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FY2017 SAVANNAH RIVER SITE COMPOSITE ANALYSIS ANNUAL REVIEW

N. V. Halverson

G. T. Jannik

April 2018

SRNL-STI-2018-00031, Revision 0

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EXECUTIVE SUMMARY

The FY2017 Department of Energy (DOE) Order 435.1, Radioactive Waste Management (DOE 1999c), Annual Review for the Savannah River Site (SRS) Composite Analysis (CA) is documented, herein. This Annual Review provides the following information in association with the 2010 SRS CA (SRNL 2010):

- A review of maintenance items completed or worked but not completed in FY2017 (Sections 3.1 and 3.2),
- A review of maintenance items anticipated to be worked in FY2018 (Section 3.3)
- The potential impact of Performance Assessment (PA) and CA Research and Development (R&D) on the SRS CA (Section 3.4),
- A status of resolution of the secondary issue from the Low-Level Waste Disposal Facility Federal Review Group (LFRG) review of the SRS CA (Section 3.5),
- A discussion of any changes to the key SRS CA inputs and assumptions including those associated with land use, source term, and models (Section 3.6),
- An overview of the SRS CA model validation conducted through 2017 (Section 4.0), and
- An assessment of the continued adequacy of the SRS CA (Section 5.0).

Progress made to date toward addressing the secondary issue from the LFRG review of the 2010 SRS CA has focused primarily upon inventory estimate improvements, because inventory impacts dose on a one-to-one linear fashion and reduces the uncertainty with the CA conclusions. The status of actions to address the secondary issue is shown in Appendix A. Maintenance items are addressed, as funding allows, based on the relative risk associated with meeting the performance objectives. Currently, there is minimal risk in exceeding the 100 mrem/yr CA primary dose limit or the 30 mrem/yr dose constraint (administrative limit).

Proposed activities, discoveries, new information and changes potentially affecting the 2010 SRS CA have been documented in this and earlier Annual Summary reports, and a consolidated list of changes since the 2010 CA is provided in Appendix B.

The 2010 SRS CA model validation performed herein indicates that the CA projected dose, while generally conservative, provides a reasonable representation of the maximum annual doses. Additionally, all doses evaluated here are well below the SRS established 15 mrem/yr administrative limit (Crapse et al. 2011) indicating that no additional model validation action is required.

Based on the assessment presented within this annual review and collective engineering judgement, the conclusions of the 2010 SRS CA remain valid and there is reasonable assurance that SRS will meet the performance objectives delineated in DOE Order 435.1. Although CA-related work completed in FY17 provides indications that the conclusions of the CA are still valid, the 2010 SRS CA should be updated upon revision of the SRS PA(s) to incorporate PA changes and to address the number of proposed changes to inventories and sources and model improvements accumulated since the 2010 CA.

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LIST OF ACRONYMS / DEFINITIONS

ACP	Area Completion Projects
AER	Annual Environmental Report
ALARA	As Low As Reasonably Achievable
CA	Composite Analysis
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
D&D	Deactivation and decommissioning
DP	Distributed Processing
DOE	Department of Energy
EAV	E-Area Vault
ELLWF	E-Area Low-Level Waste Facility
FMB	Fourmile Branch
FTF	F-Tank Farm
FY	Fiscal year
GSA	General Separations Area
HEU	High Enriched Uranium
HQ	Headquarters
HTF	H-Tank Farm
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IOU	Integrator Operable Unit
ISD	In Situ Disposal
K_d	Distribution Coefficient
LFRG	Low Level Waste Disposal Facility Federal Review Group
LLRWDF	Low-Level Radioactive Waste Disposal Facility
LLW	Low-Level Waste
LTR	Lower Three Runs
M&O	Management and Operating
MEI	Maximally Exposed Individual
MWMF	Mixed Waste Management Facility
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NRCDA	Naval Reactor Component Disposal Area
ORWBG	Old Radioactive Waste Burial Grounds
PA	Performance Assessment

PB	Pen Branch
PEST	Parameter ESTimation Software
POA	Point of Assessment
PORFLOW	Primary flow and transport code used in SRS PA and CA modeling
QA	Quality Assurance
R&D	Research and Development
RCRA	Resource Conservation and Recovery Act
RGFM	Regional Groundwater Flow Model
SA	Special Analysis
SAR	Safety Analysis Report
SC	Steel Creek
SCDHEC	South Carolina Department of Health and Environmental Control
SDF	Saltstone Disposal Facility
SDU	Saltstone Disposal Unit
SR	Savannah River
SRNL	Savannah River National Laboratory
SRNS	Savannah River Nuclear Solutions
SRR	Savannah River Remediation
SRS	Savannah River Site
TRU	Transuranic
UDQE	Unreviewed Disposal Question Evaluation
US	United States
USGS	United States Geologic Survey
UTR	Upper Three Runs
UWMQE	Unreviewed Waste Management Question Evaluation
WSRC	Westinghouse or Washington Savannah River Company

1.0 SRS and 2010 SRS Composite Analysis Background/History

1.1 SRS Background/History

The Savannah River Site (SRS) is a Department of Energy (DOE) site encompassing approximately 310 square miles in South Carolina. It is bounded on the southwest by the Savannah River (SR) and is situated approximately 12 miles south of Aiken, South Carolina, and 15 miles southeast of Augusta, Georgia. Construction of and subsequent operations at the SRS began in 1951 under the direction of the Atomic Energy Commission. The primary mission of the SRS was to produce tritium and plutonium for the national nuclear weapons complex. Between 1953 and 1955, SRS brought five reactors and various support facilities into operation in support of its primary mission. Support facilities included two chemical separations plants, a heavy water extraction plant, a nuclear fuel and target fabrication facility, a tritium extraction facility and waste management facilities (DOE 1997; Mamatey 2007; Reed et al. 2002; SRS 2008; WSRC 2007a).

With the declining need for a large nuclear weapons stockpile since the end of the Cold War, many SRS facilities no longer produce or process nuclear materials. All reactors were shut down by 1988. However, the SRS continues as the DOE's center for the supply of tritium to the nuclear weapons stockpile with the startup of the 2006 Tritium Extraction Facility, which extracts tritium from rods irradiated in commercial reactors. Additionally, operations at the K-Area Complex currently provide interim safe storage for much of DOE's excess plutonium (Pu) and high enriched uranium (HEU), in a building which formerly housed K Reactor. As the SRS mission has changed, many surplus facilities are being dispositioned safely and economically. In 2002, SRS began extensive decommissioning activities in D-Area, M-Area, P-Area, R-Area, and T-Area (Mamatey 2007; SRS 2008) which have since been completed, with groundwater remediation still underway. High-level waste tanks continue to be emptied and closed.

1.2 2010 SRS CA Background/History

The 2010 SRS Composite Analysis (CA) (SRNL 2010) was required by DOE Order 435.1, Radioactive Waste Management (DOE 1999c), as part of the Disposal Authorization Statements (DOE 1999a, 2008a) for the E-Area Low-Level Waste Facility (ELLWF) and Saltstone Disposal Facility (SDF), and the Tier 1 Closure Authorization for the F- and H-Tank Farms (FTF; HTF). The 2010 SRS CA was a site-specific, cumulative, all-pathways dose projection to a hypothetical future member of the public at the mouths of the site creeks (i.e. Upper Three Runs (UTR), Fourmile Branch (FMB), Steel Creek (SC), and Lower Three Runs (LTR)) and within the SR (at the United States (US) Highway 301 Bridge, downstream from SRS). The dose projection accounted for radionuclide migration from the ELLWF, SDF, FTF and HTF closures and all other known projected end-state sources of radioactive material to remain at SRS. The all-pathways dose was projected over a 1,000-year period beginning at the assumed end-state date of 2025 and was compared to the primary public dose limit of 100 mrem/yr and an administrative limit of 30 mrem/yr (CA performance measures). The analysis resulted in a maximum projected three mrem/yr dose over the 1,000-yr assessment period at the LTR Point of Assessment (POA), primarily due to Cs-137 contained within the streambed sediments. The projected dose was less at all other creek mouth POAs and the SR POA. It is also worth noting that subsequent work has determined that the Cs-137 inventory in LTR streambed sediments is more accurately estimated to be 1/5 of the inventory initially utilized in the CA calculations (Hiergesell and Phifer 2012); so, in summary, the analysis provided a reasonable expectation that the CA performance measures will not be exceeded.

In July 2010 DOE approved the SRS CA (SRNL 2010) with the condition that the secondary issue identified by the Low-Level Waste Disposal Facility Federal Review Group (LFRG) Review Team (Carilli and

Golian 2010) be resolved (Marcinowski 2010). Approval required that the secondary issue be tracked through the CA Maintenance Plan and progress reported in the SRS CA Annual Report (Appendix A).

2.0 Changes Potentially Affecting the CA

Potential changes affecting the CA may include completed or in-progress CA Maintenance items (see Sections 3.1 to 3.3), Performance Assessment (PA) and CA research and development (R&D) (see Section 3.4), changes addressing the LFRG Secondary Issue (see Section 3.5 and Appendix A), and changes to key inputs and assumptions (see Section 3.6). These sections of this report identify and address potential changes identified in FY2017 in detail, so that information is not repeated here. A consolidated list of all known CA-affecting changes that have occurred since the 2010 SRS CA is provided in Appendix B. Although CA-related work completed in FY17 provides indications that the conclusions of the CA are still valid, the 2010 SRS CA should be updated upon revision of the SRS PA(s) and to address the number of proposed changes to inventories and sources and model improvements accumulated since the 2010 CA.

3.0 CA Maintenance and Control

3.1 CA Maintenance Items and Related Activities Completed in FY2017

The following annual CA maintenance items were completed in FY2017:

- FY2016 SRS CA Annual Review:

  The FY2016 CA Annual Review (Halverson and Stagich 2017) concluded that the 2010 SRS CA is adequate and, specifically, that: 1) changes identified from completed maintenance items are not expected to alter CA conclusions; 2) no R&D activity impacting the CA conclusions was performed; 3) changes identified from resolution of the LFRG Secondary Issue are not foreseen to alter CA conclusions; 4) changes identified to CA inputs and assumptions are not foreseen to alter CA conclusions; 5) there have been no changes in land use and therefore the POAs remain valid; and 6) CA model validation indicates the CA is a reasonable representation of the maximum annual dose. The FY2016 Annual Review of the 2010 SRS CA was approved by DOE-Headquarters (HQ) in December 2017 (Seifert and Tonkay 2017).

The following studies, calculations and related activities supporting CA Maintenance were completed in FY2017:

- 643-26E Naval Reactor Component Disposal Area (NRCDA) – Revised Radionuclide Inventories at Closure (Sink 2016a): Discussed in Section 3.6.2.
- ELLWF projected radionuclide inventory at closure calculations (Sink 2016b): Discussed in Section 3.6.2.
- New ELLWF conceptual closure cap design (SRNS 2016a): Discussed in Section 3.6.3.
- Updated parameters (characteristics of meat, milk, and vegetable production/consumption; river recreational activities; and other human usage parameters) required in SRS dosimetry models (Jannik and Stagich 2017): Discussed in Section 3.6.3.
- Special Analysis (SA) issued for SDF to reflect a change in the layout of SDUs 6, 7, 8, and 9 (SRR 2016, SRR 2018a): Discussed in Section 3.6.3.
- Unreviewed Waste Management Question Evaluation (UWMQE) of Saltstone Disposal Unit 6 As-Built Conditions (SRR 2017, 2018): Discussed in Section 3.6.3.
- Updated and recalibrated 2004 GSA/PORFLOW groundwater flow using the Parameter ESTimation Software (PEST) optimization code to create the model, "GSA2016" (Flach et al. 2017): Discussed in Section 3.6.4.

3.2 CA Maintenance Items Worked but Not Completed in FY2017

The following is a list of CA Maintenance items worked on but not completed during FY2017.

- Develop a new combined Dose and Intruder software application incorporating current radionuclide and dose parameters and latest dose calculation methodology. Document model features and associated quality assurance (QA) and testing. Work will continue in FY2018.
- Develop a new Radionuclide Screening software application for screening the set of 1252 radionuclides (ICRP 2008) for those that will be carried forward into detailed PA calculations. Document model features and associated QA and testing. Work will continue in FY2018.
- Assess and document initial metal coupon corrosion data from SRNL's B-25 box corrosion monitoring field site to determine the optimum time following burial to perform waste stabilization measures prior to final closure cap installation. Work was begun in FY2017 and will be completed in FY2018.

3.3 CA Maintenance Items Anticipated for FY2018

The following is a list of CA Maintenance items anticipated to be initiated and/or performed in FY2018 subject to available funding (not including items listed in Section 3.2):

- Conduct the FY2017 SRS CA Annual Review and Model Validation (this report). The SRS CA Annual Review is scheduled to be performed annually as listed in the SRS CA Maintenance Program FY 2016 Implementation Plan (Butcher 2016b).
- Set up a centralized electronic archive of documents identified in Appendix B "List of Proposed Activities/Discoveries/New Information/Changes to the 2010 SRS CA through FY2017".
- Update the CA end state radionuclide inventory report (Hiergesell et al. 2008) with C, K, and L-Reactor inventories developed since the 2010 SRS CA (Vinson and Webb 2010).
- Develop a process that identifies which changes and new information with respect to the CA require further evaluation.

3.4 PA and CA Research and Development

The following is a list of CA-specific R&D work performed in FY2017, as well as R&D work performed in FY2017 in association with the PAs for ELLWF (WSRC 2008a, Hang et al. 2018), SDF (SRR 2009, SRR 2018a), FTF (SRR 2010), and HTF (SRR 2012a), that may have a bearing on the conclusions of the 2010 SRS CA (SRNL 2010).

- Measurement of distribution coefficient (K_d) values in SRS subsurface sediments and cementitious materials, specifically for I-129 (SRR 2018a, Seaman and Thomas 2017) in FY2017. Work is part of an ongoing study to continue in FY2018.
- Determine radionuclide leaching characteristics for Tc-99 and I-129 from Saltstone samples (SRR 2018a, Seaman and Coutelot 2017).

