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United States Government **Department of Energy**

memorandum

Richland Operations Office

DATE: AUG 29 2007

REPLY TO ATTN OF: SED:BEH/07-SED-0369

SUBJECT: K BASINS SLUDGE TREATMENT PROJECT TECHNOLOGY READINESS ASSESSMENT

TO: Matthew McCormick, Acting Federal Director for K Basin Closure

Attached is the K Basins Sludge Treatment Project Technology Readiness Assessment that you requested. If you have any questions, please contact me, or your staff may contact Burt Hill of my staff, on (509) 376-6863.

Pete J. Garcia Jr.

Pete J. Garcia Jr., Director
Engineering and Safety Division

Attachment

U.S. Department of Energy, Richland Operations Office

K Basins Sludge Treatment Process

Technology Readiness Assessment

Final Report

A-07-SED-017

TRA Lead: [signature]
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Executive Summary

The U.S Department of Energy (DOE), Richland Operations Office (RL) is constructing a K Basins Sludge Treatment Process (STP) for the retrieval, treatment and packaging of the various sludge streams currently stored in the K West Basin at the Hanford Site in Washington State. The STP Project is comprised of seven (7) major sub-systems: sludge containerization, retrieval, transfer, oxidation (corrosion), assay, packaging and drum handling.

A Technology Readiness Assessment (TRA) was jointly performed by DOE-RL in collaboration with Fluor Hanford, the site contractor. The Team was composed of technical experts and Contractor representatives, having experience in process operations, process engineering and system design/construction. The TRA methodology was customized by the STP TRA Team but was modeled on the DOE TRAs that were previously conducted and the DoD TRA Deskbook.

The TRA team concluded that the critical technologies associated with the Sludge Treatment Project are not at the maturity level needed to support a Critical Decision "3" (CD-3) to procure and construct the sludge treatment process. This conclusion supports the recent Fluor Hanford recommendation and subsequent DOE-RL decision to re-baseline the Sludge Treatment Project to between CD-0 and CD-1.

A summary of the results of the TRA is provided in Table ES-1. The Technology Readiness Level (TRL) determined for each Critical Technology Element (CTE), as well as each Critical Technology sub-Element, is identified in this table. TRL values of TRL-2 (i.e., technology concept and/or application formulated) were determined for four CTEs, i.e., Material Mobilization, Mixing, Process Chemistry and Assay and TRL-4 (i.e., component and/or system validation in laboratory environment) for Material Transfer, Process Instrumentation and Waste Package. In many cases, a primary barrier to establishing higher TRLs relates to the unknowns associated with the physical properties of the containerized and/or the corroded sludge. This includes the unavailability of a legitimate simulant for testing and demonstration. Because the properties of the corroded sludge are not well understood, development of a range of simulants for testing and testing of the process using these simulants has not occurred. Therefore, laboratory scale testing with a high fidelity system has not yet been demonstrated.

The results also indicate that while the overall CTE may be at a low technology maturity level, there are several technology sub-elements at a higher maturity level (indicated by the blue high-lights). This indicates the need for a targeted maturation plan that focuses on those key technology gaps which, if addressed, will raise the technical readiness levels of the critical technologies.

The TRA process provides a useful methodology for determining the technology maturity levels for candidate technologies. Additionally, the resultant TRL that is determined is useful to provide relative comparisons between technologies and to identify technologies that need further efforts to reach an appropriate technology maturity level. However, to fully understand the overall effects on the project for a given TRL, it is necessary to complete the Technology Maturity Plan (TMP); for a candidate technology may be at a TRL-2, but could, with a relatively small effort, be advanced to a TRL-6. For this reason, the STP TRA Team is recommending that FH STP Technical Staff complete a detailed TMP, based on the results of this TRA.

Table ES-1 Sludge Treatment Process Critical Technology Element Technology Readiness Levels Summary

CRITICAL TECHNOLOGY ELEMENTS																				
CTE-01			CTE-02			CTE-03			CTE-04			CTE-05			CTE-06			CTE-07		
Material Mobilization			Material Transfer			Process Chemistry			Process Instrumentation			Assay			Mixing			Waste Package		
Technology Readiness Level (TRL) Determination																				
TRL-2			TRL-4			TRL-2			TRL-4			TRL-2			TRL-2			TRL-4		
Critical Technology sub-Elements																				
CTsE-1	KOP/Strainer Material Retrieval	TRL-4	CTsE-6	Sludge Transfer	TRL-4	CTsE-7	Process Chemistry	TRL-2	CTsE-5B	Feed Stream Concentration	TRL-4	CTsE-15	IPAN Level Detection	TRL-3	CTsE-5E.1	Feed Stream Preparation (Day Tank)	TRL-5	CTsE-19	Product Container	TRL-5/6
CTsE-2	Settler Tubes Material Retrieval	TRL-3	CTsE-12.1	Corrosion Product Transfer Mechanics	TRL-4		Feed Stock Characterization	TRL-3	CTsE-5E.2	Feed Stream Preparation (Day Tank)	TRL-4	CTsE-18	IPAN Assay/Detector System	TRL-2	CTsE-8	Corrosion Vessel Mechanical Agitation	TRL-2	CTsE-21	Dosing Heads (Wet and Dry)	TRL-4
CTsE-3B	Container/Settler Tubes Stored Sludge Retrieval	TRL-6	CTsE-16.2	IPAN Product Retrieval (Pinch Valve)	TRL-4		Processing Parameters	TRL-2/3	CTsE-12.2	Corrosion Product Transfer Measurement	TRL-4				CTsE-14	IPAN Agitation	TRL-2	CTsE-22	WIPP Certifiable Waste Form	TRL-5/6
CTsE-4B	KOP/Strainer Material Retrieval from CON-101	TRL-2	CTsE-17.1	IPAN Product Transfer Mechanics	TRL-4				CTsE-13.2	Quench Vessel Off-gas Monitoring	TRL-4				CTsE-20	Drum Mixing	TRL-6	CTsE-24	Drum Decontamination	TRL-4
CTsE-4E	KOP/Strainer Material Retrieval (Auger)	TRL-4/5	CTsE-17.2	IPAN Product Transfer Measurement	TRL-4															
CTsE-5E.3	Feed Stream Preparation (Day Tank)	TRL-2																		
CTsE-11	Corrosion Product Retrieval	TRL-2																		
CTsE-16.1	IPAN Product Retrieval	TRL-2																		

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1.0 INTRODUCTION

The U.S Department of Energy (DOE), Richland Operations Office (RL) is developing a K Basins Sludge Treatment Process (STP) for the retrieval, treatment and packaging of the various sludge streams currently stored in the K West Basin on the Hanford Site in Washington State. The STP Project is comprised of seven (7) major sub-systems: sludge containerization, retrieval, transfer, oxidation (corrosion), assay (Imaging Passive Active Neutron System [IPAN]), packaging (Mobile Solidification System [MOSS]) and drum handling, as shown in Figure 1 below. The first three sub-systems are planned to be located in the K West Basin, while the remaining four sub-systems would be placed into the Cold Vacuum Drying Facility (CVDF), which is located about 700 feet to the west of the Basin. A hose-in-hose transfer system would be utilized to move the sludge streams from the K West Basin to the CVDF.

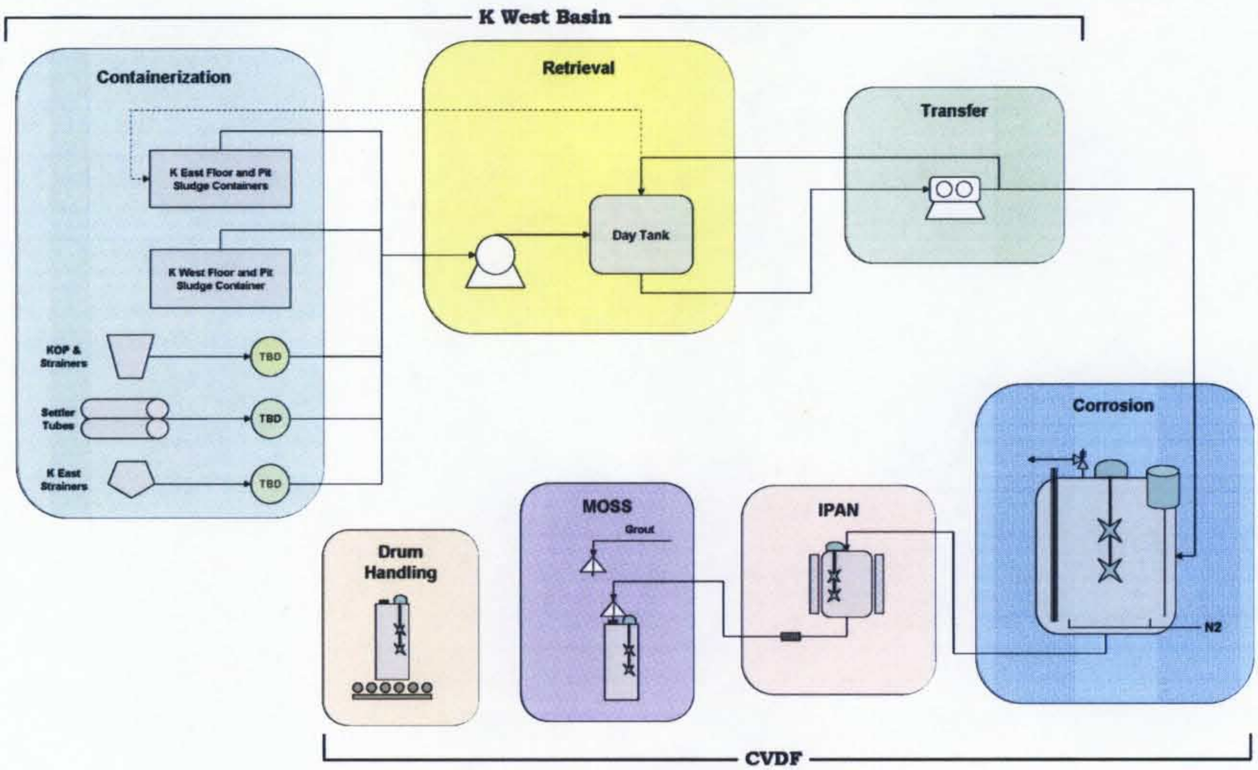

Figure 1. Sludge Treatment Process Flow Diagram

A Technology Readiness Assessment (TRA) was conducted to determine the technical maturity of sludge retrieval, transfer, treatment and packaging technologies identified in the current STP baseline; emerging enhancements to the baseline design were also included in the review scope. Figure 1, above, shows the Day Tank as part of the retrieval process, which is one of the emerging enhancements. The current baseline does not include the use of the Day Tank. Both scenarios are evaluated by this TRA.

2.0 SCOPE

The Sludge Treatment Process (STP) Technology Readiness Assessment (TRA) was jointly performed by DOE-RL in collaboration with the Contractor (Fluor Hanford [FH]). The STP TRA Team was lead by the DOE-RL STP Chief Engineer, who reports to the Manager, Safety and Engineering Division. The STP TRA Team was composed of technical experts and Contractor representatives, having experience in process testing and development, process operations, process engineering and system design/construction.

The purpose of the STP TRA is to perform a "finding-of-fact" appraisal of the project's overall technical maturity. This was accomplished by first identifying individual technology elements (TEs) utilized in the STP design. These TEs and their associated critical functional and operational characteristics are then evaluated to identify the Critical Technology Elements (CTEs). A technology element is deemed "critical" if the system being acquired depends on the technology element to meet operational requirements, and the technology element or its application is either new or novel (Ref: DOD TRA Deskbook, May 2005). A systematic, metrics-based evaluation was then performed to screen and assess the maturity, i.e., technology readiness level (TRL), of the CTEs, as related to potential future deployment and operation in the sludge treatment process.

The TRA does not predict future system's performance nor does it assess the quality of the system's architecture, design, or integration plan(s). The TRA simply strives to identify any gaps which may exist between the current maturity of a CTE to that required for commencing construction of the overall processing system. The level of technical maturity, once determined, is assigned a numerical identifier, ranging from 1 to 9 based on predetermined criteria. A maturity level of 6, as a minimum, is required to consider a CTE construction-ready. Identified gaps are addressed in a "technology maturation plan" (TMP), which will be developed subsequent to this TRA.

3.0 TECHNOLOGY READINESS ASSESSMENT PROCESS DESCRIPTION

Prior to initiating the STP TRA, a Technology Readiness Assessment Plan, see Appendix D, was prepared. This document provided a "road map" for the STP TRA Team and served to communicate to management the purpose, scope, methodology, and deliverables for the subsequent STP TRA, prior to its initiation.

The STP TRA methodology was developed by the STP TRA Team in a formal, interactive manner. This methodology is modeled on the DOE TRAs which were previously conducted (e.g., Hanford Waste Treatment Plant and Savannah River Site Tank 48) and the DoD TRA Deskbook (May 2005). The methodology also incorporated strategies and lessons learned from the previous DOE TRAs. These strategies and lessons learned were obtained via discussions with Pacific Northwest National Laboratory (PNNL) personnel that participated in previous TRAs. These personnel were also utilized to review and validate the STP TRA process methodology.

The STP TRA methodology is discussed in detail in the following sections. Figure 2 is a flow chart that depicts the STP TRA process steps and follow-on project activities.

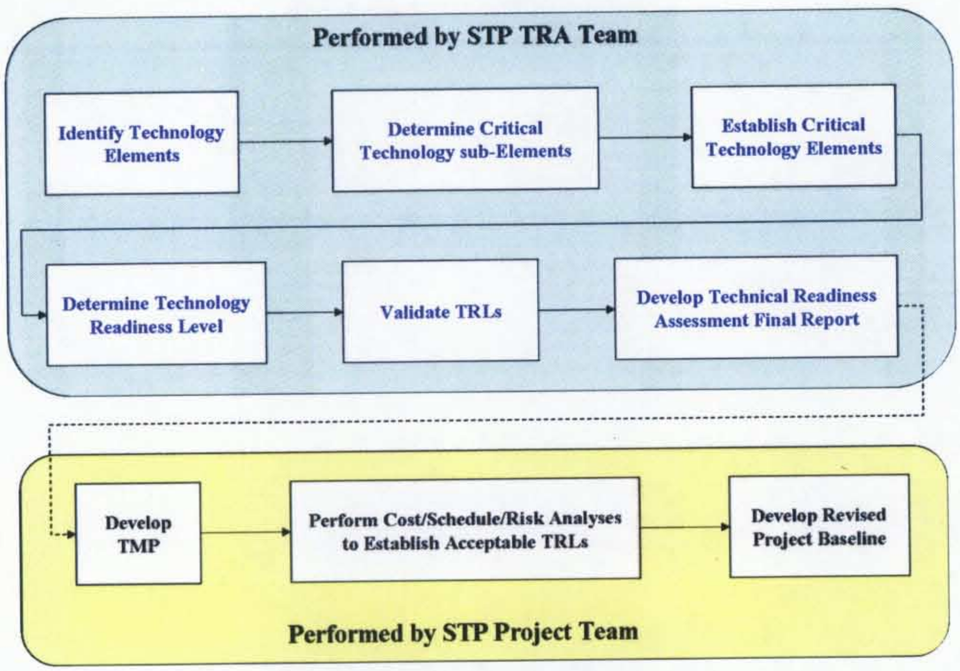

Figure 2. STP TRA Process Flow Steps

3.1 Technology Element Determination

Technology Element (TE) determination was conducted by performing a review of the STP design documents (e.g., system plans, system descriptions, component lists, process flow diagrams, and piping and instrument diagrams). The TEs may consist of systems, sub-systems, components, and/or concepts of use or function. The initial determination of the TEs was made by the STP TRA Team based on their review. The list of Technology Elements was then given to the STP engineering technical staff to validate that the list was complete. Additions, deletions and modifications were made to establish a complete listing of Technology Elements.

3.2 Critical Technology Element Determination

The technology elements were then evaluated to determine their essential functional and operational characteristics required for the success of the STP project. This was accomplished through an evaluation of the STP system, subsystem, component, and/or process design and comparing it to the design input/requirements. The design input/requirements are identified in:

- Preliminary Documented Safety Analysis
- Safety Evaluation Report for the Preliminary Documented Safety Analysis for Sludge Treatment Project
- KBC-24540, Functional Design Criteria, K Basins Closure, Sludge Treatment Project
- DOE/WIPP-02-3214, Remote-Handled Transuranic Waste Characterization Program Implementation Plan

The technology elements and their associated critical functional and operational characteristics are then evaluated to identify the Critical Technology sub-Elements (CTsEs). A technology element was deemed "critical" if the system being acquired depends on the technology element to meet operational requirements, and the technology element or its application is either new or novel (Reference: DOD TRA Deskbook, May 2005).

The decision logic that was followed to select the CTsEs is depicted in Figure 3. It consists of applying a series of questions to each of the technology elements, and the documented answers to those questions are used to determine if the technology element is identified as a CTsE. Appendix A provides the specific Critical Technology sub-Element Determination Worksheets, which were used to individually evaluate each Technology Element, and to determine the CTsEs.

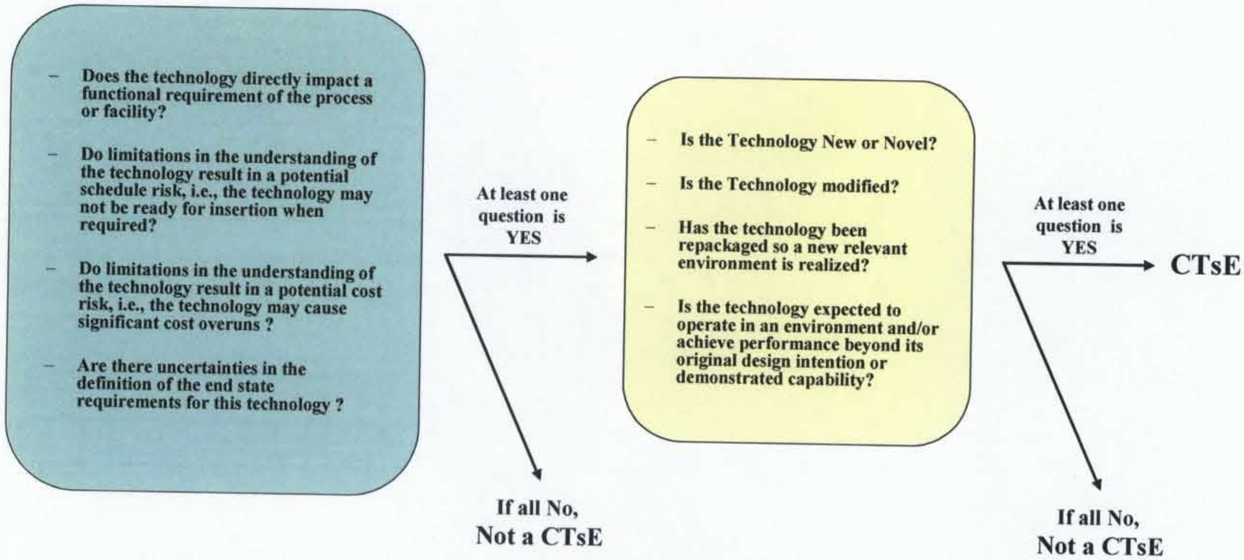

Figure 3. Critical Technology sub-Element Determination Process

Following identification of all the Critical Technology sub-Elements, a consolidation of similar CTsEs was performed. For each group of CTsEs, a single functional or operational characteristic was identified. This function or characteristic was determined to be the Critical Technology Element (CTE).

3.3 Technology Readiness Level Determination

Following identification of the CTEs, a "finding-of-fact" investigation was preformed to establish each CTE's technical maturity. The desired TRL was "6" which equates to the technology having been proven in an engineering/pilot scale test or a similar technology having been validated in a relevant environment.

Since each CTE consisted of several CTsEs, it was recognized that there may be several TRL values within the CTE under consideration. The individual Critical Technology sub-Element's TRLs were determined subjectively by the STP TRA Team. The overall TRL established for the specific CTE was determined by completing the specific lines of inquiry for the most immature CTsE(s). The following figure provides a summary definition of the various Technology Readiness Levels.

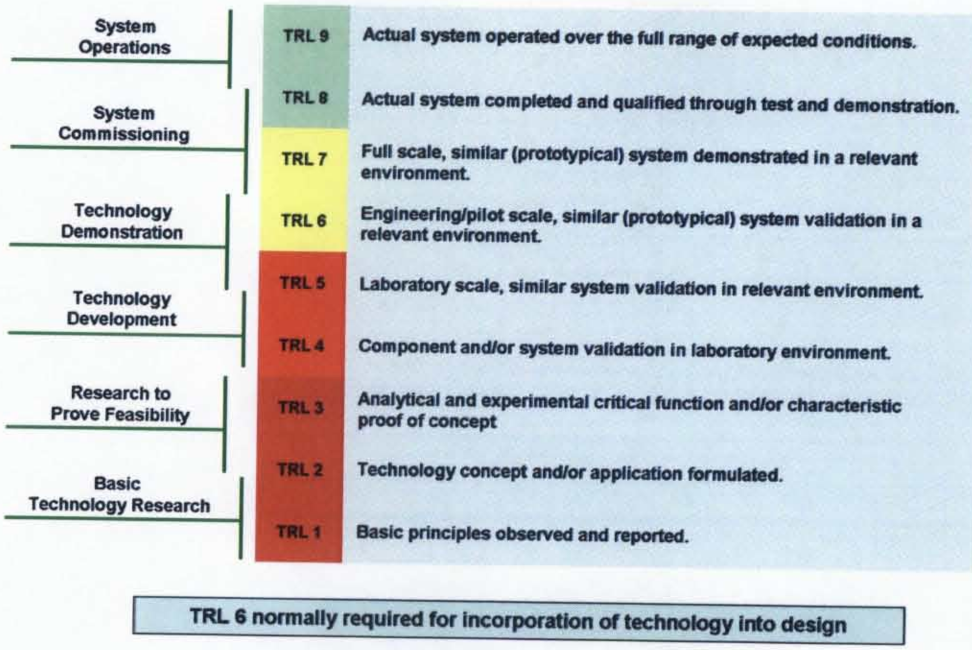

Figure 4. Technology Readiness Levels Definitions

The STP TRA Team modified the WTP TRA question set (lines of inquiry) as the basis for determining the TRL values of STP CTEs. The questions used by the WTP to establish a TRL values were derived from the TRL "calculator" (Reference: Nolte) and modified for fundamental applicability to the DOE environment. These lines of inquiry are discussed and provided in Appendix D (Attachment C).

