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Revision 0

Performance Assessment Monitoring Plan for the Saltstone Disposal Facility at the Savannah River Site

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ACRONYMS

C&WDA	Closure & Waste Disposal Authority
CA	Composite Analysis
CPT	Cone Penetrometer Test
DOE	United States Department of Energy
DAS	Disposal Authorization Statement
GSA	General Separations Area
GWPS	Groundwater Protection Standard
LLW	Low-Level Waste
LZ	Lower Aquifer Zone
MOP	Member of the Public
MSL	Mean Sea Level
NDAA	National Defense Authorization Act
NRC	United States Nuclear Regulatory Commission
PA	Performance Assessment
PDWS	Primary Drinking Water Standard
SCDHEC	South Carolina Department of Health and Environmental Control
SDF	Saltstone Disposal Facility
SDU	Saltstone Disposal Unit
SDWS	Secondary Drinking Water Standard
SPF	Saltstone Production Facility
SRR	Savannah River Remediation LLC
SRS	Savannah River Site
SSL	Soil-Screening Level
UTR	Upper Three Runs
UWMQ	Unreviewed Waste Management Question
UWMQE	Unreviewed Waste Management Question Evaluation
WAC	Waste Acceptance Criteria

1.0 INTRODUCTION

This Saltstone Disposal Facility (SDF) Performance Assessment (PA) Monitoring Plan has been developed to meet the requirements for monitoring Low-Level Waste (LLW) disposal facilities according to United States Department of Energy (DOE) Order 435.1 (DOE O 435.1, Chg. 1) and its associated manual and implementation guidance with regard to actual performance versus projected performance for the SDF at the Savannah River Site (SRS) as they relate to the requirements of the *Disposal Authorization Statement* (DAS) *for the Savannah River Site Saltstone Disposal Facility*. [WDPD-12-49] This SDF PA Monitoring Plan is intended to detect changing trends in performance to allow application of corrective actions prior to exceeding any performance objectives.

In addition, while not the purpose of this DOE M 435.1-1 monitoring plan, results of this monitoring plan may be used to support the monitoring defined by *Public Law 108-375, Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005, Section 3116, Defense Site Acceleration Completion*, October 28, 2004. [NDAA Section 3116] The Nuclear Regulatory Commission (NRC) performs separate monitoring activities in coordination with the South Carolina Department of Health and Environmental Control (SCDHEC) per their responsibilities defined in NDAA Section 3116 to assess compliance with the performance objectives in 10 CFR 61, Subpart C.

Section 2.0 provides the key assumptions relevant to the *Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site* (SRR-CWDA-2009-00017) to ensure compliance with the DAS issued for the SDF (WDPD-12-49). Section 3.0 provides a general description of the location of the facility and the relevant aspects of the environmental setting for the facility. Descriptions of the SDF and associated waste form are provided in Section 4.0. Section 5.0 identifies pertinent documents that govern or monitor the SDF. The monitoring approach, including media to be monitored; types, locations, and frequencies of sampling; and analytical information are provided in Section 6.0. Section 7.0 provides a discussion on data evaluation, management, and reporting. Section 8.0 provides guidance on recommendations and corrective actions based on data evaluations as they relate to the monitoring program, SDF PA, and the SDF.

This monitoring plan is a living document, representing a snapshot in time, and will be updated, if necessary, to accommodate any deviations from the conceptual model analyzed in the PA. This monitoring plan will also be evaluated annually, or as conditions at the facility change (e.g., the installation of new groundwater monitoring wells) as part of the PA maintenance program and an update, if required, will be submitted for approval by DOE, as necessary.

Attachment 1 is an assessment of this PA monitoring plan versus the proposed review criteria outlined in *Draft Radioactive Waste Management Disposal Authorization Statement Technical Standard* that indicates whether the review criteria are applicable and, if applicable, how and where within this PA monitoring plan they are addressed.

Attachment 2 provides a list of the associated monitoring well network to be sampled for the SDF with as-built well information extracted from the SRS Environmental Restoration Data Management System database.

2.0 KEY ASSUMPTIONS

This SDF PA Monitoring Plan documents monitoring to confirm performance expectations in the SDF PA as they relate to the DAS. This monitoring plan does not address the SRS Composite Analysis, which is the responsibility of Savannah River Nuclear Solutions. This monitoring plan will use existing monitoring from other required programs whenever possible. These existing programs have been reviewed and are referenced as appropriate. Currently, all monitoring proposed in this monitoring plan is performed under existing programs/permits. Exposure pathways and facility characteristics considered important and requiring monitoring in the SDF PA include water resource protection and Saltstone Disposal Unit (SDU) integrity to ensure water intrusion into the disposals units is minimized for as long as practical.

Groundwater monitoring is performed by the Savannah River Nuclear Solutions Environmental Compliance & Area Completion Projects organization consistent with the *Groundwater Monitoring Plan for Z Area Saltstone Disposal Facility.* [WSRC-TR-2005-00257].

DOE O 435.1, Chg. 1 requires that a fiscal year SDF PA annual review is performed to confirm the adequacy of the current SDF PA and to evaluate the need to conduct Special Analyses or prepare a revision to the SDF PA. This review includes an evaluation of radionuclide inventories, waste volumes, waste types disposed throughout the year, groundwater monitoring results, and testing and research activities performed during the year.

Visual inspections of the disposal units (e.g., roofs, walls, and cell penetrations) and the structural waste form (e.g., for cracking/degradation, oxidation) will be performed by SDF personnel to ensure unit integrity. During layup status, the SDUs are monitored as a maintenance function for conditions that could affect structural and waste form integrity thus leading to releases earlier than evaluated in the SDF PA.

3.0 SITE DESCRIPTION

3.1 Regional Physiographic and Structural Features

The SRS is located on the Atlantic Coastal Plain, Physiographic Province approximately 25 miles southeast of the fall line that separates the relatively unconsolidated Coastal Plain sediments from the underlying Piedmont crystalline basement. The Atlantic Coastal Plain sediments were derived from erosion of the crystalline basement during late Mesozoic (Cretaceous) in stream and river valleys and are represented locally by gravel deposits adjacent to present-day streams and by sediments filling upland depressions (sinks and Carolina Bays). The Cretaceous and younger sediments are not significantly indurated. The total thickness of the sediment package at SRS varies between approximately 700 feet at the northwest boundary and 1,200 feet at the southeast boundary.

Figure 3-1 details the regional physiographic and geologic provinces in South Carolina. As can be seen on Figure 3-1, much of SRS lies within the Aiken Plateau, and this Plateau slopes to the southeast approximately five feet per mile. The Plateau is bounded by the Savannah and Congaree Rivers and extends from the fall line to the Orangeburg Escarpment. The highly dissected surface of the Aiken Plateau is characterized by broad interfluvial areas with narrow, steep-sided valleys. Local relief can vary by as much as 300 feet.

Beneath the Atlantic Coastal Plain sedimentary sequence are two geologic terranes: (1) the Dunbarton basin, a Triassic-Jurassic Rift basin, filled with lithified terrigenous and lacustrine sediments, and (2) a crystalline terrane of metamorphosed sedimentary and igneous rock that may range in age from Precambrian to late Paleozoic. Early to middle Mesozoic (Triassic to Jurassic) rocks occur in isolated fault-bounded valleys either exposed within the crystalline belts or buried beneath the Atlantic Coastal Plain sediments.

