DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Washington, DC 20004-2901

May 2, 2014

Mr. Matthew S. McCormick
Manager, Richland Operations Office
U.S. Department of Energy
P.O. Box 550, Mail Stop 7-50
Richland, Washington 99352

Dear Mr. McCormick:

The Defense Nuclear Facilities Safety Board (Board) has closely followed final design activities and safety basis development for Phase I of the Sludge Treatment Project (STP), also known as the Engineered Container Retrieval and Transfer System (ECRTS), at the Hanford Site. At this time, the Board has not identified any significant safety concerns with the current approved final design and safety basis for the ECRTS.

The Board understands that your contractor, CH2M Hill Plateau Remediation Company, is developing several nuclear safety initiatives likely to result in changes to the ECRTS safety basis and design. Specifically these initiatives include potential changes in the safety control set based on a revised spray leak accident analysis methodology and blending of currently segregated sludge streams. These changes would require further review by the Board and its staff.

The interaction between the Board's staff and STP project personnel has been productive, and we look forward to continuing this dialogue as the project moves forward.

Sincerely,

Jessie Roberson

for Peter S. Winokur, Ph.D.
Chairman

Enclosure

c: Mr. David Huizenga
Mrs. Mari-Jo Campagnone

Enclosure

Summary of Sludge Treatment Project Final Design and Safety Basis

Background. The Sludge Treatment Project (STP) will dispose of the Hanford K-basins sludge. The sludge is a combination of spent fuel corrosion product, debris from fuel storage racks and containers, windblown dust, and spallation from the fuel basins' concrete walls and floors. The sludge is now stored underwater in six engineered containers within the 105-K West (KW) Basin at the Hanford Site. The Engineered Container Retrieval and Transfer System (ECRTS) will retrieve and transport it to T-Plant for temporary storage. DOE-RL and its contractor, CH2M Hill Plateau Remediation Company (CHPRC), are evaluating treatment facilities and technologies for final disposition of the sludge in Phase II of the STP.

The STP team tailored the requirements of Department of Energy (DOE) Order 413.3A, *Program and Project Management for the Acquisition of Capital Assets,* by combining the Critical Decision (CD) -2 and -3 milestones for Phase I of the STP, also known as the ECRTS, at the Hanford Site. Members of the Defense Nuclear Facilities Safety Board's (Board) staff reviewed the design and safety basis of the ECRTS as found in the Preliminary Documented Safety Analysis (PDSA) and a CD-2/3 package approved by DOE's Richland Operations Office (RL) on February 3, 2014. Members of the Board's staff identified no significant safety concern in the approved PDSA.

ECRTS equipment will be located in the existing KW Basin building and a new modified KW Basin Annex that is under construction as approved in milestone CD-3A. The existing KW Basin Fuel Transfer System Annex was modified to accommodate the ECRTS process equipment and to provide a loading bay supporting sludge transfer and packaging. The ECRTS will transfer approximately 27 m^3 of sludge in multiple batches as slurry, through a hose-in-hose transfer system into the Sludge Transport and Storage Containers (STSCs) located in the Modified KW Basin Annex. The loaded STSCs will next be transported by truck in Sludge Transport System (STS) casks to the T-Plant for interim storage. The ECRTS and the Modified KW Basin Annex are designed to last five years, except the STSCs are designed to last 30 years. The expected mission life is one year during which only nine cumulative hours of slurry retrieval and transfer are expected.

Design Basis Accidents and Controls. The STP team performed hazard and accident evaluation studies to determine the potential effects of operational events and natural phenomena hazards. The studies identified two accidents that require safety significant controls: a slurry spray release and a hydrogen explosion. These accidents can be initiated by operational events, a facility fire, natural phenomena, or external events.

Spray Release—The PDSA accident analysis performed for retrieving sludge as slurry from the engineered containers and loading that sludge into STSCs identified the settler tank spray release of sludge material as the bounding accident. The operational spray release is a pressurized aerosol release, initiated by a failure in system containment while the system is under pressure. A spray release could occur during sludge retrieval and transfer, decanting, sand filter backwash, or overfill recovery activities.

The STP project team has taken a reasonably conservative approach to predicting dose consequences from spray leak accidents. In estimating the dose consequence for the spray leak event, the STP team decided to avoid a complex derivation and parameterization of the spray release phenomenon to calculate the main radioactive source factor and the airborne release fraction. Instead, the project team approach for estimating the dose consequence to the collocated worker uses a correlation-independent model approach that assumed an aerosol concentration of 100 mg/m^3, a recommended value in ANSI N46.1-1980, *American National Standard—Guidance for Defining Safety-Related Features of Nuclear Fuel Cycle Facilities.*

Table 1 shows the operational spray leak accident dose consequences as documented in the PDSA. These accident consequences resulted in the selection of safety significant controls to mitigate the effects of spray release events during sludge retrieval and transfer operations. The STP team chose to credit a safety instrumented system in the ECRTS design. During a seismic event the system interlock will interrupt power to the pumps that provide pressure in the sludge transfer piping to mitigate a seismic-induced spray leak event.