3.5 Status of Secondary Issue from LFRG Review of the 2010 SRS CA

The LFRG review of the 2010 SRS CA identified a number of observations. Eighteen of these, when viewed collectively, were deemed to have a potential impact on the integration of results and were consolidated under a single Secondary Issue to be resolved. Nine of the 18 observations were closed out prior to final issue and DOE approval of the CA. The remaining nine observations (observations 2, 4, 5, 6, 7, 13, 14, 16, and 21) must be resolved through the CA Maintenance Plan and tracked through the CA Annual Review report until complete. Changes to sources, inventories and models identified as a result of work items addressing these observations will be included in the next update to the CA. These nine

observations were to be resolved by the performance of 17 specific work items, which the LFRG concurred would resolve the observations once completed. Completed work items and their closure status are listed below:

- Work Item 1 (Re-evaluation of the SRS facility and waste site lists) was completed and closed out with DOE approval of the FY2015 CA Annual Review (Hiergesell et al. 2016).
- Work Item 5 (LTR Integrator Operable Unit (IOU) Inventory and Distribution) was closed out with DOE approval of the FY2013 CA Annual Review (Phifer et al. 2014).
- Work Item 6 (FMB, SC, and PB Inventory and Uncertainty) and Item 7 (H-Canyon, HB-Line, and H-Canyon Outside Facilities Inventory and Uncertainty) were closed out with DOE approval of the FY2014 CA Annual Review (Phifer et al. 2015).
- Work Item 8 (F&H Seepage Basin Groundwater Plume Inventories and Distributions) was completed in FY2016 and was closed out upon approval of the FY2016 CA Annual Review (Halverson and Stagich 2017; Seifert and Tonkay 2017).
- Work Item 15 (Procure 36 Processor Windows Cluster and GoldSim DP-Plus Module) was closed out with DOE approval of the FY2012 CA Annual Review.

Open work items that have been initiated but not completed, or have not been initiated, are listed below:

- Work Item 2 (Revise CA inventory report with corrections made during CA development)
- Work Item 4 (Develop and implement methodologies to estimate inventory uncertainty associated with significant radionuclide source locations)
- Work Item 9 (Revise inventory estimation ratio based on final data from facilities demolished since publication of the 2010 SRS CA)
- Work Item 10 (Revise the CA radionuclide screening by using the CA base case model and by considering radionuclides associated with the SDF PA)
- Work Item 11 (Perform a water balance study to provide estimates of natural stream flow for UTR, FMB, SC/PB and LTR)
- Work Item 12 (Develop an SRS regional groundwater flow model (RGFM) encompassing the entire SRS) is under review. A formal request was submitted by DOE-SR to DOE-HQ in August 2015 to reconsider the need for a RGFM (DOE 2015). As of the end of FY2017, SRS was awaiting response from LFRG on a SRS position paper (Phifer 2015) providing justification for the removal the RGFM from the LFRG secondary issue.
- Work Item 13 (Perform field characterization study of UTR, FMB, SC/PB and LTR streambeds to reduce uncertainty with release of radionuclides from streambed sediments)
- Work Item 14 (Investigate the distribution of uranium within Tims Branch between that dissolved in water, that bound to streambed sediment, and that bound to particulates in transit)
- Work Item 16 (Perform a systematic sensitivity analysis to identify model parameters that have the greatest impact on CA results)
- Work Item 17 (Perform a more structured uncertainty analysis to identify those stochastic variables that have the greatest/least impact on model results) has been initiated. Further work on this item has been deferred until work on the next CA revision is initiated.

A summary of all the LFRG observations and status of associated work items is provided in Appendix A.

3.6 Key SRS CA Inputs and Assumptions

3.6.1 Land Use (Points of Assessment)

There were no changes in land use planning assumptions in FY2017. The SRS Land Use Plan (SRNS 2014b) and the SRS Ten Year Site Plan (SRNS 2015b) were not updated in FY2017. The Environmental

Management Program Management Plan (DOE 2017b) was updated in FY 2017, but reiterates the statement, "The future use for the SRS is non-residential and will be maintained as such using institutional controls."

3.6.2 SRS CA Source Terms

The following are FY2017 changes associated with the SRS CA source terms (end-state configuration and inventory). The following revised inventory forecasts will be used in development of the next ELLWF PA at which time they will need to be evaluated as a change for the CA. These and past potential source term changes are captured in Appendix B.

- Revised Radionuclide Inventories for 643-26E NRCDA at Closure (Sink 2016a):

  The original Bettis and KAPL radionuclide inventories of planned components to be sent for disposal to 643-26E was updated in 2016 for use in the next PA revision (Sink 2016a). The updated forecast information was used along with radionuclide inventories disposed to date to generate a forecast through both FY2025 and FY2040. This information was not previously reported in a CA Annual Review.

- ELLWF Projected Radionuclide Inventory at Closure Calculations

  Radionuclide inventories of all active and future ELLWF disposal units were projected out to the closure of each facility, using a combination of current historical data and process knowledge (Sink 2016b). The expected closure date used for the first 100 acres of the ELLWF was FY2040 compared to the FY2025 date used in the 2008 PA. This item was not previously reported in a CA Annual Review.

3.6.3 CA Model Inputs and Assumptions

The items in this section were completed and approved in FY2017. Potential changes in model inputs and assumptions along with PA baseline updates are captured in Appendix B.

The following proposed changes will be incorporated into future PA baseline updates at which time they will need to be evaluated as a change for the CA.

- Proposed new ELLWF conceptual closure cap design

  A new ELLWF conceptual closure cap design has been produced to address as-built trench unit layouts and implement best-practice multi-layer closure cap design (SRNS 2016a). The new features include a reorientation of the cap producing longer slope lengths and incorporation of a high-density polyethylene geomembrane above the geosynthetic clay liner. This item was not previously reported in a CA Annual Review.

- Updated Parameters for Dosimetry Models

  Detailed surveys of local land-use and water-use parameters were used to update parameters (characteristics of meat, milk, and vegetable production/consumption; river recreational activities; and other human usage parameters) required in the SRS dosimetry models. The preferred elemental bioaccumulation factors and transfer factors were also documented (Jannik and Stagich 2017). The revised parameters were used in the SRS Environmental Report completed in FY 2017 and will be used in future E-Area PA and CA updates.

The following changes to the respective PA baselines are determined using engineering judgement to have not adversely impacted CA results.

- ELLWF Unreviewed Disposal Question Evaluation for waste disposal in Engineered Trench 3

This 2013 UDQE addressed the proposal to place ET 3 in the footprint designated for ST 12 and to operate it using ST 12 disposal limits (Hamm et al. 2013). The evaluation concluded that the proposed operations result in an acceptably small risk of exceeding a SOF of 1.0 and approve this action from a PA perspective. This change will not have a significant impact on SRS CA conclusions because ELLWF facilities are managed to a SOF of less than one and because the ELLWF is not a major contributor to the total dose. This item was not previously reported in a CA Annual Review.

- SDF SA reflecting a change in the layout of SDUs 6, 7, 8, and 9

  An SA was performed for SDF to reflect a change in the layout of SDUs 6, 7, 8, and 9. The SA also updated the model to incorporate observed field conditions and lessons learned and to provide additional design margins. The SA built upon the SDF PA (SRR 2009) and previously completed SAs. Results indicated a reduction in peak dose (SRR 2016, SRR 2018a) and therefore no adverse impacts to the CA results.

- SDF UWMQE of Saltstone Disposal Unit 6 As-Built Conditions

  A UWMQE (SRR 2017) was completed in FY2017 for the SDF. Saltstone Disposal Unit 6 as-built conditions were evaluated against the assumptions used in 2009 SDF PA (SRR 2009), the CA (SRNL 2010), and other documents. None of the changes evaluated by the UWMQE were found to impact the conclusions of the SDF PA, the CA, or the other documents. Therefore, the conclusions in the PA and CA remained valid (SRR 2018a).

3.6.4 CA Models

The following modifications to CA models and supporting work were completed in FY2017. When these model updates are adopted into the respective PA baselines they will need to be evaluated as a change for the CA.

- Updated the 2004 GSA/PORFLOW groundwater flow model to "GSA2016"

  The 2004 GSA/PORFLOW groundwater flow was updated and recalibrated using new calibration target data, the updated hydrogeologic database, and the PEST optimization code. The model, "GSA2016," uses field data current through at least 2015. The update addressed issues raised by the LFRG in a 2008 review of the E-Area Performance Assessment, and by the Nuclear Regulatory Commission in its reviews of tank closure and Saltstone Disposal Facility Performance Assessments. The GSA2016 model exhibits good agreement with well water level, stream baseflow and seepline data. Model updates, calibration approach and flow simulation validation and results were documented in Flach et al. (2017).

4.0 CA Model Validation

Based on the projected SRS end-state dates presented in SRS planning documents (SRNS 2009b, WSRC 2003a, WSRC 2003b, DOE 2005, WSRC 2007b, and WSRC 2007c), the SRS CA end-state date was taken as 2025 [i.e., earliest time that a) all SRS operations have been assumed to cease after all LLW disposal facilities and tanks have been closed; b) all Resource Conservation and Recovery Act (RCRA)/ Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remediation has been completed; c) all site deactivation and decommissioning (D&D) has been completed; and d) all DOE site operations, other than long-term stewardship, National Nuclear Security Administration missions, and other future missions, have ceased]. The year assigned to the inventory for each facility and waste site within the CA model was generally based upon one of the following:

- a year representative of when the end-state inventory actually was placed (past);
- a year representative of the data used to develop the end-state inventory (past); or

- the year that it is anticipated that the end-state inventory will be achieved (future).

SRS CA modeling for each facility and waste site began on the inventory year assigned to it so that source depletion and radionuclide transport out of the system could be appropriately captured. This helped to ensure that an artificially high model peak would not occur at the 2025 end-state date. This means that SRS CA modeled results were obtained prior to the assumed end state date of 2025.

Some SRS waste sites that have already achieved their end states (i.e. end-state inventories and end-state configuration) are currently contributing to the potential off-site public dose through source release, groundwater transport, discharge to on-site surface streams, and stream transport to the CA POAs. These waste sites include Old Radioactive Waste Burial Grounds (ORWBG), Mixed Waste Management Facility (MWMF), Low-Level Radioactive Waste Disposal Facility (LLRWDF), F- and H-Area Seepage Basins, Reactor Area Seepage Basins (K-, L-, P-, and R-Areas), UTR, FMB, PB, SC, and LTR. The inventory year assigned to all of these waste sites is 2002 or before. This means that SRS CA results from 2002 and beyond are a reasonable representation for these waste sites that have already achieved their end states and are currently contributing to the potential off-site public dose.

As part of SRS Annual Environmental Report (AER) monitoring, the total radionuclide release through the liquid pathway to the Savannah River (both in terms of curies released and concentration) is estimated using liquid effluent discharge-point data along with groundwater migration pathway data based upon concentrations and flow rates. In addition, the AER monitoring takes into account Cs-137 originating from streambeds through fish concentration monitoring (Mamatey 2010). The groundwater migration pathway data plus the Cs-137 fish data represent the contribution from waste sites that have already achieved their end states (i.e. ORWBG, MWMF, LLRWDF, F- and H-Area Seepage Basins, Reactor Area Seepage Basins (K, L, P, and R Areas), UTR, FMB, PB, SC, and LTR). In contrast, the effluent discharge-point data represent operating, not end-state, conditions. AER monitoring is able to differentiate and separate the effluent discharge point data from the groundwater migration pathway and Cs-137 fish data so that data representing only waste sites at their end state can be produced.

Because the SRS CA has projected reasonable end-state impacts from 2002 and beyond, and the AER monitoring can differentiate and separate operating and end-state contributions to annual liquid pathway release, an opportunity exists to use the AER monitoring data to validate the SRS CA model. CA model validation, based upon AER monitoring data, is a tool to improve future CA predictions, inform the CA maintenance plan relative to work required to make such improvements, and inform future AER monitoring. Additionally, it can be a tool to indicate that actions may need to be taken to provide continued reasonable assurance that future doses will be within the limit.

In conformance with the DOE order/manual/guide requirements (DOE 1999b, DOE 1999c, DOE 1999d), a full revision of the SRS CA model validation plan was issued on September 19, 2011 (Crapse et al. 2011) based upon the 2010 SRS CA (SRNL 2010). SRNL used the 2010 SRS CA to determine the media, locations, and radionuclides to be considered, and designed the program to detect changing trends to allow any necessary corrective action prior to exceeding the CA performance measures. The CA model validation program can be considered performance monitoring. The program is used as an indicator of the CA model validation and as a tool to ensure that future radiological protection of the public will be maintained. 100 mrem/yr is the primary dose limit established as the CA performance measure based upon DOE Order 5400.5 (DOE 1990). Compliance with the primary dose limit at SRS is ensured through the SRS AER monitoring conducted in compliance with DOE Order 458.1, Radiological Protection of the Public and the Environment (DOE 2011b).

The CA model validation program uses a graded and systematic approach for taking corrective action, starting with an SRS established administrative limit of 15 mrem/yr, below which no action is required. Based on the location of the 2010 SRS CA POAs, the only potential exposure pathway for the public is through surface water. Consequently, a stream monitoring based approach that utilizes data already produced as part of the SRS AER has been designed (Phifer et al. 2011 and Crapse et al. 2011). Concurrence for implementation of this approach was received from the LFRG in May 2011. The updated Monitoring Plan was approved by DOE-Savannah River in October 2012.

Based on the adoption of the POAs identified in the 2010 SRS CA, groundwater monitoring is not required. Because all SRS groundwater discharges into site streams, monitoring of water samples collected from SRS streams at their mouths and from the SR becomes the means to evaluate SRS releases against the CA Performance Measure as outlined in the monitoring plan (Crapse et al. 2011).

In accordance with the CA model validation plan (Crapse et al. 2011, Section 4.0), the following are evaluated annually. Each is presented in more detail in Sections 4.1 through 4.3.

- AER (MEI + Irrigation doses) versus SRS CA Dose: The AER Maximally Exposed Individual (MEI) plus AER irrigation doses are compared to the SRS CA projected dose for the SR POA at the US Highway 301 Bridge.
- AER Fisherman versus SRS CA Fisherman Dose: The AER creek-mouth fisherman dose for each SRS creek (i.e. UTR, FMB, SC/PB, LTR) and the SR is compared to the respective SRS CA projected creek-mouth and SR fisherman dose.
- AER End-State Equivalent Doses: The appropriate AER data for each SRS creek and the SR is used as input to the CA dose module to produce an "AER end-state equivalent dose" for comparison with the SRS CA projected dose for that respective year.

4.1 AER (MEI + Irrigation doses) versus SRS CA Dose

The AER MEI and irrigation doses and the corresponding CA doses at the SR US Highway 301 Bridge are provided in Table 4-1. While the combined AER MEI and irrigation dose includes both operating (liquid effluent discharge point data) and end-state (groundwater migration pathway data) impact and the CA dose includes only the end-state impact, this is considered an easy comparison that demonstrates the conservative nature of the CA results. The 2016 data are in bold within the table. The trend of 2002 to 2016 AER MEI and irrigation doses versus CA doses at the SR US Highway 301 Bridge is presented in Figure 4-1. As shown in this figure, the AER combined MEI and Irrigation dose (solid black markers and line) for 2016 is about the same as 2015. However, the SRS CA projected dose at the US Highway 301 Bridge (solid blue line and markers) is slightly greater than the AER combined MEI and Irrigation dose and trends slightly downward over time.