Additional information on regional and local physiographic features is provided in Section 3.1 of the SDF PA. [SRR-CWDA-2009-00017]

Figure 3-1: Regional Physiographic and Geologic Provinces of South Carolina

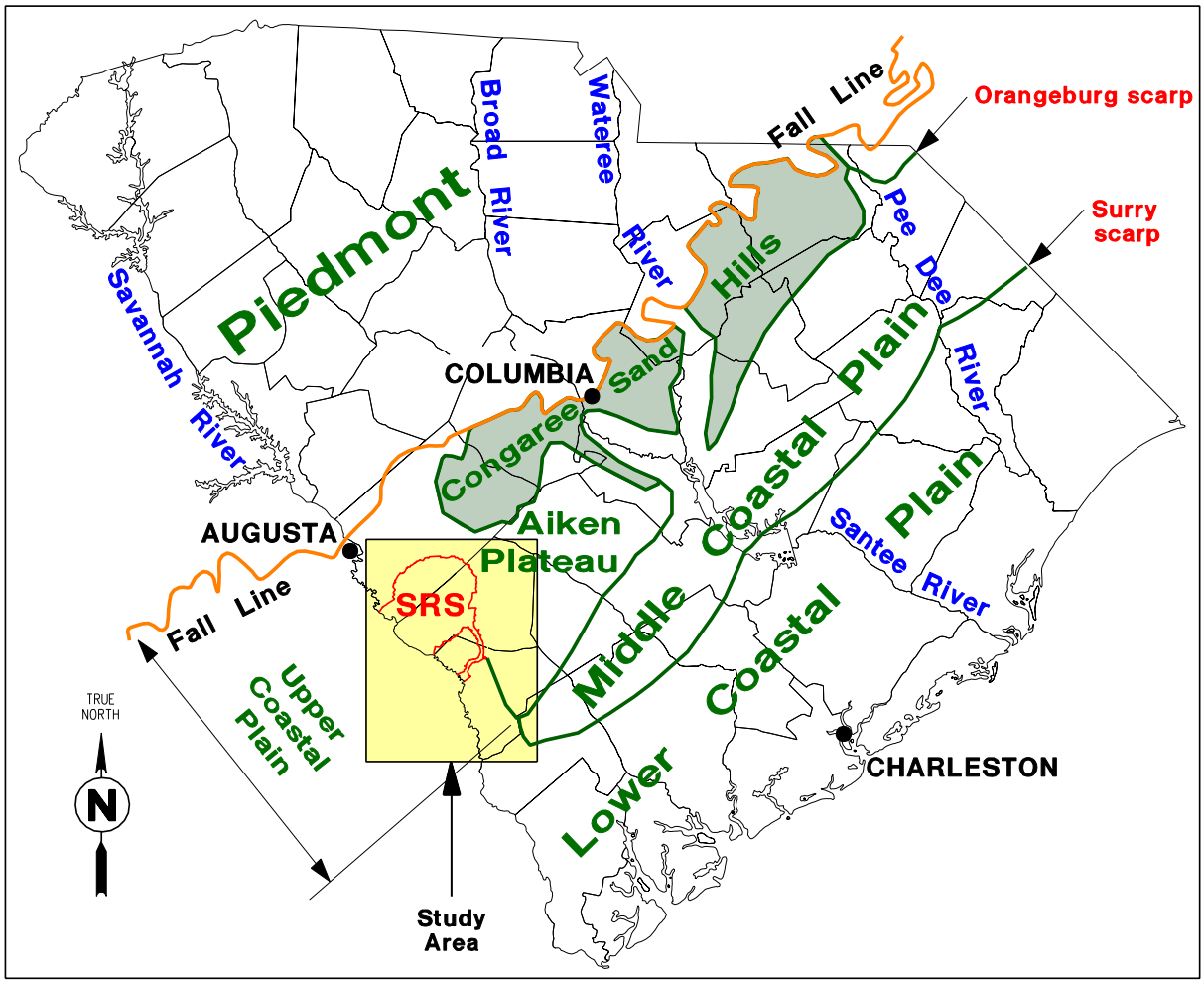
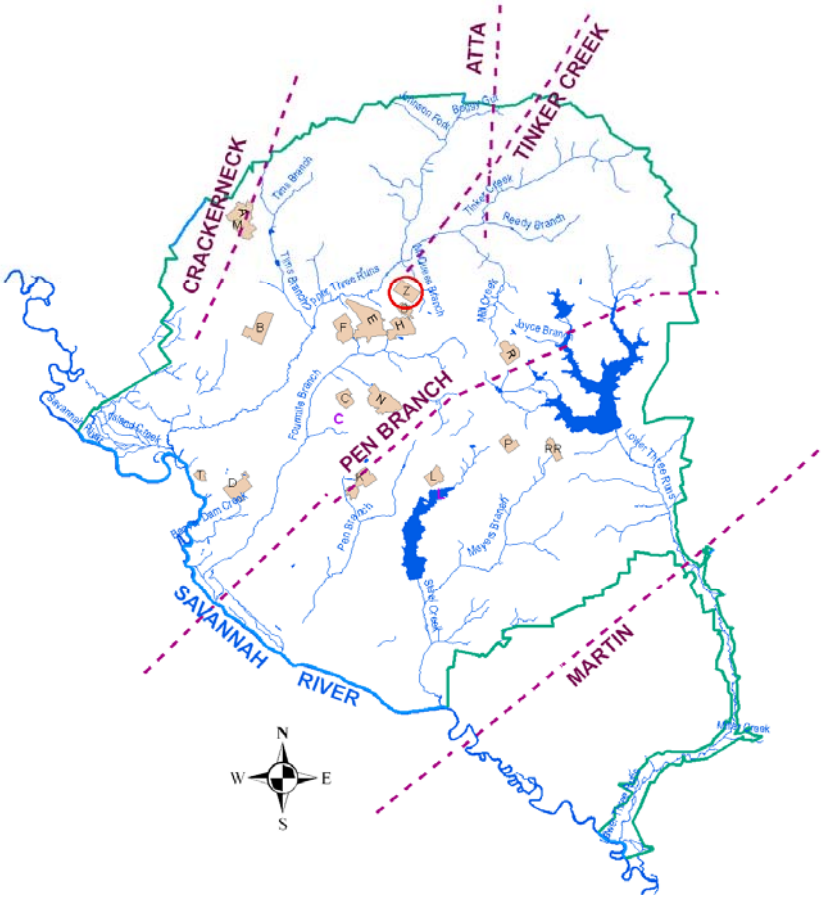


Figure 3-2 shows the locations of regional scale faults below the SRS. In particular, Z Area, because of its proximity to the Tinker Creek fault, could be subject to seismic activity associated with the Atlantic Coastal Plain sediments. A seismic evaluation of Z Area shows that soils beneath Z Area are not susceptible to significant liquefaction for earthquakes leaving a peak ground acceleration less than or equal to 0.17g. [K-CLC-Z-00001]

Additional information on seismic considerations and evaluations are presented in Section 3.1.4 of the SDF PA. [SRR-CWDA-2009-00017]

Figure 3-2: Regional Scale Faults for SRS and Vicinity



3.2 Climate Considerations

The SRS region has a humid subtropical climate characterized by relatively short, mild winters and long, warm, and humid summers. Summer-like conditions typically last from May through September, when the area is frequently under the influence of a western extension in the semi-permanent Atlantic subtropical anticyclone (i.e., the 'Bermuda' high). Winds in summer are light and cold fronts generally remain well north of the area. Daily high temperatures during the summer months exceed 90°F on more than half of all days on average. Scattered afternoon and evening thunderstorms are common. The influence of the Bermuda high begins to diminish during the fall as continental air masses become more prevalent, resulting in lower humidity and more moderate temperatures.

Average rainfall during the fall is usually the least of the four seasons. In the winter months, mid-latitude low pressure systems and associated fronts often migrate through the region. As a result, conditions frequently alternate between warm, moist, subtropical air from the Gulf of Mexico region and cool, dry, Arctic air. The Appalachian Mountains to the north and northwest of SRS help to moderate the extremely cold temperatures that are associated with occasional outbreaks of Arctic air. Consequently, less than one-third of winter days have minimum temperatures below freezing on average, and days with temperatures below 20°F are infrequent.

Measurable snowfall occurs on an average of once every two years. Tornadoes occur more frequently in spring than the other seasons of the year. Although spring weather is somewhat windy, temperatures are usually mild and humidity is relatively low.

Weather data pertinent to the SDF PA are atmospheric dispersion, precipitation, and air temperature.