STP management and technical staff were provided with the list of CTEs and a request was made for supporting documentation, to allow assessment of the technical maturity of each CTE. The STP TRA Team members reviewed the provided documentation in the context of the TRL lines of inquiry. Answers to the TRL lines of inquiry were documented and used to establish a TRL value. Additionally, technical personnel from the STP were interviewed during the TRL process to validate the STP TRA Team's interpretation of information used to establish the CTE TRL value.

4.0 ASSESSMENT RESULTS

The TRA process discussed in Section 3.0 was followed by the TRA Team. The following sections describe the process followed and the specific STP results.

4.1 Identified Technology Elements

The technology elements were identified by a process that consisted of a review of each unit operation of sludge treatment system. This was accomplished by reviewing the process flow diagrams (PFDs) and the piping and instrument diagrams (P&IDs) for each part of the sludge treatment process. Current issues associated with each of the unit operations were also discussed in order to determine if there was a technology element associated with the unit operation. A distinction was made between a "technology element" and a "design" related issue. The STP TRA Team defined a "design" related issue as an issue that the team believed was due to the selection of a technology by the design team, versus the immaturity of a selected technology. Observations associated with the "design" issues were captured and are provided in Appendix C.

Table 2 provides the list STP TEs that the STP TRA Team identified, and their associated issues/concerns that were considered during the selection process.

4.2 Identified Critical Technology sub-Elements

The technology elements identified in Section 4.1 were then analyzed using the process discussed in Section 3.2 to determine if the technology element was a critical technology sub-element (CTsE). This analysis is documented in worksheets that are provided in Appendix A. The CTsE's are also identified in Table 2.

Table 2 Technology Elements to Critical Technology sub-Elements Cross-walk

Technology Element Number	System	Technology Element	Technology Element Concerns/Issues	Critical Technology sub-Element Number
TE-1	Retrieval/Mobilization	KOP/Strainer material retrieval	• Tooling/Methodology for mobilizing material in the KOPs and Strainers is currently under-development. • Material properties not verified.	CTsE-1
TE-2	Retrieval/Mobilization	Settler Tubes material retrieval	• Tooling/Methodology for mobilizing material in the Settler Tubes is currently under-development. • Material properties not verified	CTsE-2
TE-3B	Retrieval/Mobilization	Container and Settler Tubes sludge retrieval from storage container	• (Baseline) Bottom Retrieval approach	CTsE-3B
TE-4B	Retrieval/Mobilization	KOP/Strainer material retrieval from accumulation tank (CON-101)	• (Baseline) Bottom Retrieval	CTsE-4B
TE-5B	Feed Stream	Feed stream concentration	• (Baseline) Ability to measure • Ability to control to desired concentration	CTsE-5B
TE-3E	Retrieval/Mobilization	Container sludge retrieval from storage container	• (Enhanced) Top Retrieval	N/A
TE-4E	Retrieval/Mobilization	KOP/Strainer material retrieval from accumulation tank (CON-101)	• (Enhanced) Auger and Mobilization method.	CTsE-4E
TE-5E.1	Feed stream preparation	Feed stream preparation (Day Tank)	• (Enhanced) Ability to establish and maintain a homogeneous mixture (norm and off norm)	CTsE-5E.1
TE-5E.2	Feed stream preparation	Feed stream preparation (Day Tank)	• (Enhanced) Ability to measure critical variables	CTsE-5E.2
TE-5E.3	Feed stream preparation	Feed stream preparation (Day Tank)	• (Enhanced) Ability to reach and maintain desired concentration, • Ability to capture fine material without return to the basin.	CTsE-5E.3
TE-6	Material Transfer	Ability to transfer	• Can material be maintained in suspension and transferred over the distance, • Plugging of line/pumps, Line flushing • Erosion of pumps, • Pumps in series (hydraulic validation).	CTsE-6
TE-7	Corrosion	Process Chemistry	• Feedstock Characterization, • Process Chemistry not well understood, • Effects of processing parameters not well understood, • DOE directed lower STP conditions untested.	CTsE-7

Technology Element Number	System	Technology Element	Technology Element Concerns/Issues	Critical Technology sub-Element Number
TE-8	Corrosion	Corrosion Vessel Mechanical Agitation	• Is an agitator the correct tool for this application? • Are agitation capabilities sufficient for normal and off-normal conditions? • Effects on/from other corrosion vessel components; • Reliability/Maintainability; • Baffle side effects (material buildup, etc); • Ability to make well mixed product (IPAN Feed).	CTsE-8
TE-9	Corrosion	Level Detection	• Reliability & effectiveness under process conditions; • Effects from corrosion vessel components and foaming.	N/A
TE-10	Corrosion	N2 Sparge Ring	• Reliability & effectiveness under process conditions; • Effects on/from other corrosion vessel components; • Rationale for not including backup N2 to corrosion vessel.	N/A
TE-11	Corrosion	Product Retrieval	• Can material be maintained in suspension and retrieved from vessel? • Ability to retrieve well mixed product (IPAN Feed)	CTsE-11
TE-12.1	Corrosion	Product Transfer Mechanics	• Potential plugging and plug clearing; • Product solids settling in line/flushing; • Effects on overall process due to flushing (how often, how much, where does it go. Etc.	CTsE-12.1
TE-12.2	Corrosion	Product Transfer Measurement	• Volume/Mass meter (corriolis meter)	CTsE-12.2
TE-13.1	Corrosion	Quench Vessel	• Cool off-gas from Corrosion Vessel and condense vapors.	N/A
TE-13.2	Corrosion	Quench Vessel Off-gas Monitoring	• Hydrogen and Oxygen monitoring instrumentation/detectors.	CTsE-13.2
TE-14	IPAN	Agitation	• Agitation capabilities sufficient for norm and off-norm conditions; • Effects on/from other vessel components; • Reliability/Maintainability; • Baffle side effects (material buildup, etc); • Ability to make homogeneous product (IPAN Product).	CTsE-14
TE-15	IPAN	Level Detection	• Reliability & effectiveness under process conditions; • Effects from IPAN vessel components and foaming	CTsE-15
TE-16.1	IPAN	Product Retrieval	• Can material be maintained in suspension and provide ability to retrieve well mixed product (IPAN Product).	CTsE-16.1

Technology Element Number	System	Technology Element	Technology Element Concerns/Issues	Critical Technology sub-Element Number
TE-16.2	IPAN	Product Retrieval	• Pinch valve materials of construction.	CTsE-16.2
TE-17.1	IPAN	Product Transfer Mechanics	• Potential plugging and plug clearing; • Product solids settling in line/flushing; • Effects on overall process due to flushing (how often, how much, where does it go. Etc); • Elevation changes may be of concern.	CTsE-17.1
TE-17.2	IPAN	Product Transfer Measurement	• Ability to precisely meter desired amount of product.	CTsE-17.2
TE-18	IPAN	Assay/Detector System	• Software, • Use in high radiation/RH environments, • sludge self-shielding, • partial filled vessel; • Deployment in agitated.	CTsE-18
TE-19	MOSS	Product Container	• Overall container design; • Material compatibility of waste package and ability to support exterior decontamination;	CTsE-19
TE-20	MOSS	Drum Mixing	• Uniform waste matrix in Container (Hot Spot concerns).	CTsE-20
TE-21	MOSS	Dosing Head (wet and dry)	• Contamination Control/Confinement; • Demonstrate that ventilation pipe provides appropriate protection from airborne releases.	CTsE-21
TE-22	MOSS	WIPP Certifiable Waste Form	• Verify ability to produce a WIPP certifiable waste package;	CTsE-22
TE-23	MOSS	Automated Drum Positioning	• Automated nature in RH environment, • Mechanical alignment of mixer, dosing heads, trolley, monorail, etc.	N/A
TE-24	Drum Handling	Drum Decontamination	• Verify ability to perform remote decontamination to acceptable levels	CTsE-24
TE-25	MOSS	Cement Feed System	• Dust handling, Bridging/Plugging Concern	N/A
TE-26	Drum Handling	Automated Drum Handling	• Automated nature in RH environment	N/A
TE-27	Drum Loadout	Drum Integrity	• Environmental Effects (Water intrusion)	N/A
TE-28	Drum Loadout	Drum Handling associated with Cask Loading	• ALARA Considerations, Sky shine and personal protection not adequately addressed	N/A

4.3 Identified Critical Technology Elements

The CTsE identified in Section 4.2 were then grouped into a limited number of Critical Technology Elements (CTEs) in order to provide a more meaningful representation of the critical technologies and avoid unnecessary overlap. For each group of CTsEs, a single functional or operational characteristic was identified. This function or characteristic was determined to be the Critical Technology Element (CTE). This resulted in seven CTEs. These CTEs are identified in Table 3 and are discussed in the following sections.

CRITICAL TECHNOLOGY ELEMENTS						
CTE-01	**CTE-02**	**CTE-03**	**CTE-04**	**CTE-05**	**CTE-06**	**CTE-07**
Material Mobilization	**Material Transfer**	**Process Chemistry**	**Process Instrumentation**	**Assay**	**Mixing**	**Waste Package**
Critical Technology sub-Elements						
CTsE-1	CTsE-6	CTsE-7	CTsE-5B	CTsE-15	CTsE-5E.1	CTsE-19
CTsE-2	CTsE-12.1		CTsE-5E.2	CTsE-18	CTsE-8	CTsE-21
CTsE-3B	CTsE-16.2		CTsE-12.2		CTsE-14	CTsE-22
CTsE-4B	CTsE-17.1		CTsE-13.2		CTsE-20	CTsE-24
CTSE-4E	CTsE-17.2					
CTsE-5E.3						
CTsE-11						
CTsE-16.1						

Table 3 Sludge Treatment Process Critical Technology Elements

4.3.1 Material Mobilization

4.3.1.1 Overview

Material Mobilization was selected as a CTE because of its significant importance and influence relative to sludge retrieval. Sludge retrieval is required in several parts of the STP process coupled with corresponding sludge mobilization challenges in several areas of the STP process:

- KOP/Strainer mobilization
- Container Sludge mobilization
- Settler Tank mobilization
- Corrosion vessel mobilization (e.g., following off normal/loss-of-power event)
- Assay vessel corroded sludge mobilization (e.g., following off normal/loss-of-power event)

4.3.1.2 Critical Technology sub-Elements

Eight critical technology sub-elements were identified under the Material Mobilization CTE related to mobilization and retrieval of pre- and post-corroded sludge.

CRITICAL TECHNOLOGY ELEMENT		
CTE-01	**Material Mobilization**	**TRL-2**
Critical Technology sub-Elements		
CTsE-1	KOP/Strainer Material Retrieval	TRL-4
CTsE-2	Settler Tubes Material Retrieval	TRL-3
CTsE-3B	Container/Settler Tubes Stored Sludge Retrieval	TRL-6
CTsE-4B	KOP/Strainer Material Retrieval from CON-101	TRL-2
CTSE-4E	KOP/Strainer Material Retrieval (Auger)	TRL-4/5
CTsE-5E.3	Feed Stream Preparation (Day Tank)	TRL-2
CTsE-11	Corrosion Product Retrieval	TRL-2
CTsE-16.1	IPAN Product Retrieval	TRL-2

Table 4 CTE-01 Critical Technology sub-Elements

KOP/Strainer Material Retrieval – KOP/strainer material retrieval was determined to be a critical technology element due to the unique configuration of the containers and significance as a fundamental feed stream to the corrosion process. Material characteristics are uncertain and may dictate refinements to the technology.

Settler Tubes Material Retrieval – Mobilization of settler tank material retrieval was determined to be a critical technology element due to the unique configuration of the containers and significance as a fundamental feed stream to the corrosion process. Technology must be adapted for use in the Settler Tubes environment. Material characteristics are uncertain and may dictate refinements to the technology.

Container/Settler Tubes Stored Sludge Retrieval - Mobilization of K-West container/settler tank material was determined to be a critical technology element due to the unique configuration of the containers and significance as a fundamental feed stream to the corrosion process. The technology is being repackaged for deployment in the project, e.g., the storage container design has been modified. Technology performance requirements, i.e., feed stream concentration of 12 percent solids, are beyond demonstrated capability.

KOP/Strainer Material Retrieval from CON-101 – Mobilization of KOP/strainer material was determined to be a critical technology element due to uncertainties regarding effective retrieval of material from the KOP/strainer accumulation tank (CON-101). Technology performance requirements, i.e., KOP/Strainer simulant could not be removed from the storage container during a demonstration test, are beyond demonstrated capability.

KOP/Strainer Material Retrieval (Auger) – Mobilization of KOP/strainer material was determined to be a critical technology element due to uncertainties regarding effective retrieval of material from the KOP/strainer accumulation tank (CON-101). Product measurement has not been demonstrated with the product (rheology of the product, materials of construction and gas retention). Technology performance requirements, i.e., KOP/Strainer simulant could not be removed from storage container during a demonstration test, so it may be beyond demonstrated capability.

Feed Stream Preparation (Day Tank) – The use of a day tank as part of the feed stream preparations is a new unit operations applied to the STP project, and is part of the "enhanced" baseline design. The use of a day tank is widely used in general industry, but a specific demonstration using sludge materials with the specific sludge physical characteristics has not been done. Therefore, a TRL-2 value is assigned.

Corrosion Product Retrieval – Mobilization of material in the corrosion vessel was determined to be a critical technology element since it is required during the corrosion process, including recovery from an off-normal event (e.g., loss of power). The properties of the corroded sludge have not been fully determined and may vary during the actual corrosion/oxidation process.

IPAN Product Retrieval - Mobilization of material in the assay vessel was determined to be a critical technology element as it is required to support transfer of batches to MOSS, and material retrieval following an off-normal event (e.g., loss of power). The properties of the corroded sludge have not been fully determined and may vary.

4.3.1.3 Technology Readiness Level Determination

The major factor contributing to the lower TRL-2 value for the Material Mobilization CTE is the immaturity of the understanding of the STP process chemistry (CTE-03). Additional information related to the properties of corroded sludge is needed to further the development of relevant aspects of the corrosion and assay vessel retrieval system design (re: CTsE-11 and CTsE-16.1).

KOP/Strainer Material Retrieval – K Basins Closure Project (KBCP) experience to date is credited for some aspects of sludge mobilization and retrieval from the KOP/strainers. KOP/strainer material mobilization and retrieval is expected to be similar to previous experience mobilizing fuel canister sludge during sampling activities. Verification of KOP and strainer contents and form are warranted to validate relevance of previously performed fuel canister sludge mobilization tasks and resulted in a TRL-4.

Settler Tubes Material Retrieval – Previous testing using a settler tank mockup configuration was performed and documented the remote mobilization concept specific to STP. Although a TRL-3 value was assigned, subsequent analysis of the contents of the settler tanks is in planning and may reveal unexpected physical properties of the settler tank sludge material. Settler tank sludge mobilization was previously evaluated but results did not adequately validate the mobilization concept. Recent efforts have been initiated to further refine settler tank sludge mobilization design concepts but are not credited since actual objective evidence has not been developed. A predecessor activity to determine the settler tank sludge inventory is recommended to verify the form and content of the settler tank.

Container/Settler Tubes Stored Sludge Retrieval – Material Mobilization of K-West container sludge is expected to be similar to mobilization of the K-East container sludge. There were many issues associated with mobilization of the sludge, but it was accomplished. Design improvements were implemented on the K-West containers to improve performance over the K-East container mobilization, however these design changes have not been tested/validated. Further non-radioactive testing with simulants to validate the design concept is warranted. A TRL-6 value was assigned.

KOP/Strainer Material Retrieval from CON-101 – Demonstration tests have been performed on a mockup of the accumulation tank (CON-101) with simulated KOP/strainer material. Problems were experienced in mobilizing the simulated KOP/strainer material due to bridging and blockage at the discharge port of the tank. Therefore, Mobilization of KOP/strainer material in a CON-101 configuration is unproven to date resulting in a TRL-2.

KOP/Strainer Material Retrieval (Auger) – The project is currently evaluating a design improvement to solve KOP/strainer material mobilization problems encountered during testing of the baseline design. The modified design utilizes an auger system and refinement of fluidization nozzles to prevent bridging and blockage of KOP/strainer material during transfer from the accumulation tank. Testing is in progress and results are encouraging, but are not complete. Use of an auger for transfer of similar material is well understood and utilized in many industrial applications for similar material. Therefore, a TRL-5 is assigned.

Feed Stream Preparation (Day Tank) – The use of a day tank as part of the feed stream preparations is a new unit operations applied to the STP project. The use of a day tank is widely used in general industry, but a specific demonstration using sludge materials with the specific sludge physical characteristics has not been done. Therefore, a TRL-2 value is assigned.

Corrosion Product Retrieval – The retrieval of corroded sludge from the corrosion vessel has not been demonstrated. Corroded sludge rheological properties have not been fully determined and may vary during the actual corrosion/oxidation process. There have been a limited number of laboratory tests done on sludge spiked with uranium metal that were not characteristic of all process conditions. The results of these tests indicate that there may be difficulties in retrieving the corroded sludge. Prototypical tests need to be conducted to determine the physical and rheological properties of the corroded sludge. Therefore, a TRL-2 value is assigned.

IPAN Product Retrieval – Similar to retrieval of corroded sludge from the corrosion vessel, there are many similar uncertainties with mobilization and retrieval of sludge from the IPAN vessel. Therefore, a TRL-2 value is assigned.

4.3.2 Material Transfer

4.3.2.1 Overview

Material Transfer was selected as a CTE due to the ability to transfer material within unit operations or from one unit operation to another is critical in the Sludge Treatment process. The sludge is to be transferred from the storage containers to a day tank and then to the corrosion vessel. The corroded sludge will then be transferred from the corrosion vessel to the IPAN vessel and from the IPAN vessel to the MOSS unit where it is grouted as the final product.

4.3.2.2 Critical Technology sub-Elements

The Sludge Treatment process critical technology sub-elements that are associated with transfer of specific process unit operations are provided in the below table. Each of these CTsE's are discussed below.

CRITICAL TECHNOLOGY ELEMENT		
CTE-02	**Material Mobilization**	**TRL-4**
Critical Technology sub-Elements		
CTsE-6	Ability to Transfer Sludge	TRL-4
CTsE-12.1	Corrosion Product Transfer Mechanics	TRL-4
CTsE-16.2	IPAN Product Retrieval (Pinch Valve)	TRL-4
CTsE-17.1	IPAN Product Transfer Mechanics	TRL-4
CTsE-17.2	IPAN Product Transfer Measurement	TRL-4

Table 5 CTE-02 Critical Technology sub-Elements

Sludge Transfer – The sludge transfer system was determined to be a critical technology since it must reliably transfer sludge at the desired concentration. This will require use of an instrument to accurately measure solids concentration and provide timely feedback into a control mechanism to maintain the desired concentration. The sludge will need to be maintained in suspension as it is transferred from K-West to the CVD facility to minimize the potential for plugging. Dilute sludge concentrations or excessive flush water contribute directly to more corrosion batches, which directly increases the cost and schedule of the project.

Corrosion Product Transfer Mechanics – Corrosion product transfer mechanics was determined to be a critical technology. The determination was based on the need to be able to transfer the corroded sludge without plugging the piping or the need for excessive flush water.

IPAN Product Retrieval (Pinch Valve) – The pinch valve was determined to be a critical technology. This determination was based primarily on the critical need to have the pinch valve open and allow the assayed sludge to flow to the suction of the metering pump, which feeds directly into a grout barrel. The pinch valve in the shut position must seal tightly or the suction of the metering pump may accumulate enough sludge to jam and stall the pump. The materials used in the pinch valve must be able to perform reliably (e.g., minimal radiation effect on valve materials - rubber diaphragm) as valve replacement would be very difficult.

IPAN Product Transfer Mechanics – IPAN product transfer mechanics was determined to be a critical technology based on the need to accurately transfer the sludge from the IPAN without hang up, plugging, or excessive flushing. After the transfer is complete the dosing head must not drip excessively.

IPAN Product Transfer Measurement – IPAN product transfer measurement was determined to be a Critical Technology primarily based on the importance of being able to meet the waste acceptance criteria for remote handled radiation limits and not create excessive barrels of low level grout, which would significantly increase cost and schedule.