4.2 AER Fisherman versus SRS CA Fisherman Dose

The AER creek-mouth fisherman doses and the corresponding CA fisherman doses are presented in Table 4-2. As discussed in Section 4.0, both the AER creek-mouth fisherman and the CA fisherman doses represent the anticipated end-state Cs-137 conditions within the site streams and SR. The 2016 data are in bold within the table. The AER versus CA creek-mouth fish pathway doses are presented in Figures 4-2 through 4-6 for UTR, FMB, SC-PB, LTR, and the SR, respectively. As shown in these figures, the SRS CA projected fisherman doses trend downward over time and are usually greater than the AER fisherman doses. In 2016, the AER fisherman doses for FMB, SC-PB, LTR, and SR were lower than the stream-specific SRS CA projected fisherman doses. For UTR, the AER fisherman dose increased in 2016 and exceeded the SRS CA projected fisherman dose for that stream; however, the two values are reasonably equivalent. Yearly variation in the doses can be due to relatively large variability in fish radionuclide

concentrations resulting from differences in the size of fish collected, time of year fish were collected, and water quality changes stemming from stream flow rates, among other factors.

4.3 AER End-State Equivalent Doses

Total AER releases to streams data consist of both groundwater discharges originating from closed waste sites and direct operational effluent releases to streams. CA model validation is concerned with only the end-state discharges (i.e. groundwater discharges) because operational discharges will be discontinued at the SRS end state. Therefore, SRS CA doses are compared to only "AER End-State Equivalent Doses" produced from AER groundwater discharge data and not AER operational release data as outlined in the formula developed by Phifer et al. (see Table 3 on page 11 of Phifer et al. 2011).

Table 4-1. 2002 to 2016 AER versus CA Doses at SR US Highway 301 Bridge

Year	AER Liquid Pathway MEI Dose [1]	AER Irrigation Pathway Dose [1]	AER MEI plus AER Irrigation Dose	SRS CA SR US Hwy 301 Bridge Dose [2]
	All Data in mrem/yr			
2002	0.12	0.108	0.23	0.359
2003	0.12	0.084	0.20	0.346
2004	0.09	0.078	0.17	0.334
2005	0.08	0.049	0.13	0.322
2006	0.09	0.079	0.17	0.311
2007	0.05	0.054	0.11	0.300
2008	0.08	0.098	0.18	0.296
2009	0.08	0.060	0.14	0.285
2010	0.06	0.1	0.16	0.275
2011	0.08	0.09	0.18	0.266
2012 [3]	0.10	0.13	0.23	0.257
2013	0.052	0.09	0.14	0.25
2014	0.041	0.074	0.12	0.24
2015	0.053	0.093	0.15	0.232
2016 [4]	**0.053**	**0.100**	**0.15**	**0.225**

[1] AER Liquid Pathway MEI dose and AER Irrigation Pathway dose obtained from each year's respective AER (Mamatey 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011; Ackerman and Jannik 2012; SRNS 2013b, 2014a, 2015a, 2016b, 2017).

[2] SRS CA SR US Highway 301 Bridge Dose obtained from the CA Excel file, POA_Pathway_SR_FishCum, worksheet, SR_RecCum, column M, 301 Bridge Cumulative (i.e. extracted from SRNL (2010)).

[3] Beginning in 2012, the Representative Person concept (gender and age averaged at the 95th percentile of usage rates) was adopted by SRS as a replacement for the MEI for the AER.

[4] 2016 AER data provided by Jannik (2018), Attachment 2.

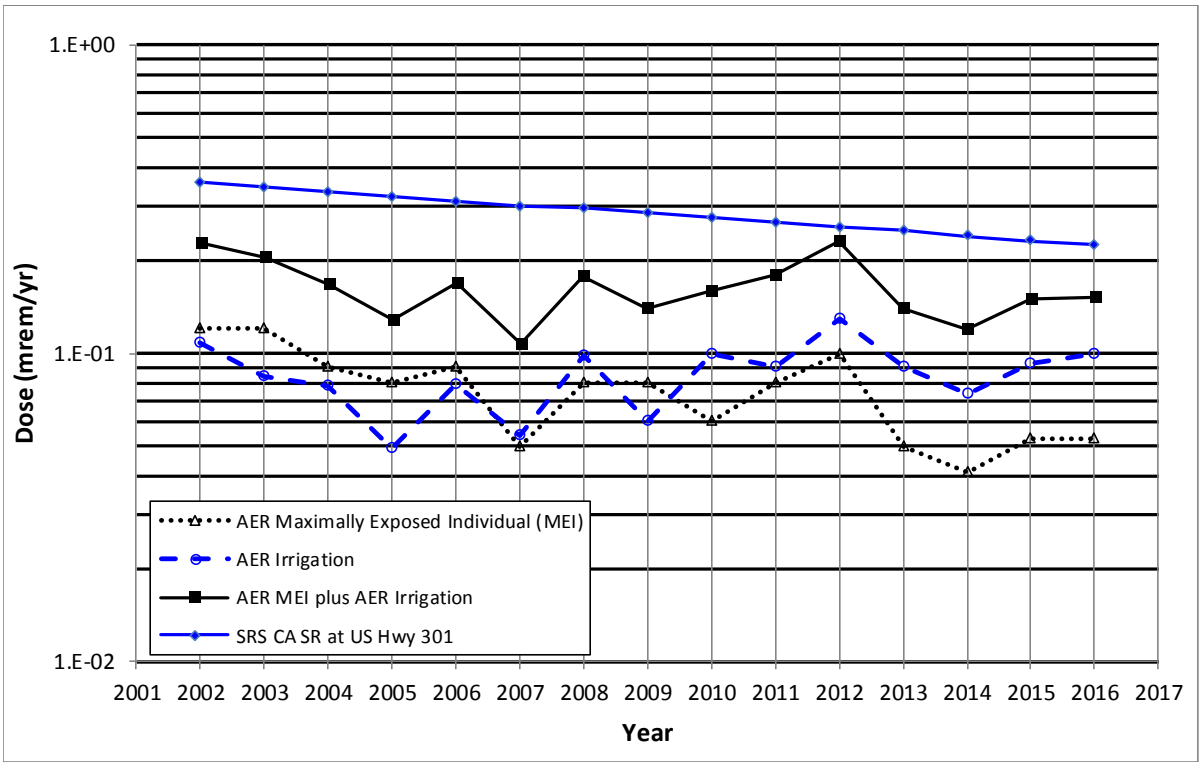

Figure 4-1. 2002 to 2016 AER versus CA Doses at SR US Highway 301 Bridge

Table 4-2. 2002 to 2016 AER versus CA Fish Consumption Doses at Mouths of Creeks and SR

Year	UTR		FMB		SC-PB		LTR		SR	
	AER Max Fish Dose[1]	CA Fish Dose[2]	AER Max Fish Dose[1]	CA Fish Dose[3]	AER Max Fish Dose[1]	CA Fish Dose[4]	AER Max Fish Dose[1]	CA Fish Dose[5]	AER Max Fish Dose[1]	CA Fish Dose[6]
	All Data in mrem/yr									
2002	1.10E-01	1.23E-01	1.13E-01	3.50E+00	8.35E-02	6.04E-01	3.46E-01	5.04E+00	8.68E-02	1.30E-01
2003	3.38E-02	1.20E-01	5.79E-01	3.43E+00	1.21E-01	5.87E-01	6.70E-02	4.92E+00	5.44E-02	1.27E-01
2004	7.28E-02	1.18E-01	9.65E-01	3.36E+00	1.67E-01	5.71E-01	1.30E-01	4.81E+00	6.30E-02	1.24E-01
2005	1.07E-01	1.15E-01	1.95E-01	3.29E+00	2.42E-01	5.55E-01	1.12E-01	4.69E+00	7.66E-02	1.21E-01
2006	1.02E-01	1.12E-01	1.90E-01	3.22E+00	2.44E-01	5.40E-01	1.59E-01	4.58E+00	5.88E-02	1.18E-01
2007	5.81E-02	1.10E-01	9.22E-02	3.15E+00	2.16E-01	5.25E-01	2.39E-01	4.47E+00	7.56E-02	1.16E-01
2008	1.14E-01	1.07E-01	8.24E-02	3.10E+00	9.40E-02	5.11E-01	9.25E-02	4.37E+00	4.50E-02	1.13E-01
2009	1.12E-01	1.05E-01	1.01E-01	3.03E+00	9.71E-02	4.97E-01	3.54E-01	4.26E+00	5.32E-02	1.10E-01
2010	1.45E-01	1.02E-01	8.26E-02	2.96E+00	2.20E-01	4.84E-01	2.13E-01	4.16E+00	1.25E-01	1.08E-01
2011	5.20E-02	1.00E-01	5.30E-02	2.90E+00	6.80E-02	4.71E-01	5.30E-02	4.06E+00	2.90E-02	1.05E-01
2012	1.20E-01	9.77E-02	2.20E-01	2.84E+00	5.50E-02	4.58E-01	9.40E-02	3.97E+00	1.00E-01	1.03E-01
2013	4.70E-02	9.56E-02	8.90E-02	2.78E+00	2.80E-01	4.46E-01	1.10E-01	3.87E+00	5.50E-02	1.00E-01
2014	4.30E-02	9.37E-02	9.80E-02	2.72E+00	1.60E-01	4.34E-01	2.80E-01	3.78E+00	3.10E-02	9.78E-02
2015	1.40E-02	9.27E-02	1.00E-01	2.66E+00	2.80E-01	4.23E-01	2.80E-01	3.69E+00	4.40E-02	9.56E-02
2016 [7]	**1.48E-01**	**9.30E-02**	**2.15E-01**	**2.60E+00**	**1.36E-01**	**4.11E-01**	**2.10E-01**	**3.60E+00**	**5.06E-02**	**9.34E-02**

1 AER Liquid Pathway and Fish Pathway Dose data obtained from AER (Mamatey 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011; Ackerman and Jannik 2012; SRNS 2013b, 2014a, 2015a, 2016b, 2017).

2 UTR CA Fish Pathway Dose obtained from the CA Excel file, "POA_Pathway_SR_FishCum", worksheet, "UTR_Fish", column CE, "Total", for that respective year (i.e. extracted from SRNL (2010)).

3 FMB CA Fish Pathway Dose obtained from the CA Excel file, "POA_Pathway_SR_FishCum", worksheet, "FMB_Fish", column W, "Total", for that respective year (i.e. extracted from SRNL (2010)).

4 SC-PB CA Fish Pathway Dose obtained from the CA Excel file, "POA_Pathway_SR_FishCum", worksheet, "SC_Fish", column Y, "Total", for that respective year (i.e. extracted from SRNL (2010)).

5 LTR CA Fish Pathway Dose obtained from the CA Excel file, "POA_Pathway_SR_FishCum", worksheet, "LTR_Fish", column M, "Total", for that respective year (i.e. extracted from SRNL (2010)).

6 SR 301 CA Fish Pathway Dose obtained from the CA Excel file, "POA_Pathway_SR_FishCum", worksheet, "SR_FishCum", column H, "301 Bridge Cumulative", for that respective year (i.e. extracted from SRNL (2010)).

7 2016 AER data provided by Jannik (2018) Attachment 2.