3.2.1 Atmospheric Dispersion

Since the mid-1970s, a rolling five-year database of meteorological conditions at SRS is updated in order to support dose calculations for accident or routine release scenarios for onsite and offsite populations. The meteorological database includes wind speed, wind direction, temperature, dew point, and horizontal and vertical turbulence intensities. Additional information on atmospheric dispersion is provided in the SDF PA. [SRR-CWDA-2009-00017]

3.2.2 Precipitation

An average precipitation of 48.5 inches per year results from the 55-year monitoring period for the site. Additional information on precipitation is provided in the SDF PA. [SRR-CWDA-2009-00017]

3.2.3 Air Temperature

For a 37-year period, the annual average air temperature is approximately 64°F with an average monthly air temperature from a low of approximately 46°F, to a high of approximately 81°F. Additional information on air temperature is provided in the SDF PA. [SRR-CWDA-2009-00017]

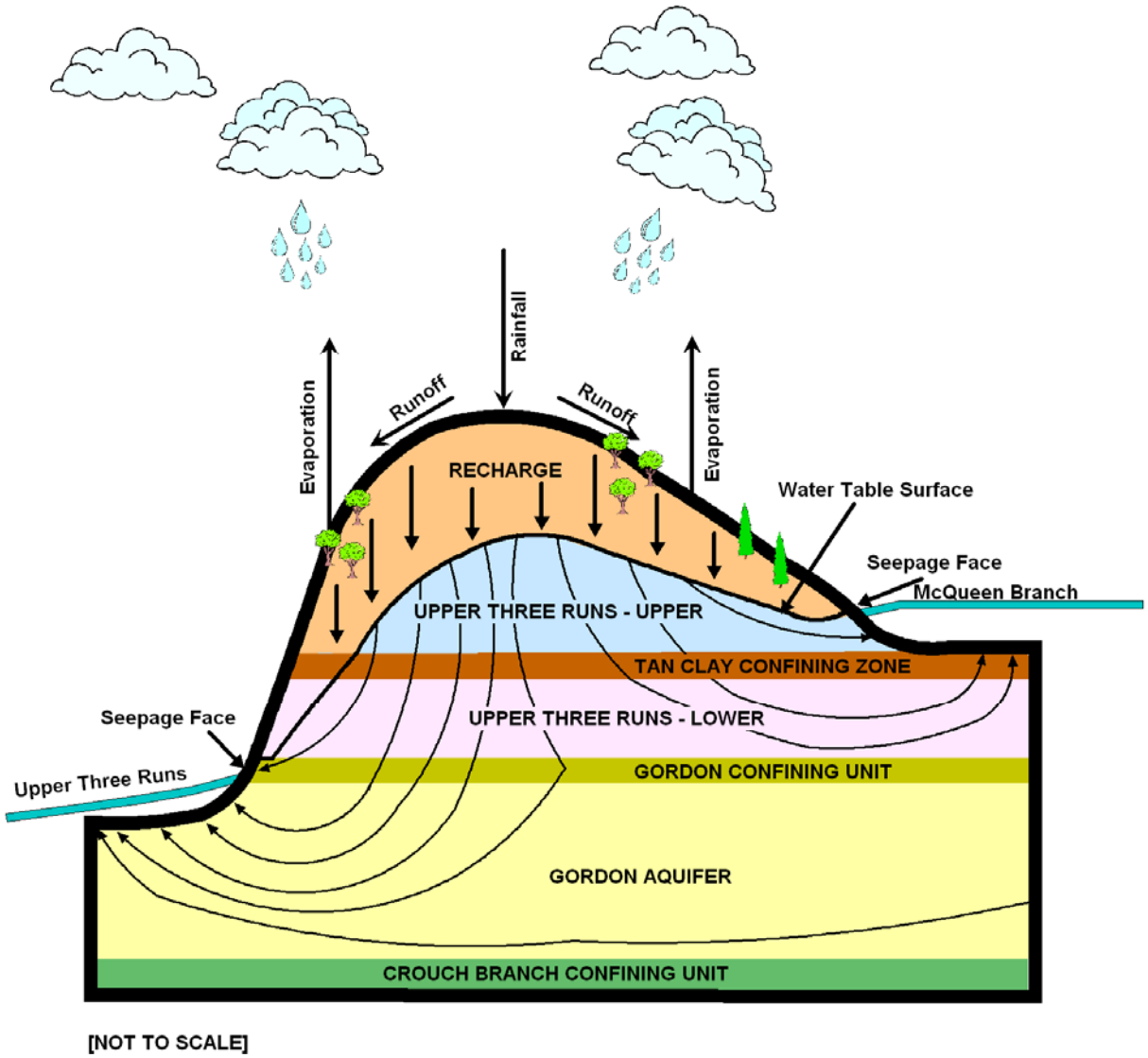
3.3 Key Local Hydrogeologic Considerations

Z Area lies on a local topographic high, at approximately 300 feet above sea level. Z Area is bounded by McQueen Branch in the northeast and Upper Three Runs (UTR) in the northwest. The local relief varies by approximately 160 feet. McQueen Branch is a tributary of UTR and UTR drains into the Savannah River, approximately 10 miles southwest of Z Area. Upper Three Runs lies approximately 4,000 feet from the northwest corner of Z Area. The east corner of Z Area is located approximately 500 feet from McQueen Branch. McQueen Branch and Crouch Branch are incised into the topographic high, southeast and southwest of Z Area, such that their headwaters come within approximately 3,300 feet of each other at approximately 4,600 feet south of Z Area.

Except in the vicinity of the creeks, the water table in Z Area occurs in the “Upland Unit” of the southwestern South Carolina Upper Coastal Plain (Figure 3-1). The average water table beneath the SDF is approximately 210 feet to 230 feet above mean sea level (MSL) with the probable maximum water table calculated to be approximately 234 feet to 248 feet above MSL. For perspective, the disposal unit base elevations above MSL of existing Vaults 1 and 4, and SDUs 2A and 2B, are 281.5 feet and 269.0 feet, respectively. The horizontal gradient ranges from 0.002 feet/foot in the southern part of Z Area to 0.05 feet/foot at the northeastern hill slope. [SRR-CWDA-2009-00017]

Figure 3-3 is a cross-sectional schematic representation of hydrogeology and groundwater flow patterns in the UTR and Gordon Aquifers along a north-south cross-section running through the General Separations Area (GSA), which includes the SDF, shown with significant vertical exaggeration.

Figure 3-3: Conceptual Diagram of Hydrogeology and Groundwater Flow beneath the GSA, including the Saltstone Disposal Facility



As discussed in the Comment Response Matrix for the NRC Second Request for Additional Information on the SDF PA (SRR-CWDA-2011-00044), the potential exists for soft zones with the carbonates of the UTR-Lower Aquifer Zone (LZ) in the vicinity of the SDF. Soft zones and carbonates are generally represented by very small and infrequent pockets in the UTR-LZ that do not continuously run the length of the flow path of the plume, are located near the base of the UTR-LZ, and appear to be filled in with fine sand from the surrounding formation. [WSRC-TR-94-0369]

Two supporting PA reference documents (K-ESR-Z-00001; K-ESR-Z-00002) addressed geotechnical issues regarding calcareous zones at Z Area, which includes the SDF. As stated in the geotechnical evaluation report for SDU 2, K-ESR-Z-00001, soft zones are defined as intervals with a cone penetrometer test (CPT) tip resistance less than 15 ton/ft^2 over a continuous interval of two feet or greater. Ground elevation at SDU 2 is approximately 270 feet above MSL. A soft zone approximately 14-feet thick was identified in one CPT below SDU 2 designated CP-15, centered at an elevation of 170 feet above MSL (approximately 100 feet below ground surface). Looking at the tip resistance for CP-15 (K-ESR-Z-00001, Figure 2), the interval identified is represented by a tip pressure of less than 15 ton/ft^2, but does not appear to represent a void, as there is still tip resistance apparent on the CPT log. This would indicate a zone of underconsolidation as opposed to an actual void. As indicated in Appendix A of K-ESR-Z-00001, three other borings surrounding CP-15, all approximately 75 feet away laterally, did not indicate the presence of soft zones, thereby limiting the potential lateral extent of the zone.

The amount of potential SDU 2 settlement due to a Design Basis Earthquake (a peak ground acceleration of 0.21 g), has been calculated and summarized in Section 5.3.3 of K-ESR-Z-00001. The results of this analysis indicate potential compression of the soft zone represented at ground surface due to a Design Basis Earthquake would only be a maximum of one inch.

In addition, SDF geotechnical evaluation report K-ESR-Z-00002, which summarizes the results of subsurface characterization below future SDUs, identified one soft zone less than three inches thick in one boring out of 21 borings or CPTs, which indicates that soft zones are infrequent and laterally discontinuous.

Although various early documents describe voids, drilling fluid losses, and grout takes associated with the Santee Formation (located in the UTR-LZ), there is in fact no evidence of subsurface voids, karst, or caves that would act as open flow conduits at the SDF. In historical and recent literature, no documentation of void spaces or other phenomena was found that would influence contaminant migration in a manner not already captured by the SDF PA Flow Model. To assume the effects of the presence of carbonate material and soft zones on mobility should be spread across the entire UTR is not reasonable. Any localized increase in mobility would be very short relative to the total distance of transport. [SRR-CWDA-2011-00044]

In 2012, a report summarizing the potential impacts of soft zones within the H-Area Tank Farm, adjacent to the SDF, concludes that soft zones beneath SRS are not cavernous voids, but are small, isolated, poorly connected, three-dimensional features filled with loose, fine-grained, water-saturated sediment.