4.3.2.3 Technology Readiness Level Determination

The overall CTE technology readiness level was determined to be at a TRL-4. This determination was primarily driven by past experience with the K-East to K-West Hose in Hose sludge transfer, and the testing performed on IPAN mixing and transfer.

Sludge Transfer – The ability to transfer sludge to the corrosion vessel was determined to be at a TRL-4 value. This determination was based on previous experience with the containerized sludge transfer from K-East Basin to K-West Basin. However, the basin to basin transfer failed to be able to produce or control the concentration in the desired range. The sludge transfer to the corrosion vessel requires an even higher concentration level. This will need to be demonstrated or a new mechanism to achieve the desired concentration demonstrated and implemented.

Corrosion Product Transfer Mechanics – Corrosion product transfer mechanics was determined to be at a TRL-4. This determination was based on previous sludge transfer operations and testing. However, the corroded sludge rheology is not well understood. A better understanding of the corroded sludge physical properties is necessary to take this element to a higher TRL value.

IPAN Product Retrieval (Pinch Valve) – The pinch valve was determined to be at a TRL-4. This determination was based on IPAN transfer testing performed where the pinch valve was used. Further testing will be required when the corroded sludge rheology is known to advance to higher TRLs.

IPAN Product Transfer Mechanics – The IPAN product transfer mechanics was determined to be at a TRL-4. This determination was based on IPAN sludge transfer testing that showed a simulant could be transferred, however, it is uncertain to what degree the simulant matched the corroded sludge rheology. Further testing will be required to advance to a higher TRL when the corroded sludge rheology is known.

IPAN Product Transfer Measurement – The IPAN product transfer measurement was determined to be at a TRL-4. This determination is based on IPAN transfer testing where volume measurement to a grout barrel was shown to be possible; however adequate control of the transfer was not verified. Many uncertainties still remain and significant testing still needs to be performed.

4.3.3 Process Chemistry

4.3.3.1 Overview

Process Chemistry was selected as a CTE because of the critical nature associated with the potential physical and chemical interactions and changes which may occur during the oxidation process of the Sludge Treatment process. Process chemistry includes thorough characterization of the various feed stocks, verification of the oxidation (corrosion) process chemistry and validation of processing parameters, including simulant preparation, operating parameters, etc. Process Chemistry is critical because a full and thorough understanding of this CTE is essential for supporting the maturation of several other CTEs, for developing a testable and effective design, and for ensuring that the overall STP can be constructed and operated with confidence.

4.3.3.2 Critical Technology sub-Elements

The STP critical technology sub-elements that are associated with the process chemistry are shown in the table below. Although only as single CTsE was identified, three distinct sub-elements were addressed. Each of these sub-elements is discussed below.

CRITICAL TECHNOLOGY ELEMENT		
CTE-03	**Process Chemistry**	**TRL-2**
Critical Technology sub-Elements		
CTsE-7	Process Chemistry	TRL-2
	Feed Stock Characterization	TRL-3
	Processing Parameters	TRL-2/3

Table 6 CTE-03 Critical Technology sub-Elements

<u>Process Chemistry</u> – The chemistry associated with the oxidation (corrosion) of the K Basins sludge materials was determined to be a critical technology. To date, extensive literature searches and laboratory experiments have focused on understanding and validating the oxidation of the metallic uranium which is contained within the sludge matrices. Limited testing has been performed on actual K Basins sludges at the proposed processing temperatures and pressures, and those tests which have been accomplished resulted in the formation of very thick, high shear strength products which could adversely affect the ability to operate the STP. Laboratory experiments to more fully understand the basic K Basin sludge oxidation chemistry, the affects of various trace constituents, and verification of the physical and chemical properties of the final

corrosion vessel product materials. These uncertainties significantly impact the technical readiness of several STP CTEs.

Feed Stock Characterization – Although an extensive data book has been prepared to support the STP, questions remain regarding the current physical and chemical composition of the various feedstreams. This is due in part to the consolidation of the K East sludge in the K West Basin and the physical changes which may have occurred during the transfer processes, e.g., particle fracturing, as well at the "blending" of the various sludge streams. Feed stock characterization may prove vital once a thorough understanding of the corrosion process chemistry has been developed, as trace constituents may be shown to have a significant impact on the corroded sludge product rheology.

Processing Parameters – The processing parameters affects on the process chemistry are not clearly understood. Additionally, the two fundamental parameters, i.e., temperature and pressure, has been established and modified on arbitrary and/or subjective decisions, e.g., to meet a specific process campaign duration. Processing parameters may have a significant effect on the design and operation of the STP and should be based on sound technical drivers.

4.3.3.3 Technology Readiness Level Determination

The overall Process Chemistry technology readiness level was determined to be a TRL-2. This determination was primarily driven by the technology maturity of the oxidation (corrosion) process chemistry.

Process Chemistry – The TRL for the oxidation (corrosion) process chemistry was determined to be at TRL-2. This determination is based on the completion of extensive literature searches and laboratory experiments which have focused on understanding and validating the oxidation of the metallic uranium which is contained within the sludge matrices. Additionally, only limited testing has been performed on actual K Basins sludges at the proposed processing temperatures and pressures, and those tests which have been accomplished resulted in more questions and uncertainties than answers. Thus, extensive testing remains to be completed to fully understand and validate the ability to use the STP for the oxidation of K Basins sludges.

Feed Stock Characterization – The TRL for the feed stock characterization was determined to be at TRL-3. This determination is based on the project's understanding of some of the physical characteristics of several of the sludge streams. The pumping, transfer and containerization activities which have been completed to date utilized engineered systems which accomplished specific size separation. However, questions remain regarding the current physical and chemical composition of the various feedstreams, especially with respect to the concentration of the various trace constituents may be shown to have a significant impact on the corroded sludge product rheology. Feed stock characterization may prove vital once a thorough understanding of the corrosion process chemistry has been developed.

Processing Parameters – The TRL for the STP processing parameters was determined to be at TRL-2/3. This determination is based on the project's understanding of some of the parameters associated with K Basin STP, e.g., the metallic uranium reaction rate. However, many of the processing parameters, including the two fundamental parameters, i.e., temperature and pressure, have not been technically developed and/or verified as valid for the STP.

4.3.4 Process Instrumentation

4.3.4.1 Overview

The Process Instrumentation category was identified as a CTE based on a) relevance to sludge corrosion process safety monitoring and b) significant influence on sludge transfer process efficiency. The overall TRL value supported for the Process Instrumentation CTE was a "4" (component and/or system validation in laboratory environment).

The assessment identified key process instrumentation categorized as Critical Technology Elements for the STP design. One instrumentation system/function was identified as necessary to maintain a safe operating environment while several systems were relied upon for effective control of portions of the STP process.

4.3.4.2 Critical Technology sub-Elements

The following table is a summary of critical technology sub-elements related to the Process Instrumentation CTE.

CRITICAL TECHNOLOGY ELEMENT		
CTE-04	**Process Instrumentation**	**TRL-4**
Critical Technology sub-Elements		
CTsE-5B	Feed Stream Concentration	TRL-4
CTsE-5E.2	Feed Stream Preparation (Day Tank)	TRL-4
CTsE-12.2	Corrosion Product Transfer Measurement	TRL-4
CTsE-13.2	Quench Vessel Off-gas Monitoring	TRL-4

Table 7 CTE-04 Critical Technology sub-Elements

Feed Stream Concentration - The current project baseline design includes a percent solids instrument and control system in the transfer line to the corrosion vessel. This process instrument and control system was determined to be a critical technology. This determination was primarily based on the need to accurately determine the solids concentration in the output of the sludge storage containers. This output is used to adjust dilution water injection to maintain the desired sludge concentration in the feed to the corrosion vessel.

Feed Stream Preparation (Day Tank) - The Day Tank, proposed as part of the enhanced project baseline, was determined to be a critical technology. A component of the Day Tank is the process instrumentation to determine the percent solids. The determination that percent solids process instrumentation for the Day Tank is a critical technology was primarily based on the need to accurately determine the solids concentration in the Day Tank in order to control the solids concentration process. This will ensure that the feed to the corrosion vessel is at the proper solids concentration.

Corrosion Product Transfer Measurement – The corrosion product transfer volume/mass flow-rate measurement was determined to be a critical technology. The determination that this was a critical technology was primarily based on the accuracy required in filling the IPAN vessel, a small vessel, but allowing for sufficient receiver tank space to flush the transfer line at the completion of the transfer. The volume/mass flow-rate instrument also provides critical data to the IPAN assay system.

Quench Vessel Off-gas Monitoring - The quench vessel off-gas monitoring system was determined to be a critical technology. Hydrogen and oxygen monitoring are required in the quench vessel off-gas to determine uranium corrosion reaction completion and ensure that the vessel is not in the flammable range to prevent a deflagration in the headspace.

4.3.4.3 Technology Readiness Level Determination

The overall CTE technology readiness level was determined to be at a TRL-4. This determination was driven by the technology maturity of all the process instrumentation critical sub-elements.

Feed Stream Concentration - The TRL level for the feed stream concentration instrument and control system was determined to be at a TRL-4 for the baseline case. This determination was based on the relevant experience in the KBCP's Hose-In-Hose (HIH) Sludge Transfer project. There were issues in controlling to the desired concentration in that project (1.8 volume percent). The desired concentration for the transfer to the corrosion vessel (up to 12 volume percent) is going to me more difficult to maintain and has not been demonstrated.

Feed Stream Preparation (Day Tank) - The TRL level for the Day Tank instrumentation, enhanced project baseline, was determined to be at a TRL-4. This determination was based on past experience in industrial applications of measuring solids concentration, but has not been demonstrated for this situation where there is significant variation in density, size, and concentration.

Corrosion Product Transfer Measurement - The TRL level for corrosion product volume and solids flow-rate instrumentation was determined to be at a TRL-4. This determination was based on past experience in industrial applications of measuring solids concentration, but has not been demonstrated for the relevant environment, where there is significant variation in density, size, and concentration.

Quench Vessel Off-gas Monitoring - The TRL level for quench vessel off-gas monitoring instrumentation for hydrogen and oxygen was determined to be at a TRL-4. This determination was based on wide-spread experience in industrial applications of measuring hydrogen and oxygen concentration. But, it apparently has not been demonstrated to operate reliably in the relevant environment, where there is significant moisture content in the off-gas.

4.3.5 Assay

4.3.5.1 Overview

Assay was selected as a CTE because of the critical nature associated with properly loading the waste drums so that the final waste package is WIPP certifiable. This requires that the IPAN Assay system be capable of verifying the radio-nuclide constituents and levels, and accurately determine the required amount of corroded sludge to be placed into each waste drum.

4.3.5.2 Critical Technology sub-Elements

The STP critical technology sub-elements that are associated with corroded sludge material assay are shown in the table below. Each of these sub-elements is discussed below.

CRITICAL TECHNOLOGY ELEMENT		
CTE-04	**Assay**	**TRL-2**
Critical Technology sub-Elements		
CTsE-15	IPAN Level Detection	TRL-3
CTsE-18	IPAN Assay/Detector System	TRL-2

Table 8 CTE-05 Critical Technology sub-Elements

IPAN Level Detection – The IPAN level detection is a vital part of the system's ability to accurately perform its calculations. The technology associated with the level detection system is a radar level measurement system that operates on the principle of Time Domain Reflectrometry (TDR). This technology works on the principle of the time of flight between a radar pulse being emitted from a transmitter to the time at which is received back at the transmitter. This technology has not been shown to perform with accuracy in an agitated vessel or with materials similar to the corroded sludge.

IPAN Assay/Detector System – The IPAN Assay/Detector system was determined to be a critical technology. This system is essential in establishing the radio-nuclide content and quantities in the corroded sludge material. This information is essential for determining the maximum amount of corroded sludge material to be placed into the waste drums to ensure that the final waste packages will be WIPP certifiable.

4.3.5.3 Technology Readiness Level Determination

The overall assay technology readiness level was determined to be a TRL-2. This determination was primarily driven by the technology maturity of the IPAN Assay/Detector system.

IPAN Level Detection – The TRL for the IPAN level detection system was determined to be at a TRL-3 level. This determination is based on the robustness and commercial use of the radar level measurement system and the fact that this technology has not been shown to perform with accuracy in an agitated vessel or with materials similar to the corroded sludge.

IPAN Assay/Detector System – The TRL for the IPAN Assay/Detector system was determined to be at a TRL-2 level. Although these detectors have been utilized in both DOE and commercial industry, their use has been limited to low level and contact handled materials, e.g., LLW waste drum and box counters. These detectors have not been tested or used in an environment similar to the IPAN vessel, which presents the following unique characteristics:

- Extremely high radiation levels
- Agitated vessel
- Self-shielding of corroded sludge materials
- Partially filled IPAN vessel.

Demonstration that the IPAN Assay/Detectors can operate reliably and accurately in the unique environment has not been accomplished.

4.3.6 Mixing

4.3.6.1 Overview

Mixing was selected as a CTE because of the critical nature of mixing process slurries in several unit operations of the Sludge Treatment process. Mixing/agitation is critical because it is plays an important role in effectively mobilize and transfer slurries from process tanks, ensuring the uranium oxidation reaction goes to completion, and enabling the final waste form to meet the waste acceptance criteria. The critical design variables that are needed to select the appropriate mixing technology are the rheology of the slurry that is to be mixed and the degree of mixing that is required for the unit operation to perform its function. To a large degree, the technology maturity level is based on the knowledge of these critical design variables and the degree of validation by testing/demonstration that the selected mixing technology will achieve the degree of mixing required.

4.3.6.2 Critical Technology sub-Elements

The Sludge Treatment process critical technology sub-elements that are associated with the mixing/agitation of specific process unit operations are provided in the below table. Each of these CTsE's are discussed below.

CRITICAL TECHNOLOGY ELEMENT		
CTE-06	**Mixing**	**TRL-2**
Critical Technology sub-Elements		
CTsE-5E.1	Feed Stream Preparation (Day Tank)	TRL-5
CTsE-8	Corrosion Vessel Mechanical Agitation	TRL-2
CTsE-14	IPAN Agitation	TRL-2
CTsE-20	Drum Mixing	TRL-6

Table 9 CTE-06 Critical Technology sub-Elements

Feed Stream Preparation (Day Tank) – The Day Tank, proposed as part of the enhanced project baseline, was determined to be a critical technology. A component of the Day Tank is the agitation of this tank. The determination that agitation of the Day Tank is a critical technology was primarily based on the ability to suspend slurries consisting of materials with significant variation in density, size, and concentration is an important process parameter. The ability to have a well mixed Day Tank will ensure that the amount of solids in the feed to the corrosion vessel is relatively uniform.

Corrosion Vessel Mechanical Agitation – The corrosion vessel mechanical agitation was determined to be a critical technology. This determination was primarily based on the unknown rheology properties of the corroded sludge matrix. This represents a different environment than has been previously demonstrated with mechanical agitation technology.

IPAN Agitation – The IPAN vessel mechanical agitation was determined to be a critical technology. This determination was primarily based on the unknown rheology properties of the corroded sludge matrix. This represents a different environment than has been previously demonstrated with mechanical agitation technology. Additionally, the degree of mixing required in the IPAN vessel in order to meet the assay system performance requirements is an important process parameter.

Drum Mixing – Drum mixing was determined to be a critical technology. This determination was primarily based on the importance of having a well mixed waste in order to meet waste acceptance criteria related to hot spots. The specific rheology properties for this waste form are not fully known so it represents a different environment for use of this technology.

4.3.6.3 Technology Readiness Level Determination

The overall CTE technology readiness level was determined to be at a TRL-2. This determination was primarily driven by the technology maturity of the corrosion vessel mechanical agitation and the IPAN agitation.

Feed Stream Preparation (Day Tank) – The TRL level for the Day Tank agitation was determined to be at a TRL-5. This determination was based on past experience in industrial applications of mixing of slurries with a significant variation in density, size, and concentration. However, the degree of variation in this application is potentially more extreme due to the density of uranium metal. The ability to suspend materials with this degree of variation in density has not been demonstrated.

Corrosion Vessel Mechanical Agitation – The TRL level for the corrosion vessel mechanical agitation was determined to be at a TRL-2. This determination was primarily based on the lack of rheology data for the corroded waste produced in the corrosion vessel. PNNL lab test results indicate the potential for extreme rheology properties under certain conditions. The validity of these conditions is not fully understood and needs to be the subject of prototypic testing (e.g., agitated sludge at process temperatures and pressures).

IPAN Agitation – The TRL level for the IPAN Vessel agitation was determined to be at a TRL-2. This determination was primarily based on the lack of rheology data for the corroded waste produced in the corrosion vessel. PNNL lab test results indicate the potential for extreme rheology properties under certain conditions. The validity of these conditions is not fully understood and needs to be the subject of prototypic testing (e.g., agitated sludge at process temperatures and pressures). Additionally, the degree of mixing required in the IPAN vessel in order to meet the assay system performance requirements have not been demonstrated.

Drum Mixing – The TRL level for drum mixing was determined to be at a TRL-6. This determination was based on the successful use of similar drum mixing technology in many other applications and the successful demonstration of drum mixing with the full-scale production unit.

4.3.7 Waste Package

4.3.7.1 Overview

The Waste Packaging critical technology element includes the waste drums (product container), Mobile Solidification System (MOSS) corroded product/grout drum filling methods with ability to confine/control contamination, decontamination of the product container, and ability to provide a WIPP certifiable waste package. These issues were rolled up to an overall Critical Technology Element concerning the overall Waste Package product of the STP process.

The MOSS subsystem has been successfully full scale tested in Europe for contact handled, low-level waste packaging consisting of contaminate resin beads of uniform shape, size and density. For the STP project, it is being used to package remote handled, transuranic waste in a slurry, semi-solid state, an application for which it has not been previously tested or demonstrated.

4.3.7.2 Critical Technology sub-Elements

CTE-07 is composed of the critical technology sub-elements. Each sub-element is discussed below.

CRITICAL TECHNOLOGY ELEMENT		
CTE-07	**Waste Package**	**TRL-4**
Critical Technology sub-Elements		
CTsE-19	Product Container	TRL-5/6
CTsE-21	Dosing Heads (Wet and Dry)	TRL-4
CTsE-22	WIPP Certifiable Waste Form	TRL-5/6
CTsE-24	Drum Decontamination	TRL-4

Table 10 CTE-07 Critical Technology sub-Elements

Product Container – The Product Container was identified as a critical technology sub-element because the container drum is modified from standard drum container design and the container design is critical to meet a WIPP certifiable waste form.

Dosing Head (wet and dry) – The wet and dry dosing heads were determined to be a critical technology. This determination was primarily based on the need for no contamination spread to outside of the product container in order to meet a WIPP certifiable waste form. The critical factor in ensuring that contamination does not migrate is the design of the wet and dry dosing heads.

WIPP Certifiable Waste Form – WIPP Certifiable Waste Form was identified as a critical technology sub-element due to uncertainties in requirements for what constitutes a "certifiable" waste form. These uncertainties can have a significant impact on the project cost and schedule.

Drum Decontamination – The ability to decontaminate a drum was determined to be a critical technology. This determination was primarily based on the need to meet the requirements for a WIPP certifiable waste form.

4.3.7.3 Technology Readiness Level Determination

The overall CTE technology readiness level was determined to be at a TRL-4. This determination was primarily driven by the technology maturity of the drum dosing heads (wet and dry) and the drum decontamination system.

Product Container – The TRL level for the product container was determined to be at a TRL-5/6. This determination was primarily based on testing of the full-scale production unit on surrogate materials as well as the successful use of similar drums to contain transuranic waste and meet WIPP waste acceptance criteria.

Dosing Head (wet and dry) – The TRL level for the wet and dry dosing heads was determined to be at a TRL-4. This determination was primarily based on the issues associated with the testing of the full-scale production unit and past MOSS operating experience. This information indicates that the design of the wet and dry dosing heads may not provide adequate containment of radionuclides.

WIPP Certifiable Waste Form – The TRL level for the ability to create a WIPP Certifiable Waste Form was determined to be at a TRL-5/6. This determination was primarily based on the fact that the end state requirements for WIPP certified waste packages have been developed and identified, but these requirements have not been integrated into the project. In addition, the ability to provide sufficient agitation of the product contents to ensure adequate mixing (for void volume and hot spot distribution) and final package decontamination (for acceptable surface contamination level) has not been adequately demonstrated. As a result, demonstrated capability that the packaging system can produce waste packages which can be certified for WIPP storage is incomplete.

Drum Decontamination – The TRL level for drum decontamination was determined to be at a TRL-4. This determination was primarily based on the degree of contamination a drum may be exposed to during filling has not been determined and the proposed technique for drum decontamination (remote decontamination with a manipulator arm) has not been demonstrated.

5.0 CONCLUSIONS

The STP TRA Team concluded that the critical technologies associated with the Sludge Treatment Project are not at the maturity level needed to support a CD-3 decision to procure and construct the sludge treatment process, unless additional risk was accepted by the DOE. This conclusion supports the recent Fluor Hanford recommendation and subsequent DOE-RL decision to re-baseline the Sludge Treatment Project to between CD-0 and CD-1.