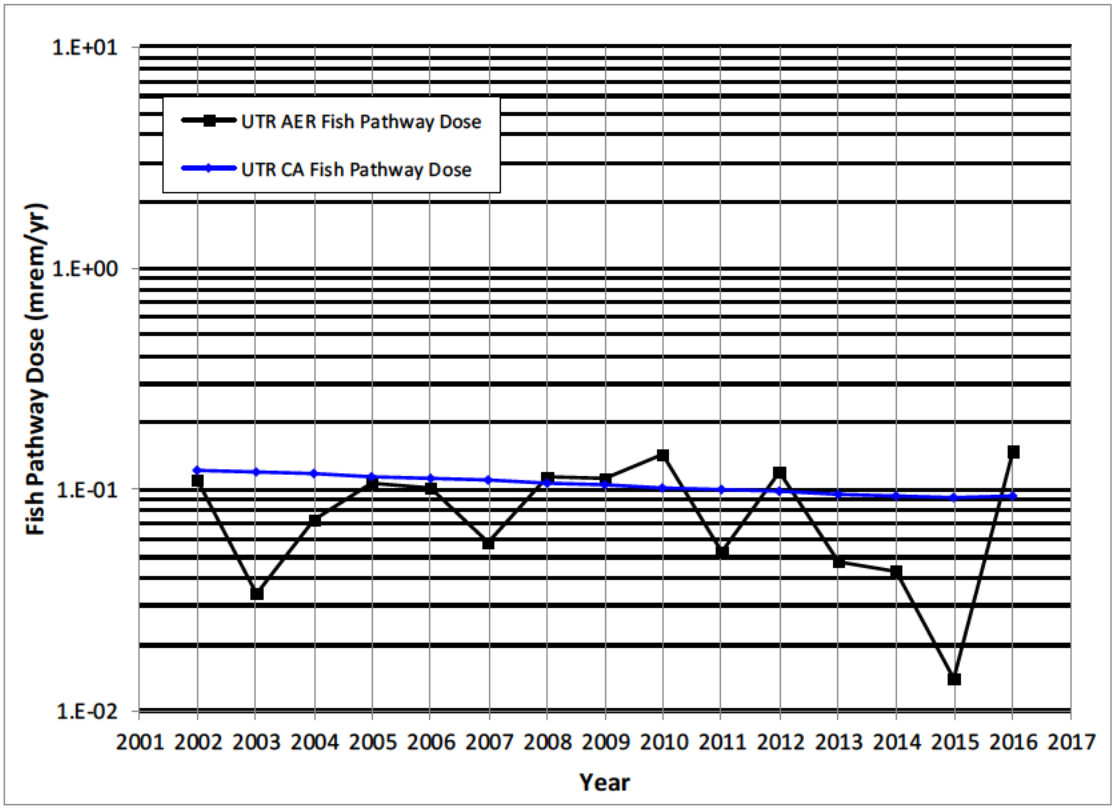

Figure 4-2. 2002 to 2016 UTR AER versus CA Creek-Mouth Fish Pathway Doses

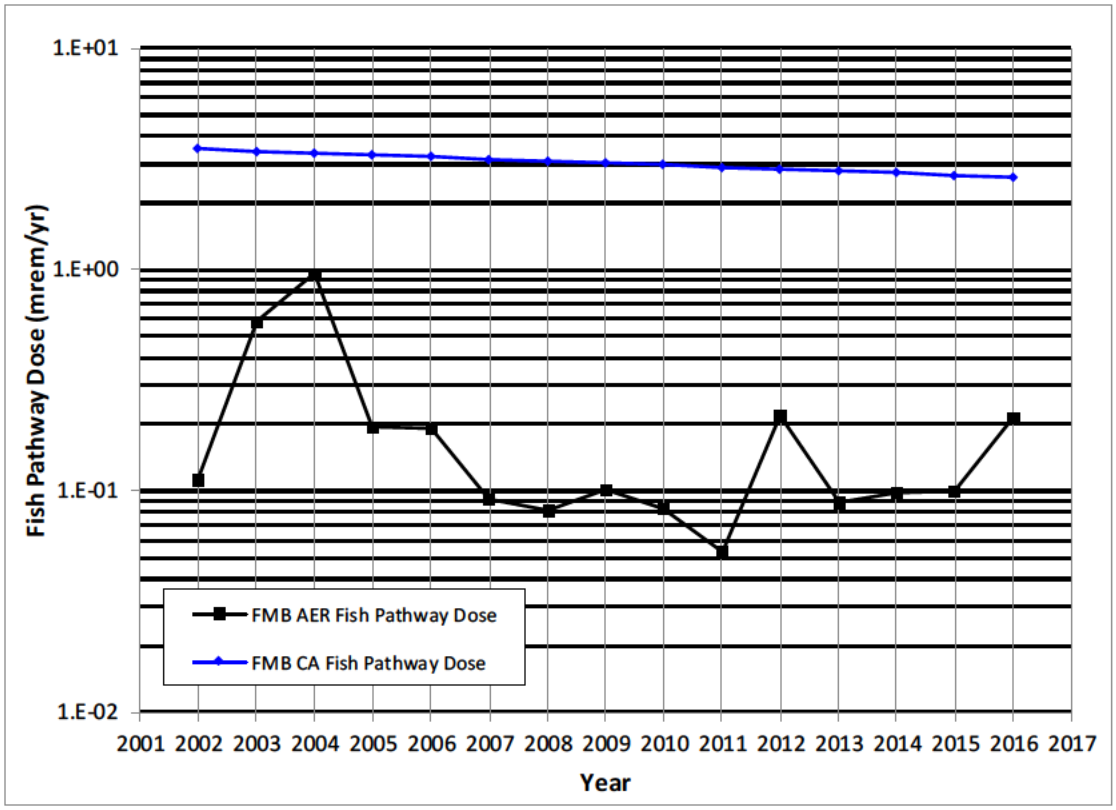

Figure 4-3. 2002 to 2016 FMB AER versus CA Creek-Mouth Fish Pathway Doses

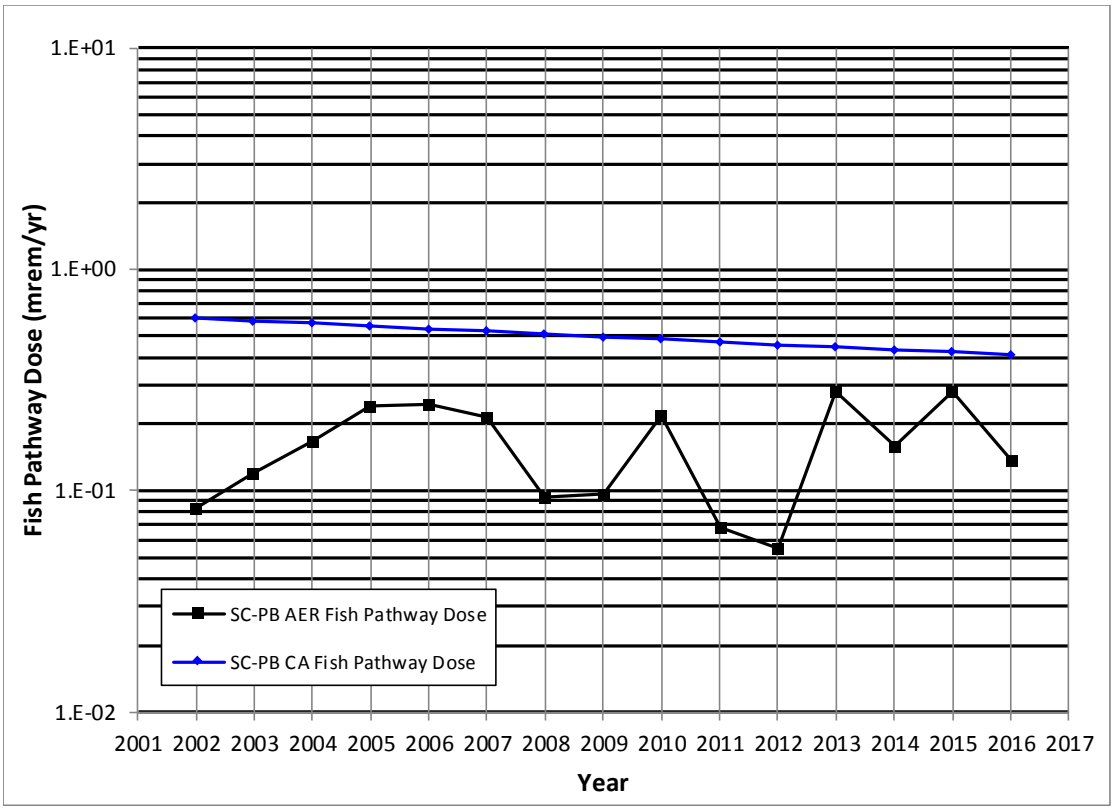

Figure 4-4. 2002 to 2016 SC-PB AER versus CA Creek-Mouth Fish Pathway Doses

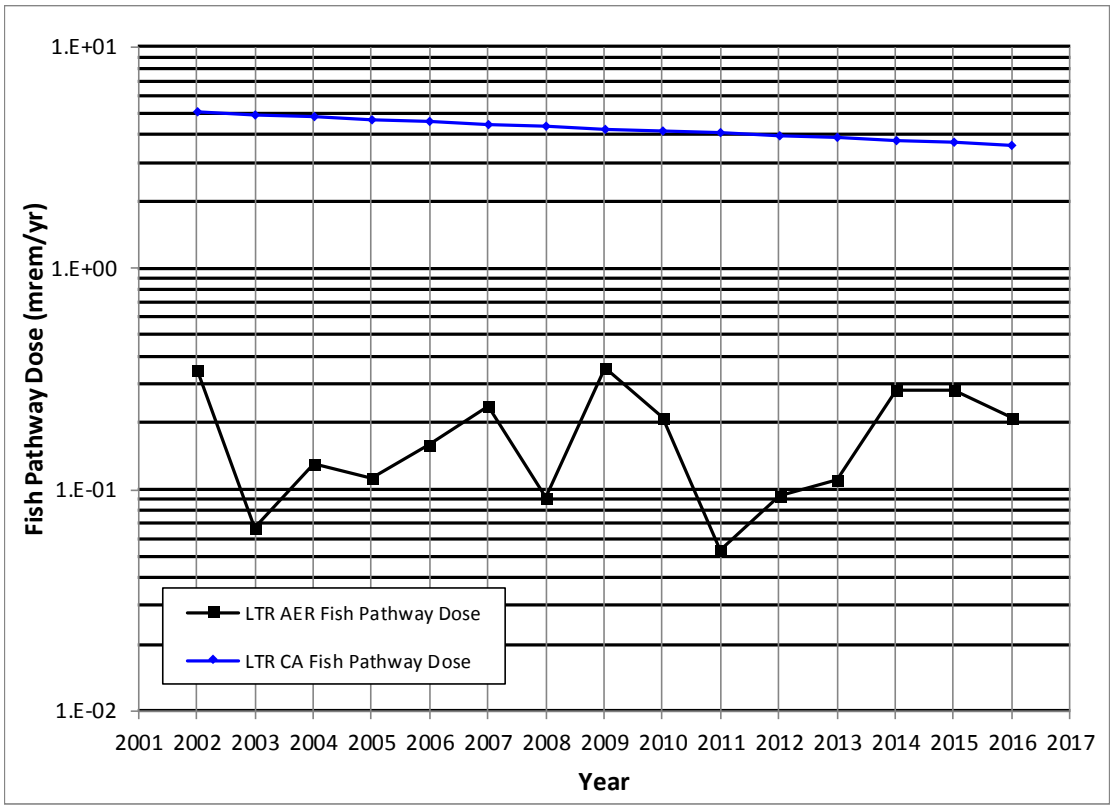

Figure 4-5. 2002 to 2016 LTR AER versus CA Creek-Mouth Fish Pathway Doses

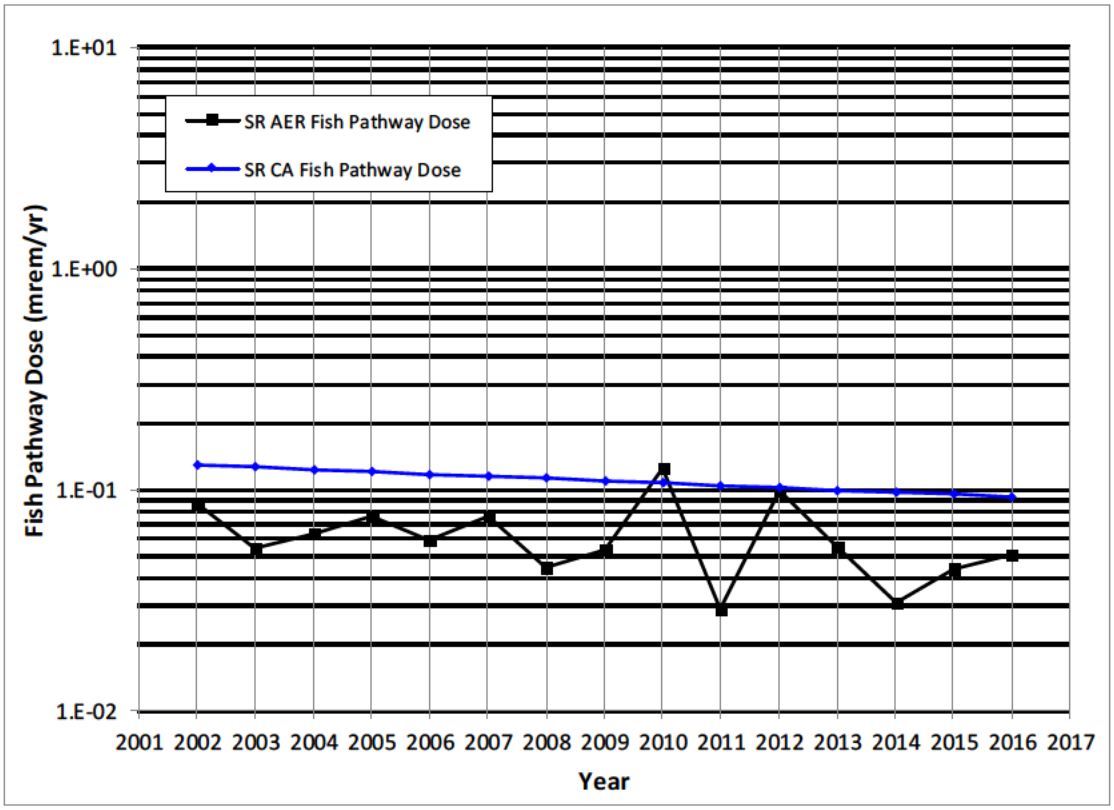

Figure 4-6. 2002 to 2016 SR AER versus CA SR 301 Bridge Fish Pathway Doses

Table 4-3 summarizes production of the AER end-state equivalent concentrations associated with each stream and the SR. The long-term average annual flow for each site stream and the SR is provided in the top portion of the table. The middle section of the table shows total Curies by nuclide derived from the 2016 AER groundwater discharge data for each stream and the SR (i.e. AER End-State Equivalent Curies). This information was provided in Jannik (2018) Attachment 1. The AER End-State Equivalent Curies were divided by the long-term average flow to produce the AER End-State Equivalent Concentrations by nuclide for each SRS stream and the SR (see bottom section of Table 4-3). These AER End-State Equivalent Concentrations were used as input to the SRS CA dose module to produce "AER End-State Equivalent Doses" for comparison with the SRS CA dose for that respective year. The dose results are presented in Table 4-4.

Table 4-5 presents the SRS CA projected dose and the "AER End-State Equivalent Dose" for each site stream and the SR for 2009 through 2016. The data indicate that the SRS CA projected doses are generally either greater than the AER end-state equivalent doses or reasonably equivalent. These data are illustrated graphically in Figure 4-7.

Table 4-3. 2016 AER Total Curies, Stream Annual Average Flow Rates and Resulting Concentrations

Long-Term Average Annual Flow [1]					
Flow (L/yr)	**UTR**	**FMB**	**SC/PB**	**LTR**	**SR**
	2.12E+11	2.86E+10	7.95E+10	1.46E+11	9.09E+12
AER End-State Equivalent Curies [2]					
Radionuclide	**UTR**	**FMB**	**SC/PB**	**LTR**	**SR**
H-3	9.23E+01	3.80E+02	2.35E+02	5.31E+00	7.12E+02
Sr-90	0	1.83E-02	0	0	1.83E-02
Tc-99	0	1.86E-02	0	0	1.86E-02
I-129	0	1.82E-02	0	0	1.82E-02
Cs-137	7.28E-03	4.80E-03	8.78E-04	3.03E-03	1.60E-02
AER End-State Equivalent Concentrations (Ci/L) [3]					
Radionuclide	**UTR**	**FMB**	**SC/PB**	**LTR**	**SR**
H-3	4.36E-10	1.33E-08	2.95E-09	3.63E-11	7.84E-11
Sr-90	0	6.40E-13	0	0	2.01E-15
Tc-99	0	6.50E-13	0	0	2.05E-15
I-129	0	6.37E-13	0	0	2.00E-15
Cs-137	3.44E-14	1.68E-13	1.10E-14	2.07E-14	1.76E-15

1 Extracted from Table 3-1 of Jones (2009).

2 From Jannik (2018), Attachment 1.

3 "AER End-State Equivalent Concentration" = "AER End-State Equivalent Curies" / Long-Term Average Annual Flow.

Table 4-4. 2016 CA Dose Module Processed "AER End-State Equivalent Doses"

Radionuclide	**UTR**	**FMB**	**SC/PB**	**LTR**	**SR**
	All Data in mrem/yr				
H-3	4.80E-02	1.46E+00	3.25E-01	3.99E-03	8.63E-03
Sr-90	0	2.73E-01	0	0	8.60E-04
Tc-99	0	2.09E-03	0	0	6.57E-06
I-129	0	4.91E-01	0	0	1.54E-03
Cs-137	7.36E-02	3.59E-01	2.36E-02	4.42E-02	3.76E-03
Total Dose [1]	2.06E-01	2.63E+00	3.48E-01	4.82E-02	1.69E-02

1 The total dose includes the dose from radionuclides other than the five primary radionuclides listed; therefore, the sum of the dose from the listed radionuclides does not equal the total dose.