In spite of their underconsolidated nature, soft zones have survived for a very long time and remain structurally competent in the presence of significant overburden stresses. In addition, soft zones appear not to be a critical influence on either groundwater flow or contaminant transport. [SRNL-TR-2012-00160]

Additional information on potential soft zones at the SDF is presented in the Comment Response Matrix for NRC Requests for Additional Information on the SDF PA (SRR-CWDA-2011-00044). This information will also be included in future revisions to the SDF PA.

Additional information on local geology/hydrogeology is presented in Section 3.1.5 of the SDF PA. [SRR-CWDA-2009-00017]

4.0 FACILITY DESCRIPTION

The SDF Class 3 Landfill is located within Z Area (Figure 4-1) on the SRS in Aiken County and is operated by Savannah River Remediation LLC (SRR) for the DOE. Z Area is approximately 238 acres, which currently contains two rectangular disposal units, two circular SDUs in operation, and four circular SDUs under construction (Figure 4-2). The locations of monitoring wells associated with the SDF at the time of the issuance of this monitoring plan are presented on Figure 4-2.

The waste to be solidified is an aqueous waste stream containing soluble salts removed from the SRS liquid waste tanks. The waste contains sodium salts of various anions, predominately nitrate, nitrite, and hydroxide. This waste is primarily the result of pretreating the waste stored in the FTF and HTF, in addition to Effluent Treatment Facility bottoms and the H-Canyon low-level waste. The dissolved salt solution is staged in Tank 50, where it is subsequently piped to the Saltstone Production Facility (SPF) also located in Z Area. In the SPF, the waste is mixed with a blend of dry materials (i.e., slag, flyash, and cement). The resulting grout is pumped to SDUs where it sets into a dense, microporous, monolithic, and non-hazardous solid.

Figure 4-1: Layout of Z Area within the SRS

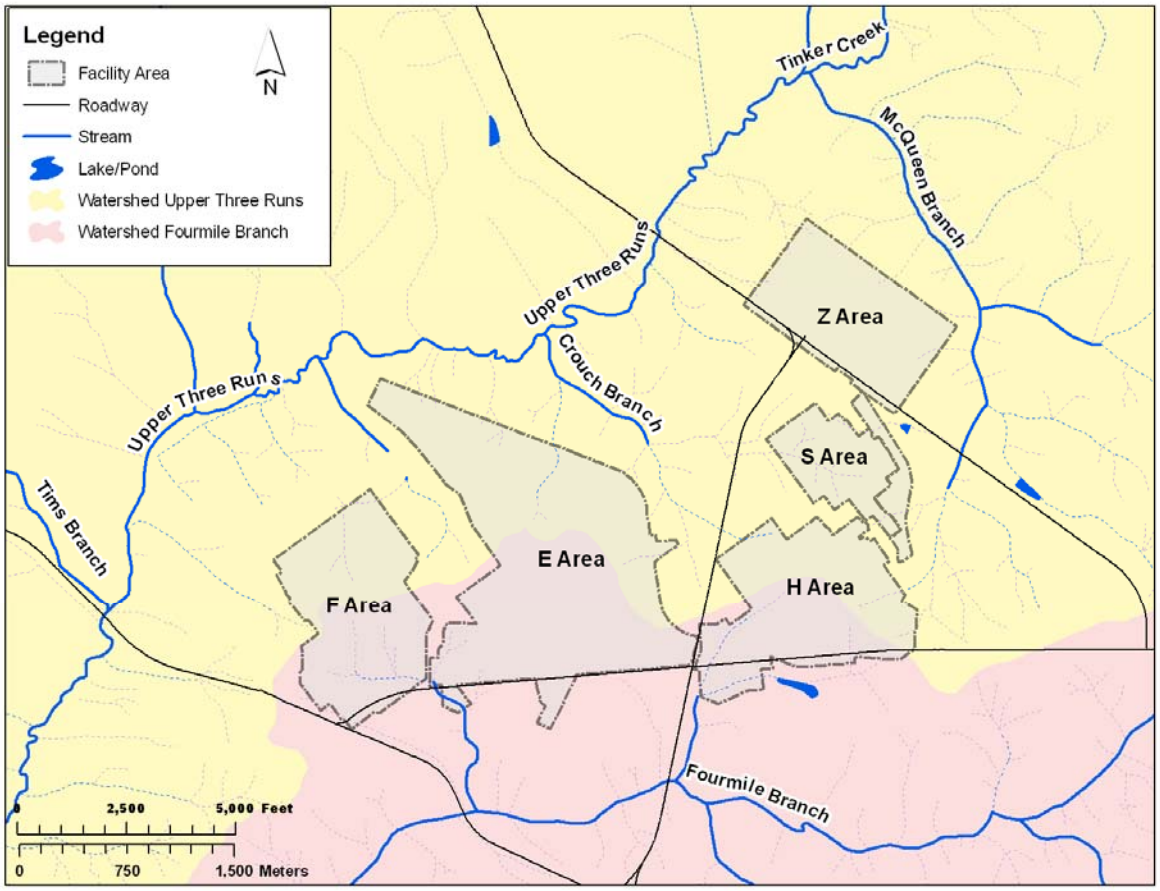
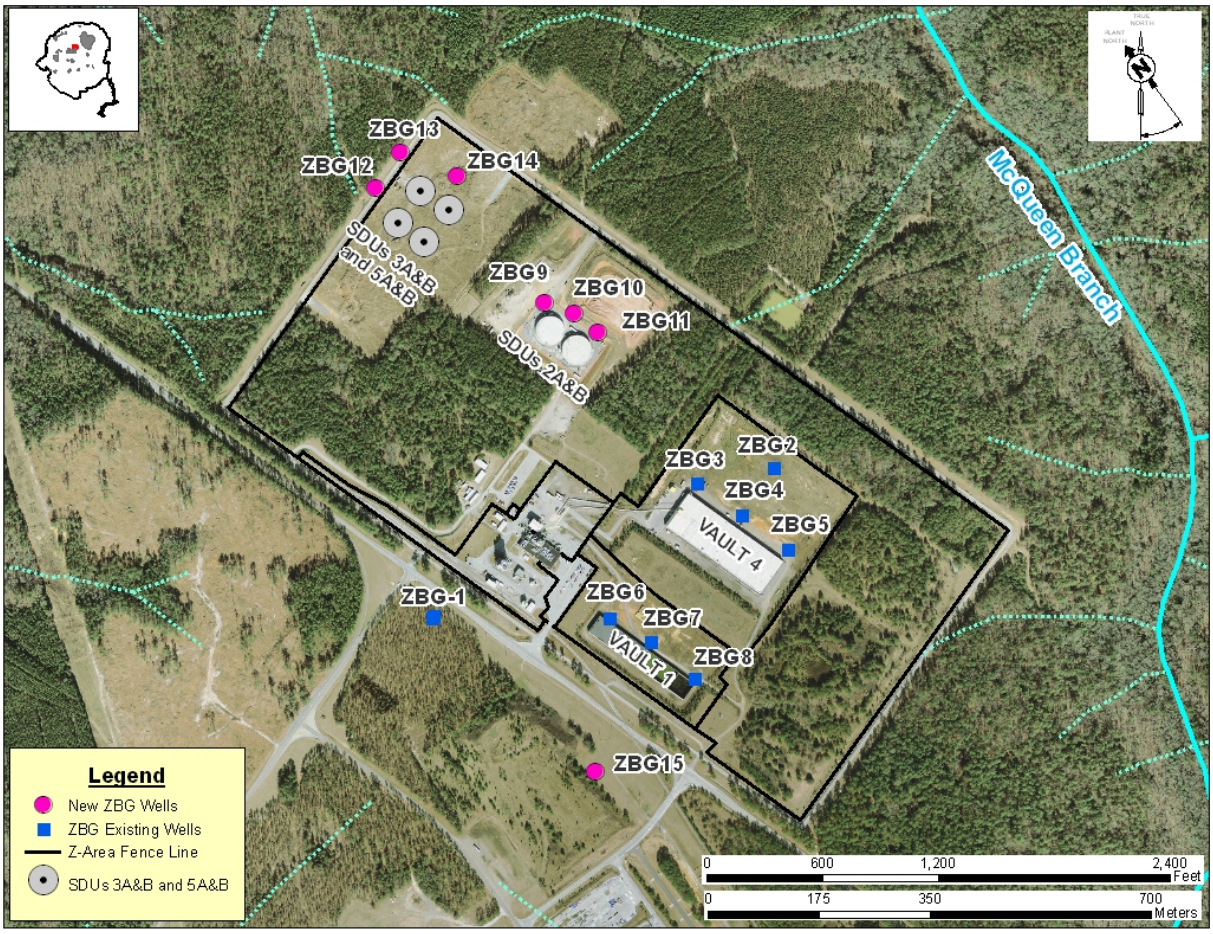


Figure 4-2: Location of SDUs and Associated Monitoring Wells at the SDF



5.0 BASIS FOR MONITORING

A revised DAS for the Savannah River Site Saltstone Disposal Facility (WDPD-12-49) issued in May 2012 superseded DL-LWO DOE_09-28-1999, DAS for the Savannah River site E-Area Vaults and Saltstone Disposal Facilities. This plan supersedes the previous SDF PA monitoring plan (WSRC-RP-2000-00325) and has been prepared to support the revised DAS and updates the PA monitoring program for the Savannah River Site SDF.