A summary of the results of the TRA is provided in Table 11. The Technology Readiness Level (TRL) determined for each Critical Technology Element (CTE), as well as each Critical Technology sub-Element, is identified in this table. TRL values of TRL-2 (i.e., technology concept and/or application formulated) were determined for four CTEs, i.e., Material Mobilization, Mixing, Process Chemistry and Assay and TRL-4 (i.e., component and/or system validation in laboratory environment) for Material Transfer, Process Instrumentation and Waste Package. In many cases, a primary barrier to establishing higher TRLs relates to the unknowns associated with the physical properties of the containerized and/or the corroded sludge. This includes the unavailability of a legitimate simulant for testing and demonstration. Because the properties of the corroded sludge are not well understood, development of a range of simulants for testing and testing of the process using these simulants has not occurred. Therefore, laboratory scale testing with a high fidelity system has not yet been demonstrated.

The results also indicate that while the overall CTE may be at a low technology maturity level, there are several technology sub-elements at a higher maturity level (indicated by the blue high-lights). This indicates the need for a targeted maturation plan that focuses on those key technology gaps which, if addressed, will raise the technical readiness levels of the critical technologies.

The TRA process provides a useful methodology for determining the technology maturity levels for candidate technologies. Additionally, the resultant TRL that is determined is useful to provide relative comparisons between technologies and to identify technologies that need further efforts to reach an appropriate technology maturity level. However, to fully understand the overall effects on the project for a given TRL, it is necessary to complete the Technology Maturity Plan (TMP); for a candidate technology may be at a TRL-2, but could, with a relatively small effort, be advanced to a TRL-6. For this reason, the STP TRA Team is recommending that FH STP Technical Staff complete a detailed TMP, based on the results of this TRA.

Table 11 Sludge Treatment Process Critical Technology Element Technology Readiness Levels Summary

CRITICAL TECHNOLOGY ELEMENTS						
CTE-01	CTE-02	CTE-03	CTE-04	CTE-05	CTE-06	CTE-07
Material Mobilization	Material Transfer	Process Chemistry	Process Instrumentation	Assay	Mixing	Waste Package
Technology Readiness Level (TRL) Determination						
TRL-2	TRL-4	TRL-2	TRL-4	TRL-2	TRL-2	TRL-4
Critical Technology sub-Elements						
CTsE-1 KOP/Strainer Material Retrieval TRL-4	CTsE-6 Ability to Transfer Sludge TRL-4	CTsE-7 Process Chemistry TRL-2	CTsE-5B Feed Stream Concentration TRL-4	CTsE-15 IPAN Level Detection TRL-3	CTsE-5E.1 Feed Stream Preparation (Day Tank) TRL-5	CTsE-19 Product Container TRL-5/6
CTsE-2 Settler Tubes Material Retrieval TRL-3	CTsE-12.1 Corrosion Product Transfer Mechanics TRL-4	Feed Stock Characterization TRL-3	CTsE-5E.2 Feed Stream Preparation (Day Tank) TRL-4	CTsE-18 IPAN Assay/Detector System TRL-2	CTsE-8 Corrosion Vessel Mechanical Agitation TRL-2	CTsE-21 Dosing Heads (Wet and Dry) TRL-4
CTsE-3B Container/Settler Tubes Stored Sludge Retrieval TRL-6	CTsE-16.2 IPAN Product Retrieval (Pinch Valve) TRL-4	Processing Parameters TRL-2/3	CTsE-12.2 Corrosion Product Transfer Measurement TRL-4		CTsE-14 IPAN Agitation TRL-2	CTsE-22 WIPP Certifiable Waste Form TRL-5/6
CTsE-4B KOP/Strainer Material Retrieval from CON-101 TRL-2	CTsE-17.1 IPAN Product Transfer Mechanics TRL-4		CTsE-13.2 Quench Vessel Off-gas Monitoring TRL-4		CTsE-20 Drum Mixing TRL-6	CTsE-24 Drum Decontamination TRL-4
CTsE-4E KOP/Strainer Material Retrieval (Auger) TRL-4-5	CTsE-17.2 IPAN Product Transfer Measurement TRL-4					
CTsE-5E.3 Feed Stream Preparation (Day Tank) TRL-2						
CTsE-11 Corrosion Product Retrieval TRL-2						
CTsE-16.1 IPAN Product Retrieval TRL-2						

6.0 RECOMMENDED PATH FORWARD

The STP TRA Team was tasked to provide a recommended path forward. The below recommended path forward is intended to be a "rough cut" at the additional testing and demonstrations that need to be done in order to increase the maturity level of the subject technologies. This is not a detailed or a comprehensive plan, but rather a high level strategy of what needs to be done. Flour Hanford is expected to be tasked to develop a Technology Maturation Plan (TMP) for the sludge treatment process.

6.1 Technology Maturation Process

The technology maturation process consists of the use of a TRA-like process to determine the current maturity of the technology. The TMP then does a gap analysis by comparing the current maturity of the technology to the desired level of maturity to determine. The technology maturity gap is then analyzed to understand the programmatic risk and to determine the activities (e.g., additional tests, demonstrations, analyses) required to mature a given technology element to an acceptable level for deployment in the proposed environment. The TMP will include for each proposed activity the estimated costs, schedule and predecessor/successor activities, as well as the risk of not conducting the activity. The TMP will be used by the decision makers to determine the activities that need to be conducted prior to the CD-3 decision milestone.

6.2 Recommended Strategy

The STP TRA Team developed a "rough cut" technology maturation strategy, as shown in Figure 5, which is intended to identify the additional testing and demonstrations that need to be done in order to increase the maturity level of the subject technologies. This is not a detailed or a comprehensive plan, but rather a high level strategy of what the STP TRA Team believes remains to be done.

As can be seen from Figure 5, the key driver of technology maturity is the completion of corrosion process chemistry tests, IPAN detector system validation, and Settler Tubes material retrieval issues. The STP TRA Team believes that all testing and process validation should be prototypic in nature, utilizing actual waste and process conditions (e.g., agitated sludge at process temperatures and pressures). Completion of the tests under these conditions will ensure that a technical readiness level of TRL-6 can be achieved for all critical technology elements.

Recommended Technology Maturation Strategy

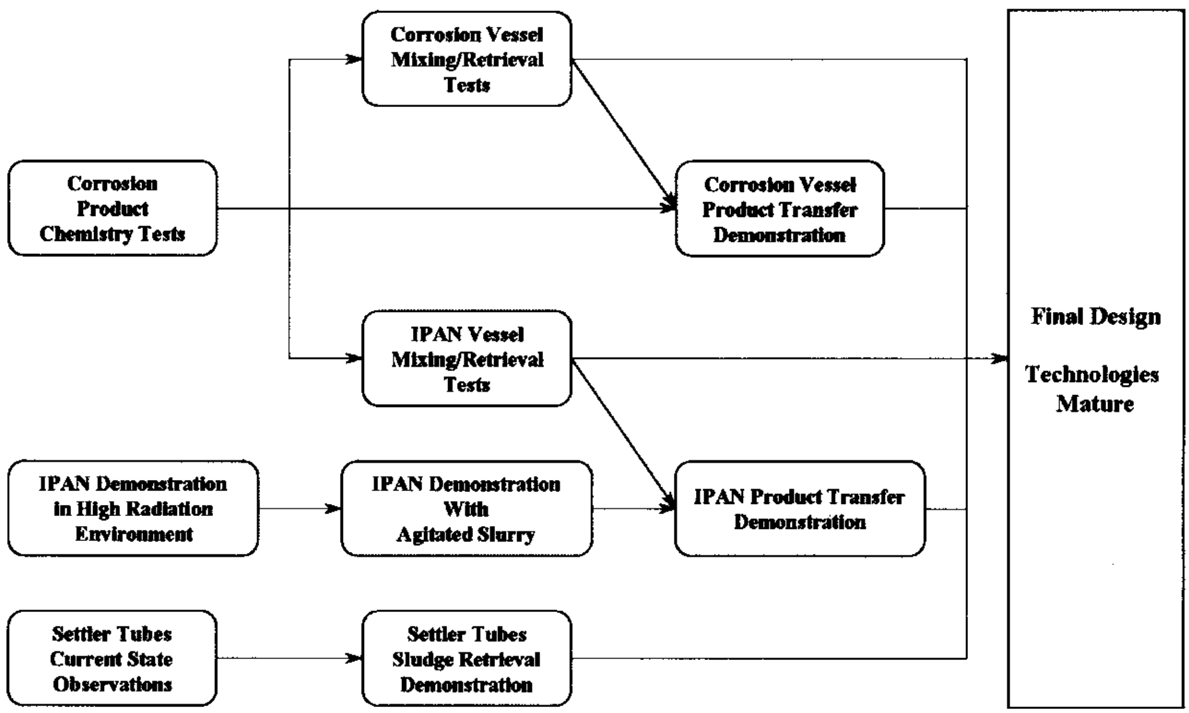

Figure 5. STP TRA Team Recommended Technology Maturation Strategy

7.0 REFERENCES

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General Accounting Office, Department of Energy, *Consistent Application of Requirements Needed to Improve Project Management,* GAO-07-518, May 2007

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8.0 DEFINITIONS

Technology Elements (TEs): Technology elements of the STP Project that have been identified and which should be evaluated to determine if they are Critical Technology Elements.

Critical Technology Elements (CTEs): Technology components which are essential to the successful function and operation the STP. A CTE may be comprised of a single component, a subsystem, a system, or a concept of use or function.

A technology element is "critical" if the functionality, operability, reliability or maintainability of the system depends on this technology element and/or if the technology element or its application is either new or novel. An element that is new or novel or is being used in a new or novel way is critical if it is necessary to achieve the successful development of a system, its acquisition, or its operation utility.

Technology Readiness Level (TRL): Numerical value/ranking system describing the maturity of a given technology element relative to the intended application in the deployment and operation of the STP project.

Technology Maturation Plan (TMP): Planned activities, including estimated costs, schedule and predecessors/successors required to mature a given technology element to an acceptable level for deployment in the proposed environment.

Appendix A

Critical Technology sub-Element Determination Work Sheets

Technology Element Number: TE-1

System: Retrieval/Mobilization

Technology Element: KOP/Strainer Material Retrieval

Technology Element Concerns/Issues:

- Tooling/Methodology for mobilizing material in the KOPs and Strainers is currently under-development.
- Material properties not verified.

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	KOP/Strainer is a feed stream. Retrieval of the material is necessary to complete the mission.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	Technology of material retrieval under development. Retrieval specific tooling dependent on the material properties.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Technology of material retrieval under development. Retrieval specific tooling dependent on the material properties.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements are understood. Technology used must completely clean out KOP and Strainers.
Question Set No. 2		
Is the Technology New or Novel?	No	Retrieval technology has been used previously.
Is the Technology modified?	No	Technology isn't modified.
Has the technology been repackaged so a new relevant environment is realized?	No	Technology not repackaged to work in intended environment.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Technology must be adapted for use in the KOP and Strainer environment. Material characteristics are unknown and may dictate refinements. Performance with this material not demonstrated.

Conclusion:

Is this a Critical Technology sub-Element?	Yes
If Yes, assign CTsE Number	CTsE-1

Technology Element Number: TE-2

System: Retrieval/Mobilization

Technology Element: Settler Tubes Material Retrieval

Technology Element Concerns/Issues:
- Tooling/Methodology for mobilizing material in the Settler Tubes is currently under-development.
- Material properties not verified

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Settler Tubes are a feed stream. Retrieval of the material is necessary to complete the mission.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	Technology of material retrieval under development. Retrieval specific tooling dependent on the material properties.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Technology of material retrieval under development. Retrieval specific tooling dependent on the material properties.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements are understood. Technology used must completely clean out Settler Tubes.
Question Set No. 2		
Is the Technology New or Novel?	No	Sluicing technology has been previously used for material retrieval from tanks and vessels.
Is the Technology modified?	No	Technology does not need to be modified for use in the Settler Tube environment.
Has the technology been repackaged so a new relevant environment is realized?	Yes	Technology must be repackaged for deployment in the Settler Tube environment. Remotely deployed, underwater, and contaminated environment.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Technology must be adapted for use in the Settler Tubes environment. Material characteristics are unknown and may dictate refinements. Performance with this material not demonstrated.

Conclusion:

Is this a Critical Technology sub-Element?	Yes
If Yes, assign CTsE Number	CTsE-2

Technology Element Number: TE-3B

System: Retrieval/Mobilization

Technology Element: Container and Settler Tubes Sludge Retrieval from Storage Containers

Technology Element Concerns/Issues:

- (Baseline) Bottom Retrieval approach.

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Retrieval of material from Containers is necessary to complete the mission.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	Technology demonstrated on KE containers showed incomplete removal and insufficient solid concentration control.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Technology demonstrated on KE containers showed incomplete removal and insufficient solid concentration control.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements are understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Technology used in KE Hose-In-Hose.
Is the Technology modified?	No	Technology would not need to be modified.
Has the technology been repackaged so a new relevant environment is realized?	Yes	Technology must be repackaged for deployment in the project. Container design was modified.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Technology Performance requirement beyond demonstrated capability.

Conclusion:

Is this a Critical Technology sub-Element? Yes
If Yes, assign CTsE Number CTsE-3B

Technology Element Number: TE-4B

System: Retrieval/Mobilization

Technology Element: KOP/Strainer Material Retrieval from Accumulation Tank (CON-101)

Technology Element Concerns/Issues:

- (Baseline)

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Retrieval from accumulation tank is necessary to complete the mission.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	Technology demonstrated on KE containers showed incomplete removal and insufficient solid concentration control.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Technology demonstrated on KE containers showed incomplete removal and insufficient solid concentration control.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements are understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Technology used in KE Hose-In-Hose.
Is the Technology modified?	No	Technology would not need to be modified.
Has the technology been repackaged so a new relevant environment is realized?	No	Technology does not need to be repackaged for deployment in the project.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Technology Performance requirement beyond demonstrated capability.

Conclusion:

Is this a Critical Technology sub-Element?	Yes
If Yes, assign CTsE Number	CTsE-4B

Technology Element Number: TE-5B

System: Feed stream

Technology Element: Feed Stream Concentration

Technology Element Concerns/Issues:
- (Baseline) Ability to measure
- Ability to control to desired concentration

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	No	Functional requirement not directly affected by use of this technology.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	Technology has not been demonstrated to meet the performance requirements of the project.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Technology limitation (i.e. less than desired concentrations) will increase processing time and schedule/cost.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements are understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Measurement and control technology is not new or novel.
Is the Technology modified?	No	Technology is not modified.
Has the technology been repackaged so a new relevant environment is realized?	Yes	Technology requires repackaging so a new relevant environment is realized.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Product measurement has not been demonstrated with the product (rheology of the product, materials of construction and gas retention).

Conclusion:

Is this a Critical Technology sub-Element? Yes
If Yes, assign CTsE Number CTsE-5B

Technology Element Number: TE-3E

System: Retrieval/Mobilization

Technology Element: Container Sludge Retrieval from Storage Containers

Technology Element Concerns/Issues:

- (Enhanced) Top Retrieval

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Retrieval of material from Containers is necessary to complete the mission.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	No	Technology demonstrated on KE HIH POP testing containers showed insufficient solid concentration control, however for this application, concentration control is not a factor.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	No	Technology demonstrated on KE HIH POP testing containers showed insufficient solid concentration control, however for this application, concentration control is not a factor.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements are understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Not new or novel.
Is the Technology modified?	No	Technology is not modified.
Has the technology been repackaged so a new relevant environment is realized?	No	Technology is not repackaged.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	No	Operational environment and performance are per original design and demonstrated capability

Conclusion:

Is this a Critical Technology sub-Element?	No
If Yes, assign CTsE Number	NA

Technology Element Number: TE-4E

System: Retrieval/Mobilization

Technology Element: KOP/Strainer Material Retrieval from Accumulation Tank (CON-101)

Technology Element Concerns/Issues:
- (Enhanced) Auger and Mobilization method.

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Retrieval from accumulation tank is necessary to complete the mission.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	No	Technology is well understood.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	No	Technology is well understood.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements are understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Auger technology is off the shelf.
Is the Technology modified?	No	No modification to existing technology.
Has the technology been repackaged so a new relevant environment is realized?	No	Technology has not been repackaged.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Technology has not been demonstrated in environment used.

Conclusion:

Is this a Critical Technology sub-Element? Yes
If Yes, assign CTsE Number CTsE-4E

Technology Element Number: TE-5E.1

System: Feed stream preparation

Technology Element: Feed Stream Preparation (Day Tank)

Technology Element Concerns/Issues:

- (Enhanced) Ability to establish and maintain a homogeneous mixture (norm and off norm)

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	No	Functional requirement not directly affected by use of this technology.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	Technology has not been demonstrated to meet the performance requirements of the project.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Technology limitation (i.e. less than desired concentrations) will increase processing time and schedule/cost.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements are understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Not new or novel technology.
Is the Technology modified?	No	Technology not modified.
Has the technology been repackaged so a new relevant environment is realized?	No	Technology has not been repackaged.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Demonstrated capability to suspend materials with significant variation in density, size, and concentration is unknown.

Conclusion:

Is this a Critical Technology sub-Element?	Yes
If Yes, assign CTsE Number	CTsE-5E.1

Technology Element Number: TE-5E.2

System: Feed stream preparation

Technology Element: Feed Stream Preparation (Day Tank)

Technology Element Concerns/Issues:

- (Enhanced) Ability to measure critical variables

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	No	Functional requirement not directly affected by use of this technology.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	Technology has not been demonstrated to meet the performance requirements of the project.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Technology limitation (i.e. less than desired concentrations) will increase processing time and schedule/cost.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements are understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Not new or novel technology.
Is the Technology modified?	No	Technology not modified.
Has the technology been repackaged so a new relevant environment is realized?	No	Technology has not been repackaged.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Technology used to measure concentration is under consideration and no decision made.

Conclusion:

Is this a Critical Technology sub-Element? Yes
If Yes, assign CTsE Number CTsE-5E.2

Technology Element Number: TE-5E.3

System: Feed stream preparation

Technology Element: Feed Stream Preparation (Day Tank)

Technology Element Concerns/Issues:

- (Enhanced) Ability to reach and maintain desired concentration,
- Ability to capture fine material without return to the basin.

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	No	Functional requirement not directly affected by use of this technology.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	Technology has not been demonstrated to meet the performance requirements of the project.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Technology limitation (i.e. less than desired concentrations) will increase processing time and schedule/cost.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements are understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Not new or novel technology.
Is the Technology modified?	No	Technology not modified.
Has the technology been repackaged so a new relevant environment is realized?	No	Technology has not been repackaged.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Demonstrated capability to decant to desired fine containment has not been demonstrated.

Conclusion:

Is this a Critical Technology sub-Element? Yes
If Yes, assign CTsE Number CTsE-5E.3

Technology Element Number: TE-6

System: Material Transfer

Technology Element: Sludge Transfer

Technology Element Concerns/Issues:
- Can material be maintained in suspension and transferred over the distance,
- Plugging of line/pumps, Line flushing
- Erosion of pumps,
- Pumps in series (hydraulic validation).

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Transfer to Corrosion Vessel is required to meet functional requirements of the project/system.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	Pumping characteristics (rheology) of material being pumped is not well understood.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Pumping characteristics (rheology) of material being pumped is not well understood.
Are there uncertainties in the definition of the end state requirements for this technology?	No	Ends state conditions are well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Pumping technology used is not new or novel.
Is the Technology modified?	No	Pumps are off the shelf technology.
Has the technology been repackaged so a new relevant environment is realized?	No	Pumps are used in relevant environment.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Pumps will move material beyond its demonstrated capability (e.g. material density concentration is beyond demonstrated capability).

Conclusion:

Is this a Critical Technology sub-Element? — Yes
If Yes, assign CTsE Number — CTsE-6

Technology Element Number: TE-7

System: Corrosion

Technology Element: Process Chemistry

Technology Element Concerns/Issues:

- Feedstock Characterization,
- Process Chemistry not well understood,
- Effects of processing parameters not well understood,
- DOE directed lower STP conditions untested.

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Corrosion of U metal is the main function of the system.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	Technology of the corrosion process not adequately understood. Additional testing is required to understand process and side effects.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Technology of the corrosion process not adequately understood. Additional testing is required to understand process and side effects.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state of U metal corrosion is well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Corrosion of U is not new/novel.
Is the Technology modified?	Yes	Corrosion is performed at a higher temperature than typical.
Has the technology been repackaged so a new relevant environment is realized?	Yes	Constituents contained within the sludge matrix presents a different environment than has been previously demonstrated.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Constituents contained within the sludge matrix presents a different environment than has been previously demonstrated.

Conclusion:

Is this a Critical Technology sub-Element? — Yes
If Yes, assign CTsE Number — CTsE-7

Technology Element Number: TE-8

System: Corrosion

Technology Element: Corrosion Vessel Mechanical Agitation

Technology Element Concerns/Issues:

- Is an agitator the correct tool for this application?
- Are agitation capabilities sufficient for normal and off-normal conditions?
- Effects on/from other corrosion vessel components;
- Reliability/Maintainability;
- Baffle side effects (material buildup, etc);
- Ability to make well mixed product (IPAN Feed).

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Agitation not required for U metal corrosion, however, agitation maybe required for product retrieval from the corrosion vessel.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	No	Agitation technology is well understood, however the use of mechanical agitation has not been validated for use with the sludge matrix.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Use of mechanical agitation has not been validated for use with the sludge matrix.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements are well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Agitation technology is not new or novel.
Is the Technology modified?	No	Agitation technology is not modified.
Has the technology been repackaged so a new relevant environment is realized?	No	Agitation technology has not been repackaged.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Sludge matrix presents a different environment than has been previously demonstrated with agitation technology.

