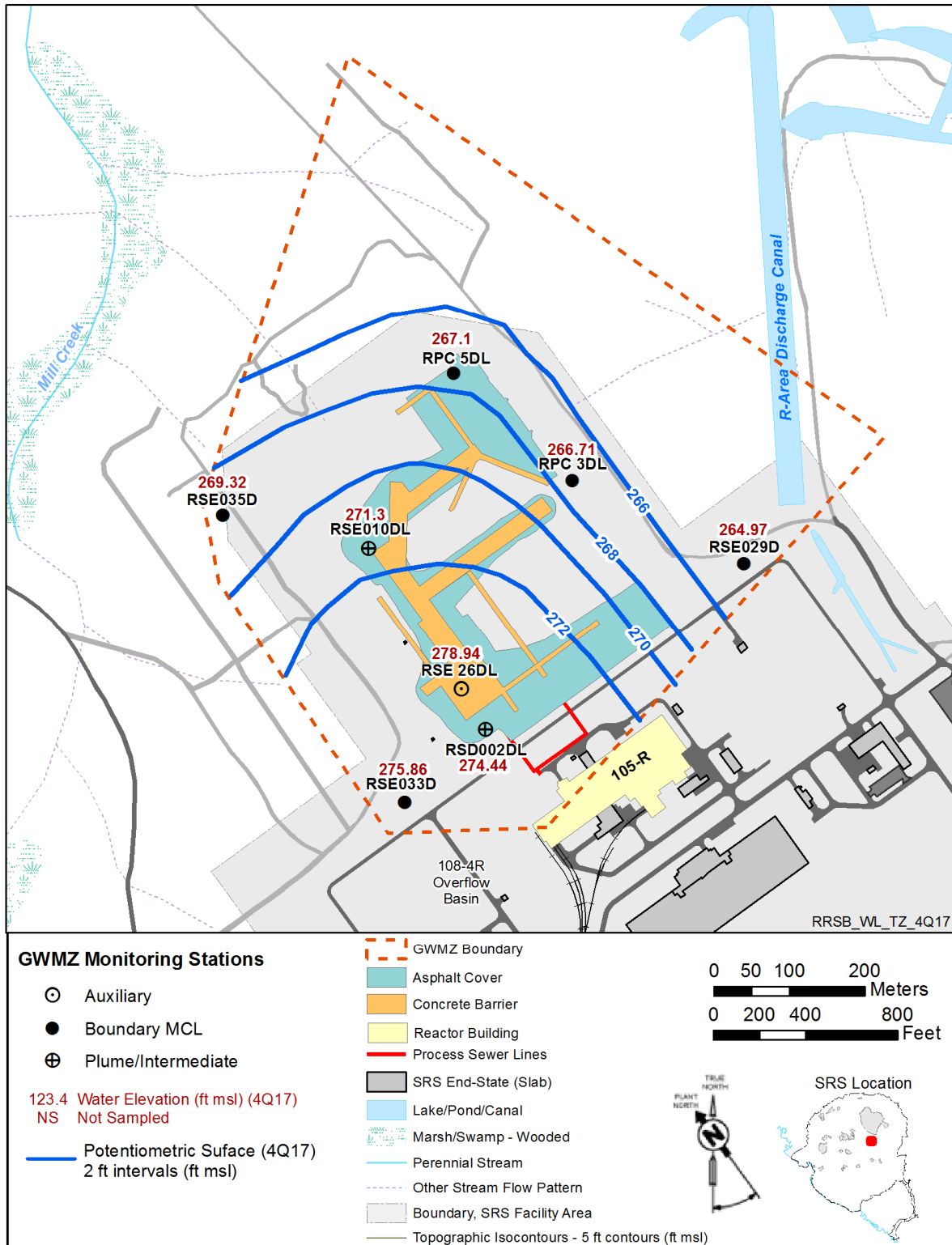


Figure B-5. Potentiometric Surface in the Transmissive Zone (4Q2017)