Table 4-5. 2009 to 2016 CA Dose Module Processed "AER End-State Equivalent Doses

Dose	UTR[1]	FMB[1]	SC/PB[1]	LTR	SR[1]
	All Data in mrem/yr				
2009 End-State Equivalent Dose[2]	6.61E-02	4.19E+00	8.29E-01	1.07E-01	2.37E-02
2009 SRS CA Projected Dose[3]	1.07E-01	3.07E+00	6.44E-01	4.46E+00	2.85E-01
2010 End-State Equivalent Dose[4]	6.88E-02	3.22E+00	7.62E-01	8.11E-02	1.97E-02
2010 SRS CA Projected Dose[3]	1.04E-01	3.00E+00	6.23E-01	4.35E+00	2.75E-01
2011 End-State Equivalent Dose[5]	2.19E-01	4.30E+00	3.20E-01	7.88E-01	3.41E-02
2011 SRS CA Projected Dose[3]	1.02E-01	2.93E+00	6.04E-01	4.24E+00	2.66E-01
2012 End-State Equivalent Dose[6]	2.47E-01	5.47E+00	3.30E-01	4.06E-02	2.65E-02
2012 SRS CA Projected Dose[3]	9.97E-02	2.87E+00	5.85E-01	4.14E+00	2.57E-01
2013 End-State Equivalent Dose[7]	2.42E-01	3.36E+00	3.53E-01	7.72E-02	2.05E-02
2013 SRS CA Projected Dose[3]	9.75E-02	2.81E+00	5.67E-01	4.04E+00	2.48E-01
2014 End-State Equivalent Dose[8]	1.76E-01	6.86E+00	3.09E-01	8.09E-02	2.97E-02
2014 SRS CA Projected Dose[3]	9.57E-02	2.75E+00	5.49E-01	3.94E+00	2.40E-01
2015 End-State Equivalent Dose[9]	2.02E-01	2.48E+00	3.51E-01	2.97E-02	1.61E-02
2015 SRS CA Projected Dose[3]	9.47E-02	2.69E+00	5.33E-01	3.84E+00	2.32E-01
2016 End-State Equivalent Dose[10]	2.06E-01	2.63E+00	3.48E-01	4.82E-02	1.69E-02
2016 SRS CA Projected Dose[3]	9.53E-02	2.63E+00	5.16E-01	3.75E+00	2.25E-01

1 End-State Equivalent Dose data for 2011 through 2015 have been revised to remove dose related to direct discharges. Resulting values for UTR, FMB, SC/PB and SR are generally somewhat lower than previously reported.

2 Extracted from the Excel file Doses.xls file in the "2009" tab, row 66, columns B-F.

[3] Extracted from the Excel file POA.xls in the "POA Summary" tab, columns B-E and G. Data for SR here are reported as being for the 301 Bridge in the Excel file.
[4] Extracted from the Excel file Doses.xls file in the "2010" tab, row 66, columns B-F.
[5] Extracted from the Excel file Doses.xls file in the "2011" tab, row 85, columns B-F.
[6] Extracted from the Excel file Doses.xls file in the "2012" tab, row 85, columns B-F.
[7] Extracted from the Excel file Doses.xls file in the "2013" tab, row 85, columns B-F.
[8] Extracted from the Excel file Doses.xls file in the "2014" tab, row 85, columns B-F.
[9] Extracted from the Excel file Doses.xls file in the "2015" tab, row 85, columns B-F.
[10] Extracted from the Excel file Doses.xls file in the "2016" tab, row 85, columns B-F.

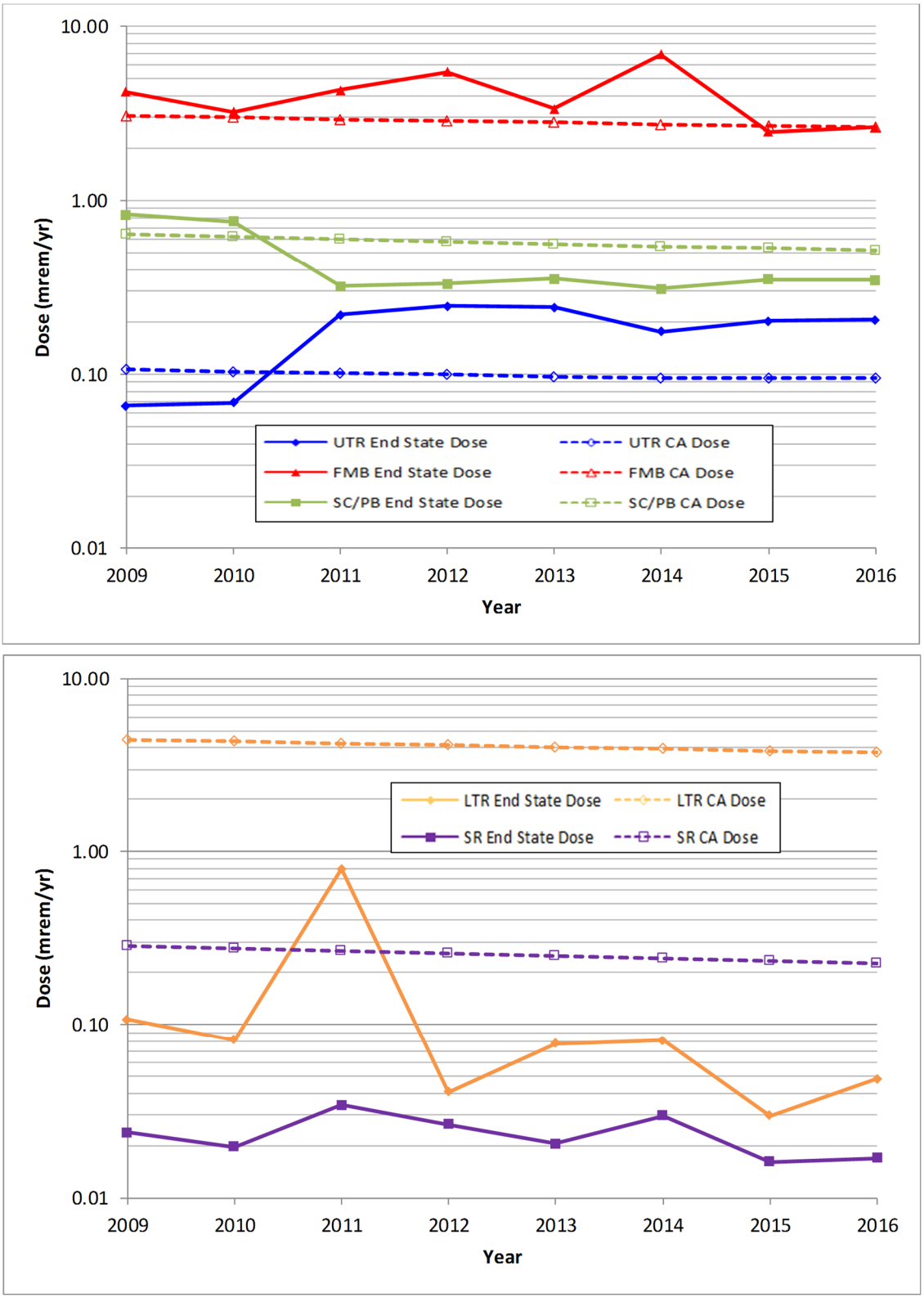

Figure 4-7. 2009 to 2016 SRS End-State Equivalent Dose versus SRS CA Dose

4.4 CA Model Validation Summary

In summary, the following observations were made regarding the CA model validation results in Sections 4.1 through 4.3:

- The SRS CA projected dose at the US Highway 301 Bridge is slightly greater than the AER combined MEI and Irrigation dose for all years evaluated (Figure 4-1).
- The SRS CA projected fisherman doses continue to be greater than the AER fisherman doses or are reasonably equivalent (Figures 4-2 through 4-6).
- The SRS CA projected doses are either greater than the AER end-state equivalent doses or are reasonably equivalent (Table 4-5 and Figure 4-7).

This indicates that the SRS CA projected dose, while generally conservative, provides a reasonable representation of the maximum annual doses. Because all doses evaluated are well below the SRS established 15 mrem/yr administrative limit (Crapse et al. 2011) no additional action is required.

5.0 Declaration of the Continued Adequacy of the CA

Based on all the information presented in this annual review, it is SRS's engineering judgement that the continued adequacy of the 2010 SRS CA is confirmed.

- Changes identified from completed maintenance items are not expected to alter CA conclusions.
- No R&D activity impacting the CA conclusions was performed.
- Changes identified from resolution of the LFRG Secondary Issue are not foreseen to alter CA conclusions.
- Changes identified to CA inputs and assumptions implemented into respective PA baselines through the UDQE, UMWQE and SA processes are not foreseen to alter CA conclusions.
- Because any potential lease or transfer of SRS land would have to comply with DOE Orders 458.1 and 435.1, it is anticipated that the current 2010 SRS CA POAs at the mouths of site streams to the SR and the SR itself would remain valid.
- CA model validation indicates the CA is a reasonable representation of the maximum annual dose.

Based on the assessment presented within this annual review and collective engineering judgement, the conclusions of the 2010 SRS CA remain valid and there is reasonable assurance that SRS will meet the performance objectives delineated in DOE Order 435.1. Although CA-related work completed in FY17 provides indications that the conclusions of the CA are still valid, the 2010 SRS CA should be updated upon revision of the SRS PA(s) to incorporate PA changes and to address the number of proposed changes to inventories and sources and model improvements accumulated since the 2010 CA (see Appendix B).

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Appendix A. Status of Secondary Issue from LFRG Review of the 2010 SRS CA

The SRS CA Review Report (Carilli and Golian 2010) documented the results of the LFRG Review Team's review of the 2010 SRS CA (SRNL 2010). The Review Team created one Secondary Issue through the consolidation of eighteen observations that the team concluded, when evaluated collectively, could potentially impact the integration of the CA results based on the following Results Integration review criterion in the Low-Level Waste Disposal Facility Federal Review Group Manual (DOE 2008b):

3.3.10.1 The results of the analysis for the source terms and transport of radionuclides, dose analysis, available site monitoring data, supporting field investigations, sensitivity or uncertainty analysis, and options analysis are reasonable representations of the existing knowledge of the site, disposal facility, and contributing sources.

According to Carilli and Golian (2010) the secondary issue must be addressed as indicated below.

Secondary Issue: Eighteen observations, when viewed collectively, were deemed to have a potential impact on the integration of results presented in the CA and were consolidated under a single Secondary Issue to be resolved.

- Nine observations involved missing data or a clarification of the information provided in the CA to ensure the document is complete. (Observations 1, 3, 9, 11, 12, 18, 19, 20, and 23 from Carilli and Golian 2010).
- Nine observations were related to ensuring specific future work items listed in Chapter 11 of the SRS CA Review Report are included in the CA maintenance plan. (Observations 2, 4, 5, 6, 7, 13, 14, 16, and 21 from Carilli and Golian (2010)).

Recommendation: Revise the CA to include/clarify the information and revise the maintenance plan to include specific items identified in the above observations. Further, SR must report on the progress of this secondary issue in its annual summary to the LFRG until closed (Carilli and Golian 2010).

The following outlines the status of SRNS progress in addressing the Secondary Issue:

- The LFRG approved resolution for the nine Secondary Issue observations that involved missing data or a clarification of the information was to incorporate that data or information into the 2010 SRS CA prior to its approval (Marcinowski 2010). Therefore, these nine observations were closed with DOE approval of the 2010 SRS CA. Additionally, the LFRG Observation and Recommendation (Carilli and Golian 2010) and the resolution (SRNL 2010) to these nine observations were documented within Appendix A of the FY2012 SRS CA Annual Review (Phifer et al. 2013) and will not be reproduced herein because these nine observations have been officially closed.
- Table A-1 provides the LFRG Observation and Recommendation (Carilli and Golian 2010), the LFRG approved resolution (SRNL 2010), and the status for the nine secondary issue observations related to ensuring specific future work items are included in the CA maintenance plan. These nine observations are to be resolved by the performance of 17 specific work items.

Table A-1. Secondary Issue Observations Related to Future Work

LFRG CA Criteria [1]	LFRG Observation and Recommendation [2]	LFRG Approved Resolution [3]	Status	Documentation	Closure Method
3.3.2.2	Observation 2: The inventory of radionuclides other than Tritium (H-3) in GSA groundwater plumes has not been estimated and evaluated. Yet site monitoring data indicates that other radionuclides of concern [e.g., Strontium 90 (Sr-90), Technetium 99 (Tc-99), Cesium 137 (Cs-137), Iodine 129 (I-129)] are present in GSA groundwater and being released to Four Mile Branch. Recommendation: The maintenance program should address the neglected inventory of detected radionuclides in GSA groundwater plumes and their impacts assessed through CA screening or dose assessment, as appropriate.	Work Item 8 (SRNL 2010 Table 11-2): The inventory and inventory distribution for radionuclides within the F and H-Area Seepage Basins groundwater plumes, such as Strontium 90, Technetium 99, Cesium 137, Iodine 129, should be developed in addition to that for tritium. This inventory and its distribution should be evaluated within the SRS CA through screening or an actual dose assessment, as appropriate.	**Completed**	Groundwater sample analyses obtained from the wells that monitor groundwater contamination emanating from the F- and H-Area Seepage Basins were evaluated. Generalized groundwater plume maps for the radionuclides that occur in elevated concentrations (Am-241, Cm-243/244, Cs-137, I-129, Ni-63, Ra-226/228, Sr-90, Tc-99, U-233/234, U-235 and U-238) were generated and utilized to calculate both the inventory of radionuclides dissolved in groundwater, and their spatial distribution. (Hiergesell and Kubilius 2016).	FY2016 CA Annual Review [9]
	Observation 4: Limitations of the current CA inventory and its uncertainty are well recognized by SRS. Section 11.1 of the CA discusses CA related maintenance items, which include the maintenance of the SRS CA Inventory Database. Future work items of Table 11-2 also include items related to inventory updates and uncertainty assessments (Items 1, 3, 7, 13, 14, 15, 16, 17, and 21). Recommendation: If not already initiated, these items should be given top priority in the maintenance plan. *(CA Table 11-2 Items 1, 3, 7, 13, 14, 15, 16, 17, and 21 have been renumbered as Items 5, 1, 6, 3, 2, 9, 7, 4 and 10,*	Work Item 1 (SRNL 2010 Table 11-2): A re-evaluation of SRS facility and waste site lists will be conducted to identify any facilities or waste sites, which were overlooked in the 2009 CA inventory (i.e., SRS facilities and waste sites anticipated to have an "End-State" radionuclide inventory that were not included in the 2009 CA inventory). This item was specifically added to the 2010 SRNS PA/CA Maintenance Plan, and work on this item has been initiated.	**Completed**	• Other Industrial Facility Screening – Screened 523 facilities from CA (Phifer and Smith 2011). • Waste Site Screening – Conducted screening of 585 waste sites and identified five with inventories to include in the CA and 32 to evaluate once characterization completed (Hiergesell and Schiefer 2012, Hiergesell and Schiefer 2013). • Total Facilities Screening – Conducted screening of 1141 SRS facilities and identified 61 that require further consideration within the CA (Phifer and Swingle 2013). • Management and Operating (M&O) Contractor Overlooked Facilities and Waste Sites Evaluation and	**Closed** FY2015 CA Annual Review.[4]