Conclusion:

Is this a Critical Technology sub-Element? Yes
If Yes, assign CTsE Number CTsE-8

Technology Element Number: TE-9

System: Corrosion

Technology Element: Level Detection

Technology Element Concerns/Issues:
- Reliability & effectiveness under process conditions;
- Effects from corrosion vessel components and foaming.

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Corrosion Vessel product must be retrievable. Level detection is part of the overall process control system
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	No	Level Detection technology is well understood, however the use of the technology has not been validated for use with the sludge matrix.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	No	Level Detection technology is well understood, however the use of the technology has not been validated for use with the sludge matrix.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirement of the technology is well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Level Detection technology is not new or novel.
Is the Technology modified?	No	Level Detection technology is not being modified.
Has the technology been repackaged so a new relevant environment is realized?	No	Level Detection technology is not being repackaged for the process environment.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	No	Technology is being deployed in an environment which has previously been demonstrated.

Conclusion:

Is this a Critical Technology sub-Element? No
If Yes, assign CTsE Number N/A

Technology Element Number: TE-10

System: Corrosion

Technology Element: N2 Sparge Ring

Technology Element Concerns/Issues:

- Reliability & effectiveness under process conditions;
- Effects on/from other corrosion vessel components;
- Rationale for not including backup N2 to corrosion vessel.

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	N2 provides for continuous flow of gases/vapors out of the Corrosion Vessel. N2 also affects the reaction/corrosion of the sludge matrix. Provides cool down, oxygen removal, and dehydration.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	No	N2 sparging technology is well understood.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	No	N2 sparging technology is well understood.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements are well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Technology is not new or novel and is well demonstrated.
Is the Technology modified?	No	Technology is not modified for intended use.
Has the technology been repackaged so a new relevant environment is realized?	No	Technology has not been repackaged for intended use.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	No	N2 sparging is used within its demonstrated capability.

Conclusion:

Is this a Critical Technology sub-Element? No
If Yes, assign CTsE Number N/A

Technology Element Number: TE-11

System: Corrosion

Technology Element: Product Retrieval

Technology Element Concerns/Issues:
- Can material be maintained in suspension and retrieved from vessel?
- Ability to retrieve well mixed product (IPAN Feed)

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Retrieval of product from the Corrosion Vessel directly impacts function of the process.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	Uncertainties of the properties of the corroded product.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Uncertainties of the properties of the corroded product.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Corroded product is pumped by off the shelf positive displacement pump.
Is the Technology modified?	No	Corroded product is pumped by off the shelf positive displacement pump.
Has the technology been repackaged so a new relevant environment is realized?	No	Technology has not been repackaged for this application.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Product retrieval has not been demonstrated with the product (rheology of the product).

Conclusion:

Is this a Critical Technology sub-Element? Yes
If Yes, assign CTsE Number CTsE-11

Technology Element Number: TE-12.1

System: Corrosion

Technology Element: Product Transfer Mechanics

Technology Element Concerns/Issues:
- Potential plugging and plug clearing;
- Product solids settling in line/flushing;
- Effects on overall process due to flushing (how often, how much, where does it go. Etc.

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Transfer of the product from the Corrosion Vessel directly impacts function of the process.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	Uncertainties of the properties of the corroded product.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Uncertainties of the properties of the corroded product.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Corroded product is pumped by off the shelf positive displacement pump.
Is the Technology modified?	No	Corroded product is pumped by off the shelf positive displacement pump.
Has the technology been repackaged so a new relevant environment is realized?	No	Technology has not been repackaged for this application.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Product retrieval has not been demonstrated with the product (rheology of the product).

Conclusion:

Is this a Critical Technology sub-Element? Yes
If Yes, assign CTsE Number CTsE-12.1

Technology Element Number: TE-12.2

System: Corrosion

Technology Element: Product Transfer Measurement

Technology Element Concerns/Issues:

- Volume/Mass meter (corriolis meter)

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Measurement of the products volume/mass/density used as input into IPAN
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	No	Measurement technology will not significantly impact schedule.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	No	Measurement technology will not significantly impact cost.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Measurement technology is not new or novel.
Is the Technology modified?	No	Measurement technology does not need to be modified.
Has the technology been repackaged so a new relevant environment is realized?	No	Measurement technology does not need to be repackaged for this environment.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Product measurement has not been demonstrated with the product (rheology of the product and gas entrainment).

Conclusion:

Is this a Critical Technology sub-Element? Yes
If Yes, assign CTsE Number CTsE-12.2

Technology Element Number: TE-13.1

System: Corrosion

Technology Element: Quench Vessel

Technology Element Concerns/Issues:

- Cool off-gas from Corrosion Vessel and condense vapors.

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Functional requirement to treat off gas and water from process.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	No	Cooling technology is well understood.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	No	Cooling technology is well understood.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements are well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Quenching technology is not new or novel.
Is the Technology modified?	No	Quenching technology is not modified.
Has the technology been repackaged so a new relevant environment is realized?	No	Quenching technology does not need to be repackaged for process environment.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	No	Quenching technology is well demonstrated.

Conclusion:

Is this a Critical Technology sub-Element?	No
If Yes, assign CTsE Number	N/A

Technology Element Number: TE-13.2

System: Corrosion

Technology Element: Quench Vessel Off-gas Monitoring

Technology Element Issue/Concern:
- Hydrogen and Oxygen monitoring instrumentation/detectors.

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Monitoring Quench Vessel off-gas for Hydrogen and Oxygen is required to comply with NFPA-69.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	No	Technology is well understood.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	No	Technology is well understood.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements are well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	The technology is not new or novel.
Is the Technology modified?	No	The technology is not expected to be modified.
Has the technology been repackaged so a new relevant environment is realized?	Yes	The technology will be deployed in a very moist environment.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	The technology will be expected to operate in an environment and achieve performance beyond its original design.

Conclusion:

Is this a Critical Technology sub-Element?	Yes
If Yes, assign CTsE Number	CTsE-13.2

Technology Element Number: TE-14

System: IPAN

Technology Element: Agitation

Technology Element Concerns/Issues:

- Agitation capabilities sufficient for norm and off-norm conditions;
- Effects on/from other vessel components;
- Reliability/Maintainability;
- Baffle side effects (material buildup, etc);
- Ability to make homogeneous product (IPAN Product).

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Agitation affects value of the assay and uniformity of the product that goes into the drum.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	IPAN Agitation technology is not sufficiently understood and could impact project schedule.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	IPAN Agitation technology is not sufficiently understood and could impact project cost.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirement is for homogeneous product.
Question Set No. 2		
Is the Technology New or Novel?	No	Agitation technology is not new or novel.
Is the Technology modified?	No	Agitation technology is not modified.
Has the technology been repackaged so a new relevant environment is realized?	No	Agitation technology has not been repackaged.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Sludge matrix presents a different environment than has been previously demonstrated with agitation technology.

Conclusion:

Is this a Critical Technology sub-Element? Yes
If Yes, assign CTsE Number CTsE-14

Technology Element Number: TE-15

System: IPAN

Technology Element: Level Detection

Technology Element Concerns/Issues:

- Reliability & effectiveness under process conditions;
- Effects from IPAN vessel components and foaming

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Level Detector provides an operational functional requirement for the process. In addition, vessel is vented to the atmosphere.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	No	Level Detection technology is well understood, however the use of the technology has not been validated for use with the sludge matrix.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	No	Level Detection technology is well understood, however the use of the technology has not been validated for use with the sludge matrix.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirement of the technology is well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Level Detection technology is not new or novel.
Is the Technology modified?	No	Level Detection technology is not being modified.
Has the technology been repackaged so a new relevant environment is realized?	No	Level Detection technology is not being repackaged for the process environment.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Technology is being deployed in an environment which has not been previously been demonstrated and may require a level of accuracy that the technology can not provide.

Conclusion:

Is this a Critical Technology sub-Element?	Yes
If Yes, assign CTE Number	CTsE-15

Technology Element Number: TE-16.1

System: IPAN

Technology Element: Product Retrieval

Technology Element Concerns/Issues:

- Can material be maintained in suspension and provide ability to retrieve well mixed product (IPAN Product).

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Retrieval of product from the IPAN Vessel directly impacts function of the process.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	Uncertainties of the properties of the corroded product.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Uncertainties of the properties of the corroded product.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Corroded product is pumped by off the shelf positive displacement pump.
Is the Technology modified?	No	Corroded product is pumped by off the shelf positive displacement pump.
Has the technology been repackaged so a new relevant environment is realized?	Yes	Technology is repackaged to work in a high radiation environment, but has not been demonstrated in this application
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Product retrieval has not been demonstrated with the product (rheology of the product).

Conclusion:

Is this a Critical Technology sub-Element? Yes
If Yes, assign CTsE Number CTsE-16.1

Technology Element Number: TE-16.2

System: IPAN

Technology Element: Product Retrieval

Technology Element Concerns/Issues:

- Pinch valve materials of construction.

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Retrieval of product from the IPAN Vessel directly impacts function of the process.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	Uncertainties of the properties of the corroded product.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Uncertainties of the properties of the corroded product.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Corroded product is pumped by off the shelf positive displacement pump.
Is the Technology modified?	No	Corroded product is pumped by off the shelf positive displacement pump.
Has the technology been repackaged so a new relevant environment is realized?	Yes	Technology is repackaged to work in a high radiation environment, but has not been demonstrated in this application
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Product retrieval has not been demonstrated with the product (rheology of the product).

Conclusion:

Is this a Critical Technology sub-Element? Yes
If Yes, assign CTsE Number CTsE-16.2

Technology Element Number: TE-17.1

System: IPAN

Technology Element: Product Transfer Mechanics

Technology Element Concerns/Issues:

- Potential plugging and plug clearing;
- Product solids settling in line/flushing;
- Effects on overall process due to flushing (how often, how much, where does it go. Etc);
- Elevation changes may be of concern.

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Transfer of the product from the IPAN Vessel directly impacts function of the process.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	Uncertainties of the properties of the corroded product.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Uncertainties of the properties of the corroded product.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Corroded product is pumped by off the shelf positive displacement pump.
Is the Technology modified?	No	Corroded product is pumped by off the shelf positive displacement pump.
Has the technology been repackaged so a new relevant environment is realized?	No	Technology has not been repackaged for this application.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Product retrieval has not been demonstrated with the product (rheology of the product).

Conclusion:

Is this a Critical Technology sub-Element?	Yes
If Yes, assign CTsE Number	CTsE-17.1

Technology Element Number: TE-17.2

System: IPAN

Technology Element: Product Transfer Measurement

Technology Element Concerns/Issues:

- Ability to precisely meter desired amount of product.

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Precision metering of the products into MOSS Wet Dose Head.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	No	Measurement technology will not significantly impact schedule.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	No	Measurement technology will not significantly impact cost.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Measurement technology is not new or novel.
Is the Technology modified?	Yes	Measurement technology needs to be modified to operate in the process.
Has the technology been repackaged so a new relevant environment is realized?	No	Measurement technology does not need to be repackaged for this environment.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Product measurement has not been demonstrated with the product (rheology of the product) or for the intended operation.

Conclusion:

Is this a Critical Technology sub-Element? — Yes
If Yes, assign CTsE Number — CTsE-17.2

Technology Element Number: TE-18

System: IPAN

Technology Element: Assay/Detector System

Technology Element Concerns/Issues:

- Software,
- Use in high radiation/RH environments,
- sludge self-shielding,
- partial filled vessel;
- Deployment in agitated.

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Technology used to determine acceptable amount of product to place in drum and records constituents of product.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	Technology has never been demonstrated in process environment.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Technology has never been demonstrated in process environment. Bad data can result in significant costs.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements are well known.
Question Set No. 2		
Is the Technology New or Novel?	No	Technology is not new or novel.
Is the Technology modified?	Yes	Technology has been modified to operate in intended process environment.
Has the technology been repackaged so a new relevant environment is realized?	Yes	Technology has been repackaged to operate in intended environment.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Technology has not been demonstrated in intended environment. Intended environment is beyond original designed intent.

Conclusion:

Is this a Critical Technology sub-Element? Yes
If Yes, assign CTsE Number CTsE-18

Technology Element Number: TE-19

System: MOSS

Technology Element: Product Container

Technology Element Concerns/Issues:

- Overall container design;
- Material compatibility of waste package and ability to support exterior decontamination;

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Technology required for final product waste form and packaging.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	No	Product container technology well understood.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	No	Product container technology well understood.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Product container technology is not new and novel.
Is the Technology modified?	No	Product container technology has not been modified from standard drum containers.
Has the technology been repackaged so a new relevant environment is realized?	Yes	Product container technology is repackaged to work within MOSS.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Product container technology is utilized in an environment beyond standard drum container usage (Interior coating compatibility with waste form) and has not been demonstrated.

Conclusion:

Is this a Critical Technology sub-Element? Yes
If Yes, assign CTsE Number CTsE-19

Technology Element Number: TE-20

System: MOSS

Technology Element: Drum Mixing

Technology Element Concerns/Issues:

- Uniform waste matrix in Container (Hot Spot concerns).

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Acceptance criteria for Hot Spots contained in functional requirements.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	No	Mixing technology should not affect project schedule.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Uncertainties regarding mixing and Hot Spot mitigation can result in higher costs.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements are well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Mixing technology is not new or novel.
Is the Technology modified?	No	Mixing technology is not modified.
Has the technology been repackaged so a new relevant environment is realized?	No	Mixing technology will not need to be repackaged to operate in a remote, high radiation environment.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Technology has not been demonstrated with this waste form.

Conclusion:

Is this a Critical Technology sub-Element? Yes
If Yes, assign CTsE Number CTsE-20

Technology Element Number: TE-21

System: MOSS

Technology Element: Dosing Head (wet and dry)

Technology Element Concerns/Issues:
- Contamination Control/Confinement;
- Demonstrate that ventilation pipe provides appropriate protection from airborne releases.

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Technology required to place product in product container and grout in product container.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	Lack of understanding of Technology and associated contamination control can impact project schedule.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Lack of understanding of Technology and associated contamination control can impact project costs.
Are there uncertainties in the definition of the end state requirements for this technology?	Yes	End state requirements are not well understood (Contamination Control levels for Dosing head not yet established)
Question Set No. 2		
Is the Technology New or Novel?	No	Technology used previously.
Is the Technology modified?	Yes	Technology has been modified.
Has the technology been repackaged so a new relevant environment is realized?	Yes	Dosing head use in drum filling has been modified to perform in project environment, i.e. remote handled, TRU wastes.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Technology is expected to operate in an environment for which it does not have demonstrated capability.

Conclusion:

Is this a Critical Technology sub-Element? Yes
If Yes, assign CTsE Number CTsE-21

Technology Element Number: TE-22

System: MOSS

Technology Element: WIPP Certifiable Waste Form

Technology Element Concerns/Issues:

- Verify ability to produce a WIPP certifiable waste package;

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Acceptable waste form for WIPP path is a functional requirement.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	No	Waste Form Technology is well understood.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	WIPP Certification requirements for packaged waste have not been identified and integrated into the project.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state requirements exist but are not integrated into the project.
Question Set No. 2		
Is the Technology New or Novel?	No	Waste Form technology is not new or novel.
Is the Technology modified?	No	It is unclear at this time if the technology has been modified.
Has the technology been repackaged so a new relevant environment is realized?	No	It is unclear at this time if the technology has been repackaged.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	There has been no demonstration that a WIPP certifiable waste can be generated.

Conclusion:

Is this a Critical Technology sub-Element? Yes
If Yes, assign CTsE Number CTsE-22

Technology Element Number: TE-23

System: MOSS

Technology Element: Automated Drum Positioning

Technology Element Concerns/Issues:

- Automated nature in RH environment,
- Mechanical alignment of mixer, dosing heads, trolley, monorail, etc.

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Remote operations requires automated drum handling
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	No	Drum handling is a well established technology.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	No	Drum handling is a well established technology.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End State is well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Drum positioning is well understood technology.
Is the Technology modified?	No	Drum positioning technology has not been modified.
Has the technology been repackaged so a new relevant environment is realized?	No	Drum positioning has been previous performed in remote environments.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	No	Not beyond capabilities or design intention

Conclusion:

Is this a Critical Technology sub-Element? No
If Yes, assign CTsE Number N/A

Technology Element Number: TE-24

System: Drum Handling

Technology Element: Drum Decontamination

Technology Element Concerns/Issues:

- Verify ability to perform remote decontamination to acceptable levels

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Ability to perform remote decontamination to acceptable levels is necessary to meet Packaged Drum Acceptance Requirements.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Yes	Immaturity of design of decontamination methodology. Technology (decontamination solutions, etc.) has not been selected.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	Yes	Immaturity of design of decontamination methodology. Technology has not been selected.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state is well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Although the technology has not yet been selected, it is anticipated that an off-the-shelf technology will be utilized.
Is the Technology modified?	No	Although the technology has not yet been selected, it is anticipated that an off-the-shelf technology will be utilized.
Has the technology been repackaged so a new relevant environment is realized?	No	Although the technology has not yet been selected, it is anticipated that an off-the-shelf technology will be utilized.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Yes	Technology has not been selected and therefore specific demonstrated capabilities, i.e., deployment in a remote environment and/or from a Master Slave Manipulator, are unknown.

Conclusion:

Is this a Critical Technology sub-Element? Yes
If Yes, assign CTsE Number CTsE-24

Technology Element Number: TE-25

System: MOSS

Technology Element: Cement Feed System

Technology Element Concerns/Issues:

- Dust handling, Bridging/Plugging Concern

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Cement feed and dust handling is essential for grouting of drums.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	No	Cement feed and dust handling is well understood technology.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	No	Cement feed and dust handling is well understood technology.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state is well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Cement feed and dust handling is well understood technology.
Is the Technology modified?	No	Cement feed and dust handling is well understood technology.
Has the technology been repackaged so a new relevant environment is realized?	No	Cement feed and dust handling is well understood technology.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	No	Cement feed and dust handling is well understood technology.

Conclusion:

Is this a Critical Technology sub-Element? No
If Yes, assign CTsE Number N/A

Technology Element Number: TE-26

System: Drum Handling

Technology Element: Automated Drum Handling

Technology Element Concerns/Issues:

- Automated nature in RH environment

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Ability to perform automated drum handling is essential
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	No	Automated drum handling is well understood technology.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	No	Automated drum handling is well understood technology.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state is well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Automated drum handling is well understood technology.
Is the Technology modified?	No	Automated drum handling is well understood technology.
Has the technology been repackaged so a new relevant environment is realized?	No	Automated drum handling is well understood technology.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	No	Automated drum handling is well understood technology.

Conclusion:

Is this a Critical Technology sub-Element? No
If Yes, assign CTsE Number N/A

Technology Element Number: TE-27

System: Drum Loadout

Technology Element: Drum Integrity

Technology Element Concerns/Issues:

- Environmental Effects (Water intrusion)

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Waste package acceptance criteria must be met.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	No	Ensuring drum integrity is well understood.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	No	Ensuring drum integrity is well understood.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state is well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Although not specified, it is anticipated that no new or novel technology will be required.
Is the Technology modified?	No	Although not specified, it is anticipated that no modification of a technology will be required.
Has the technology been repackaged so a new relevant environment is realized?	No	Although not specified, it is anticipated that a technology will not be repackaged so a new relevant environment is realized.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	No	Although not specified, it is anticipated that a technology will not operate in an environment or achieve performance beyond its original design intention.

Conclusion:

Is this a Critical Technology sub-Element? No
If Yes, assign CTsE Number N/A

Technology Element Number: TE-28

System: Drum Loadout

Technology Element: Drum handling associated with Cask Loading

Technology Element Concerns/Issues:

- ALARA Considerations, Sky shine and personal protection not adequately addressed

CTE Question	Yes/No	Rationale
Question Set No. 1		
Does the technology directly impact a functional requirement of the process or facility?	Yes	Design is immature and although no specified, it is anticipated that a technology will not be repackaged so a new relevant environment is realized.
Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	No	Design is immature and although no specified, it is anticipated that a technology will chosen which does not result in potential schedule risks.
Do limitations in the understanding of the technology result in a potential cost risk, i.e., the technology may cause significant cost overruns?	No	Design is immature and although no specified, it is anticipated that a technology will chosen which does not result in potential cost risks.
Are there uncertainties in the definition of the end state requirements for this technology?	No	End state is well understood.
Question Set No. 2		
Is the Technology New or Novel?	No	Design is immature and although no specified, it is anticipated that a technology will not be new or novel.
Is the Technology modified?	No	Design is immature and although no specified, it is anticipated that a technology will not be modified.
Has the technology been repackaged so a new relevant environment is realized?	No	Design is immature and although no specified, it is anticipated that a technology will not be repackaged so a new relevant environment is realized.
Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	No	Design is immature and although no specified, it is anticipated that a technology will not be expected to operate in an environment or achieve performance beyond its original design intention.

Conclusion:

Is this a Critical Technology sub-Element?	No
If Yes, assign CTsE Number	N/A

Appendix B

Technology Readiness Level Determination Lines of Inquiry

The Technology Readiness Level (TRL) was determined for each Critical Technology Element (CTE). These TRLs were determined by performing a "finding-of-fact" evaluation to establish each CTE's technical maturity. These evaluations were completed by validating the specific lines of inquiry for each TRL.