Monitoring performed as part of this plan meets the requirements of DOE Order 435.1 and its associated manual and guide. The PA monitoring program is designed to detect changing trends in performance to allow application of any necessary corrective action prior to exceeding the PA performance objectives. To this end:

- The SDF PA (SRR-CWDA-2009-00017) was used to determine the media, locations, radionuclides, and other substances to be monitored. The SDF Waste Acceptance Criteria (WAC), required by the DOE 435.1 Radioactive Waste Management directives, functions as a means to monitor performance related to radionuclide inventories modeled in the PA.
- *Saltstone Disposal Facility Post Operations/Pre Closure Surveillance and Maintenance Program Plan* (SRR-CWDA-2012-00130) is also a component of the Performance Assessment Monitoring Plan for the SDF. This program plan, which supports the *Closure Plan for the Z-Area Saltstone Disposal Facility* [SRR-CWDA-2013-00037], identifies inspections to be performed to evaluate and document the physical status of the vaults and SDUs prior to facility closure.

The SDF is also permitted as a Class 3 Landfill by the State of South Carolina. *The Modified Industrial Solid Waste Permit for Vault 6 in Z-Area SRS – Z-Area Saltstone Disposal Facility* ID No. 025500-1603, Aiken County (DHEC_12-17-2012) has been issued by the SCDHEC Office of Environmental Quality Control Bureau of Land and Waste Management. This permit specifies conditions of operation and requirements for groundwater monitoring, corrective action, reporting, and closure/post-closure care. The groundwater monitoring required by this permit, performed by Savannah River Nuclear Solutions Environmental Compliance & Area Completion Projects per the *Groundwater Monitoring Plan for the Z-Area Saltstone Disposal Facility* (WSRC-TR-2005-00257), serves as the groundwater monitoring component of this SDF PA Monitoring Plan.

Any new information from the above monitoring which may impact the ability to meet performance objectives will be evaluated via the Unreviewed Waste Management Question Evaluation (UWMQE) process. The details regarding specific elements of the monitoring program, data evaluations, and potential reporting actions are detailed in Sections 6.0 through 8.0.

6.0 MONITORING APPROACH

6.1 Monitoring Elements

This section provides a brief discussion and justification of the relevant features and exposure pathways to be monitored at the SDF and the appropriate media to be sampled or inspections to be performed to evaluate compliance with the PA objectives and/or to identify early indications of possible releases

6.1.1 SDF PA Modeling Features

6.1.1.1 Waste Inventory

Inter-area transfers of feed solution from Tank 50 to the Salt Feed Tank at SDF for the preparation of saltstone are monitored through sampling and analysis against the Saltstone Waste Acceptance Criteria (WAC). Attachment 3 of Manual 24.6, Section 2.1 (Manual 24.6, Section 2.1) is completed by SRR Engineering prior to individual transfers from Tank 50. Engineering obtains the authorization for a transfer from Tank 50 to the SPF upon completion of this attachment.

6.1.1.2 SDU Features

SDU periphery inspections per *Saltstone Disposal Facility Post Operations/Pre Closure Surveillance and Maintenance Program Plan* (SRR-CWDA-2012-00130) are an appropriate method for detecting indications of compromised unit integrity. The internal video camera inspections for the active or most recently active disposal cell/unit provide early warning information regarding the internal features of the SDU and waste form. SDF PA elements of the SDUs that are essential to long-term performance are presented in SRR-CWDA-2012-00130 and include:

1. Structures, Systems, and Components integrity
    a. Roof
    b. Walls
    c. Cell Penetrations
2. Waste Form Integrity
    a. Environmental Water Infiltration
    b. Oxidation (inspection of “clean concrete cap” poured over the waste form for cracking or spalling that could expose the waste form to contact with oxygen from either air or infiltrating water)
3. SDU Liquid Collection Systems, if installed
4. Heave Markers (established during construction of the SDUs to monitor for settlement during the operational life of the SDU)

6.1.2 SDF PA Exposure Pathways and Media to be Monitored

This section provides a brief discussion and justification of the exposure pathways and relevant features to be monitored at the SDF and the appropriate media to be sampled or inspections to be performed to evaluate compliance with the PA objectives and/or to identify early indications of possible releases.

The SDF PA evaluates pathways for human exposure to disposal facility constituents in the following categories:

- All pathways,
- Air pathway,
- Radon flux,
- Inadvertent human intruder, and
- Water resource protection (groundwater).

The DAS for the facility includes the performance objectives analyzed in the PA for each of these categories. The relevance of each of these categories to the SDF PA monitoring plan is discussed below.

As described in Section 7.1.3 of the SDF PA, the peak all-pathways annual dose for a Member of the Public (MOP) at 100 meters is calculated using the highest 100-meter groundwater pathways dose results during the performance period in combination with the air pathways results. The all-pathways dose is dominated by the groundwater pathways, with the airborne dose contribution being negligible under all postulated scenarios. Accordingly, this plan monitors groundwater only.

6.1.2.1 Air Pathway

The annual dose from airborne releases resulted in a projected total dose of less than 4E-09 mrem/yr, principally from tritium in the first ten years after closure at 100 meters from the SDF. Based on these results, the air pathway is not monitored. [SRR-CWDA-2009-00017]

6.1.2.2 Radon Flux

Using modeling described in Section 4.5 of the SDF PA, the peak instantaneous flux of 2E-13 pCi/m^2/sec occurs above Vault 1 at approximately 10,000 years after closure as summarized in Section 7.1.6 of the SDF PA. Based on this radon flux analysis, radon is not monitored.

6.1.2.3 Inadvertent Human Intruder

The exposure scenarios for the inadvertent human intruder analysis are summarized in Section 7.1.4 of the SDF PA.

Because groundwater contamination is limited due to the groundwater protection performance objective, the only significant pathways for the inadvertent human intruder involve direct contact with the waste. Since these pathways are not appropriate for monitoring until after control of the site is relinquished, the inadvertent human intruder

pathway is not monitored. In addition to exposure pathways, certain facility features are relevant to monitoring release of constituents to the surrounding environment.

Table 6-1 presents the pathways/relevant features to be monitored and the media that are sampled or inspections that are performed.

6.1.2.4 Radioactivity and Other Substances to be Monitored

The radionuclide concentrations in groundwater at 100 meters are provided in Section 5.2.1 of the SDF PA and the total projected β/γ dose is summarized in Section 7.1.7 of the SDF PA. Section 5.2.1 also includes the maximum total projected α concentration and the maximum total projected radium concentration.

The chemical concentrations in groundwater at 100 meters provided in Section 5.2.1 of the SDF PA indicate that the maximum total projected uranium concentration is 8E-09 µg/L. Based on this maximum uranium concentration as compared to the groundwater protection standard of 30 µg/L, uranium is not monitored in groundwater at the SDF. Table 6-1 identifies the radionuclides and other substances to be monitored per this monitoring plan.

Additional information on radionuclides and chemicals to be monitored in groundwater at the SDF (WSRC-TR-2005-00257) is presented in Section 7.1.

6.1.3 Locations of Sampling and Inspections

For the constituents discussed in Section 6.1.2.4, groundwater monitoring is performed both upgradient and immediately downgradient of the facility to provide data for evaluation to determine whether waste constituents are migrating from the facility. As described in the SDF Industrial Solid Waste Permit (DHEC_12-17-2012), the 'ZBG-series' groundwater monitoring wells are monitored for the constituents listed in the permit to provide both upgradient and downgradient data for the facility.

