Contract No:

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Disclaimer:

10. QUALITY ASSURANCE

This chapter summarizes activities performed to ensure the quality of the information throughout the PA.

- **Section 10.1** discusses the SRS Quality Assurance Management Plan (QAMP) and SRS Quality Assurance 1Q Manual.
- **Section 10.2** describes software QA requirements and compliance.
- **Section 10.3** explains the technical review and design check processes used at SRS for models and reports prepared for the PA.
- **Table 10-1** provides a summary of the software QA survey for this PA.

KEY TAKEAWAYS

- ✓ The SRS QAMP and 1Q Manual ensure the quality of the information in the PA.
- ✓ SRS 1Q Manual, Procedure 20-1, addresses SQA requirements for the PA.
- ✓ A graded approach to SQA is applied to computer software using controls commensurate with software classification based on intended use, risk, safety, hazard analysis, facility life cycle, complexity, and project quality requirements.
- ✓ A survey of software and quality assurance for the 2008 and current PAs identified 21 relevant software codes and applications.
- ✓ The software classification, SWCD, SQAP, and software testing plan or verification document are listed in Table 10-1 for the 21 relevant software codes and applications used in this PA.
- ✓ The E7 Conduct of Engineering Manual, Procedure 2.60, Technical Reviews is the QA implementation procedure used for conducting technical reviews of models and reports developed for the PA.
- ✓ The atmospheric release model and inventory uncertainty model are rarely used outside the PA. As such, they are treated as engineering calculations and are design checked on a project-specific basis in lieu of a developing a SQAP.

10.1. SRS QUALITY ASSURANCE

Title 10 Code of Federal Regulations (CFR), Part 830 Subpart A, Quality Assurance Requirements (U.S. DOE, 2005), also known as the Quality Assurance Rule, was issued to govern the conduct of DOE, prime contractors of DOE, subcontractors, and others conducting activities or providing items or services that affect, or may affect, the safety of DOE nuclear facilities. DOE has also developed Order 414.1D, "Quality Assurance" (U.S. DOE, 2011b) and its associated manuals to integrate multiple QA Program drivers imposed by external regulations and other DOE directives. DOE contractors are required via the Standards / Requirements Identification Documents (S/RIDs) process to identify and incorporate the requirements of 10 CFR 830 and DOE Order 414.1D in their company-level procedures and processes.

10.1.1. Quality Assurance Management Plan

The Management and Operations (M&O) QAMP (SRNS, 2018a) demonstrates the relationship between the QA Program, Integrated Safety Management System, and the Contractor Assurance System. The QA Program, as described in the QAMP, implements the Quality Assurance Rule (10 CFR 830 Subpart A), DOE O 414.1D, and DOE O 226.1B in accordance with the SRNS Site Standards/Requirements Identification Document that is also approved by the U.S.

DOE Savannah River Office (DOE-SR) and the National Nuclear Safety Administration Savannah River Site Office. This document incorporates and satisfies the requirements of 10 CFR 830 Subpart A, DOE O 414.1D, DOE O 226.1A, and others as described.

The QAMP (SRNS, 2018a) establishes QA requirements for conducting activities, including providing items or services that affect, or may affect, nuclear safety of facilities in a tailored manner to ensure that environmental, safety, and health risks and impacts are minimized, and that safety, reliability, products, and performance are maximized by using effective management systems.

10.1.2. Quality Assurance Manual

The SRS Quality Assurance Manual (SRS, 2021b), often referred to as the 1Q Manual, presents the structure and procedures for achieving and verifying SRS requirements for quality. The manual consists of a series of QA procedures (QAPs) that describe applicable QA requirements. Section 5.2 of Procedure 2-1 (*Quality Assurance Program*) in the 1Q Manual states that the QA program has been developed to be responsive to the requirements of DOE O 414.1D and DOE Nuclear Safety Management, Title 10 CFR 830, Subpart A, Quality Assurance Requirements. Because of the size and complexity of SRS and its varied products, services, and missions, the QA program is defined in a standard framework of company policy, procedures, and instructions to be applied by the implementing organizations to perform quality-related activities.

10.2. SOFTWARE QUALITY ASSURANCE

SRNS employs an administrative system for controlling software throughout its life cycle. This administrative system is governed by and described in SRS 1Q Manual, Procedure (QAP) 20-1, Software Quality Assurance (SRS, 2022c). QAP 20-1 addresses software quality assurance (SQA) requirements for Purchased Software, Software Development, and Existing Software. Existing Software includes those software applications that were not developed or acquired in accordance with this procedure. A graded approach to SQA is applied to computer software using controls commensurate with the software classification based on intended use of the software, risk, safety, hazard analysis, facility life cycle, complexity, and project quality requirements. The basis of the graded approach for SQA requirements is documented in G-QP-G-00002, SRS M&O Quality Assurance Graded Approach (SRNS, 2021).