Since each CTE consisted of several CTsEs, it was recognized that there may be several TRL values within the CTE under consideration. The individual Critical Technology sub-Elements' TRLs were determined subjectively, through consensus, by the STP TRA Team. The overall TRL established for the specific CTE was determined by completing the specific lines of inquiry for the most immature CTsE(s).

The following provides the completed evaluations for each CTEs. Only the final two, highest maturity levels, lines of inquiry are provided, i.e., the one validating the determined TRL value and the next higher one showing the items currently remaining unresolved. Lines of inquiry (criteria) which received a "No" response have been hi-lighted in yellow.

Critical Technology Element

Technology Readiness Level Determination

CTE-01 Material Mobilization

Applicable Critical Technology sub-Elements (CTsE)

CTsE-01	**KOP Material Retrieval**	Tooling/Methodology for mobilizing material in the KOPs and Strainers is currently under-development. Material properties not verified
CTsE-02	**Settler Tubes Material Retrieval**	Tooling/Methodology for mobilizing material in the Settler Tubes is currently under-development. Material properties not verified.
CTsE-03B	**Storage Container Bottom Retrieval**	(Baseline) Bottom Retrieval approach.
CTsE-4B	**KOP Accumulation Tank Material Mobilization**	(Baseline)
CTsE-4E	**KOP Accumulation Tank Material Mobilization (Auger)**	(Enhanced) Auger and Mobilization method.
CTsE-5E.3	**Feed Stream Preparation (Day Tank)**	(Enhanced) Ability to reach and maintain desired concentration, Ability to capture fine material without return to the basin.
CTsE-11	**Corrosion Vessel Product Retrieval**	Can material be maintained in suspension and retrieved from vessel? Ability to retrieve well mixed product (IPAN Feed)
CTsE-16.1	**IPAN Product Retrieval**	Can material be maintained in suspension and provide ability to retrieve well mixed product (IPAN Product).

Technology Readiness Level Established

TRL-02 **Technology Concept and/or Application Formulated**

TRL 2 Question Set

T/P/M	Y/N (N/A)	Criteria	Basis
T-2.1	Yes	Potential system or components have been identified	1. DWG-5477-PR-R-0001-01, Sludge Retrieval & Transfer PFD 2. DWG-5477-PR-R-0001-02, Sludge Retrieval & Transfer PFD 3. DWG-5477-PR-T-0001-01, Sludge Treatment PFD 4. DWG-5477-PR-T-0103-01, Assay P&ID 5. DWG-5477-PR-T-0102-01, Corrosion P&ID 6. DWG-5477-PR-R-0101-05, Sludge Retrieval & Transfer P&ID 7. DWG-5477-PR-R-0101-04, Sludge Retrieval & Transfer P&ID 8. DWG-5477-PR-R-0101-03, Sludge Retrieval & Transfer P&ID 9. DWG-5477-PR-R-0101-02, Sludge Retrieval & Transfer P&ID 10. DWG-5477-PR-R-0101-01, Sludge Retrieval & Transfer P&ID 11. CALC-5477-PR-T-0004, Sizing of Sludge Corrosion Vessel (TRT-K-01)
T-2.2	Yes	Paper studies show that application is feasible	*1.* CALC-5477-PR-R-0002, *Sizing of KOP Sludge Accumulation Container (RET-CON-101)* 2. CALC-5477-PR-T-0004, *Sizing of Sludge Corrosion Vessel (TRT-K-01)*
T-2.3	Yes	An apparent theoretical or empirical design solution identified	*1.* SD-5477-PR-R-0001, *Sludge Retrieval and Transfer System Description* *2.* CALC-5477-PR-R-0002, *Sizing of KOP Sludge Accumulation Container (RET-CON-101)* 3. CALC-5477-PR-T-0004, *Sizing of Sludge Corrosion Vessel (TRT-K-01)*
T-2.4	Yes	Basic elements of technology have been identified	*1.* SD-5477-PR-R-0001, *Sludge Retrieval and Transfer System Description* 2. CALC-5477-PR-T-0004, *Sizing of Sludge Corrosion Vessel (TRT-K-01)*
T-2.5	Yes	Desktop environment (paper studies)	RPT-5477-EG-G-0009, *Cavitation in Agitated Vessels*
T-2.6	Yes	Components of technology have been partially characterized	RPT-5477-EG-G-0009, *Cavitation in Agitated Vessels*

T/P/M	Y/N (N/A)	Criteria	Basis
T-2.7	Yes	Performance predictions made for each element	1. CALC-5477-PR-R-0002, *Sizing of KOP Sludge Accumulation Container (RET-CON-101)* 2. CALC-5477-PR-T-0004, *Sizing of Sludge Corrosion Vessel (TRT-K-01)*
T-2.8	Yes	Initial analysis shows what major functions need to be done	CALC-5477-PR-T-0004, *Sizing of Sludge Corrosion Vessel (TRT-K-01)*
T-2.9	Yes	Modeling & Simulation used to verify physical principles	1. CALC-5477-PR-R-0002, *Sizing of KOP Sludge Accumulation Container (RET-CON-101)* 2. CALC-5477-PR-T-0004, *Sizing of Sludge Corrosion Vessel (TRT-K-01)*
T-2.10	Yes	Analytical studies confirm basic principles	Agitation and sluicing are generally accepted methodology to mobilize insoluble solid material in a water matrix
T-2.11	Yes	Analytical studies reported in scientific journals/conference proceedings/technical reports.	Agitation and sluicing are generally accepted methodology to mobilize insoluble solid material in a water matrix
T-2.12	Yes	Individual parts of the technology work (No real attempt at integration)	CALC-5477-PR-T-0004, *Sizing of Sludge Corrosion Vessel (TRT-K-01)*
T-2.13	Yes	Know what output devices are available	
T-2.14	Yes	The scope and scale of the waste problem has been determined	KBC-28475, *Sludge Treatment Project/Integrated Test Plan*
T-2.15	Yes	Know what experiments are required (research approach)	KBC-28475, *Sludge Treatment Project/Integrated Test Plan*
P-2.1	Yes	System architecture defined in terms of major functions to be performed	1. SD-5477-PR-R-0001, *Sludge Retrieval and Transfer System Description* 2. CALC-5477-PR-R-0002, *Sizing of KOP Sludge Accumulation Container (RET-CON-101)* 3. CALC-5477-PR-T-0004, *Sizing of Sludge Corrosion Vessel (TRT-K-01)* 4. SP-5477-EG-G-0107, *KBCSP Vessel Agitator Design and Fabrication Specification*
P-2.2	Yes	Know capabilities and limitations of researchers and research facilities	KBC-28475, *Sludge Treatment Project/Integrated Test Plan*

T - Technology, technical aspects
M - Manufacturing and quality
P - Programmatic, Customer Focus, Documentation
N/A – Criteria which does not apply to the Sludge Treatment Process

TRL 3 Question Set

T/P/M	Y/N (N/A)	Criteria	Basis
T-3.1	Yes	Some key process requirements are identified	1. KBC-24540, *STP Functional Design Criteria* 2. HNF-20135, *STP Functional Requirements Document* 3. SD-5477-PR-R-0001, *Sludge Retrieval and Transfer System Description* 4. RPT-5477-EG-G-0116, *K Basin Closure Stabilization and Packaging Project - Evaluation of and Response to Independent Engineering Reviews of the Design for K Basins Sludge Retrieval and Treatment*
T-3.2	No	Predictions of elements of technology capability validated by analytical studies	Analytical studies have not been completed to validate the elements of the technology's capabilities
T-3.3	Yes	Science known to extent that mathematical and/or computer models and simulations are possible	Agitation and sluicing are generally accepted methodology to mobilize insoluble solid material in a water matrix
T-3.4	No	Predictions of elements of technology capability validated by Modeling and Simulation (M&S)	Limited testing in progress (i.e., KOP auger system for retrieving KOP material from the KOP accumulation tank).
T-3.5	No	Laboratory experiments verify feasibility of application	Limited testing in progress (i.e., KOP auger system for retrieving KOP material from the KOP accumulation tank).
T-3.6	No	Predictions of elements of technology capability validated by laboratory experiments	Limited testing in progress (i.e., KOP auger system for retrieving KOP material from the KOP accumulation tank).
T-3.7	Yes	Key process parameters/variables have begun to be identified.	RPT-5477-EG-G-0116, *K Basin Closure Stabilization and Packaging Project - Evaluation of and Response to Independent Engineering Reviews of the Design for K Basins Sludge Retrieval and Treatment.*
T-3.8	Yes	Paper studies indicate that system components ought to work together	SD-5477-PR-R-0001, *Sludge Retrieval and Transfer System Description*
T-3.9	Yes	Performance metrics for the system are established (What must it do)	SP-5477-EG-G-0107, *KBCSP Vessel Agitator Design and Fabrication Specification*

T/P/M	Y/N (N/A)	Criteria	Basis
T-3.10	No	Scaling studies have been started	1. KOP Accumulation Tank Retrieval Proof-of-Principle Testing 2. TSRT-0105455-RT-00002, *Test Report for KE Container Retrieval Proof-of-Principle Test*
T-3.11	No	Scientific feasibility demonstrated	1. Scientific feasibility demonstrated for mobilization of simulated container sludge (TSRT-0105455-RT-00002, *Test Report for KE Container Retrieval Proof-of-Principle Test*) 2. Scientific feasibility not demonstrated for mobilization of corroded sludge in the corrosion or assay vessel. 3. Scientific feasibility not demonstrated for mobilization of settler tank sludge. 4. Scientific feasibility demonstrated for mobilization of simulated KOP material in the KOP accumulation tank however results not yet published.
T-3.12	No	Key physical and chemical properties have been characterized for a number of waste samples	
T-3.13	Yes	A simulant has been developed that approximates key waste properties	*1.* SP-5477-EG-G-0107, *KBCSP Vessel Agitator Design and Fabrication Specification.* 2. PNNL-16619, *Composition and Technical Basis for K Basin Settler Sludge Simulant for Inspection, Retrieval, and Pump Testing.*
T-3.14	No	Laboratory scale tests on a simulant have been completed	1. Scientific feasibility demonstrated for mobilization of simulated container sludge (TSRT-0105455-RT-00002, *Test Report for KE Container Retrieval Proof-of-Principle Test*) 2. Scientific feasibility not demonstrated for mobilization of corroded sludge in the corrosion or assay vessel. 3. Scientific feasibility not demonstrated for mobilization of settler tank sludge. 4. Scientific feasibility demonstrated for mobilization of simulated KOP material in the KOP accumulation tank however results not yet published.
T-3.15	Yes	Specific waste(s) and waste disposition site(s) has (have) been identified (WAC)	KBC-24540, *STP Functional Design Criteria*

T/P/M	Y/N (N/A)	Criteria	Basis
T-3.16	No	The individual system components have been tested at the laboratory scale	1. MCE-TR-491011-001, *Test Report for Sludge Receipt and Filter Vessel Recirculation/Transfer Pump Proof of Principle Test* 2. MCE-TR-5472-001, *Test Report for Corrosion Vessel to Assay Vessel Transfer Line Test* 3. TSRT-0105455-RT-00002, *Test Report for KE Container Retrieval Proof-of-Principle Test*
P-3.1	Yes	The basic science has been validated at the laboratory scale	1. TSRT-0105455-RT-00002, *Test Report for KE Container Retrieval Proof-of-Principle Test* 2. Philadelphia Mixers Laboratory Test Program, Final Report, *Fluor Fernald Silos 1 and 2 Project*, November 13, 2002 3. Philadelphia Mixers Test Report, Silos 1 & 2 Project, *Mixer Laboratory Tests with Simulant Slurry*, September 25, 2002
P-3.2	Yes	Preliminary system performance characteristics and measures have been identified and estimated	1. SD-5477-PR-R-0001, *Sludge Retrieval and Transfer System Description* 2. SD-5477-PR-T-0001, *Sludge Treatment System Description*
M-3.1	Yes	No system components, just basic laboratory research equipment to verify physical principles	1. MCE-TR-491011-001, *Test Report for Sludge Receipt and Filter Vessel Recirculation/Transfer Pump Proof of Principle Test* 2. MCE-TR-5472-001, *Test Report for Corrosion Vessel to Assay Vessel Transfer Line Test*
M-3.2	N/A	Current manufacturability concepts assessed	N/A
M-3.3	Yes	Sources of key components for laboratory testing identified	KBC-28475, *Sludge Treatment Project/Integrated Test Plan*

T - Technology, technical aspects
M - Manufacturing and quality
P - Programmatic, Customer Focus, Documentation
N/A – Criteria which does not apply to the Sludge Treatment Process

Critical Technology Element

Technology Readiness Level Determination

CTE-02 Material Transfer

Applicable Critical Technology sub-Elements (CTsE)

CTsE-06	**Ability to Transfer**	Can material be maintained in suspension and transferred over the distance, Plugging of line/pumps, Erosion of pumps, Pumps in series (hydraulic validation), Line flushing.
CTsE-12.1	**Corrosion Product Transfer Mechanics**	Potential plugging and plug clearing; Product solids settling in line/flushing; Effects on overall process due to flushing (how often, how much, where does it go. Etc.
CTsE-16.2	**IPAN Product Retrieval**	Pinch valve materials of construction.
CTsE-17.1	**IPAN Product Transfer Mechanics**	Potential plugging and plug clearing; Product solids settling in line/flushing; Effects on overall process due to flushing (how often, how much, where does it go. Etc); Elevation changes may be of concern.
CTsE-17.2	**IPAN Product Transfer Measurement**	Ability to precisely meter desired amount of product.

Technology Readiness Level Established

TRL-04 **Concept and/or System Validation in Laboratory Environment**

TRL 4 Question Set

T/P/M	Y/N (N/A)	Criteria	Documentation
T-4.1	Yes	Key process variables/parameters have been fully identified.	1. Existing 100% Design for CSAPS (Submittal 63), Assay Submittal (40),and R&T (Submittal 9). 2. RPT-5477-PRG-002 (White Paper- Submittal 39)
T-4.2	Yes	Individual process equipment/components tested in laboratory or by supplier	1. Testing in progress for KOP auger system under CO-52, KOP Sludge Accumulation Vessel Screw conveyor Testing. 2. MCE-TR-491011-001, Test report for sludge receipt and filter vessel recirculation/transfer pump proof of principle test. 3. MCE-TR-491013-001, Proof of principle for hose-in-hose slurry transfer pump. 4. MCE-TR-5472-001, Test report for corrosion vessel to assay vessel transfer line test. 5. See A21C-25147-FH-RCI-213, Corriolis Meter Evaluation for additional testing required.
T-4.3	Yes	Subsystems composed of multiple components tested at lab scale using simulants	1. Existing 100% Design for CSAPS (Submittal 63), Assay Submittal (40), and R&T (Submittal 9). 2. RPT-5477-PRG-002 (White Paper- Submittal 39) 3. P&ID DWG-5477-PRT-0102-01
T-4.4	Yes	Modeling & Simulation used to simulate some components and interfaces between components	1. RPT-5477-PRG-002 (White Paper- Submittal 39) 2. P&ID-DWG-5477-PR-T-0102-01
T-4.5	Yes	Overall system requirements for end user's application are documented	Submittal 034 V3; HNF-33942 (DQO)
T-4.6	Yes	System performance metrics measuring requirements have been established	Existing 100% Design for CSAPS (Submittal 63),
T-4.7	Yes	Laboratory testing requirements derived from system requirements are established	1. MCE-TR-491011-001, Test report for sludge receipt and filter vessel recirculation/transfer pump proof of principle test. 2. MCE-TR-491013-001, Proof of principle for hose-in-hose slurry transfer pump. 3. MCE-TR-5472-001, Test report for corrosion vessel to assay vessel transfer line test.

T/P/M	Y/N (N/A)	Criteria	Documentation
T-4.8	Yes	Analysis completed to establish component compatibility (Do components work together)	1. MCE-TR-491011-001, Test report for sludge receipt and filter vessel recirculation/transfer pump proof of principle test. 2. MCE-TR-491013-001, Proof of principle for hose-in-hose slurry transfer pump. 3. MCE-TR-5472-001, Test report for corrosion vessel to assay vessel transfer line test. 4. Submittal 034 V3-V8
T-4.9	Yes	Technology demonstrates basic functionality in simulated environment	1. Existing 100% Design for CSAPS (Submittal 63), Assay Submittal (40), and R&T (Submittal 9). 2. Submittal 034 V3; 3. HNF-33942 (DQO)
T-4.10 M-4.1	Yes	Equipment scale-up relationships are understood/accounted for in technology development program	1. MCE-TR-491011-001, Test report for sludge receipt and filter vessel recirculation/transfer pump proof of principle test. 2. MCE-TR-491013-001, Proof of principle for hose-in-hose slurry transfer pump. 3. MCE-TR-5472-001, Test report for corrosion vessel to assay vessel transfer line test.
T-4.11	Yes	Integration studies have been started	RPT-5477-PRG-002 (White Paper- Submittal 39)
T-4.12	Yes	Scaling documents and designs of technology have been completed	1. Existing 100% Design for CSAPS (Submittal 63), Assay Submittal (40), and R&T (Submittal 9). 2. Submittal 034 V3; 3. HNF-33942 (DQO)
T-4.13	Yes	Functional process description developed. (Systems/subsystems identified)	RPT-5477-PRG-002 (White Paper- Submittal 39)
T-4.14	Yes	Low fidelity technology "system" integration and engineering completed in a lab environment	1. CE-TR-491011-001, Test report for sludge receipt and filter vessel recirculation/transfer pump proof of principle test. 2. MCE-TR-491013-001, Proof of principle for hose-in-hose slurry transfer pump. 3. MCE-TR-5472-001, Test report for corrosion vessel to assay vessel transfer line test.
T-4.15	Yes	Key physical and chemical properties have been characterized for a range of wastes	1. SP-5477-EG-G0107, KBCSP Vessel Agitator Design and Fabrication Specification. 2. PNNL-16619, Composition and Technical Basis for Basin Setter Sludge Simulant for Inspection, Retrieval, and Pump Testing.

T/P/M	Y/N (N/A)	Criteria	Documentation
T-4.16	Yes	A limited number of simulants have been developed that approximate the range of waste properties	1. SP-5477-EG-G0107, KBCSP Vessel Agitator Design and Fabrication Specification. 2. PNNL-16619, Composition and Technical Basis for Basin Setter Sludge Simulant for Inspection, Retrieval, and Pump Testing.
T-4.17	Yes	Laboratory scale tests on a range of simulants have been completed	1. SP-5477-EG-G0107, KBCSP Vessel Agitator Design and Fabrication Specification. 2. PNNL-16619, Composition and Technical Basis for Basin Setter Sludge Simulant for Inspection, Retrieval, and Pump Testing.
T-4.18	Yes	Process/parameter limits are being explored	1. Existing 100% Design for CSAPS (Submittal 63), Assay Submittal (40), and R&T (Submittal 9). 2. Submittal 034 V3; 3. HNF-33942 (DQO)
T-4.19	Yes	Test results are analyzed and documented	MCE-TR-5472-001, Test report for corrosion vessel to assay vessel transfer line test. See A21C-25147-FH-RCI-213, Corriolis Meter Evaluation for additional testing required.
P-4.1	Yes	Draft conceptual designs have been documented	1. Existing 100% Design for CSAPS (Submittal 63), Assay Submittal (40), and R&T (Submittal 9). 2. RPT-5477-PRG-002 (White Paper- Submittal 39)
M-4.2	Yes	Laboratory components tested are prototypical of system components	1. CE-TR-491011-001, Test report for sludge receipt and filter vessel recirculation/transfer pump proof of principle test. 2. MCE-TR-491013-001, Proof of principle for hose-in-hose slurry transfer pump. 3. MCE-TR-5472-001, Test report for corrosion vessel to assay vessel transfer line test.
M-4.3	Yes	Available components assembled into laboratory scale system	1. CE-TR-491011-001, Test report for sludge receipt and filter vessel recirculation/transfer pump proof of principle test. 2. MCE-TR-491013-001, Proof of principle for hose-in-hose slurry transfer pump. 3. MCE-TR-5472-001, Test report for corrosion vessel to assay vessel transfer line test.

