DEFENSE NUCLEAR FACILITIES SAFETY BOARD
Washington, DC 20004-2901

October 20, 2015

Dr. Monica Regalbuto
Assistant Secretary for Environmental Management
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-1000

Dear Dr. Regalbuto:

During a recent review at the Savannah River Site, members of the Defense Nuclear Facilities Safety Board's (Board) staff identified several areas for improvement within the L-Area safety basis. The enclosed report details these areas and is provided for your information. The L-Area storage basin is a Hazard Category 2 nuclear facility with a long-term safety mission that needs an accurate, high-quality safety basis document. During the review and in post-review discussions, Department of Energy (DOE) staff members agreed that our suggestions for improvement would strengthen the safety basis.

The Board's staff noted areas for improvement that included programs credited for risk reduction without identification of Specific Administrative Controls, inappropriate initial conditions and assumptions used in the unmitigated accident analysis, legacy assumptions in the safety basis, and deficient implementation of compensatory measures specified in a waiver associated with a safety system. The Board's staff will continue to monitor DOE's efforts to improve safety basis development and implementation for L-Area and other Savannah River Site facilities.

Sincerely,

Joyce L. Connery
Chairman

Enclosure

c: Mr. Jack Craig
Mr. Joe Olencz

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

July 28, 2015

MEMORANDUM FOR: S. A. Stokes, Technical Director

COPIES: Board Members

FROM: C. Beaty

SUBJECT: Savannah River Site L-Area Safety Basis

Members of the Defense Nuclear Facilities Safety Board's (Board) staff conducted a review of the L-Area Documented Safety Analysis (DSA) and Technical Safety Requirements (TSR) during the week of June 8, 2015. The staff review team held meetings and interviews with Department of Energy Savannah River Operations Office (DOE-SR) and Savannah River Nuclear Solutions (SRNS) representatives, and then conducted a walkdown of the L-Area Facility. The team noted several areas for improvement within the L-Area safety basis, including programs credited for risk reduction without identification of Specific Administrative Controls (SACs), inappropriate initial conditions and assumptions used in the unmitigated accident analysis, legacy assumptions in the DSA, and deficient implementation of compensatory measures specified in a waiver associated with a safety system.

Background. The L-Area Facility was initially constructed as a nuclear reactor for nuclear material production in the 1950s. In the 1990s the mission was changed to nuclear material storage, mainly spent nuclear fuel in the water basin and moderator in tanks and drums. The current mission for this facility is to provide for the safe receipt, storage, handling, and shipping of spent nuclear fuel, other special nuclear materials, and moderator.

The L-Area Basis for Interim Operation (BIO) was converted to a DSA in 2002. During this conversion, the inputs and assumptions, hazard analysis, accident analysis, and safety strategy were copied from the BIO. The L-Area DSA and primary safety controls have had minimal revision after the BIO-to-DSA conversion. Since then, SRNS completed safety basis annual updates and changes as required to support new missions (mainly receipt of new fuel types). DOE-SR Safety Evaluation Reports over this time only reviewed DSA changes. DOE-SR has not recently reviewed the full scope of the L-Area safety basis. There are no DOE requirements for DOE-SR to periodically complete a full review of the safety basis.

Safety Basis Review. The review team evaluated the DSA and TSR for alignment with the requirements of DOE Standard (STD) 3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, and identified the following areas for improvement.

Administrative Controls—The L-Area DSA credits several programs to reduce the risk (frequency or consequence) of hazard scenarios without identification of SACs, which is inconsistent with DOE-STD-3009-94 and DOE-STD-1186, *Specific Administrative Controls*. DOE-STD-3009-94 specifies that "programmatic administrative controls should not be used to provide preventive or mitigative functions for accident scenarios identified in the safety basis where the safety function has importance similar to, or the same as the safety function of safety-class or safety-significant SSCs [structures, systems, and components]. The classification of SAC was specifically created for this safety function." DOE-STD-1186 states that "Programmatic ACs [Administrative Controls] should not be used to provide specific or mitigative functions for accident scenarios identified in DSAs where the safety function has importance similar to, or the same as, the safety function of safety class or safety significant SSCs. The classification of SAC, as defined in this Standard, was specifically created for this safety function." Appendix A lists specific examples of administrative programs identified in the L-Area DSA and credited in the hazard or accident analysis.