10.2.1. Software Classification

Software is controlled throughout its life cycle using a graded approach based on software classification. The software classification document (SWCD) is form OSR 19-337 (SRNS, 2020c), which has been completed for all PA modeling software. Software used to evaluate dose impacts, set PA limits, or provide input to other calculations for setting limits, has been classified as Level C. The Level C classification includes “software applications used to comply with regulatory laws, environmental permits or regulations and/or commitments to compliance.” PA analyses establish a “reasonable expectation” (U.S. DOE, 2021b) that the performance objectives of DOE O 435.1, Chg 2: 1-11-2021 (U.S. DOE, 2021a) and other regulatory requirements will be met for radionuclide waste disposal. A Level C classification is consistent with the software classification

used by Savannah River Remediation in their PA documents, including the 2019 Saltstone PA revision (Savannah River Remediation, 2019).

10.2.2. Software Quality Assurance Survey

A survey of software and quality assurance for codes/applications used in the 2008 ELLWF PA was conducted by Butcher and Seitz (2007) and resulted in a list of ten codes/applications. A subsequent survey of SQA documentation undertaken by Hang (2019b) in preparation for the current ELLWF PA resulted in the identification of 20 relevant software codes/applications. Since the 2019 survey, several more additions and subtractions resulted in the current listing of 21 codes/applications in Table 10-1. For each of the 21 codes/applications and as delineated in SRS 1Q Manual, Procedure 20-1 (SRS, 2022c), the SQAP and/or associated test plan/report addresses the required lifecycle components (i.e., function, design, testing, installation and acceptance, operation and maintenance and software retirement) and SQA actions (configuration control, access control, evaluation problem reporting and corrective action, and cyber security analysis) for the stated software classification level using a graded approach. The number of lifecycle elements and the relative emphasis placed on each phase of software development or maintenance described in each SQAP is dependent on the nature and complexity of the software. Because of the graded approach employed for software QA, some commercial software codes also have SQAPs associated with them, while others do not. Regardless, verification testing is performed to verify the functionality of each software code.

The Atmospheric Release Model (Section 3.6.1) used in the air pathways and radon flux calculations, the inventory uncertainty and bias estimation tool (Section 2.3.5.3), the Microsoft Excel-based CWTS emulator (Appendix H, Section H.8), and the Closure Analysis Toolkit (Section 3.9.6 and Appendix I, Section I.3) are rarely used beyond revisions to the ELLWF PA; therefore, they are treated as engineering calculations. As such, model results are design checked on a project-by-project basis in lieu of a developing a SQAP.

10.3. TECHNICAL REVIEWS

The E7 Manual, Conduct of Engineering Manual, Procedure 2.60, Technical Reviews (SRS, 2021f) is the QA implementation procedure for conducting technical reviews of SRS models and reports developed/prepared for the ELLWF PA. Procedure 2.60 defines the processes used at SRS to verify the inputs and outputs for all models and calculations. The level of review required is determined by the planned end use for the data.

- Design Verification: highest-level review, which must be performed for work impacting Safety Significant/Safety Class systems.
- Design Check: next lower level of review, which is required for all Production Support and General Service design output documents.

For the ELLWF PA, the Design Check represents the appropriate level of rigor for model and calculation checking because no Safety Significant or Safety Class systems are associated with ELLWF PA activities and processes.

During the Design Check, the design document(s) and supporting input and output files are reviewed to assure technical accuracy. The following steps are performed (SRS, 2021f):

- Check all calculations, if appropriate.
- Review for the correct use and transcription of technical input data, including quality requirements.
- Check for appropriate use of methods, computer programs, etc.
- Review the approach used and the reasonableness of the output (data, conceptual model, graphical output, etc.).
- Check reports and documents for clarity, grammar, spelling, format, page numbering, etc.

The design checker must satisfy the following criteria (SRS, 2021f):

- Cannot be a participant in the development of the portion of the document being checked (e.g., sufficiently independent of the document section preparation).
- Must be knowledgeable in the technical area of the design or analysis they have been asked to review.
- Must be capable of performing similar design or analysis activities.