T/P/M	Y/N (N/A)	Criteria	Documentation
M-4.4	Yes	Scalable technology prototypes have been produced (Can components be made bigger than lab scale)	1. CE-TR-491011-001, Test report for sludge receipt and filter vessel recirculation/transfer pump proof of principle test. 2. MCE-TR-491013-001, Proof of principle for hose-in-hose slurry transfer pump. 3. MCE-TR-5472-001, Test report for corrosion vessel to assay vessel transfer line test.
M-4.5	Yes	Key manufacturing processes for equipment systems identified	SP-5477-EG-G0107, KBCSP Vessel Agitator Design and Fabrication Specification.
M-4.6	N/A	Key manufacturing processes assessed in laboratory	
M-4.7	N/A	Mitigation strategies identified to address manufacturability/producibility shortfalls	

T - Technology, technical aspects
M - Manufacturing and quality
P - Programmatic, Customer Focus, Documentation
N/A – Criteria which does not apply to the Sludge Treatment Process

TRL 5 Question Set

T/P/M	Y/N (N/A)	Criteria	Documentation
T-5.1	Yes	The relationships between major system and sub-system parameters are understood on a laboratory scale.	1. Existing 100% Design for CSAPS (Submittal 63), 2. Assay Submittal (40), and 3. R&T (Submittal 9). 4. RPT-5477-PRG-002 (White Paper- Submittal 39) 5. PNNL-16643, Report on Expert Review of the Sludge Treatment Project Testing; 6. PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions; 7. PNNL-53451(Draft), Sludge Treatment Project Corrosion Process Chemistry Follow-on Testing Test Plan 53451-TP01, Rev. 0.
T-5.2	Yes	Plant size components available for testing	1. Testing in progress for KOP auger system under CO-52, KOP Sludge Accumulation Vessel Screw conveyor Testing. 2. MCE-TR-491011-001, test report for sludge receipt and filter vessel recirculation and transfer pump proof of principle test. 3. MCE-TR-491013-001, Proof of principle for hose-in-hose slurry transfer pump. 4. MCE-TR-5472-001, test report for corrosion vessel to assay vessel transfer line test. See A21C-25147-FH-RCI-213, Corriolis Meter Evaluation for additional testing required.
T-5.3	Yes	System interface requirements known (How will system be integrated into the plant?)	Existing Submittal 9, 100% R&T. P&ID-DWG-5477-PR-T-0102-01
T-5.4	Yes	Preliminary design engineering begins	Existing Submittal 9, 100% R&T. RPT-5477-EGG-0116, Report On Engineering Studies in Response to CO-58 - Evaluation of Independent Engineering Reviews. Miscellaneous project requirement documents.
T-5.5	Yes	Requirements for technology verification established	RPT-5477-EG-G0116, Report On Engineering Studies in Response to CO-58 – Evaluation of Independent Engineering Reviews. Miscellaneous project requirement documents.
T-5.6	No	Interfaces between components/subsystems in testing are realistic (benchtop with realistic interfaces)	Although process components exist (Item T-5.2), the interfaces between the various components and subsystems have not been tested or evaluated.

T/P/M	Y/N (N/A)	Criteria	Documentation
T-5.7	Yes	High fidelity lab integration of system completed, ready for test in relevant environments	See Item T-5.2
T-5.8	Yes	Lab scale similar system tested with range of simulants	See Item T-5.2
T-5.9	Yes	Fidelity of system mock-up improves from laboratory to benchscale testing	See Item T-5.2
T-5.10	Yes	Laboratory environment for testing approximates operational environment	See Item T-5.2
T-5.11	No	Component integration issues and requirements identified	Control System Design in progress but not complete.
T-5.12	Yes	Requirements definition with performance thresholds and objectives established for final plant design	1. Existing 100% Design for CSAPS (Submittal 63), Assay Submittal (40), and R&T (Submittal 9). 2. Submittal 034 V3; 3. HNF-33942 (DQO)
T-5.13	Yes	Preliminary technology feasibility engineering report completed	RPT-5477-PRG-002 (White Paper- Submittal 39)
T-5.14	No	Integration of modules/functions demonstrated in a laboratory/bench scale environment	No Lab/bench scale environment testing performed for control system as design is still in progress.
T-5.15	No	The range of relevant physical and chemical properties has been determined	The full range has not been determined. Rheology after corrosion is unknown. Settler Tube and KOP Sludge has not been observed or accurately characterized.
T-5.16	No	Simulants have been developed that bound the relevant range of waste properties	The physical and chemical properties of the corroded sludge have not well characterized. This includes development of a simulant that approximates key waste properties. Additionally, PNNL-16643, Report on Expert Review of the Sludge Treatment Project Testing, discusses the need for a representative simulant.
T-5.17	No	Testing has verified that the relevant properties/performance of the simulants match the properties/performance of the actual wastes	The physical and chemical properties of the corroded sludge have not well characterized. This includes development of a simulant that approximates key waste properties. Additionally, PNNL-16643, Report on Expert Review of the Sludge Treatment Project Testing, discusses the need for a representative simulant.

T/P/M	Y/N (N/A)	Criteria	Documentation
T-5.18	No	Laboratory scale tests on the full range of simulants and/or real wastes using a high-fidelity system have been completed	The physical and chemical properties of the corroded sludge have not well characterized. This includes development of a simulant that approximates key waste properties. Additionally, PNNL-16643, Report on Expert Review of the Sludge Treatment Project Testing, discusses the need for a representative simulant.
T-5.19	No	Test results for simulants and real waste are consistent	The physical and chemical properties of the corroded sludge have not well characterized. This includes development of a simulant that approximates key waste properties. Additionally, PNNL-16643, Report on Expert Review of the Sludge Treatment Project Testing, discusses the need for a representative simulant.
T-5.20	No	Laboratory to engineering scale scale-up issues are understood and resolved	Issues identified, but not resolved PNNL 16643.
T-5.21	No	Limits for process variables/parameters are being refined	Setpoint Document not started.
T-5.22	No	Test plan for high-fidelity lab scale tests executed – results validate design	
M-5.1	N/A	Tooling and machines demonstrated in lab for new manufacturing processes to make component	
M-5.2	Yes	Manufacturing techniques have been defined to the point where largest problems defined	1. SP-5477-EG-G0107, KBCSP Vessel Agitator Design and Fabrication Specification. 2. PNNL-16619, Composition and Technical Basis for Basin Setter Sludge Simulant for Inspection, Retrieval, and Pump Testing.
M-5.3	No	Reliability, availability, maintainability and inspectability (RAMI) target levels identified	

T - Technology, technical aspects
M - Manufacturing and quality
P - Programmatic, Customer Focus, Documentation
N/A – Criteria which does not apply to the Sludge Treatment Process

Critical Technology Element

Technology Readiness Level Determination

CTE-03 Process Chemistry

Applicable Critical Technology sub-Elements (CTsE)

CTsE-07	**Process Chemistry**	Feedstock Characterization, Process Chemistry not well understood, Effects of processing parameters not well understood, DOE directed lower STP conditions untested.

Technology Readiness Level Established

TRL-02 **Technology Concept and/or Application Formulated**

TRL 2 Question Set

T/P/M	Y/N (N/A*)	Criteria	Basis
T-2.1	Yes	Potential system or components have been identified	KBC-24540, Functional Design Criteria K Basin Closure Sludge Treatment Process, Rev. 3.
T-2.2	Yes	Paper studies show that application is feasible	With respect to uranium metal oxidation: 1. SNF-7765, Rev. 3C, Supporting Basis for SNF Project Technical Databook, Appendix G, Updated Evaluation of Uranium Metal Reaction Rates in Oxygen-free Liquid Water. 2. PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions.
T-2.3	Yes	An apparent theoretical or empirical design solution identified	With respect to uranium metal oxidation: 1. SNF-7765, Rev. 3C, Supporting Basis for SNF Project Technical Databook, Appendix G, Updated Evaluation of Uranium Metal Reaction Rates in Oxygen-free Liquid Water. 2. PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions. 3. KBC-24540, Functional Design Criteria K Basin Closure Sludge Treatment Process, Rev. 3.
T-2.4	Yes	Basic elements of technology have been identified	With respect to uranium metal oxidation: 1. HNF-SD-SNF-TI-015, Spent Nuclear Fuel project Databook, Rev. 13A. 2. SNF-7765, Rev. 3C, Supporting Basis for SNF Project Technical Databook, Appendix G, Updated Evaluation of Uranium Metal Reaction Rates in Oxygen-free Liquid Water. 3. PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions. 4. KBC-24540, Functional Design Criteria K Basin Closure Sludge Treatment Process, Rev. 3.

T-2.5	Yes	Desktop environment (paper studies)	With respect to uranium metal oxidation: 1. SNF-7765, Rev. 3C, Supporting Basis for SNF Project Technical Databook, Appendix G, Updated Evaluation of Uranium Metal Reaction Rates in Oxygen-free Liquid Water. 2. PNNL-13341, Testing and Analysis of Consolidated Sludge Samples from the 105 K East Basin floor and Canisters.
T-2.6	Yes	Components of technology have been partially characterized	1. HNF-SD-SNF-TI-015, Spent Nuclear Fuel project Databook, Rev. 13A. 2. PNNL-13341, Testing and Analysis of Consolidated Sludge Samples from the 105 K East Basin floor and Canisters.
T-2.7	Yes	Performance predictions made for each element	SD-5477-PR-T-0001, Rev. 0, K Basins Closure Stabilization and Packaging Project – Sludge Treatment System Description.
T-2.8	Yes	Initial analysis shows what major functions need to be done	1. SNF-7765, Rev. 3C, Supporting Basis for SNF Project Technical Databook, Appendix G, Updated Evaluation of Uranium Metal Reaction Rates in Oxygen-free Liquid Water. 2. KBC-24540, Functional Design Criteria K Basin Closure Sludge Treatment Process, Rev. 3.
T-2.9	Yes	Modeling & Simulation used to verify physical principles	With respect to uranium metal oxidation: 1. SNF-7765, Rev. 3C, Supporting Basis for SNF Project Technical Databook, Appendix G, Updated Evaluation of Uranium Metal Reaction Rates in Oxygen-free Liquid Water. 2. PNNL-13341, Testing and Analysis of Consolidated Sludge Samples from the 105 K East Basin floor and Canisters.
T-2.10	Yes	Analytical studies confirm basic principles	With respect to uranium metal oxidation: 1. SNF-7765, Rev. 3C, Supporting Basis for SNF Project Technical Databook, Appendix G, Updated Evaluation of Uranium Metal Reaction Rates in Oxygen-free Liquid Water. 2. PNNL-13341, Testing and Analysis of Consolidated Sludge Samples from the 105 K East Basin floor and Canisters.

T-2.11	Yes	Analytical studies reported in scientific journals/conference proceedings/technical reports.	With respect to uranium metal oxidation: 1. SNF-7765, Rev. 3C, Supporting Basis for SNF Project Technical Databook, Appendix G, Updated Evaluation of Uranium Metal Reaction Rates in Oxygen-free Liquid Water. 2. PNNL-13341, Testing and Analysis of Consolidated Sludge Samples from the 105 K East Basin floor and Canisters.
T-2.12	Yes	Individual parts of the technology work (No real attempt at integration)	With respect to uranium metal oxidation: 1. SNF-7765, Rev. 3C, Supporting Basis for SNF Project Technical Databook, Appendix G, Updated Evaluation of Uranium Metal Reaction Rates in Oxygen-free Liquid Water. 2. PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions.
T-2.13	N/A	Know what output devices are available	
T-2.14	Yes	The scope and scale of the waste problem has been determined	Various K Basin Closure documents address the need to produce a WIPP certifiable waste form. Several of the documents were prepared prior to the approval of the WIPP Remote Handled TRU WAC, and therefore, these documents contain the requirements for Hanford Remote Handled TRU WAC. 1. KBC-24540, Functional Design Criteria K Basin Closure Sludge Treatment Process, Rev. 3.
T-2.15	Yes	Know what experiments are required (research approach)	Test Plans have been developed, including: 1. Test Plan 53451-TP01, Rev. 0, Sludge Treatment Project Corrosion Process Chemistry Follow-on Testing, June 2007
P-2.1	Yes	System architecture defined in terms of major functions to be performed	KBC-24540, Functional Design Criteria K Basin Closure Sludge Treatment Process, Rev. 3.
P-2.2	Yes	Know capabilities and limitations of researchers and research facilities	K Basin Sludge Treatment testing has been and will continue to be performed by PNNL, utilizing their hot cell capabilities.

T - Technology, technical aspects
M - Manufacturing and quality
P - Programmatic, Customer Focus, Documentation
N/A – Criteria which does not apply to the Sludge Treatment Process

TRL 3 Question Set

T/P/M	Y/N (N/A*)	Criteria	Basis
T-3.1	Yes	Some key process requirements are identified	KBC-24540, Functional Design Criteria K Basin Closure Sludge Treatment Process, Rev. 3.
T-3.2	Yes	Predictions of elements of technology capability validated by analytical studies	1. SNF-7765, Rev. 3C, Supporting Basis for SNF Project Technical Databook, Appendix G, Updated Evaluation of Uranium Metal Reaction Rates in Oxygen-free Liquid Water. 2. HNF-SD-SNF-TI-015, Spent Nuclear Fuel project Databook, Rev. 13A.
T-3.3	Yes	Science known to extent that mathematical and/or computer models and simulations are possible	The science of uranium metal oxidation is well understood and an abundance of tests and scientific literature exists.
T-3.4	No	Predictions of elements of technology capability validated by Modeling and Simulation (M&S)	Although recently initiated, these activities have not yet been completed.
T-3.5	No	Laboratory experiments verify feasibility of application	To date, only the corrosion of the Uranium metal at Process Conditions has been verified. The assumptions that side reactions have no effect has not validated and in fact has been proven to be invalid, as the Uranium-oxides effects have been shown to negatively impact the corrosion process. Reference PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions.
T-3.6	No	Predictions of elements of technology capability validated by laboratory experiments	To date, only the corrosion of the Uranium metal at Process Conditions has been verified. The assumptions that side reactions have no effect has not validated and in fact has been proven to be invalid, as the Uranium-oxides effects have been shown to negatively impact the corrosion process. Reference PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions.
T-3.7	Yes	Key process parameters/variables have begun to be identified.	Test Plans have been developed, including: 1. Test Plan 53451-TP01, Rev. 0, Sludge Treatment Project Corrosion Process Chemistry Follow-on Testing, June 2007
T-3.8	Yes	Paper studies indicate that system components ought to work together	SD-5477-PR-T-0001, Rev. 0, K Basins Closure Stabilization and Packaging Project – Sludge Treatment System Description.

T-3.9	Yes	Performance metrics for the system are established (What must it do)	1. KBC-24540, Functional Design Criteria K Basin Closure Sludge Treatment Process, Rev. 3. 2. SNF-7765, Rev. 3C, Supporting Basis for SNF Project Technical Databook, Appendix G, Updated Evaluation of Uranium Metal Reaction Rates in Oxygen-free Liquid Water.
T-3.10	Yes	Scaling studies have been started	Test Plans have been developed, including: 1. Test Plan 53451-TP01, Rev. 0, Sludge Treatment Project Corrosion Process Chemistry Follow-on Testing, June 2007
T-3.11	No	Scientific feasibility demonstrated	To date, only the corrosion of the Uranium metal at Process Conditions has been verified. The assumptions that side reactions have no effect has not validated and in fact has been proven to be invalid, as the Uranium-oxides effects have been shown to negatively impact the corrosion process. Reference PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions.
T-3.12	Yes	Key physical and chemical properties have been characterized for a number of waste samples	HNF-SD-SNF-TI-015, Spent Nuclear Fuel Project Databook, Rev. 13A.
T-3.13	No	A simulant has been developed that approximates key waste properties	The physical and chemical properties of the corroded sludge have not well characterized. This includes development of a simulant that approximates key waste properties. Additionally, PNNL-16643, Report on Expert Review of the Sludge Treatment Project Testing, discusses the need for a representative simulant.
T-3.14	No	Laboratory scale tests on a simulant have been completed	The physical and chemical properties of the corroded sludge have not well characterized. This includes development of a simulant that approximates key waste properties. Additionally, PNNL-16643, Report on Expert Review of the Sludge Treatment Project Testing, discusses the need for a representative simulant.

T-3.15	Yes	Specific waste(s) and waste disposition site(s) has (have) been identified (WAC)	Various K Basin Closure documents address the need to produce a WIPP certifiable waste form. Several of the documents were prepared prior to the approval of the WIPP Remote Handled TRU WAC, and therefore, these documents contain the requirements for Hanford Remote Handled TRU WAC. 1. KBC-24540, Functional Design Criteria K Basin Closure Sludge Treatment Process, Rev. 3.
T-3.16	No	The individual system components have been tested at the laboratory scale	No testing on mixing, sparging, evaporation has been completed. The individual system components have not yet been tested at the laboratory scale. Testing to date has focused on establishing Uranium metal oxidation reaction rate and the actual sludge testing was performed in an un-stirred test vessel.
P-3.1	No	The basic science has been validated at the laboratory scale	The basic science of uranium metal oxidation has been validated by laboratory tests, including the oxidation of metal in K Basin Sludge; Reference PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions. However, the basic science of K Basin Sludge Treatment has not been validated. Additionally, the above referenced document actually raises significant concerns with the oxidation of K Basin Sludge and the resulting products.
P-3.2	Yes	Preliminary system performance characteristics and measures have been identified and estimated	SD-5477-PR-T-0001, Rev. 0, K Basins Closure Stabilization and Packaging Project – Sludge Treatment System Description.
M-3.1	No	No system components, just basic laboratory research equipment to verify physical principles	The basic science of uranium metal oxidation has been validated by laboratory tests, including the oxidation of metal in K Basin Sludge; Reference PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions. However, the basic science of K Basin Sludge Treatment has not been validated. Additionally, the above referenced document actually raises significant concerns with the oxidation of K Basin Sludge and the resulting products.
M-3.2	N/A	Current manufacturability concepts assessed	

M-3.3	Yes	Sources of key components for laboratory testing identified	K Basin Sludge Treatment testing has been and will continue to be performed by PNNL, utilizing their hot cell capabilities.

T - Technology, technical aspects
M - Manufacturing and quality
P - Programmatic, Customer Focus, Documentation
N/A – Criteria which does not apply to the Sludge Treatment Process

Critical Technology Element

Technology Readiness Level Determination

CTE-04 Process Instrumentation

Applicable Critical Technology sub-Elements (CTsE)

CTsE-05B	**Feed Stream Concentration**	Ability to measure and to control to desired concentration
CTsE-05E.2	**Feed Stream Preparation (Day Tank)**	Ability to measure critical variables
CTsE-12.2	**Product Transfer Measurement**	Volume/Mass Meter (corriolis meter)
CTsE-13.2	**Quench Vessel Off-gas Monitoring**	H2 and O2 monitoring instrumentation/detectors

Technology Readiness Level Established

TRL-04 **Component and/or System Validation in Laboratory Environment**

TRL 4 Question Set

T/P/M	Y/N (N/A)	Criteria	Basis
T-4.1	Yes	Key process variables/parameters have been fully identified.	• SP-5477-J-T-0002, *Corrosion Vessel Offgas Sampling and Monitoring Equipment, Section 40 91 13*
T-4.2	Yes	Individual process equipment/components tested in laboratory or by supplier	• Ongoing KOP retrieval tests to provide information using mass flow meter (corriolis) technology
T-4.3	Yes	Subsystems composed of multiple components tested at lab scale using simulants	• Ongoing KOP retrieval tests to provide information using mass flow meter (corriolis) technology
T-4.4	N/A	Modeling & Simulation used to simulate some components and interfaces between components	N/A
T-4.5	Yes	Overall system requirements for end user's application are documented	• KBC-24540, *STP Functional Design Criteria* • HNF-20135, *STP Functional Requirements Document*
T-4.6	Yes	System performance metrics measuring requirements have been established	• SP-5477-J-T-0002, *Corrosion Vessel Offgas Sampling and Monitoring Equipment, Section 40 91 13*
T-4.7	Yes	Laboratory testing requirements derived from system requirements are established	• KBC-28475, *Sludge Treatment Project/Integrated Test Plan*
T-4.8	Yes	Analysis completed to establish component compatibility (Do components work together)	• SD-5477-PR-R-0001, *Sludge Retrieval and Transfer System Description* • SD-5477-PR-T-0001, *Sludge Treatment System Description*
T-4.9	Yes	Technology demonstrates basic functionality in simulated environment	• TSRT-0105455-RT-00002, *Test Report for KE Container Retrieval Proof-of-Principle Test* • Ongoing KOP retrieval tests to provide information using mass flow meter (corriolis) technology • Hydrogen monitoring in Hanford's high level waste tanks demonstrates functionality in high humidity environments
T-4.10 M-4.1	Yes	Equipment scale up relationships are understood/accounted for in technology development program	• KBC-24540, *STP Functional Design Criteria* • HNF-20135, *STP Functional Requirements Document*
T-4.11	Yes	Integration studies have been started	• RPT-5477-EG-G-0116, *K Basin Closure Stabilization and Packaging Project - Evaluation of and Response to Independent Engineering Reviews of the Design for K Basins Sludge Retrieval and Treatment.* • Ongoing KOP retrieval tests to provide information using mass flow meter (corriolis) technology