LFRG CA Criteria [1]	LFRG Observation and Recommendation [2]	LFRG Approved Resolution [3]	Status	Documentation	Closure Method
	respectively, within the approved 2010 SRS CA (SRNL 2010))			Inventory Development – Conducted screening of 27 facilities and developed inventories for 16 facilities (Hiergesell and Phifer 2014b). • Liquid Waste Contractor Overlooked Facilities and Waste Sites Evaluation and Inventory Development - Conducted screening of 35 facilities and developed inventories for 17, none of the other facilities found to require an inventory (Watkins 2015)	
		Work Item 2 (SRNL 2010 Table 11-2): The CA inventory report (Hiergesell et al. 2008) should be revised with corrections made during CA development (e.g., see Tables A-17, A-46, A-61, A-73, A-74, A-75, and A-78 in Volume II) and other appropriate changes (Smith et al. 2009).	Not Started	None	See Note 1

LFRG CA Criteria [1]	LFRG Observation and Recommendation [2]	LFRG Approved Resolution [3]	Status	Documentation	Closure Method
		Work Item 3 (SRNL 2010 Table 11-2): FTF and SDF PAs are currently under review by the LFRG and/or Nuclear Regulatory Commission (NRC). Results of those reviews could impact the inventories or base case flux to the water table for both PAs. In fact, revision 1 of the FTF PA is under development to incorporate comments from the NRC, Environmental Protection Agency (EPA), and South Carolina Department of Health and Environmental Control (SCDHEC), and it was issued in FY 2010. The CA will consider any such future changes to these PAs.	**Completed** After the HTF, FTF and SDF PAs were prepared, work was conducted through the Liquid Waste PA Maintenance Program to update certain tank and disposal unit design features and inventories and to evaluate the associated fluxes to the water table.	Inventories for FTF Tanks 5 and 6 were updated in a Special Analysis (SA) (SRR 2013b); HTF inventories for Tanks 12 and 16 in were updated in SAs (SRR 2015a, and 2015d); all Saltstone Disposal Unit (SDU) inventories, some of which are the result of a new SDU design feature, were updated in an SA (SRR 2014); and Tank inventories for Tanks 9, 10, 11, 13, 14 and 15 and tank annulus inventories for Tanks 9, 10 and 14 were updated (Dixon and Layton 2016).	FY2016 CA Annual Review [9]
		Work Item 4 (SRNL 2010 Table 11-2): Methodologies to estimate the inventory uncertainty associated with significant radionuclide source locations should be developed and implemented. The effort should focus on the most significant sources first, with significance defined in terms of the maximum dose from Table 9-26 through Table 9-30. The initial effort will focus on the Lower Three Runs (LTR) Integrator Operable Unit (IOU) as outlined in Item 5 below. Work on other significant sources should follow, such as the FMB and SC/PB IOUs (Item 6 below) and the H-Canyon (Item 7 below). Additionally, defensible criteria to categorize whether sources require a distribution or not should be established.	Not Started	None	See Note 1

LFRG CA Criteria [1]	LFRG Observation and Recommendation [2]	LFRG Approved Resolution [3]	Status	Documentation	Closure Method
		Work Item 5 (SRNL 2010 Table 11-2): As summarized in Section 10.0, Cs-137 in the LTR IOU (i.e., streambed and floodplain) is the primary CA dose driver. Therefore, the uncertainty associated with the LTR IOU inventory (i.e., inventory distribution) will be developed along with a re-evaluation of the base case inventory. While Cs-137 is the most significant and abundant radionuclide associated with the LTR IOU, it is not the only radionuclide. Therefore, streambed inventories and distributions for other radionuclides will also be developed. This effort will initially focus on existing sampling and analysis data. However this effort may require additional streambed and floodplain sampling and analysis that may include horizontal and vertical distributions of the radionuclides and correlation with water concentrations including Cs-137. This item was specifically added to the 2010 SRNS PA/CA maintenance plan, and work on this item has been initiated.	**Completed**	Lower Three Runs (LTR) Inventory and Uncertainty – Developed inventory estimates and uncertainty for Cs-137, Co-60, Sr-90, Pu-239, Pu-238, Cm-244, Np-237, and Am-241 within LTR based upon existing sampling and analysis data (Hiergesell and Phifer 2012).	**Closed** FY2013 CA Annual Review.[5]
		Work Item 6 (SRNL 2010 Table 11-2): As summarized in Section 10.0, Cs-137 from the FMB and SC/PB IOUs (i.e., streambed and floodplain) is the primary dose driver for those respective Points of Assessment (POA). Therefore, the uncertainty associated with the FMB and SC/PB IOU inventories (i.e., inventory distribution) should be developed along with a re-evaluation of the base case inventories. While Cs-137 is the most significant and abundant radionuclide associated with the FMB and SC/PB IOUs, it is not the only radionuclide. Therefore, streambed inventories and	**Completed**	Fourmile Branch (FMB), Steel Creek (SC), and Pen Branch (PB) Inventory and Uncertainty – Developed inventory estimates and uncertainty for Cs-137 and seventeen other radionuclides within FMB, SC, and PB based upon existing sampling and analysis data (Hiergesell and Phifer 2014a).	**Closed** FY2014 CA Annual Review.[6]

LFRG CA Criteria [1]	LFRG Observation and Recommendation [2]	LFRG Approved Resolution [3]	Status	Documentation	Closure Method
		distributions for other significant radionuclides should also be developed. This effort should initially focus on existing sampling and analysis data. However, this effort may require additional streambed and floodplain sampling and analysis that may include horizontal and vertical distributions of the radionuclides and correlation with water concentrations including Cs-137.			
		Work Item 7 (SRNL 2010 Table 11-2): As summarized in Section 10.0, H-Canyon and its associated Np-237 inventory is the primary dose driver for the UTR POA. Therefore, the uncertainty associated with the H-Canyon inventory (i.e., inventory distribution) should be developed along with a re-evaluation of the base case inventory. Additionally, an investigation of H-Canyon Np-237 should be conducted to determine how and in what form the Np-237 is distributed, and whether or not the large end-state inventory calculated from the Safety Analysis Report (SAR) information is credible.	**Completed**	H-Canyon, HB-Line, and H-Canyon Outside Facilities Inventory and Uncertainty – Developed inventory estimates and uncertainty for Np-237 and other radionuclides within H-Canyon, HB-Line, and H-Canyon Outside Facilities based upon inventory data produced after bulk flushing facility vessels (Phifer and Dixon 2014).	**Closed** FY2014 CA Annual Review.[6]
		Work Item 9 (SRNL 2010 Table 11-2): A method has been developed to estimate the residual inventory for operational facilities and future facilities whose end states are slated to be in-situ disposal (ISD) or demolish to slab. The method consists of using facilities for which safety documentation, both during operation and following deactivation, exists. The ratio of inventories provides an estimate of the factor by which the operational inventory might be reduced prior to reaching the End State. At this time, the reduction factors are based upon two facilities, the F Canyon complex and the 321-M building. As more facilities are deinventoried	Not Started	None	See Note 1

LFRG CA Criteria [1]	LFRG Observation and Recommendation [2]	LFRG Approved Resolution [3]	Status	Documentation	Closure Method
		and either closed by in-situ disposal or demolish to slab, the inventory estimation ratio should be revised based on the new final data from those facilities.			
		Work Item 10 (SRNL 2010 Table 11-2): The CA radionuclide screening (Taylor et al. 2008) should be revised by using the CA base case model (transport plus dose modules) and also by considering key radionuclides associated with the SDF PA. Key radionuclides from the ELLWF and FTF PAs were considered during the CA radionuclide screening, but the SDF PA had not been performed at the time of the screening.	Not Started	None	See Note 1
3.3.2.3	Observation 5: The CA recognizes the limitations of the characterization data currently in the CA, as evidenced by the CA Maintenance Items listed and summarized in Section 11.1, as well as the future work items listed in Table 11-2. These include revisions of the properties and geochemical data packages, sorption behavior of key PA radionuclides, fate of Carbon 14 (C-14) and I-129 at the seeplines. Recommendation: Add the above items to the CA maintenance plan.	As outlined in Section 11.1 of the CA, material properties data package revision, geochemical data package revision, sorption behavior of key PA radionuclides, fate of C-14, and phenomenon of I-129 at the seepline were all incorporated within the 2009 SRNS PA/CA maintenance plan (SRNS 2009a) within Sections 5.1.1, 5.1.2, 5.1.9, 5.2.1, and 5.2.3 of that plan, respectively. Investigation of the geochemistry and environmental fate of C-14 in the SRS environment has been completed with issuance of the following two reports: • Carbon-14 Geochemistry at Savannah River Site (Roberts and Kaplan 2008), and • Systems Model of Carbon Dynamics in Four Mile Branch on the Savannah River Site (Hinton et al. 2009)	Initiated	Completed: • C-14 Geochemistry – C-14 K_ds developed for clayey sediment, sandy sediment, concrete, and reducing grout (Roberts and Kaplan 2008). • Carbon Dynamics in Fourmile Branch – Developed a C-14 specific bioaccumulation factor (Hinton et al. 2009). • I-129 Geochemistry in SRS Wetland Environment – R&D conducted to explain the accumulation of I-129 in high organic carbon environments (Schwehr et al. 2009, 2014; Kaplan et al. 2010, 2014a, 2014b; Powell et al. 2010; Xu et al. 2011a, 2011b, 2012, 2013; Zhang et al. 2011, 2013; Chang et al. 2014; Emerson et al. 2014; Li et al. 2014; Kaplan 2016a).	FY2016 PA Annual Review[7] for the Radionuclide data package and See Note 1.

LFRG CA Criteria [1]	LFRG Observation and Recommendation [2]	LFRG Approved Resolution [3]	Status	Documentation	Closure Method
				• Sorption Behavior of Key PA Radionuclides – Updated the Radionuclide Data Package for PA's and CA's (Kaplan 2016a and 2016b) Remaining Work: • The update of the material properties of the ELLWF disposal system will be addressed as item 3.14 under PA maintenance (Butcher 2016a), with expected completion of FY18.	
	Observation 6: Radionuclide streambed inventories are minimally described. Recommendation: Radionuclide inventory of the streambed sediments should be better quantified as described in Table 11-2, Item 7 and added to the CA maintenance plan. *(CA Table 11-2 Item 7 has been renumbered as Item 6 within the approved 2010 SRS CA (SRNL 2010))*	Work Item 6 (SRNL 2010 Table 11-2): See Observation 4 for Work Item 6 LFRG approved resolution.	**Completed**	See Observation 4 for Work Item 6 documentation.	**Closed** FY2014 CA Annual Review.[6]
	Observation 7: No discussion is provided in the CA regarding the streambed sediment scour, deposition, and transport characteristics. Recommendation: Item 8 of Table 11-2 should be expanded to include these streambed transport characteristics and added to the CA maintenance plan.	Work Item 13 (SRNL 2010 Table 11-2): The following field characterization associated with the UTR, FMB, SC/PB, and LTR streambeds should be performed: • Streambed vertical gradients, sediment types, and saturated hydraulic conductivities (groundwater-surface water interactions) • Streambed sediment scour, deposition, and transport	Not started	None	See Note 1

LFRG CA Criteria [1]	LFRG Observation and Recommendation [2]	LFRG Approved Resolution [3]	Status	Documentation	Closure Method
	(CA Table 11-2 Item 8 has been renumbered as Item 13 within the approved 2010 SRS CA (SRNL 2010))	• Streambed K_ds for the predominant radionuclides. This item along with Items 5, 6, 11, and 14 will help validate the CA streambed release modeling and further reduce the uncertainty associated with the release of radionuclides from streambed sediments.			
3.3.6.1	Observation 13: The SRS CA acknowledges the limitations of the current CA methodology: (1) the lack of SRS-wide watershed model and groundwater flow and transport model; (2) the need to reduce uncertainty of the abstractions from the existing groundwater flow and transport models into the GoldSim CA model, (3) the limitations of the version of the GoldSim code used in the CA, and (4) limited capability built into the current GoldSim CA model to perform probabilistic analysis. Development of an SRS-wide watershed model and a groundwater model are proposed in items 5 and 18 of Table 11-2. Recommendation: Add the above specified items to the CA maintenance plan. *(CA Table 11-2 Items 5 and 18 have been renumbered as Items 11 and 12, respectively, within the approved 2010 SRS CA (SRNL 2010))*	Work Item 11 (SRNL 2010 Table 11-2): A water balance study to provide estimates of natural stream flow for Upper Three Runs (UTR), Fourmile Branch (FMB), Steel Creek/Pen Branch (SC/PB), and Lower Three Runs (LTR) should be performed. Such a study could also potentially correlate real-time precipitation with stream flow variations and assist in better quantification of deep infiltration, runoff, evapotranspiration, and groundwater-surface water interactions. Years wherein reactor cooling water discharges, the largest anthropogenic contributor to on-site stream flow, occurred have not been included in the stream flow estimates used in the CA. However, other, much smaller and often intermittent industrial National Pollutant Discharge Elimination System (NPDES) discharges to streams have not been subtracted from the United States Geologic Survey (USGS) stream flow measurements used. The current SRS Land Use Plan states that the entire site will be owned, controlled, and maintained by the federal government, most likely by the DOE, in perpetuity, as established by Congress. Site boundaries will remain unchanged and the Site will be used for industrial purposes for future DOE and non-DOE missions. Based upon these SRS land-use plans, the current stream flow estimates provide	Not started	None	See Note 1