Between 2002 and 2004, SRNL developed, piloted, and implemented technical review guidelines (WSRC, 2004) incorporating the E7 Manual, Procedure 2.60 requirements for performing Design Checks and Design Verification by document review. These guidelines also meet the requirements for review of Type 2 Calculations contained in E7 Manual, Procedure 2.31, Engineering Calculations (SRS, 2021a). The guidelines (WSRC, 2004) provide a flowchart to map the SRNL technical review process, lines of inquiry for performing reviews, a checklist for communicating instructions, and best management practices to set a benchmark for management expectations.

Verification of the model input traced from source documents, to modeling input, and to appropriate sections within the PA has been performed. Model inputs are implemented as components to the model files. Consequently, inputs are controlled in accordance with the QA requirements of the respective model(s) and any changes to the inputs result in a change to the model, thus requiring re-checking of the affected model file(s).

Table 10-1. Software Quality Assurance Survey for the E-Area Low-Level Waste Facility Performance Assessment

#	Application	Class[a]	Description	Documentation Complete?			SQA Documents
				SQAP	SWCD	Testing[a]	
1	PORFLOW Ver. 6.43.0	C	PORFLOW is a commercially available computer code developed by ACRi, Inc, and acquired by SRS for use in simulating GW flow and contaminant transport in the vadose zone and underlying aquifers.	Yes	Yes	Yes	G-SWCD-A-00063, Rev. 3 (Butcher, 2013b) G-SQP-A-00012, Rev. 0 (Hang, 2007) G-STP-A-00009, Rev. 1 (Hang, 2012) SRNL-STI-2020-00219 (Whiteside, 2020)
2	GoldSim® Ver. 12.1.4	C	GoldSim® is a commercially developed, highly graphical, object-oriented computer program for carrying out dynamic and probabilistic simulations. GoldSim® is used to create stochastic models of GW flow and contaminant transport from various waste disposal facilities. The stochastic results of these models can be used to evaluate uncertainty in disposal limits and dose impacts to prevent exceedance of regulatory requirements.	Yes	Yes	Yes	Q-SWCD-A-00002, Rev. 3 (Wohlwend, 2021a) G-SQA-A-00011, Rev. 1 (Wohlwend, 2021b)
3	MESH3D Ver. 3.1	C	SRNL developed MESH3D to extract a subregion of the GSA coarse mesh and to subdivide the coarse mesh to produce a higher-resolution grid. MESH3D also transfers velocity and saturation data from the original GSA/ PORFLOW grid to the refined mesh through an interpolation process.	Yes	Yes	Yes	B-SWCD-A-00582, Rev. 2 (Butcher, 2018b) Q-SQP-G-00003, Rev. 2 (Danielson, 2017)
4	MESH2D Ver. 2	C	MESH2D is a 2-D mesh generation program developed by SRNL under the Cementitious Barriers Partnership program and is intended for open-source release to the public.	Yes	Yes	Yes	B-SWCD-A-00615, Rev. 2 (Butcher, 2017b) G-SQP-G-00015, Rev. 1 (Hang, 2017b)
5	PEST Ver. 13.6	C	PEST (Parameter ESTimation) developed by Watermark Numerical Computing expedites the process of model calibration wherein values for model parameters are back calculated by matching model outputs to measurements of system state.	Yes	Yes	Yes	Q-SWCD-A-00035, Rev. 0 (Butcher, 2016) Q-SQP-G-00004, Rev. 0 (Whiteside, 2016b)

Table 10-1 (cont'd). Software Quality Assurance Survey for the E-Area Low-Level Waste Facility Performance Assessment