In accordance with the SRS Z-Area SDF Class 3 Landfill permit (DHEC_12-17-2012), a groundwater monitoring plan is in place to monitor groundwater in the vicinity of the SDF (WSRC-TR-2005-00257). Two background wells located upgradient and thirteen wells downgradient of the SDF (Figure 4-2) currently in place at the time of issuance of this plan are sampled for the constituents and parameters listed in Table 6-1.

6.1.4 Parameters Measured

Table 6-1 presents the radionuclides/other substances to be monitored per this monitoring plan. In addition, as presented in WSRC-TR-2005-00257, each time a groundwater sample is collected for the SDF, the following field measurements, at a minimum, are collected:

- pH
- specific conductance
- depth to groundwater

6.1.5 Frequency of Monitoring

Inspections of SDU integrity are performed and documented by SDF personnel in accordance with Procedure 451-Z-4001. Based on the integrity of the saltstone waste form, the secondary containment of the SDUs and other features designed to limit rainwater contact with the waste is evaluated monthly. Inspections for environmental water infiltration may occur more frequently during periods when availability of environmental sources of water (e.g., rain) are more likely. [SRR-CWDA-2012-00130]

Groundwater well sampling (performed twice per year or once every two years depending on the constituent) is appropriate to detect the presence of waste constituents migrating from the facility. These sampling frequencies provide sufficient data to evaluate trends. Table 6-1 presents the various sampling frequencies to be performed under this monitoring plan.

6.1.6 Sampling/Methods

Sampling methods used are the appropriate approved methods identified in the *Groundwater Monitoring Plan for the Z-Area Saltstone Disposal Facility* (WSRC-TR-2005-00257). Well sampling will be conducted as described in Manual 3Q1, Section 9000.

Monthly visual inspection of the SDUs integrity, per *Saltstone Disposal Facility Post Operations/Pre Closure Surveillance and Maintenance Program Plan* (SRR-CWDA-2012-00130) and as presented in Table 6-1, is sufficient to indicate conditions that may affect the SDU integrity.

Table 6-1 presents the sampling methods to be utilized under this monitoring plan.

6.1.7 Analytical Methods

Laboratory analysis will be conducted in accordance with Manual 3Q1, *Hydrogeologic Data Collection Procedures and Specifications,* Sections 3000 and 9000. The analytical methods and required minimum detectable activities or method detection limits described in the *Groundwater Monitoring Plan for the Z-Area Saltstone Disposal Facility* (WSRC-TR-2005-00257) are appropriate to use in this monitoring plan. These limits are sufficiently below the performance objective results to provide early warning of very low levels of contamination migrating from the facility, allowing time for confirmation sampling and/or implementation of corrective measures, as necessary.

6.1.8 Tabular Summary

Table 6-1 summarizes the monitoring implemented to assess the SDF compliance with the performance objectives identified in the facility's PA and included in the DAS.

Table 6-1: Summary Monitoring Table

Pathway/ Relevant Feature	Media Features/ Inspection	Monitoring Location	Radionuclide/Other Substance	Sampling Frequency	Sampling Method	Analytical Method	Minimum Detectable Activity/Method Detection Limit
WAC Transfer Compliance	Tank 50 content in compliance with Saltstone WAC	Completed evaluation on file in the Control Room	Tank 50 content as provided in the Waste Characterization System prior to transfer to Salt Feed Tank	WAC Evaluation complete prior to transfer from Tank 50 to Salt Feed Tank	N/A	N/A	Tank 50 content in compliance with Saltstone WAC
SDU integrity	Visual and video inspection of SDUs	Periphery and interior, if accessible, of SDUs	N/A	Monthly, at a minimum	Visual inspections, Video camera	N/A	N/A
Water resource protection	Groundwater	Wells ZBG-1 through ZBG-15D	Nitrate (nitrate/nitrite) Gross alpha Nonvolatile beta Beta/photon emitters I-129 Tritium	Twice per year	Well sampling	As designated in the groundwater monitoring plan (WSRC-TR-2005-00257)	As designated in the groundwater monitoring plan (WSRC-TR-2005-00257)
		Wells ZBG-1 through ZBG-15D	Radium-226 Radium-228 Technetium-99 Benzene Toluene Tetrachloroethylene Trichloroethylene	Once every two years	Well sampling	As designated in the groundwater monitoring plan (WSRC-TR-2005-00257)	As designated in the groundwater monitoring plan (WSRC-TR-2005-00257)

N/A - Not Applicable

7.0 DATA EVALUATION MANAGEMENT AND REPORTING

7.1 Data Evaluation

The DAS requires monitoring data to be evaluated against projections in the SDF PA. The change control process established to maintain the SDF PA is defined in *LW Unreviewed Waste Management Question (UWMQ)* procedure (Manual S4, Procedure ENG.46). Using this process, any proposed activities or new information resulting from monitoring activities defined in this plan are screened against criteria defined in the SDF UWMQ Requirements Document (SRR-CWDA-2011-00196) for potential to impact to SDF PA (SRR-CWDA-2009-00017). UWMQEs are performed on those with the potential to impact the SDF PA performance objectives.

The *Groundwater Monitoring Plan for Z Area Saltstone Disposal Facility* (WSRC-TR-2005-00257) developed for SCDHEC to comply with the Industrial Solid Waste Permit provides performance thresholds and details on confirmatory sampling to be taken if sample results exceed the performance thresholds. This method of data evaluation identifies early warning of potential contamination from the SDF. The monitoring results and the process by which they are evaluated are discussed in annual reports submitted to SCDHEC in January of the subsequent year.

Data collected, as described in the *Groundwater Monitoring Plan for Z Area Saltstone Disposal Facility.* [WSRC-TR-2005-00257], will be evaluated using the projections presented in the SDF PA to determine if actual results are in line with projected results. The projected results are discussed in Chapter 4.0 of the SDF PA. Data tables summarizing the projected results are provided in Section 8.1, Table 8.1-1 of the SDF PA.

Groundwater protection standards (GWPSs) (Table 7-1) are presented for all constituents listed in *Groundwater Monitoring Plan for Z Area Saltstone Disposal Facility.* [WSRC-TR-2005-00257] The GWPS consists of the Primary Drinking Water Standard (PDWS) or where no PDWS is available, the Secondary Drinking Water Standard (SDWS) is used. If there is no PDWS or SDWS for a constituent, the GWPS is set at background or the practical quantitation limit if there is no background value. The list includes all constituents that might potentially be present in future waste streams regardless of concentration. Most of these constituents, if present at all, are present in very low concentrations and could not cause a significant impact to groundwater.

Table 7-1: Groundwater Protection Standards for Constituents for the SDF

Constituents	Groundwater Protection Standard	Units	Source of Standard
Aluminum	200	ppb	SDWS
Arsenic	50	ppb	PDWS
Antimony	6	ppb	PDWS
Barium	2,000	ppb	PDWS
Beryllium	4	ppb	PDWS
1, 1-Biphenyl	N/A	N/A	Background
Boron	N/A	N/A	Background
1-Butanol	N/A	N/A	Background
Cadmium	5	ppb	PDWS
Chloride	250	ppm	SDWS
Chromium	100	ppb	PDWS
Cobalt	N/A	N/A	Background
Copper	1,300	ppb	PDWS
Fluoride	4,000	ppb	PDWS
Iron	300	ppb	SDWS
Isobutanol	N/A	N/A	Background
Lead	15	ppb	PDWS
Lithium	N/A	N/A	Background
Manganese	50	ppb	SDWS
Mercury	2	ppb	PDWS
Mercury (methyl)	N/A	N/A	Background
Molybdenum	N/A	N/A	Background
Nickel	100	ppb	PDWS
Nitrate/nitrite (as Nitrogen)	10,000	ppb	PDWS
Phenol	N/A	N/A	Background
Selenium	50	ppb	PDWS
Silver	100	ppb	SDWS
Strontium	N/A	N/A	Background
Sulfate	250	ppm	SDWS
Tetrachloroethylene	5	ppb	PDWS
Thallium	2	ppb	PDWS
Trichloroethylene	5	ppb	PDWS
Uranium	30	ppb	PDWS
Zinc	500	ppb	SDWS
Benzene	5	ppb	PDWS
Toluene	1,000	ppb	PDWS
Total Radium	5	pCi/L	PDWS
Gross Alpha	15	pCi/L	PDWS
Gross beta	4	mrem/yr	PDWS

[WSRC-TR-2005-00257]

Only constituents that are present in high concentrations relative to health-based limits are relevant for groundwater monitoring. For that reason, a list of proposed Detection Monitoring Constituents (Table 7-2) was derived based on actual grout sampling results (WSRC-TR-2005-00257, Appendix 2). The sampling results for nonradiological constituents were compared to risk-based standards multiplied by a dilution attenuation factor (DAF) of 2.5. The DAF was derived using site-specific inputs except that a soil infiltration rate was used rather than that for the virtually impermeable vault/SDU top.