LFRG CA Criteria [1]	LFRG Observation and Recommendation [2]	LFRG Approved Resolution [3]	Status	Documentation	Closure Method
		a reasonable estimate into the future, but the determination of natural stream flows would provide a basis for a low-flow sensitivity other than the 7Q10 low-flow values used by the CA.			
		Work Item 12 (SRNL 2010 Table 11-2): An SRS regional groundwater model, encompassing the entire SRS, should be developed as outlined in Table 11-1. This regional groundwater model should be used to establish boundary controls for smaller SRS groundwater models with greater grid resolution and to evaluate the impacts of transient drought and wet conditions on contaminant transport. As part of the evaluation of the impacts of transient drought and wet conditions, the model should include low, average, and high potentiometric surfaces of the water table and underlying aquifers, so that distributions about the aquifer flow path parameters can be developed.	**Completed**	A position paper to request removal of the SRS RGFM from the LFRG Secondary Issue was prepared in FY15 and submitted to LFRG in 2015 (Phifer 2015). The position paper provides justification for the removal, including an assessment of the cost-benefit of an SRS RGFM from a dose significance basis.	See Note 2.
3.3.6.3	Observation 14: To reduce uncertainty, the GoldSim CA model should be improved, by better abstractions of groundwater flow paths, flow rates, and discharges to the streams. Water balance and SRS-wide groundwater models, (proposed in Table 11-2), and	Work Item 11 (SRNL 2010 Table 11-2): See Observation 13 for Work Item 11 LFRG approved resolution.	Not started	None	See Note 1
		Work Item 12 (SRNL 2010 Table 11-2): See Observation 13 for Work Item 12 LFRG approved resolution.	**Completed**	See Observation 13 for Work Item 12 documentation.	**Closed**

LFRG CA Criteria [1]	LFRG Observation and Recommendation [2]	LFRG Approved Resolution [3]	Status	Documentation	Closure Method
	studies of streambed sediment characterizations and groundwater-surface water interactions should be completed to provide the basis for these improvements. Recommendation: Add the above specified items to the CA maintenance plan.	Work Item 13 (SRNL 2010 Table 11-2): See Observation 7 for Work Item 13 LFRG approved resolution.	Not started	None	See Note 1
3.3.6.5	Observation 16: The CA acknowledges the uncertainty of the radionuclide releases from streambed sediments. Items 1, 5, 7, 8, and 9 (Chapter 11) in table 11-2 address work proposed to further investigate releases of radionuclides from streambed sediments. Observations of LFRG M Review Criterion 3.3.2.3 should be considered to address this uncertainty. Recommendation: Add the above specified items to the CA maintenance plan. *(CA Table 11-2 Items 1, 5, 7, 8, and 9 have been renumbered as Items 5, 11, 6, 13, and 14, respectively, within the approved 2010 SRS CA (SRNL 2010))*	Work Item 5 (SRNL 2010 Table 11-2): See Observation 4 for Work Item 5 LFRG approved resolution.	**Completed**	See Observation 4 for Work Item 5 documentation.	**Closed** FY2013 CA Annual Review.[5]
		Work Item 6 (SRNL 2010 Table 11-2): See Observation 4 for Work Item 6 LFRG approved resolution.	**Completed**	See Observation 4 for Work Item 6 documentation.	**Closed** FY2014 CA Annual Review.[6]
		Work Item 11 (SRNL 2010 Table 11-2): See Observation 13 for Work Item 11 LFRG approved resolution.	Not started	None	See Note 1
		Work Item 13 (SRNL 2010 Table 11-2): See Observation 7 for Work Item 13 LFRG approved resolution.	Not started	None	See Note 1
		Work Item 14 (SRNL 2010 Table 11-2): The distribution of uranium within Tims Branch between that dissolved in the water, that bound to the streambed sediment, and that bound to particulates in transit should be investigated. The implications of this distribution on uranium mobilization and the rate of uranium transport to the CA point of assessment (mouth of UTR) should be determined. Finally the resulting dose implications of such uranium distributions, mobilization, and transport should be determined. Such an effort may require additional streambed sampling and analysis.	Not started	None	See Note1

LFRG CA Criteria [1]	LFRG Observation and Recommendation [2]	LFRG Approved Resolution [3]	Status	Documentation	Closure Method
3.3.8.1	Observation 21: There is agreement with previous comments (Appendix G) identifying the incompleteness of the sensitivity and uncertainty analysis. In particular, the omission of inventory uncertainty in the uncertainty analysis needs to be remedied. However, because all dose results are well below levels of concern, qualitative arguments used to address these limitations provide enough confidence to accept the primary conclusions of the sensitivity and uncertainty analysis. Furthermore, the future CA maintenance activities (particularly items 17, 27, and 28 in Table 11-2) identify these limitations and the need to address them. Given improved input data distributions and an improved GoldSim model, additive and multiplicative effects of factors affecting the CA results could be better assessed through a global sensitivity analysis. This effort would also better streamline future maintenance task priorities. *(CA Table 11-2 Items 2, 17, 27, and 28 have been renumbered as Items 15, 4, 16, and 17, respectively, within the approved 2010 SRS CA (SRNL 2010))*	Work Item 4 (SRNL 2010 Table 11-2): See Observation 4 for Work Item 4 LFRG approved resolution.	Not started	None	See Note 1
		Work Item 15 (SRNL 2010 Table 11-2): GoldSim™ has a Distributed Processing (DP) capability that can be used when performing probabilistic calculations. Using this feature, individual realizations can be run on as many processors as the master GoldSim™ simulation can be linked to. The basic GoldSim™ software is limited to using four processors one of which is reserved for the master simulation that farms out realizations to the connected processors. This capability was utilized in performing the CA uncertainty calculations which reduced the simulation run time by a factor of three. However, by adding the GoldSim™ DP module, available from GoldSim™ Technology Group at a nominal cost, a probabilistic GoldSim™ simulation can be connected to as many processors as are available. This offers the possibility of dramatically decreasing probabilistic simulation run times and increasing the capability of performing uncertainty calculations including more sources with more realizations. Utilizing this approach is currently limited by our inability to access other computers through the SRS network primarily from computer security concerns. If a large cluster of Windows machines could be assembled off the SRS network, all of the processors could be accessed by GoldSim™ for probabilistic calculations. This item was specifically added to the 2010 SRNS PA/CA maintenance plan, and work on this item has been initiated.	**Completed**	Procured 36 Processor Windows Cluster and Goldsim DP-Plus Module to reduce probabilistic simulation run times and to increase the number of sources included and number of realizations run (Smith and Phifer 2011).	**Closed** FY2012 CA Annual Review.[8]

LFRG CA Criteria [1]	LFRG Observation and Recommendation [2]	LFRG Approved Resolution [3]	Status	Documentation	Closure Method
		Work Item 16 (SRNL 2010 Table 11-2): A systematic sensitivity analysis should be performed to identify the model parameters that have the greatest impact on CA results. This analysis should investigate the additive and multiplicative effects of parameters on the CA results. This analysis should investigate parameters in the transport model and in the dose model separately. This systematic sensitivity analysis along with a more structured uncertainty analysis (Item 17) will assist in future work prioritization. Expertise in the SRNL statistical group should be utilized to help structure this investigation and interpret the results.	Initiated	Enhanced Sensitivity and Uncertainty Analysis – The 2010 SRS CA uncertainty analysis considered 17 sources over 2,000 years using 400 realizations. Using the 36 Processor Windows Cluster and Goldsim DP-Plus Module, the uncertainty was expanded to 39 sources over 10,000 years using 1,000 realizations (Smith and Phifer 2011).	Further work on this item deferred until work on the next CA revision is initiated per DOE approval of the FY2012 CA Annual Review.[8]
		Work Item 17 (SRNL 2010 Table 11-2): A more structured uncertainty analysis should be performed to identify both those stochastic variables that have the greatest impact on model results and stochastic variables that have an insignificant impact on model results and can be eliminated from the uncertainty analysis. In particular inventory uncertainty distributions developed from Items 4, 5, 6, and 7 should be included in the uncertainty analysis. This structured uncertainty analysis along with a more systematic sensitivity analysis (Item 16) will assist in future work prioritization. Expertise in the SRNL statistical group should be utilized to help structure this investigation and interpret the results.	Initiated	Enhanced Sensitivity and Uncertainty Analysis – The 2010 SRS CA uncertainty analysis considered 17 sources over 2,000 years using 400 realizations. Using the 36 Processor Windows Cluster and Goldsim DP-Plus Module, the uncertainty was expanded to 39 sources over 10,000 years using 1,000 realizations (Smith and Phifer 2011).	Further work on this item deferred until work on the next CA revision is initiated per DOE approval of the FY2012 CA Annual Review.[8]

1 DOE (2008)
2 Carilli and Golian (2010)
3 SRNL (2010) Appendix H and Table 11-2

[4] Hiergesell et al. (2016)
[5] Phifer et al. (2014)
[6] Phifer et al. (2015)
[7] Crapse et al. (2017)
[8] Phifer et al. (2013)
[9] Halverson and Stagich (2017)

Notes for Table A-1:

1. To be closed upon future DOE approval of the respective CA (or PA) Annual Review within which completion of the item has been documented.
2. The position paper is being used to request that the LFRG remove the requirement for an SRS RGFM from the LFRG Secondary Issue. Closure of this item is contingent on this decision.

Appendix B. List of Proposed Activities/Discoveries/New Information/Changes to the 2010 SRS CA through FY2017

The following is a list of proposed activities/discoveries/new information/changes that have occurred since the 2010 SRS CA that are pertinent to the modeled dose to the public. This list may not be comprehensive because it may not have identified all SRS facility-specific proposed activities/discoveries/new information/changes to the 2010 SRS CA. These changes and their anticipated impact on the 2010 SRS CA have been assessed using engineering judgement rather than explicit calculations in this and previous Annual Reports. Annual Reports and the sections documenting the changes are provided in parentheses after each item.

B.1. Revised inventories for existing 2010 SRS CA sources (the revised inventory data can be run in the SRS CA GoldSim model without developing any other new input data):

- A revised inventory for the 235-F facility was developed as documented within Phifer and Swingle (2013) Table I-1. *(FY2013 SRS CA Annual Review (Phifer et al. 2014) Section 3.1).*
- A revised inventory for the H-Area Sand Filter System (294-H, 294-1H, and 291-H) was developed as documented within Phifer and Swingle (2013) Table I-2 *(FY2013 SRS CA Annual Review (Phifer et al. 2014) Section 3.1).*
- A revised inventory and distribution for LTR were developed as documented within Hiergesell and Phifer (2012) Table 3-4 with a uniform distribution of ±10% about the nominal values *(FY2013 SRS CA Annual Review (Phifer et al. 2014) Section 3.1.).*
- Revised inventories and distributions for FMB, PB, and SC were developed as documented within Hiergesell and Phifer (2014a) Table 3-4 (nominal values) and Table 3-8 (upper and lower bounds) *(FY2014 SRS CA Annual Review (Phifer et al. 2015) Section 3.1).*
- Revised inventories and distributions for H-Canyon and HB-line were developed as documented within Phifer and Dixon (2014) Table 2-12 and Table 2-13, respectively *(FY2014 SRS CA Annual Review (Phifer et al. 2015) Section 3.1).*
- Revisions to the SDF inventory and flux to the water table were made as shown below. The original SDF inventory used within the 2010 SRS CA was based upon the inventory provided within Revision B of the SDF PA (LWO 2009). Additionally, the 2010 SRS CA used the flux to the water table from the base case SDF PA modeling that had been performed as a model input for Disposal Unit 2 and all future disposal cells.
  - Revision 0 of the SDF PA (SRR 2009) included updated inventories (Tables 3.3-1, 3.3-3, and 3.3-5) and an updated base case flux to the water table for Disposal Unit 2 and all future disposal cells *(FY2013 SRS CA Annual Review (Phifer et al. 2014) Section 3.6.2).*
  - A SDF Special Analysis (SRR 2013a) was completed to incorporate Tc-99 release using new solubility limits and incorporate cementitious material degradation rates calculated with the Cementitious Barriers Partnership Toolbox, resulting in new flux to the water table estimates *(FY2013 SRS CA Annual Review (Phifer et al. 2014) Section 3.6.2).*
  - A SDF Special Analysis (SRR 2014) was prepared, submitted and approved in FY2014 for a new larger disposal unit design that will result in a new footprint and new flux to the water table estimates *(FY2014 SRS CA Annual Review (Phifer et al. 2015) Section 3.6.2).*
- Revisions to the FTF inventory were made as shown below. The original FTF inventory used within the 2010 SRS CA was based upon the inventory provided within Revision 0 of the FTF PA (WSRC 2008b).
  - Revision 1 of the FTF PA (SRR 2010) included updated inventories (Tables 3.3-2, 3.3-13, 3.3-16, and 3.3-20) *(FY2013 SRS CA Annual Review (Phifer et al. 2014) Section 3.6.2).*

- Revision 0 of the Tanks 18 and 19 Special Analysis (SRR 2012b) contained updated Tank 18 and 19 closure inventories *(FY2013 SRS CA Annual Review (Phifer et al. 2014) Section 3.6.2).*
- Revision 1 of the Tanks 5 and 6 Special Analysis (SRR 2013b) contained updated Tank 5 and 6 closure inventories (*FY2013 SRS CA Annual Review (Phifer et al. 2014) Section 3.6.2).*

- Revisions to the HTF inventory have been made as shown below. The original HTF inventory used within the 2010 SRS CA was based upon the HTF PA while it was under development.
  - Revision 1 of the HTF PA, dated November 2012 (SRR 2012a), which includes updated inventories (Tables 3.4-9, 3.4-11, 3.4-13, and 3.4-15), was issued in November 2012 (*FY2013 SRS CA Annual Review (Phifer et al. 2014) Section 3.6.2).*
  - Tank 12 Special Analysis (SRR 2015b) contained an updated estimate of the residual radionuclide inventory expected to remain in H-Area Tank 12 upon closure (SRR 2015a) *(FY2015 SRS CA Annual Review (Hiergesell et al. 2016) Section 3.1).*
  - Tank 16 Special Analysis (SRR 2015d) contained an updated estimate of the residual radionuclide inventory expected to remain in H-Area Tank 16 upon closure (SRR 2015c) *(FY2015 SRS CA Annual Review (Hiergesell et al. 2016) Section 3.1).*
  - Updates to the radionuclide and chemical inventories in Tanks 9, 10, 11, 13, 14 and 15 assigned primary tank inventory values for the HTF Type I and II tanks (Tanks 9, 10, 11, 13, 14 and 15) and annulus inventory values for Tanks 9, 10 and 14 *(FY2016 CA Annual Review (Halverson and Stagich 2017) Section 3.6.2).*
- The actual disposed inventory for some radionuclides disposed in the ELLWF exceeded the estimated radionuclide inventory analyzed within the 2010 SRS CA (WSRC 2008a, SRNL 2010). A new end-state inventory needs to be developed based upon the actual disposal history to date and more up-to-date waste forecasts *(FY2013 SRS CA Annual Review (Phifer et al. 2014) Section 3.6.2).*
- Inventories for C, K, and L-Reactors were assigned the same values used for the P-Reactor Building, because the inventories for these reactors had not been developed at the time the 2010 SRS CA was prepared. Subsequent to approval of the 2010 SRS CA the inventories associated with the C, K, and L reactor vessels and surrounding shielding were developed (Vinson and Webb 2010) *(FY2014 SRS CA Annual Review (Phifer et al. 2015) Section 3.6.2).*
- The inventory for the C-Area Disassembly Basin was assigned the same values used for the P-Area Disassembly Basin, because the inventory for the C-Area Disassembly Basin had not been developed at the time the 2010 SRS CA was prepared. Subsequent to approval of the 2010 SRS CA the inventory associated with the C-Area Disassembly Basin were developed (SRNS 2013a) *(FY2014 SRS CA Annual Review (Phifer et al. 2015) Section 3.6.2).*
- Transuranic (TRU) Pad #1 was cleared of all waste and the pad was declared clean with no contamination; therefore, this facility can be removed as a source from the SRS CA (Sink 2014) *(FY2014 SRS CA Annual Review (Phifer et al. 2015) Section 3.6.2).*
- Radionuclide inventories for the F- and H-Area seepage basin groundwater plumes were quantified in Hiergesell and Kubilius (2016). Radionuclides that occur in elevated concentrations include Am-241, Cm-243/244, Cs-137, I-129, Ni-63, Ra-226/228, Sr-90, Tc-99, U-233/234, U-235 and U-238. Results were used to calculate the volume of contaminated groundwater and the representative concentration and range of uncertainty of each radionuclide associated with different plume concentration zones (*FY2016 SRS CA Annual Review (Halverson and Stagich 2017) Section 3.6.2).*
- Projected radionuclide inventories for 643-26E Naval Reactor Component Disposal Area at closure were revised (Sink 2016a). In 2016, Bettis and KAPL provided new radionuclide inventories of planned components to be sent for disposal to 643-26E between FY2015 and FY2025. The updated forecast information was used along with radionuclide inventories disposed to date to generate a forecast for both FY2025 and FY2040 (*FY2017 SRS CA Annual Review (this report) Section* 3.6.2).
- ELLWF radionuclide inventories were projected out to the closure of each active and future ELLWF disposal unit, using a combination of current historical data and process knowledge (Sink 2016b). The expected closure date used for the first 100 acres of the ELLWF was FY2040, compared to the FY2025

date used in the PA. These inventories should be used in development of the new ELLWF PA (*FY2017 SRS CA Annual Review (this report) Section* 3.6.2).