Unmitigated Analysis—The L-Area DSA contains unmitigated hazard scenarios that are dependent on initial conditions and other assumptions. These initial conditions and assumptions are essentially safety controls, but are not protected by the DSA and TSR even though failure would impact hazard scenario development. DOE-STD-3009-94 identifies that "[u]nmitigated release is meant to consider material quantity, form, location, dispersibility, and interaction with available energy sources, but not to consider safety features (e.g., ventilation systems, fire suppression, etc.) which would prevent or mitigate a release."

- *Initial Conditions*. Through review of the DSA Hazard Evaluation, the staff team identified events with initial conditions that are inappropriate and/or not protected by controls other than administrative programs.

    - The discussion for moderator event MOD-1 states, "There are essentially no combustibles in the room and there is no need to carry more than incidental combustibles (<50 lbs) into the room …. With effective implementation of the 105-L Fire Protection Program, there is insufficient available energy for a fire in this area to cause a breach of any of the storage tanks. Therefore, an initial assumption was made that no fire-induced release of moderator would occur from these tanks during a credible fire." The unmitigated analysis indicates that this event has negligible consequences, but relies upon the Fire Protection Program. A disassembly basin event, DB-2, provides another example of dependence on a Combustible Control Program. The discussion for DB-2 states, "There is no material currently stored around the cask staging area that would produce a pool fire large enough and long enough to directly impinge on the cask itself." These initial conditions are inappropriate for the unmitigated analyses. DOE-STD-3009-94 specifically references use of a SAC for combustible loading, "[s]pecific administrative controls, when designated, provide specific actions related to individual accident scenarios, such as limits on hazardous material inventory and combustible loading."

    - The material-at-risk is used as an initial condition throughout the hazard and accident analysis; however, no control is identified or implemented to protect this initial condition. DOE-STD-3009-94 states, "As appropriate to the hazard, the

safety basis may identify specific controls (e.g., hazardous material inventory limits) that are required for safety. These controls should be considered for designation as a SAC as discussed in this Standard and DOE-STD-1186."

- The DSA discusses a number of process-related initiators that are used to support the frequency analysis for criticality safety events. "The number of operations performed on a yearly basis is intended to be bounding and is as follows:

  - The number of 70-Ton Casks of Research Reactor assemblies unloaded at the MSF [Material Storage Facility] per year is two.
  - The number of 70-Ton Casks of Research Reactor bundles unloaded at the MSF per year is ten.
  - The number of HFIR [High Flux Isotope Reactor] casks unloaded per year is 24…."

  No controls are identified to protect these initial conditions.

- *Assumptions*. Through review of the hazard analysis assumptions, the team identified assumptions that are protected only by administrative programs.

  - Low Level Waste Inventory: "The Low Level Waste (LLW) inventory is based on maintaining the radionuclides below 20% of the adjusted Hazard Category 2 thresholds using the LLW inventory isotopic distributions presented in S-CLC-L-00026, as well as the criticality limits established in N-NCS-H-00171."

  - Water Chemistry Control Program: "The Basin Water Chemistry Control Program is assumed to limit the radionuclide content of the basin water. Therefore, it also limits the potential consequences of a basin water release."

  - Hazardous Material Inventory Control Program: "Hazardous chemicals as defined in 29 CFR 1910.119 are stored within the LAF [L Area Facility], only as allowed, are controlled by the Hazardous Material Inventory Control Program, and are kept below the TQs [Threshold Quantity], TPQs [Threshold Planning Quantity], and RQs [Reportable Quantity] for hazardous materials."

  - Combustible Control Program: "Fire loading in the LAF is restricted and controlled by the Fire Protection Program (Transient Combustibles Control) to minimize the potential for significant fires. The Combustible Control Program will prevent significant accumulation of combustible material within the facility. The bounding credible fire event in a single fire zone (non-propagating) is a large forklift fire. The bounding credible propagating fire would involve, at most, two adjacent fire zones."

  - Fuel Receipt and Shipping Program: "The Fuel Receipt and Shipping Program will ensure that the Lower Flammability Limit (LFL) will not be reached in the DFSCs [Dry Fuel Storage Container] while the drums are being stored in the facility."