The only constituents present in the grout at 2.5 times the health-based limit were fluoride, nitrate, molybdenum and selenium. For three constituents, fluoride, selenium and molybdenum, soil-screening levels (SSLs) were calculated using standard EPA methods. For these calculations, the DAF of 2.5 was substituted for the less conservative recommended default value of 20. For fluoride, the calculated SSL is 820 ppm. The maximum result for the grout was 492 ppm, so fluoride was eliminated as a monitoring constituent. For molybdenum, the calculated SSL is 9.2 ppm. The maximum result for the grout was 0.486 ppm, so molybdenum was eliminated as a monitoring constituent. For selenium the calculated SSL is 0.65 ppm. The maximum result for the grout was 0.163 ppm, so selenium was also eliminated as a monitoring constituent.

Radium was eliminated from the semi-annual monitoring list based on process knowledge. However, naturally occurring radium levels are of some interest, so Ra-226 and Ra-228 will be monitored on a biennial schedule. [WSRC-TR-2005-00257]

The Detection Monitoring Constituents for semiannual and biennial detection monitoring at Z Area are listed in Table 7-2. This short list is appropriate for detection monitoring since it has long been recognized that elevated levels of nitrate (which is very mobile and very abundant in saltstone) will be a reliable indicator of a SDU release. If a release is detected, the ensuing groundwater assessment will include groundwater sampling and analysis for the entire GWPS list (Table 7-1).

Table 7-2: Detection Monitoring Constituents and their Groundwater Protection Standards for Constituents for the SDF

SEMIANNUAL		
Constituents	**Groundwater Protection Standard**	**Units**
Nitrate (nitrate/nitrite)	10,000	µg/L
Gross Alpha	15	pCi/L
Nonvolatile Beta[1,2]	8/30	pCi/L
Gamma Spectroscopy for Beta/photon emitters	4	mrem
I-129	1*	pCi/L
Tritium	20,000	pCi/L
BIENNIAL		
Constituents	**Groundwater Protection Standard**	**Units**
Radium-226	5 (Ra 226 + Ra 228)	pCi/L
Radium-228	5 (Ra 226 + Ra 228)	pCi/L
Technetium-99	900*	pCi/L
Benzene	5	µg/L
Toluene	1,000	µg/L
Tetrachloroethylene	5	µg/L
Trichloroethylene	5	µg/L
Contingent Analysis		
Constituents	**Groundwater Protection Standard**	**Units**
Strontium-90	8	pCi/L

* - EPA 570/9-81-002, *Radioactivity in Drinking Water*

1 - If nonvolatile beta is equal to or exceeds 8 pCi/L, that well will be resampled within 30 days and Contingent Analysis is analyzed.

2 - If nonvolatile beta is equal to or exceeds 30 pCi/L then all constituents listed in Table 7-3 will be resampled within 30 days for that well and the background wells.

[WSRC-TR-2005-00257]

7.1.1 Special Considerations for Beta-emitters

Since the gross beta GWPS is defined in terms of dose (mrem/yr) rather than activity, the allowable activity varies from one nuclide to another (Table 7-3). Iodine-129 must be routinely monitored because of its low drinking water standard (1 pCi/L). Technetium-99 should also be monitored routinely because it is of particular concern at Z Area but is not detected by nonvolatile beta analyses. However, Tc-99 can be monitored less frequently than

I-129 since its drinking water standard is quite high (900 pCi/L). I-129 and nonvolatile beta will be monitored semiannually, and Tc-99 will be monitored biennially.

It is only necessary to run specific analyses for other beta emitters if a nonvolatile beta result indicates the possibility of an exceedance of a standard or the need for a detailed assessment. In order to avoid unnecessary analytical and sampling costs, the following sampling scheme is used for beta-emitters.

Nonvolatile beta is monitored semiannually. If the nonvolatile beta result exceeds 8 pCi/L at a given well, the well will be resampled within 30 days and a Sr-90 analysis will be run. If Sr-90 is detected, it will be added to the monitoring list in Table 7-2 for semiannual monitoring. If the nonvolatile beta result exceeds 30 pCi/L (the standard for Ru-106) at a given well, then that well and background wells (ZBG-1 and ZBG-15D) will be resampled within 30 days and analyses for nonvolatile beta and for all constituents in Table 7-3 will be run. Any nuclides detected above background will be added to the monitoring list in Table 7-2 for semiannual monitoring. If the follow-up sampling confirms results above 30 pCi/L for nonvolatile beta, a plan for assessing the lateral and vertical extent of the plume will be developed and submitted to SCDHEC within 60 days. [WSRC-TR-2005-00257]

Table 7-3: Groundwater Protection Standards for Additional Constituents for the SDF

Constituents	Groundwater Protection Standard	Unit
I-129	1	pCi/L
Sr-90	8	pCi/L
Ru-106	30	pCi/L
Ni-63	50	pCi/L
Pu-241	62.6	pCi/L (proposed)
Co-60	100	pCi/L
Cs-137	200	pCi/L
Ni-59	300	pCi/L
Sb-125	300	pCi/L
Nb-94	707	pCi/L (proposed)
Tc-99	900	pCi/L
C-14	2,000	pCi/L

[WSRC-TR-2005-00257]

7.1.2 Special Considerations for Volatile Constituents

The current grout mix contains no volatile organic compounds other than benzene and toluene. Both are present in the grout at levels below their PDWS. Since they could not become more concentrated in the groundwater than they are in the grout, these constituents will not be included in semiannual or annual monitoring at this time. However, since there is always some possibility that volatiles could escape detection during grout sampling and /or exhibit greater mobility than expected, samples from all wells are analyzed for a suite of volatile organic compounds biennially. [WSRC-TR-2005-00257]

7.1.3 Background Groundwater Quality

The regulation requires that background groundwater quality be established in the upgradient well. This is important when there is potential that background concentrations for any constituent might exceed the PDWS or other health-based concentration. When this is the case, the GWPS can be set at the background concentration rather than the more restrictive health-based limit. At Z Area, the upgradient well, ZBG-1, has been sampled for over ten years, and a large amount of background data is currently available for all of the Detection Monitoring Constituents listed in Table 7-2. The data presented in the annual groundwater monitoring reports show that health-based limits for those constituents are not exceeded in the background wells. In addition, upgradient well ZBG-15D has been added to the monitoring program in 2012 to provide additional background data for Vaults 1 and 4.

7.2 Frequency of Data Evaluation

Data evaluation of groundwater monitoring results will be performed consistently from year to year to ensure that a sound historical evaluation methodology is established for the facility. It may become necessary to add some volatile and semivolatile compounds to the sampling list as the waste stream changes to include waste from various tanks. The modified saltstone mix will have to be characterized before disposal, and the analytical results of that waste characterization will be used to determine what changes are necessary for groundwater monitoring. If changes in the waste stream require the addition of new monitoring constituents, background data for those constituents will be evaluated at that time. For some newly proposed constituents, there may be insufficient data to establish background levels. As soon as such constituents are added to the monitoring list, SRS will collect the four independent samples needed to establish an initial background concentration.

7.3 Management and Reporting of Data

Groundwater monitoring data used under this monitoring plan have been collected and compiled under other existing established SRS programs and databases (e.g., SRS Environmental Restoration Data Management System database). The monitoring results, and the process by which they are evaluated, are presented in the groundwater monitoring annual report submitted to SCDHEC in January of the subsequent year.

In addition, a fiscal year SDF PA annual review is performed to confirm the adequacy of the current SDF PA and to evaluate the need to conduct Special analyses or prepare a revision to the SDF PA. This review is conducted in a systematic manner that incorporates the following considerations:

- Radionuclide inventories, waste volumes, and waste types disposed throughout the year,
- Testing and research activities performed during the year,
- Results of monitoring conducted in accordance with this SDF PA Monitoring Plan.