B.2. New sources not included in the 2010 SRS CA (the aquifer flow path data will need to be developed for these sources to run them in the SRS CA GoldSim model):

- Changing the D&D option to ISD is being considered. While the 607-33H, 607-34H, 607-35H, and 607-36H Solvent Tanks have been screened out based on regulatory commitments within Phifer and Swingle (2013), consideration is being given to changing the D&D option to ISD, which would involve grouting the tanks in place with the current inventory left in place. Phifer and Swingle (2013) Table I-3 provides the inventory associated with the ISD option of these tanks. *(FY2013 SRS CA Annual Review (Phifer et al. 2014) Section 3.1).*
- New inventories provided in Phifer and Swingle (2013) included the following facilities and waste sites, which were not previously considered within the 2010 SRS CA *(FY2013 SRS CA Annual Review (Phifer et al. 2014) Section 3.1)*:
  - Building 294-2F Sand Filter (associated with 235-F) (Table I-6), and
  - 242-18H Concentrate Transfer System (Table I-7).
- Inventory and distribution the for H-Canyon Outside Facilities (211-H) were provided in Phifer and Dixon (2014), which were not previously considered separately from the H-Canyon inventory within the 2010 SRS CA (*FY2014 SRS CA Annual Review (Phifer et al. 2015) Section 3.1*).
- New inventories provided in Hiergesell and Phifer (2014b) included the following M&O Contractor (SRNS) facilities and waste sites, which were not previously considered within the 2010 SRS CA (*FY2014 SRS CA Annual Review (Phifer et al. 2015) Section 3.1*):
  - 794-A Sand Filter and Supply Tunnel and 791-A Pollution Control Stack - representing two facilities (Table A-1),
  - Spill on 12/01/71 of 1000 Gal of Rad Water from 773-A (Unit Index 387) (Table A-2),
  - Mixed Waste Management Facility Groundwater (Unit 103) (Table A-3),
  - 643-7E Lysimeters (Not the active E-Area Lysimeter network) (Table A-4),
  - E-Area Solvent Storage Tanks (650-23E through 650-30E and 650-32E, which are also referred to as tanks 23-30 and 32) - represent 9 facilities (Table A-5),
  - 294-2F Sand Filter for 235-F (Table A-6), and
  - R-Area Bingham Pump Outage Pits (643-8G, 643-9G and 643-10G) (Unit 113, 114 and 115) (Table A-7).
- TRU Pad #16 residual isotopes were determined in Sink (2017). TRU Pad #16 was cleared of all waste, but the slab will not be left clean. This pad had a spill several years ago. A radiological characterization (G-CLE-E-00331, Burns 2015) was performed and verified. The composite contamination isotopic characterization is presented in Table 8 of this calculation. The pad has been entombed with a concrete slab over the top of the existing pad *(FY2015 SRS CA Annual Review (Hiergesell et al. 2016) Section 3.6.2).*
- Radionuclide inventories were developed for 17 facilities associated with Effluent Treatment Facility as part of the SRS CA source completeness evaluation. A total of 35 facilities were evaluated (Watkins 2015) by the Liquid Waste Contractor (SRR). The remaining 18 facilities will not require an inventory to be developed for incorporation into the SRS CA *(FY2015 SRS CA Annual Review (Hiergesell et al. 2016) Section 3.1).*

B.3. Potential new sources that require screening and/or inventory development:

- 32 waste sites for which characterization work is scheduled in the future are identified in Hiergesell and Schiefer (2013) Appendix D. It is not known whether they will contain radionuclides requiring inclusion in the CA at their end state (*FY2013 SRS CA Annual Review (Phifer et al. 2014) Section 3.1).*

- TRU Pad 2 is scheduled to undergo characterization work in the future; at this time characterization is expected to occur at the time of closure.
- Contamination was released to Outfall Z-01 in early 2011. The SDU 4 gutter system was tied into the storm water collection system leading to Z-Area Sedimentation Basin number 4. Concurrent with the initiation of rainfall diversion to the basin in 2011, Tc-99 and Cs-137 concentrations in the basin water began to increase. In 2012, a significant rainfall event resulted in Sedimentation Basin 4 overflowing to Outfall Z-01. A characterization plan was put in place to evaluate the extent of the release. Sampling of the soil and water within Sedimentation Basin 4, at Outfall Z-01, and within McQueens Branch was performed in 2012. Those results were reported in Eddy (2012).
- A 1997 release of radioactive contamination from Vault 4 Cell G to the ground surface nearby has been seen in the groundwater at well ZBG 2 (Layton 2016). Based on the 2014 data from well ZBG 2, additional characterization for nonvolatile beta, Tc-99 and nitrates in the groundwater in Z-Area was initiated in 2014, implemented in July 2015 and reported in FY2016 (SRNS 2016c) *(FY2016 SRS CA Annual Review (Halverson and Stagich 2017) Section 3.6.2)*.

B.4. Revised input data from that utilized within the 2010 SRS CA:

- A new ELLWF PA-SRS CA geochemical data package was issued. Kaplan (2007) was the site-specific geochemical data package that was the primary source for the K_ds utilized within the 2010 SRS CA. The document was updated in Kaplan (2010). Another updated PA-CA Geochemical data package was issued (Kaplan 2016a), which provided updated information from more than 70 new studies for four general environments of interest to SRS PAs and CAs: sandy sediment, clayey sediment, oxidizing cementitious, and reducing cementitious environments. Data included best estimates and their uncertainties for K_d values, apparent solubility values, and cementitious leachate impact factors (*FY2016 SRS CA Annual Review (Halverson and Stagich 2017) Section 3.6.3).*
- An updated radionuclide screening list was prepared. Because a wider set of elements are needed in the radionuclide screening process, a supplemental report was prepared containing geochemical values for an additional 33 elements (Kaplan 2016b). The values for this wider set of elements were based on assumed speciation and chemical analogs to elements for which site-specific experimental data are available (*FY2016 SRS CA Annual Review (Halverson and Stagich 2017) Section 3.6.3).*
- A new ELLWF PA-SRS CA radionuclide data package was issued (Smith et al. 2015) which updated dose calculation methodology as well as data inputs (i.e., dose coefficients, radionuclide decay data, and transfer factors as described in the following three bullets) *(FY2015 SRS CA Annual Review (Hiergesell et al. 2016) Section 3.6.3).*
  - The ingestion and inhalation dose coefficients utilized within the 2010 SRS CA were obtained from the International Commission on Radiological Protection (ICRP) publication 72 (ICRP 1995). Subsequently DOE published a new Derived Concentration Technical Standard, DOE-STD-1196-2011 (DOE 2011a), which provided dose coefficients for use within PAs and CAs (*FY2013 SRS CA Annual Review (Phifer et al. 2014) Section 3.6.3).*
  - The radionuclide decay data utilized within the 2010 SRS CA were obtained from the 2005 Nuclear Wallet Cards (Tuli 2005). Subsequently DOE published a new Derived Concentration Technical Standard, DOE-STD-1196-2011 (DOE 2011a), which was based on radionuclide decay data from the ICRP publication 107 (ICRP 2008). For consistency with use of the DOE 2011a dose coefficients, the underlying radionuclide decay from ICRP 2008 will be utilized within the CA in the future (*FY2013 SRS CA Annual Review (Phifer et al. 2014) Section 3.6.3).*
  - The transfer factors utilized within the 2010 SRS CA were obtained from Lee and Coffield (2008). Subsequently new transfer factors were published and utilized in other SRS PAs (Taylor et al. 2008; IAEA 2010; Jannik et al. 2010; and SRR 2012a) (*FY2014 SRS CA Annual Review (Phifer et al. 2015) Section 3.6.3*).
- A 2013 Unreviewed Disposal Question Evaluation (UDQE) (Flach 2013) and subsequent update (Flach et al. 2014) considered numerous changes in the PA baseline since the 2008 ELLWF PA including

revised input parameters, revised facility design, evolving facility operations, and changed design, operation and physical phenomena assumptions. Several of these changes were identified elsewhere in Appendix B (e.g., updated K_d values). However, these two UDQE's should be reviewed for potential impacts to the CA baseline (*FY2015 SRS CA Annual Review (Phifer et al. 2015) Section 3.6.3).*

- New atmospheric-pathway dose-release factors were calculated for potential atmospheric releases of C-14 and H-3 from the ELLWF (Dixon and Moore 2016). These factors represent the maximum dose a receptor would receive if standing at either 100 m or 11,410 m (Site Boundary) from the edge of an ELLWF disposal unit, which are the points of assessment for DOE Order 435.1 PAs. These dose-release factors can be refined to take into consideration disposal unit size, proximity and timing of peak dose to establish less conservative radionuclide specific disposal limits *(FY2016 SRS CA Annual Review (Halverson and Stagich 2017) Section 3.6.3)*.
- A new GoldSim Model to calculate doses and limits to a member of the public and corresponding waste disposal limits has been developed (Smith 2016) for use in the next E-Area PA and SRS CA. The model was developed using the latest radionuclide and geochemical data (Smith et al. 2015 and Kaplan 2016a, respectively). Calculations of water pathway doses, groundwater protection concentrations, and intruder doses, along with the resulting radionuclide screening and disposal limits are provided in one software package *(FY2016 SRS CA Annual Review (Halverson and Stagich 2017) Section 3.6.4)*.
- Parameters for SRS Dosimetry Models were updated based on detailed surveys of local land-use and water-use (characteristics of meat, milk, and vegetable production/consumption; river recreational activities; and other human usage parameters). The preferred elemental bioaccumulation factors and transfer factors were also documented (Jannik and Stagich 2017) *(FY2017 SRS CA Annual Review (this report) Section 3.6.3).*

B.5. Other updated considerations since the 2010 SRS CA:

- Revisions to the SRS site planning documents have been issued, opening the possibility of public or private ownership of selected tracts of land in the future, but to-date no actual changes in land use have been proposed or made (*FY2015 SRS CA Annual Review (Hiergesell et al. 2016) Section 3.6.1*):
  - The SRS Land Use Plan (SRNS 2014b) states the following: "SRS will maintain its current physical boundary under the ownership of the federal government in perpetuity, except where lease or transfer to the private or public entities in accordance with applicable laws and regulations aligns with DOE objectives and enhances economic development in the surrounding region."
  - The new SRS Ten Year Site Plan (SRNS 2015b) states the following: "The Site anticipates future interest by both governmental and private entities in new uses of its land and is studying which, if any, tracts of land may be excess to our EM missions in support of new headquarters' initiative to eliminate under-utilized federal property."
  - The Environmental Management Program Management Plan (DOE 2017b) states the following: "The future use for the SRS is non-residential and will be maintained as such using institutional controls."
- A new ELLWF conceptual closure cap design has been produced to address as-built trench unit layouts and implement best-practice multi-layer closure cap design (SRNS 2016c). The new features include a reorientation of the cap producing longer slope lengths and incorporation of a high-density polyethylene geomembrane above the geosynthetic clay liner.
- A UDQE was approved for placing ET 3 in the footprint designated for ST 12 and to operate it using ST 12 disposal limits. The evaluation concluded that the proposed operations result in an acceptably small risk of exceeding a SOF of 1.0 (Hamm et al. 2013) *(FY2017 SRS CA Annual Review (this report) Section 3.6.3).*
- A change in the layout of SDUs 6, 7, 8, and 9 was assessed by SA (SRR 2016, SRR 2018a). The SA also updated the model to incorporate observed field conditions and lessons learned, and to provide additional design margins. Results indicated a reduction in peak dose *(FY2017 SRS CA Annual Review (this report) Section 3.6.3).*

- Saltstone Disposal Unit 6 as-built conditions were evaluated in a UWMQE against the assumptions used in 2009 SDF PA (SRR 2009), the CA (SRNL 2010), and other documents.
- The 2004 GSA/PORFLOW groundwater flow was updated and recalibrated using the PEST optimization code. The model, "GSA2016," uses field data current through at least 2015. The update addressed issues raised by the LFRG in a 2008 review of the E-Area Performance Assessment, and by the Nuclear Regulatory Commission in its reviews of tank closure and Saltstone Disposal Facility Performance Assessments. The GSA2016 model exhibits good agreement with well water level, stream baseflow and seepline data (Flach et al. 2017).
- Disposal Authorization Statement and Tank Closure Document was issued by DOE. This Standard provides a consistent approach for Federal and contractor personnel responsible for developing and/or reviewing documents that support the issuance of a Disposal Authorization Statement and Tier 1 Closure Plan authorizing radioactive waste disposal. The Standard will help assure that the technical basis for radioactive waste management disposal authorization is complete and sufficient to protect the public and the environment. The technical basis includes site characterization, facility design, laboratory and field studies, mathematical modeling, technical analyses, and commitments to continuous improvement to demonstrate that a facility should be authorized to dispose of LLW (DOE 2017a).

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