#	Application	Class[a]	Description	Documentation Complete?			SQA Documents
				SQAP	SWCD	Testing[a]	
6	GoldSimFlows Ver. 2	C	GoldSimFlows, a Fortran 90 program developed by SRNL, extracts flow field data from a series of steady-state 2-D PORFLOW simulations for selected regions in the model domain and writes the data to a tab-delimited spreadsheet-type file.	Yes	Yes	Yes	B-SWCD-A-00641, Rev. 0 (Butcher, 2013a) Q-SQP-A-00008, Rev. 0 (Flach and Butcher, 2013)
7	avgVal Ver. 1	C	avgVal, a Fortran program developed by SRNL, is designed to find the average value of a piecewise linear function over an interval to support PA- and SA-related work.	Yes	Yes	Yes	Q-SWCD-A-00036, Rev. 0 (Butcher, 2017a) Q-SQP-A-00009, Rev. 0 (Hang, 2017a)
8	PlotConc Ver. 1	C	PlotConc, a Fortran 90 program developed by SRNL, is designed to extract concentrations from a PORFLOW archive file for a 2-D transport simulation and create a Tecplot data file to support PA- and SA-related work.	Yes	Yes	Yes	Q-SWCD-A-00037, Rev. 0 (Butcher, 2017e) Q-SQP-A-00010, Rev. 0 (Hang, 2017c)
9	PlotConc3d Ver. 1	C	PlotConc3d, a Fortran 90 program developed by SRNL, is designed to extract concentrations from a PORFLOW archive file for a 3-D structured-grid transport simulation and create a Tecplot data file to support PA- and SA-related work.	Yes	Yes	Yes	Q-SWCD-A-00038, Rev. 0 (Butcher, 2017c) Q-SQP-A-00011, Rev. 0 (Hang, 2017d)
10	PlotConc3dU Ver. 1	C	PlotConc3dU, a Fortran 90 program developed by SRNL, is designed to extract concentrations from a PORFLOW archive file for a 3-D unstructured-grid transport simulation and create a Tecplot data file to support PA- and SA-related work.	Yes	Yes	Yes	Q-SWCD-A-00039, Rev. 0 (Butcher, 2017d) Q-SQP-A-00012, Rev. 0 (Hang, 2017e)
11	PlotFlux Ver. 1	C	PlotFlux is a Fortran 90 program developed by SRNL to extract information from a PORFLOW flux file and create PORFLOW and Tecplot data files.	Yes	Yes	Yes	Q-SWCD-A-00041, Rev.0 (Butcher, 2018c) Q-SQP-A-00014, Rev. 0 (Hang, 2018b)
12	PlotFlow2d Ver. 1	C	PlotFlow2d, a Fortran 90 program developed by SRNL, is designed to extract information from a PORFLOW archive file for a 2-D structured-grid flow simulation and create a Tecplot data file to support PA- and SA-related work.	Yes	Yes	Yes	Q-SWCD-A-00040, Rev. 0 (Butcher, 2017f) Q-SQP-A-00013, Rev. 0 (Hang, 2017f)

Table 10-1 (cont'd). Software Quality Assurance Survey for the E-Area Low-Level Waste Facility Performance Assessment

#	Application	Class[a]	Description	Documentation Complete?			SQA Documents
				SQAP	SWCD	Testing[a]	
13	PlotFlow3dS Ver. 1	D	PlotFlow3dS, a Fortran 90 program developed by SRNL, is designed to extract information from a PORFLOW archive file for a 3-D structured-grid flow simulation and create a Tecplot data file to support PA- and SA-related work.	Yes	Yes	Yes	Q-SWCD-A-00046, Rev. 1 (Hang, 2021a) Q-SQP-A-00020, Rev. 0 (Hang, 2021b)
14	PlotHist Ver. 1	C	PlotHist, a Fortran 90 program developed by SRNL is designed to extract information from a PORFLOW history file and create a Tecplot data file to support PA- and SA-related work.	Yes	Yes	Yes	Q-SWCD-A-00042, Rev. 0 (Butcher, 2018d) Q-SQP-A-00015, Rev. 0 (Hang, 2018c)
15	PlotStat Ver. 1	C	PlotStat, a Fortran 90 program developed by SRNL is designed to extract information from a PORFLOW statistics file and create Tecplot data file to support PA- and SA-related work.	Yes	Yes	Yes	Q-SWCD-A-00043, Rev. 0 (Butcher, 2018e) Q-SQP-A-00016, Rev. 0 (Hang, 2018d)
16	MakeWhole Ver. 1	C	MakeWhole, a Fortran 90 program developed by SRNL is designed to insert "include" file contents into the main data file to support PA- and SA-related work.	Yes	Yes	Yes	Q-SWCD-A-00045, Rev. 0 (Butcher, 2018a) Q-SQP-A-00017, Rev. 0 (Hang, 2018a)
17	RETC Ver. 6.02	C	RETC is public-domain software which may be used to analyze the soil-water retention and hydraulic conductivity functions of unsaturated soils. These hydraulic properties are key parameters in any quantitative description of water flow into and through the unsaturated zone soils.	Yes	Yes	Yes	G-SWCD-G-00040, Rev. 3 (Dixon, 2014) Q-SQP-A-00006, Rev. 0 (Jones, 2007)
18	CAP88-PC Ver 4.1	B	CAP88-PC estimates health impacts from routine atmospheric release of radioactivity. Inhalation, ingestion, air immersion, and ground surface irradiation pathways are considered, and doses are estimated for maximally exposed individuals and regional populations. CAP88-PC uses a modified Gaussian plume equation to estimate the average dispersion of radionuclides released from up to six sources at the same release location with different release heights. Assessments are done for a circular grid within a radius of 50 miles. The use of CAP88 is required when assessing health impacts for National Emission Standard for Hazardous Air Pollutants (NESHAP) applications.	Yes	Yes	Yes	Q-SWCD-A-00010, Rev. 6 (Stagich, 2021) Q-SQP-A-00002, Rev. 5 (Jannik, 2018) SRNL-L3200-2020-00028, Rev. 0 (Stagich, 2020)