Parameter	Retrieval and Transfer	Overfill Recovery	Decant	Sand Filter Backflush
Radiological Dose Consequences (rem TED)				
Facility Worker	> 100	> 100	> 100	> 100
Collocated Worker	425	79	59	59
Onsite Public	46	8.5	6.4	6.4
Offsite Public	0.9	0.17	0.12	0.12

Table 1. Unmitigated Radiological Consequences for Operational Spray Leak Events Involving Settler Tank Sludge

The onsite public receptor is a hypothetical individual located on the near bank of the Columbia River (520 m from the KW Basin). The public normally has unrestricted access to the Columbia River. While within the site borders, there are no release limits or evaluation guidelines defined in DOE directives for this location. However, DOE-RL devoted resources to develop the ability to restrict public access to the Columbia River when necessary. This capability is included in the PDSA as a safety significant Specific Administrative Control.

Hydrogen Explosion—A significant hazardous component of the K Basin's containerized sludge is uranium metal. This metal reacts exothermally with water to generate uranium oxide and hydrogen. As a result of this reaction and the radiolytic decomposition of water, the hydrogen concentration in the STSC could reach levels supporting combustion. Increased hydrogen concentration could occur if ventilation flow through a STSC is lost due to equipment failure or tank isolation. The potential also exists for the accumulation of hydrogen within the sludge in the STSC, leading to an episodic release of that hydrogen into the STSC headspace.

The ECRTS process enclosures, such as the transfer line service box, do not normally contain sludge. However, a release of slurry to the transfer line service box is possible in the event of primary containment failure within that process enclosure during a slurry transfer. If spilled slurry is not removed in a timely manner, hydrogen generation within the enclosure could result in the potential for the hydrogen concentration to reach levels supporting combustion.

The STP team analyzed hydrogen explosion/deflagration events for the sludge transfer process and concluded that the radiological consequences of these events do not exceed the evaluation guidelines for collocated workers and public receptors. However, the STP team evaluated a hydrogen explosion in an STSC, Sludge Transport System cask, or the transfer line service box as requiring safety significant controls due to the potential for serious injury or death to a facility worker.

The control strategy selected for this hazard is to prevent an explosion by maintaining the hydrogen concentration in the STSC headspace and ECRTS process enclosures below 25 percent of the lower flammability limit (LFL). Under normal operating conditions, the general service Annex Ventilation System that services the STSC and the transfer lines service box will maintain the hydrogen concentration in these headspaces below 25 percent of the LFL. If the general service Ventilation System fails to maintain a minimum air flow rate through the STSC, a safety significant Auxiliary Ventilation System will automatically activate. The Auxiliary Ventilation System uses pressurized nitrogen gas to provide a flow rate through the STSC that will maintain the hydrogen concentration below 25 percent of the LFL in air. A safety significant leak detection system is credited with limiting the amount of sludge that could be present in the transfer line service box to below an amount that would be necessary to generate a hydrogen concentration that exceeds 25 percent of the LFL.

Previous Issues from Preliminary Design. The Board's July 31, 2012, project letter to DOE identified two issues that the Board believed should be addressed during the final design process: *Non-Bounding Spray Leak Consequence Analyses* and *Safety Instrumented Systems*.

The approved PDSA contains an accident analysis that produces bounding spray leak accident dose consequences. The revised accident scenarios now consider an increased amount of radioactive material and use atmospheric dispersion parameters that are technically justified as bounding. Additionally, the unmitigated accident scenarios are consistent with requirements in DOE's directives on accident analysis by no longer crediting active engineered features or operator actions. These actions adequately address the Board's concern. The Board therefore closed the *Non-Bounding Spray Leak Consequence Analyses* issue in its December 26, 2013, Periodic Report to Congress on the Status of Significant Unresolved Issues Concerning the Design and Construction of Department of Energy Defense Nuclear Facilities.

The approved safety basis includes design criteria for all key attributes of safety instrumented systems as listed in applicable DOE directives. These criteria are being applied by invoking industry consensus standards usually reserved for safety class applications, and replacing the safety class requirement for redundancy with a requirement for fail-safe operation on all loss of power scenarios. Members of the Board's staff reviewed the final design of the credited safety instrumented systems, and found that these design requirements appear to be met by the final design. Therefore, the *Safety Instrumented Systems* issue is closed.

Areas for Future Review. The STP team is currently developing several "Nuclear Safety Initiatives" which DOE-RL will likely direct CHPRC to implement in a future revision to the ECRTS PDSA and final design. This revision is expected to be submitted to DOE-RL at the end of 2014. Due to budget reductions, the STP does not expect to begin procurement or installation of ECRTS equipment before the revised safety basis and design are approved.

Specifically, these initiatives include changes in the spray leak accident analysis methodology and the blending of currently-segregated sludge streams that could result in changes to the safety classification and safety functions of the systems and components that comprise the current safety control set. This revision will require additional review by members of the Board's staff.