Legacy Inputs and Assumptions—The L-Area DSA contains legacy inputs and assumptions that are no longer valid or not required. Most of these legacy items were carried forward from the BIO, but were not used in the current hazard and accident analysis. The DSA should contain accurate information that is required to support the hazard and accident analysis. The staff review team identified the following examples of DSA assumptions:

- "For conservatism, a radiological inventory equivalent to two worst case boxes (2 x 816 Ci = 1,632 Ci) is assumed to be in the 910 Fan Room" and "A radiological inventory equivalent to one worst case box (816 Ci) is assumed to be in the second sort area on the -40 foot elevation." These assumptions are not valid or used in the safety analysis. Instead, L-Area personnel control waste accumulation to a limit of 56 Plutonium-239 equivalent curies.

- "The HFBR/NIST [High Flux Beam Reactor/National Institute for Standards and Technology] fuel assemblies (150-megawatt-days per assembly exposure with a cooling period of 230 days) bound all fuels to be processed in the STS from an external dose perspective." During review interviews, it was indicated that this bounding assumption is no longer used.

- "The loss of the bundled Uruguay assembly configuration may be conservatively assumed to occur at the temperature for which aluminum bundle integrity is lost. This temperature is conservatively assumed to be 490°C. Therefore, 490°C is used as the success criteria for dry fuel storage in the DFSA [Dry Fuel Storage Area]." In discussion during the review, it was not clear why this assumption was needed or how it impacted the safety analysis.

A DSA containing legacy or obsolete assumptions makes it more difficult to implement the unreviewed safety question process and challenges site personnel when ensuring compliance with DSA commitments.

Area Radiation Monitors – Backup Power Waiver—Area Radiation Monitors (ARMs) are credited as Safety Significant (SS), but a waiver to the SRNS engineering manual, OBU-SFP-2004-00005, *Waiver to E7 MANUAL PROCEDURE 2.25 Requirements for Safety Significant Power Supply to Area Radiation Monitors*, allows the use of a non-safety power source without a back-up power supply. The DSA references the waiver, but the current facility operations and safety basis are not consistent with the compensatory measures identified in the waiver. As detailed below, the TSR is inconsistent with the waiver in the non-conservative direction. Additionally, the waiver does not reflect the current basin configuration (removal of Nuclear Incident Monitors [NIMs]) and modes of operation (OPERATION versus OPERATIONAL and removal of STANDBY mode).

The TSR Bases document describes the reliance on ARMs in the safety analysis: "the ARM System is the credited means of alerting FACILITY personnel to a nuclear incident which produces fission product gases. The ARM may alarm from either direct radiation from the criticality event or from fission product gases released from the FUEL and basin water surface." The DSA takes credit for ARM functionality as a SS component; however, it references the waiver enabling the ARMs to be credited, without SS backup power, stating that a power supply

meeting SS requirements was judged to not be cost effective and that cognizant facility and regulatory engineers judged that the overall power supply design provides adequate reliability.

The waiver imposes several compensatory measures, including the requirement that "ARMs will be checked for operability on a daily basis via TSR surveillance (similar to the existing NIMs) whenever the disassembly basin is in either OPERATIONAL or STANDBY mode." The current TSR only requires checking operability every 36 hours when in OPERATION mode and every seven days when in SHUTDOWN mode. The waiver further specifies that "NIM operation is verified every 24 hours (per TSR surveillance) during STANDBY or OPERATIONAL modes and when routine access to the disassembly basin area is allowed." Per the waiver, "not all events can be excluded during the SHUTDOWN mode. For this reason, the requirements for basin entry during the SHUTDOWN mode (to be added in pending TSR revision) include a check of the operational status indication for NIMs or ARMs prior to authorization for entry." The waiver was signed in 2004, but there is no mention of ARM operational checks for basin entry in the current TSR. The SHUTDOWN mode, which only requires ARM operations to be checked every seven days, still allows basin entry.

Spent Nuclear Fuel Storage—The staff team also followed up on Savannah River Site actions subsequent to the Board providing DNFSB/TECH-38, *Storage Conditions of Reactive Metal Fuel in L-Basin at the Savannah River Site*, to DOE on January 3, 2013. Beyond the processing of the Sodium Reactor Experiment spent nuclear fuel (completed in 2014), no significant actions have been taken by Savannah River Site personnel to address the reactive metal fuels stored in L-Basin. As discussed in TECH-38, these fuels are not stored in a robust configuration and continue to degrade. SRNS is performing limited evaluations of potential disposition strategies; however, the fundamental conclusion of TECH-38 remains valid: "Further attention to the disposition of the other vulnerable fuel types remaining in the L-Basin is warranted."