Table 10-1 (cont'd). Software Quality Assurance Survey for the E-Area Low-Level Waste Facility Performance Assessment

#	Application	Class[a]	Description	Documentation Complete?			SQA Documents
				SQAP	SWCD	Testing[a]	
19	HELP Ver. 4	C	The Hydrologic Evaluation of Landfill Performance (HELP) model is a quasi-two-dimensional water balance model designed to conduct landfill water balance analyses. Personnel at the U.S. Army Engineer Waterways Experiment Station in Vicksburg, MS developed the HELP model, under an interagency agreement with the U.S. EPA. The model requires the input of weather, soil, and cap design data. It provides estimates of surface runoff, evapotranspiration, lateral drainage, vertical percolation, hydraulic head, and water storage for the evaluation of various landfill designs. The HELP model has been utilized along with estimates of degraded closure cap material properties to estimate infiltration through the geomembrane layer in the ELLWF closure cap over time. This information is utilized as the upper flow boundary condition for the vadose zone PORFLOW models.	Yes	Yes	Yes	K-SWCD-A-00001, Rev. 2 (Phifer, 2007) Q-SQA-A-00005, Rev. 0 (Phifer, 2006) SRNL-STI-2017-00104, Rev. 0 (Dixon, 2017)
20	SRNL Dose Toolkit	C	The SRNL Dose Toolkit calculates GW disposal limits and GW (PA) and surface water (CA) dose impacts for PAs, CAs, UDQEs, UCAQEs and SAs. The Toolkit consists of four Fortran subroutines serving as modules/tools to implement the latest dose calculation methodology and data report by Smith et al. (2019). *PreDose* expands and converts short-chain concentrations from PORFLOW and GoldSim® transport runs into full decay-chain activities assuming secular equilibrium. *PreDoseMaxConc* generates composite 'worst-case' full-chain concentration history profiles for each existing/future inventory scenario. *SRNL PA/CA Limits and Doses* generates a series of binary concentration and dose files for each GW pathway where contributions from each full-chain progeny have been rolled up to the parent nuclide. *SRNL ELLWF Dose Investigation* quantifies the dose impacts of parent and full-chain daughter nuclides at all time steps and positions along the 100-meter boundary against the five GW POs (beta-gamma, alpha, Uranium, Radium, All-Pathways). The toolkit also calculates disposal limits and dose impacts for IHIs.	Yes	Yes	Yes	Q-SWCD-A-00047, Rev. 0 (Aleman, 2021b) Q-SQP-A-00021, Rev. 0 (Aleman, 2021a)

Table 10-1 (cont'd). Software Quality Assurance Survey for the E-Area Low-Level Waste Facility Performance Assessment

#	Application	Class[a]	Description	Documentation Complete?			SQA Documents
				SQAP	SWCD	Testing [a]	
21	MCNP Ver. 6.1	B	MCNP is a general-purpose, continuous energy (or multi-group), generalized geometry, neutral particle and electron Monte Carlo transport code developed at Los Alamos National Laboratory. The code is applicable in two modes: criticality and external source modes (the source mode is primarily for shielding evaluations). MCNP can be used to calculate the system multiplication factors (k_{eff}), the energy spectrum for neutrons and photons, the reaction rate distribution, etc. The software is distributed by the Radiation Safety Information Computational Center (RSICC) at Oak Ridge National Laboratory.	Yes	Yes	Yes	B-SWCD-C-00057, Rev. 2 (Low, 2016) N-SQP-G-00009, Rev. 2 (Finfrock, 2021a) N-STP-G-00003, Rev. 2 (Finfrock, 2021b)

Notes:

[a] Not all software applications listed have a separate test plan document. Test plans for some software applications are included as part of the SQAP document itself.

Class B: Software that is not part of a structure, system, or component and whose failure to function properly could cause the inability of the nuclear safety protection systems or toxic materials hazard systems to perform their credited Safety Significant function as cited in either a DOE approved Documented Safety Analysis or an approved hazard analysis. This classification includes software whose results are used to make decisions that could result in death or serious injury or are part of the evaluation in accident analyses.

Class C: For purposes of this PA, software applications used to comply with regulatory laws, environmental permits or regulations, and/or commitments to compliance.

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