8.0 RECOMMENDATIONS BASED ON DATA EVALUATION

8.1 Review of PA Monitoring Plan and Related Documents

Following data evaluation, the related documents discussed in Section 5.0 will be reviewed to determine if the documents and/or programs/procedures discussed in those documents need to be modified. Results and recommendations from the data evaluation will be reported and distributed in the annual review conducted through the PA maintenance program.

8.2 Corrective Actions

Section 7.1 describes the confirmatory sampling steps to be taken if sample results exceed the background upper tolerance limit. Background upper tolerance limits are established for each constituent monitored under this monitoring plan. Monitoring results are compared to action levels and confirmatory sampling may be recommended if action levels are exceeded. In addition, changes may be required to the SDF PA monitoring program, SDF PA, or disposal facility as a result of conclusions from the UWMQE process.

8.2.1 Modifications to Monitoring Program

If data evaluation identifies the need for additional monitoring, the relevant programs under which that monitoring is performed will be modified to include the required additions (e.g., the groundwater protection management program). Confirmatory sampling may be performed either under other programs or implemented directly under this monitoring plan as necessary based on the timeframe in which the additional data are required. Any modifications to these supporting programs that are needed based on data evaluated under this monitoring plan will be documented through revisions to this plan and in the PA maintenance programs and the results reported to DOE and SCDHEC within 60 days, as presented in Section 7.1.1.

8.2.2 Modifications to the Performance Assessment

If data evaluation indicates that projected results from the SDF PA are not consistent with actual results, modification of the SDF PA may be warranted. However, additional confirmatory sampling, special analyses, and tests and/or research may first be implemented through the PA maintenance programs to specifically identify modifications needed for the SDF PA.

8.2.3 Modifications to the Disposal Facility

Following any additional confirmatory sampling and tests and/or research based on data evaluation, any modifications to the facility will be implemented through the relevant functional group.

8.3 Conclusions

This monitoring plan has been developed to meet the requirements for monitoring LLW disposal facilities according to DOE O 435.1, Chg. 1 and its associated manual and implementation guidance with regard to actual performance versus projected performance for the SDF at the SRS as they relate to the requirements of the DAS. [WDPD-12-49] This plan is intended to detect

changing trends in performance to allow application of corrective actions prior to exceeding any performance objectives.

In addition, while not the purpose of this DOE M 435.1-1 monitoring plan, results of this monitoring plan may be used to support the monitoring defined by NDAA Section 3116. The NRC performs separate monitoring activities in coordination with the SCDHEC per their responsibilities defined in NDAA Section 3116 to assess compliance with the performance objectives in 10 CFR 61, Subpart C.

This monitoring plan is a living document, representing a snapshot in time, and will be updated, if necessary, to accommodate any deviations from the conceptual model analyzed in the PA. This monitoring plan will also be evaluated annually, or as conditions at the facility change (e.g., the installation of new groundwater monitoring wells) as part of the PA maintenance program and an update, if required, will be submitted for approval by DOE, as necessary.

All work activities (or new data) that may impact the SDF PA are reviewed against screening criteria for continued compliance with DOE M 435.1-1. These data are evaluated through the UWMQE process. Changes may be required to the SDF PA monitoring program, SDF PA, or disposal facility as a result of conclusions from the UWMQE process.

9.0 REFERENCES

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Manual 3Q1, *Environmental Monitoring Sampling and Measurement Procedures* (Section 3000) and *Hydrogeologic Data Collection Procedures and Specifications* (Section 9000), Savannah River Site, Aiken, SC.

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SRR-CWDA-2011-00044, *Comment Response Matrix for NRC Second RAI on the SDF PA*, Savannah River Site, Aiken, SC, Rev. 1, August 2011.

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SRR-CWDA-2013-00037, *Closure Plan for the Z-Area Saltstone Disposal Facility,* Savannah River Site, Aiken, SC, Rev. 0, April 2013.

WDPD-12-49, *Disposal Authorization Statement for the Savannah River Site Saltstone Disposal Facility,* United States Department of Energy, Washington, DC. Rev. 1, May 22, 2012.

WSRC-TR-2005-00257, *Groundwater Monitoring Plan for the Z-Area Saltstone Disposal Facility*, Savannah River Site, Aiken, SC, Rev. 5, July 2010.

WSRC-TR-94-0369, Cumbest, R., *In-Tank Processing (ITP) Geotechnical Summary Report*, Savannah River Site, Aiken, SC, Rev. 1, 1994.

ATTACHMENT 1
PA Monitoring Plan Review Criteria Matrix

Review Criteria	Requirement Applicable? (Yes/No)	Monitoring Plan Section Discussing Requirement
PA/CA monitoring plan must highlight key assumptions in the PA/CA monitoring plan that are relevant to the PA and CA, and other DAS technical basis documents	Yes	2.0
PA/CA monitoring plan must briefly describe the general location of the facility and pertinent aspects of the environmental setting that influence the monitoring strategy.	Yes	3.0
PA/CA monitoring plan must briefly describe the specific location and type of disposal facility, type(s) of waste and waste forms disposed, and any pertinent facility features relevant to monitoring the release of constituents to the surrounding environment.	Yes	4.0
PA/CA monitoring plan identifies pertinent documents that govern disposal at the disposal facility, and adequately identifies and distinguishes between the purposes of the different types of monitoring (performance versus compliance) in their program.	Yes	5.0
PA/CA monitoring Plan adequately identifies monitoring approach and adequately describes the specific key aspects of monitoring approach and strategy at their facility.	Yes	6.0
PA/CA monitoring plan has identified relevant pathways, key inputs and assumptions, and features according to the PA/CA analyses. The media types to be monitored are explicitly identified.	Yes	6.1.1
PA/CA monitoring plan clearly identifies locations to be monitored.	Yes	6.1.2
PA/CA monitoring plan adequately identifies parameters to be monitored and justifies the basis for their selection as contaminants of interest.	Yes	6.1.3
PA/CA monitoring plan sufficiently documents sampling frequency for all monitored media.	Yes	6.1.4

PA/CA monitoring plan sufficiently documents the sampling and analytical methodologies used in the monitoring program.	Yes	6.1.5
PA/CA monitoring plan adequately describes the types of evaluations to be performed, basis for any established thresholds and how monitoring data will be interpreted.	Yes	7.1
PA/CA monitoring plan specifies planned/required frequency of data evaluation. Data evaluated will, at a minimum, occur no less than once a year.	Yes	7.2
PA/CA monitoring plan adequately describes methodology being used and report monitoring results to evaluate monitoring data.	Yes	7.3
PA/CA monitoring plan adequately describes document review procedures for addressing newly acquired monitoring data.	Yes	8.1
PA/CA monitoring plan documents the corrective actions that will be taken following an exceedance of a standard or a deviation from expected conditions. The types of actions will vary according to whether the exceedance involves performance monitoring or compliance monitoring.	Yes	8.2

[*Draft Radioactive Waste Management Disposal Authorization Statement Technical Standard*]

ATTACHMENT 2
Z-Area Monitoring Well Details as of April 2013

Well	SRS Northing	SRS Easting	Screen Top (ft above MSL)	Screen Bottom (ft above MSL)	Total Depth	Well Diameter (inches)	Material
ZBG-1	440150.1	3684778	240.1	220.0	71.1	4	PVC
ZBG-2	440689.6	3685014	230.9	210.9	67.1	4	PVC
ZBG-3	440568.5	3684990	214.0	204.0	74.5	2	PVC
ZBG-4	440638.9	3684939	215.4	205.4	71.0	2	PVC
ZBG-5	440712.8	3684886	213.8	203.8	71.0	2	PVC
ZBG-6	440430.6	3684778	225.5	210.5	80.0	4	PVC
ZBG-7	440495.4	3684740	224.8	209.8	80.0	4	PVC
ZBG-8	440564.5	3684683	224.4	209.4	80.0	4	PVC
ZBG-9D	440325.8	3685289	212.7	197.7	80.0	4	PVC
ZBG-10D	440373.3	3685259	214.5	199.5	80.0	4	PVC
ZBG-11D	440411.9	3685230	217.8	202.8	80.0	4	PVC
ZBG-12D	440060.0	3685458	193.7	178.7	85.5	4	PVC
ZBG-13D	440100.7	3685513	195.7	179.7	86.0	4	PVC
ZBG-14D	440190.2	3685476	190.1	175.1	94.7	4	PVC
ZBG-15D	440409.3	3684538	234.0	214.0	87.0	4	PVC

Source: SRS Environmental Restoration Data Management System database