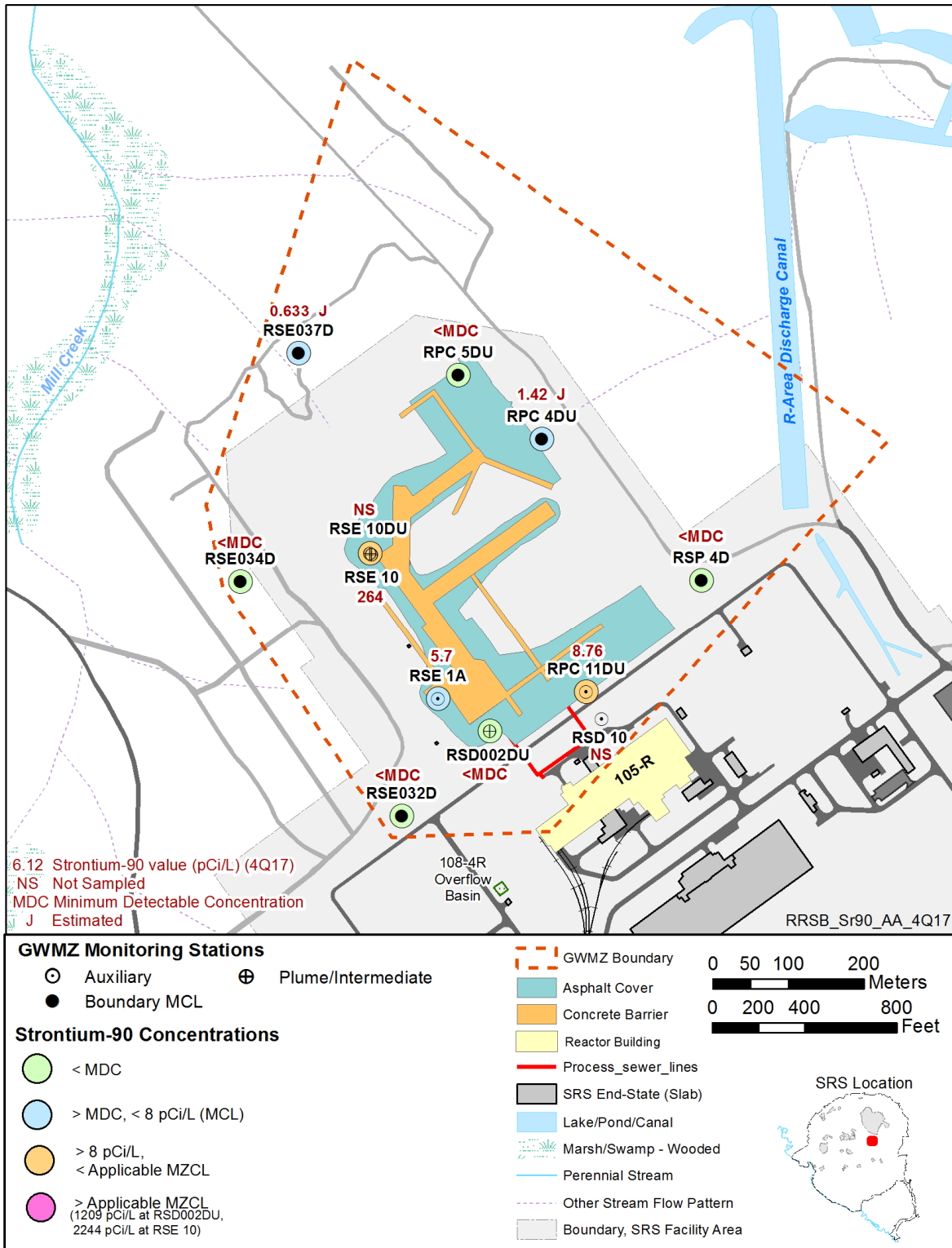


Figure B-6. Strontium-90 Concentrations in A/AA Horizons (4Q2017)

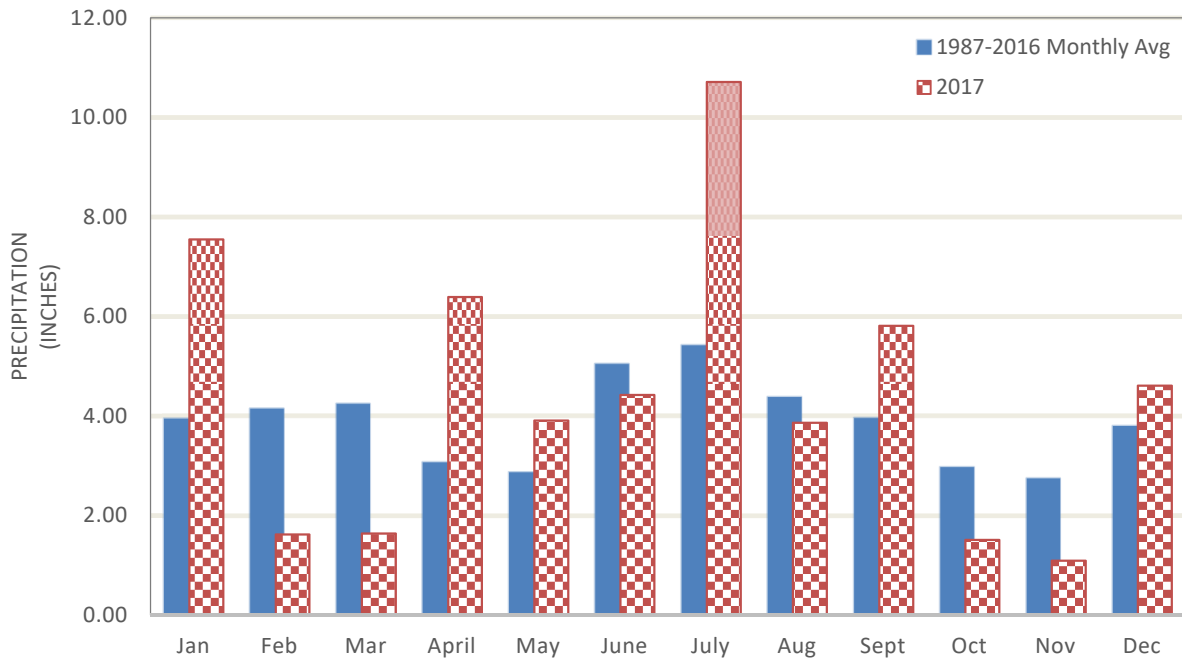


Figure B-7. Monthly Rainfall Measurements at SRS during 2017 Compared with 30-Year Average

APPENDIX C

Time Series Plots

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