The staff team reviewed the status of corrosion of mechanically damaged stainless steel and zirconium clad fuel that is isolated in overpack containers. There is no disposition pathway for this spent nuclear fuel because the cladding material is incompatible with H-Canyon chemical processes. L-Basin personnel discussed some ideas to move vulnerable fuel to dry storage or to process it by pyrochemical methods, but these are pre-conceptual. In addition, L-Basin personnel have developed three work plans for the Augmented Monitoring and Condition Assessment Program (AMCAP) for the large inventory of aluminum clad fuel, the isolated fuel discussed above, and the structural integrity of the L-Basin itself. Aside from conducting ultrasonic and visual examinations of some of the isolated fuel containers and collecting core samples from C-Reactor, there has been no significant progress to implement AMCAP actions.

Conclusion. The review team's assessment is provided to enable better alignment of the L-Area safety basis with the requirements and guidance of DOE-STD-3009-94. Areas for improvement within the L-Area safety basis include programs credited without identification of Specific Administrative Controls (SACs), inappropriate initial conditions and assumptions used in the unmitigated accident analysis, legacy assumptions in the DSA, and deficient implementation of compensatory measures specified in a waiver associated with a safety system.

APPENDIX A

This Appendix lists the events from the DSA Hazard Evaluation Tables, 3.3-3 to 3.3-6, that have a Risk Ranking Region of A1 ("High" consequences to the collocated and facility workers with the more frequent ratings of "Anticipated" or "Unlikely") for which credit is taken for programmatic administrative controls.

- DB (Disassembly Basin)-2, -3, -71, and -73 are fire- or explosion-induced events that result in the release of radiological material. These events credit the Fire Protection Program (limiting combustibles) and the Fuel Receipt and Shipping Program. DB-73 also credits the Hoisting and Rigging Program and Cask Handing Procedures.

- DB-9, -10, and -72 are explosion-based events resulting in the release of radioactive material. These events credit the Fire Protection Program and the Fuel Receipt and Shipping Program.

- DB-69 and -70 are radiological releases from shipping casks due to natural phenomena. Both events credit the Fuel Receipt and Shipping Program and Event Response Procedures. Additionally, DB-70 credits training and operating procedures.

- GE (General Event)-8, -10, and -14 are all natural phenomenon events resulting in radiological release with high offsite consequences. Among the three events, credit is taken for Event Response Procedures, training and Standard Operating Procedures (SOPs), Configuration Control Program, Fire Protection Program, Hazardous Material Inventory Control Program, Waste Management Program, Fuel Receipt and Shipping Program, L-Basin Zeolite/Deionizer Resin Replacement Program.

The following examples are all criticality events with unmitigated frequency of Anticipated and a mitigated frequency reduced to Beyond Extremely Unlikely (BEU) dependent on a programmatic control. The reduced frequency is incorporated into the accident analysis and enables the facility to operate without Nuclear Incident Monitors.

- DB-35, and -36 are nuclear criticality events that occur during cask loading or unloading. DB-36 credits SOPs, the Hoisting and Rigging Program, and Nuclear Criticality Safety Program as preventive features. DB-35 credits the Fuel Receipt and Shipping Program.

- DB-24, -46, and -63 are all criticalities due to a basin draining and fuel melt scenario. All three events result in High consequences offsite in addition to the workers. All three scenarios credit Event Response Procedures (water make-up to basin). DB-24 and -46 are events initiated by a cask drop and credit the Hoisting and Rigging Program as a preventive control.

- DB-50 is a criticality in the Dry Fuel Storage Area due to the introduction of moderator or organization of a critical mass. It credits the Fuel Receipt and Shipping Program and the Nuclear Criticality Safety Program to reduce the frequency.

- SV (Slug Vault)-1d and -1e are fire events resulting in a criticality. Each event credits the Fire Protection Program and the Nuclear Critical Safety Program.

- SV-28c and -50 are process-related human error events resulting in a criticality. They credit training, SOPs, the Nuclear Criticality Safety Program, and the Fuel Receipt and Shipping Program.

- SV-50b, -50c, -57a, and -70 are natural phenomenon or human error events resulting in criticality that credit the Nuclear Criticality Safety Program.