T/P/M	Y/N (N/A)	Criteria	Basis
T-4.12	Yes	Scaling documents and designs of technology have been completed	• SP-5477-J-T-0002, *Corrosion Vessel Offgas Sampling and Monitoring Equipment, Section 40 91 13*
T-4.13	Yes	Functional process description developed. (Systems/subsystems identified)	• SP-5477-J-T-0002, *Corrosion Vessel Offgas Sampling and Monitoring Equipment, Section 40 91 13*
T-4.14	Yes	Low fidelity technology "system" integration and engineering completed in a lab environment	• TSRT-0105455-RT-00002, *Test Report for KE Container Retrieval Proof-of-Principle Test* • Ongoing KOP retrieval tests to provide information using mass flow meter (corriolis) technology • Hydrogen monitoring in Hanford's high level waste tanks demonstrates functionality in high humidity environments
T-4.15	Yes	Key physical and chemical properties have been characterized for a range of wastes	• PNNL-16619, *Composition and Technical Basis for K Basin Settler Sludge Simulant for Inspection, Retrieval, and Pump Testing*
T-4.16	Yes	A limited number of simulants have been developed that approximate the range of waste properties	• PNNL-16619, *Composition and Technical Basis for K Basin Settler Sludge Simulant for Inspection, Retrieval, and Pump Testing* • A21C-25147-RCI-065, *KBCSP Treatment Skid Testing*
T-4.17	Yes	Laboratory scale tests on a range of simulants have been completed	• TSRT-0105455-RT-00002, *Test Report for KE Container Retrieval Proof-of-Principle Test* • Ongoing KOP retrieval tests to provide information using mass flow meter (corriolis) technology
T-4.18	Yes	Process/parameter limits are being explored	• Ongoing KOP retrieval tests to provide information using mass flow meter (corriolis) technology
T-4.19	Yes	Test results are analyzed and documented	• TSRT-0105455-RT-00002, *Test Report for KE Container Retrieval Proof-of-Principle Test* • Ongoing KOP retrieval tests to provide information using mass flow meter (corriolis) technology
P-4.1	Yes	Draft conceptual designs have been documented	• The retrieval and transfer and corrosion designs and supporting documentation/analyses are published
M-4.2	Yes	Laboratory components tested are prototypical of system components	• Ongoing KOP retrieval tests to provide information using mass flow meter (corriolis) technology
M-4.3	Yes	Available components assembled into laboratory scale system	• Ongoing KOP retrieval tests to provide information using mass flow meter (corriolis) technology
M-4.4	Yes	Scalable technology prototypes have been produced (Can components be made bigger than lab scale)	• Ongoing KOP retrieval tests to provide information using mass flow meter (corriolis) technology

T/P/M	Y/N (N/A)	Criteria	Basis
M-4.5	Yes	Key manufacturing processes for equipment systems identified	• Instrumentation is available that requires little or no customization
M-4.6	N/A	Key manufacturing processes assessed in laboratory	N/A
M-4.7	N/A	Mitigation strategies identified to address manufacturability/producibility shortfalls	N/A

T - Technology, technical aspects
M - Manufacturing and quality
P - Programmatic, Customer Focus, Documentation
N/A – Criteria which does not apply to the Sludge Treatment Process

TRL 5 Question Set

T/P/M	Y/N (N/A)	Criteria	Basis
T-5.1	Yes	The relationships between major system and sub-system parameters are understood on a laboratory scale.	1. SP-5477-IN-T-0002 2. SP-5477-J-T-0002, *Corrosion Vessel Offgas Sampling and Monitoring Equipment, Section 40 91 13*
T-5.2	No	Plant size components available for testing	1. See Submittals 9 and 63 for 100% documentation 2. H2/O2 monitor not yet built.
T-5.3	Yes	System interface requirements known (How will system be integrated into the plant?)	1. See Submittals 9 and 63 for 100% documentation 2. DWG-5477-PR-T-0107
T-5.4	Yes	Preliminary design engineering begins	1. See Submittals 9 and 63 for 100% documentation 2. H2/O2 procurement spec
T-5.5	Yes	Requirements for technology verification established	1. TP-5477-PR-P-0001, *Suspended Solids Meter Test Plan* 2. KBC-28475, *Sludge Treatment Project/Integrated Test Plan* 3. SP-5477-J-T-0002, *Corrosion Vessel Offgas Sampling and Monitoring Equipment, Section 40 91 13*
T-5.6	No	Interfaces between components/subsystems in testing are realistic (benchtop with realistic interfaces)	1. TP-5477-PR-P-0001, *Suspended Solids Meter Test Plan* 2. KBC-28475, *Sludge Treatment Project/Integrated Test Plan* 3. No quench vessel bench top testing with realistic interfaces has been performed with respect to the H2/O2 monitor.
T-5.7	No	High fidelity lab integration of system completed, ready for test in relevant environments	H2/O2 monitor not yet tested
T-5.8	No	Lab scale similar system tested with range of simulants	H2/O2 monitor not yet tested
T-5.9	No	Fidelity of system mock-up improves from laboratory to bench scale testing	1. KBC-28475, *Sludge Treatment Project/Integrated Test Plan* 2. H2/O2 monitor not yet tested
T-5.10	No	Laboratory environment for testing approximates operational environment	1. Limited testing has been conducted on solids measurement and control but not using a "high fidelity" system 2. No simulated H2/O2 monitor testing has been performed.

T/P/M	Y/N (N/A)	Criteria	Basis
T-5.11	Yes	Component integration issues and requirements identified	SP-5477-J-T-0002, *Corrosion Vessel Offgas Sampling and Monitoring Equipment, Section 40 91 13*
T-5.12	Yes	Requirements definition with performance thresholds and objectives established for final plant design	1. SP-5477-J-T-0002, *Corrosion Vessel Offgas Sampling and Monitoring Equipment, Section 40 91 13* 2. SP-5477-J-G-0001, *Process Control System Requirements Specification* 3. SP-5477-J-G-0012, *Process Control System Corrosion System Requirements Specification*
T-5.13	Yes	Preliminary technology feasibility engineering report completed	1. RPT-5477-PR-G-0002, *Technical Evaluation Study-Control & Determination of Solid Concentrations during KW-CVDF Sludge Transfers* 2. RPT-5477-PR-T-0008, *Potential Reactions that Might Modify the Reaction of Uranium Metal, Impact the Process, and Influence the Applicability of Hydrogen Concentration Measurements to Monitor Corrosion*
T-5.14	No	Integration of modules/functions demonstrated in a laboratory/bench scale environment	STP module integration not yet performed on a laboratory bench scale.
T-5.15	Yes	The range of relevant physical and chemical properties has been determined	SP-5477-J-T-0002, *Corrosion Vessel Offgas Sampling and Monitoring Equipment, Section 40 91 13*
T-5.16	Yes	Simulants have been developed that bound the relevant range of waste properties	1. SP-5477-EG-G-0107, *KBCSP Vessel Agitation Design and Fabrication Specification* 2. PNNL-16619, *Composition and Technical Basis for K Basin Settler Sludge Simulant for Inspection, Retrieval, and Pump Testing*
T-5.17	No	Testing has verified that the relevant properties/performance of the simulants match the properties/performance of the actual wastes	1. Reports PNNL-16619, *Composition and Technical Basis for K Basin Settler Sludge Simulant for Inspection, Retrieval, and Pump Testing* 2. PNNL-16496, *Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions* 3. No simulated H2/O2 monitor testing has been performed.

T/P/M	Y/N (N/A)	Criteria	Basis
T-5.18	No	Laboratory scale tests on the full range of simulants and/or real wastes using a high-fidelity system have been completed	1. Limited testing has been conducted on solids measurement and control but not using a "high fidelity" system 2. No simulated H2/O2 monitor testing has been performed.
T-5.19	No	Test results for simulants and real waste are consistent	No tests have been conducted using actual waste material. However, recent HIH experience with solids measurement and control indicates significant testing using technically defendable simulants is warranted.
T-5.20	Yes	Laboratory to engineering scale scale-up issues	1. TP-5477-PR-P-0001, *Suspended Solids Meter*

Critical Technology Element

Technology Readiness Level Determination

CTE-05 Assay

Applicable Critical Technology sub-Elements (CTsE)

CTsE-15	**Level Detection**	Reliability & effectiveness under process conditions; Effects from IPAN vessel components and foaming.
CTsE-18	**Assay/Detector System**	Use in high radiation/RH environments, sludge self-shielding and partial filled vessel; Deployment in agitated and high radiation environments.

Technology Readiness Level Established

TRL-02 **Technology Concept and/or Application Formulated**

TRL 2 Question Set

T/P/M	Y/N (N/A*)	Criteria	Basis
T-2.1	Yes	Potential system or components have been identified	1. System Specification Document, K-Basins Sludge Assay System, BII-5184-SSD-001, Revision 8. 2. BII-5184-HDD-001, KBSAS IPAN Hardware Definition Document.
T-2.2	Yes	Paper studies show that application is feasible	1. System Specification Document, K-Basins Sludge Assay System, BII-5184-SSD-001, Revision 8. 2. Preliminary system modeling completed by BIL Solutions, which is identified as reference No. 3 (G. Auchampaugh, K-Basin Sludge Assay System (KBSAS) Task 1 Memorandum, March 2005) in BII-5184-SSD-001, Revision 8. 3. BII-5184-TMU-001, KBSAS IPAN Total Measurement Uncertainty Document. 4. Application of the PAN/GHEA/AK method to the Non-Destructive Assay of Remote Handled TRU Waste, BNFL Instruments Inc. (various authors), presented at WM'04 Conference, Tucson, AZ. 5. High Sensitivity Assay of Cement Encapsulated Spent Nuclear Fuel Sludge using the Imaging Passive Active Neutron (IPAN™), Simpson A. (BIL Solutions), Abdurraham, N. (Fluor Hanford), presented at WM'07 Conference, Tucson, AZ.
T-2.3	Yes	An apparent theoretical or empirical design solution identified	1. System Specification Document, K-Basins Sludge Assay System, BII-5184-SSD-001, Revision 8. 2. BII-5184-ADD-001, KBSAS IPAN Algorithm Definition Document.
T-2.4	Yes	Basic elements of technology have been identified	1. System Specification Document, K-Basins Sludge Assay System, BII-5184-SSD-001, Revision 8. 2. BII-5184-SDD, KBSAS IPAN Software Definition Document. 3. BII-5184-HDD-001, KBSAS IPAN Hardware Definition Document.

T-2.5	Yes	Desktop environment (paper studies)	1. System Specification Document, K-Basins Sludge Assay System, BII-5184-SSD-001, Revision 8. 2. Preliminary system modeling completed by BIL Solutions, which is identified as reference No. 3 (G. Auchampaugh, K-Basin Sludge Assay System (KBSAS) Task 1 Memorandum, March 2005) in BII-5184-SSD-001, Revision 8. 3. BII-5184-TMU-001, KBSAS IPAN Total Measurement Uncertainty Document. 4. Application of the PAN/GHEA/AK method to the Non-Destructive Assay of Remote Handled TRU Waste., BNFL Instruments Inc. (various authors), presented at WM'04 Conference, Tucson, AZ. 5. High Sensitivity Assay of Cement Encapsulated Spent Nuclear Fuel Sludge using the Imaging Passive Active Neutron (IPAN™), Simpson A. (BIL Solutions), Abdurraham, N. (Fluor Hanford), presented at WM'07 Conference, Tucson, AZ.

T-2.6	Yes	Components of technology have been partially characterized	The Imaging Passive Active Neutron (IPAN) technology, which is being provided by Pajarito Scientific Corporation (PSC) (formerly BIL Solutions Inc.) for the K-Basins Closure, Stabilization and Packaging (KBCSP) Assay System, is mature and has been successfully demonstrated on Non-Destructive Assay (NDA) systems used at the following DOE Sites: • Hanford – WRAP IPAN – WIPP certified system used to assay 55-gallon drums containing CH-TRU. • Rocky Flats – RFETS Passive/Active Drum Counter (PADC) - WIPP certified system used to assay 55-gallon drums containing CH-TRU. • Rocky Flats – Multi-Purpose Crate Counter (MPCC) – WIPP certified system used to assay crated CH-TRU. • Savannah River – Mobile IPAN - WIPP certified system used to assay 55-gallon drums containing CH-TRU. • Idaho National Engineering Laboratory – AMWTP Retrieval Box Assay System (RBAS) – Process instrument used to characterize crated CH-TRU, in order to confirm that each crate meets the waste acceptance criteria for the AMWTP box processing facility.
T-2.7	Yes	Performance predictions made for each element	1. Preliminary system modeling completed by BIL Solutions, which is identified as reference No. 3 (G. Auchampaugh, K-Basin Sludge Assay System (KBSAS) Task 1 Memorandum, March 2005) in BII-5184-SSD-001, Revision 8. 2. BII-5184-TMU-001, KBSAS IPAN Total Measurement Uncertainty Document.
T-2.8	Yes	Initial analysis shows what major functions need to be done	1. System Specification Document, K-Basins Sludge Assay System, BII-5184-SSD-001, Revision 8.

T-2.9	Yes	Modeling & Simulation used to verify physical principles	1. Preliminary system modeling completed by BIL Solutions, which is identified as reference No. 3 (G. Auchampaugh, K-Basin Sludge Assay System (KBSAS) Task 1 Memorandum, March 2005) in BII-5184-SSD-001, Revision 8. 2. Note that current design for assay skid, including IPAN equipment, has been modeled using MCNP. The intention was that, subsequent to placement of contract for Assay Skid fabrication and confirmation of detailed design, the MCNP model would be as-built and then runs completed using simulated sludge matrices. The data produced by the model would then be use, in conjunction with data obtained from the site assay of simulated sludge matrices and SNM test sources, to derive the calibration library files for hot operations.
T-2.10	Yes	Analytical studies confirm basic principles	1. Preliminary system modeling completed by BIL Solutions, which is identified as reference No. 3 (G. Auchampaugh, K-Basin Sludge Assay System (KBSAS) Task 1 Memorandum, March 2005) in BII-5184-SSD-001, Revision 8.
T-2.11	Yes	Analytical studies reported in scientific journals/conference proceedings/technical reports.	1. Application of the PAN/GHEA/AK method to the Non-Destructive Assay of Remote Handled TRU Waste., BNFL Instruments Inc. (various authors), presented at WM'04 Conference, Tucson, AZ. 2. High Sensitivity Assay of Cement Encapsulated Spent Nuclear Fuel Sludge using the Imaging Passive Active Neutron (IPAN™), Simpson A. (BIL Solutions), Abdurraham, N. (Fluor Hanford), presented at WM'07 Conference, Tucson, AZ.

T-2.12	Yes	Individual parts of the technology work (No real attempt at integration)	The Imaging Passive Active Neutron (IPAN) technology, which is being provided by Pajarito Scientific Corporation (PSC) (formerly BIL Solutions Inc.) for the K-Basins Closure, Stabilization and Packaging (KBCSP) Assay System, is mature and has been successfully demonstrated on Non-Destructive Assay (NDA) systems used at the following DOE Sites: • Hanford – WRAP IPAN – WIPP certified system used to assay 55-gallon drums containing CH-TRU. • Rocky Flats – RFETS Passive/Active Drum Counter (PADC) - WIPP certified system used to assay 55-gallon drums containing CH-TRU. • Rocky Flats – Multi-Purpose Crate Counter (MPCC) – WIPP certified system used to assay crated CH-TRU. • Savannah River – Mobile IPAN - WIPP certified system used to assay 55-gallon drums containing CH-TRU. • Idaho National Engineering Laboratory – AMWTP Retrieval Box Assay System (RBAS) – Process instrument used to characterize crated CH-TRU, in order to confirm that each crate meets the waste acceptance criteria for the AMWTP box processing facility.
T-2.13	Yes	Know what output devices are available	The data from the IPAN system will be supplied to the Data Management System, which will ultimately use it to derive the BWAC reportable data for the product drums.
T-2.14	Yes	The scope and scale of the waste problem has been determined	1. Fluor Hanford Contact No. 25147, Statement of Work. 2. BNG America Statement of Work for BNFL Instruments Inc., SOW-5477-EG-007, Revision 2.
T-2.15	Yes	Know what experiments are required (research approach)	BIL Solutions Inc., Calibration and Validation Plan, K-Basins Sludge Assay System, BII-5184-CVP-001.
P-2.1	Yes	System architecture defined in terms of major functions to be performed	System Specification Document, K-Basins Sludge Assay System, BII-5184-SSD-001, Revision 8.

P-2.2	No	Know capabilities and limitations of researchers and research facilities	The Imaging Passive Active Neutron (IPAN) technology, which is being provided by Pajarito Scientific Corporation (PSC) (formerly BIL Solutions Inc.) for the K-Basins Closure, Stabilization and Packaging (KBCSP) Assay System, is mature and has been successfully demonstrated on Non-Destructive Assay (NDA) systems used at the following DOE Sites: • Hanford – WRAP IPAN – WIPP certified system used to assay 55-gallon drums containing CH-TRU. • Rocky Flats – RFETS Passive/Active Drum Counter (PADC) - WIPP certified system used to assay 55-gallon drums containing CH-TRU. • Rocky Flats – Multi-Purpose Crate Counter (MPCC) – WIPP certified system used to assay crated CH-TRU. • Savannah River – Mobile IPAN - WIPP certified system used to assay 55-gallon drums containing CH-TRU. • Idaho National Engineering Laboratory – AMWTP Retrieval Box Assay System (RBAS) – Process instrument used to characterize crated CH-TRU, in order to confirm that each crate meets the waste acceptance criteria for the AMWTP box processing facility.

T - Technology, technical aspects
M - Manufacturing and quality
P - Programmatic, Customer Focus, Documentation
N/A – Criteria which does not apply to the Sludge Treatment Process

TRL 3 Question Set

T/P/M	Y/N (N/A)	Criteria	Basis
T-3.1	Yes	Some key process requirements are identified	1. System Specification Document, K-Basins Sludge Assay System, BII-5184-SSD-001, Revision 8. 2. BII-5184-SDD, KBSAS IPAN Software Definition Document. 3. BII-5184-HDD-001, KBSAS IPAN Hardware Definition Document.
T-3.2	Yes	Predictions of elements of technology capability validated by analytical studies	1. System Specification Document, K-Basins Sludge Assay System, BII-5184-SSD-001, Revision 8. 2. Preliminary system modeling completed by BIL Solutions, which is identified as reference No. 3 (G. Auchampaugh, K-Basin Sludge Assay System (KBSAS) Task 1 Memorandum, March 2005) in BII-5184-SSD-001, Revision 8. 3. BII-5184-TMU-001, KBSAS IPAN Total Measurement Uncertainty Document. 4. Application of the PAN/GHEA/AK method to the Non-Destructive Assay of Remote Handled TRU Waste., BNFL Instruments Inc. (various authors), presented at WM'04 Conference, Tucson, AZ. 5. High Sensitivity Assay of Cement Encapsulated Spent Nuclear Fuel Sludge using the Imaging Passive Active Neutron (IPAN™), Simpson A. (BIL Solutions), Abdurraham, N. (Fluor Hanford), presented at WM'07 Conference, Tucson, AZ.
T-3.3	Yes	Science known to extent that mathematical and/or computer models and simulations are possible	1. Preliminary system modeling completed by BIL Solutions, which is identified as reference No. 3 (G. Auchampaugh, K-Basin Sludge Assay System (KBSAS) Task 1 Memorandum, March 2005) in BII-5184-SSD-001, Revision 8. 2.

T/P/M	Y/N (N/A)	Criteria	Basis
T-3.4	Yes	Predictions of elements of technology capability validated by Modeling and Simulation (M&S)	1. Preliminary system modeling completed by BIL Solutions, which is identified as reference No. 3 (G. Auchampaugh, K-Basin Sludge Assay System (KBSAS) Task 1 Memorandum, March 2005) in BII-5184-SSD-001, Revision 8. 2. Note that current design for assay skid, including IPAN equipment, has been modeled using MCNP. The intention was that, subsequent to placement of contract for Assay Skid fabrication and confirmation of detailed design, the MCNP model would be as-built and then runs completed using simulated sludge matrices. The data produced by the model would then be use, in conjunction with data obtained from the site assay of simulated sludge matrices and SNM test sources, to derive the calibration library files for hot operations.
T-3.5	No	Laboratory experiments verify feasibility of application	Use of these detectors in both a high radiation and a dynamic (i.e., agitated) environment has not been evaluated or tested.
T-3.6	No	Predictions of elements of technology capability validated by laboratory experiments	Use of these detectors in both a high radiation and a dynamic (i.e., agitated) environment has not been evaluated or tested.
T-3.7	Yes	Key process parameters/variables have begun to be identified.	1. System Specification Document, K-Basins Sludge Assay System, BII-5184-SSD-001, Revision 8.
T-3.8	Yes	Paper studies indicate that system components ought to work together	1. Preliminary system modeling completed by BIL Solutions, which is identified as reference No. 3 (G. Auchampaugh, K-Basin Sludge Assay System (KBSAS) Task 1 Memorandum, March 2005) in BII-5184-SSD-001, Revision 8. 2. BII-5184-TMU-001, KBSAS IPAN Total Measurement Uncertainty Document.
T-3.9	Yes	Performance metrics for the system are established (What must it do)	1. System Specification Document, K-Basins Sludge Assay System, BII-5184-SSD-001, Revision 8.
T-3.10	Yes	Scaling studies have been started	1. BIL Solutions Inc., Calibration and Validation Plan, K-Basins Sludge Assay System, BII-5184-CVP-001.

T/P/M	Y/N (N/A)	Criteria	Basis
T-3.11	No	Scientific feasibility demonstrated	Use of these detectors in both a high radiation and a dynamic (i.e., agitated) environment has not been evaluated or tested.
T-3.12	No	Key physical and chemical properties have been characterized for a number of waste samples	The physical and chemical properties of the corroded sludge have not well characterized.
T-3.13	No	A simulant has been developed that approximates key waste properties	The physical and chemical properties of the corroded sludge have not well characterized. This includes development of a simulant that approximates key waste properties.
T-3.14	No	Laboratory scale tests on a simulant have been completed	The physical and chemical properties of the corroded sludge have not well characterized. This includes development of a simulant that approximates key waste properties.
T-3.15	Yes	Specific waste(s) and waste disposition site(s) has (have) been identified (WAC)	1. Fluor Hanford Contact No. 25147, Statement of Work. 2. BNG America Statement of Work for BNFL Instruments Inc., SOW-5477-EG-007, Revision 2.
T-3.16	No	The individual system components have been tested at the laboratory scale	Use of these detectors in both a high radiation and a dynamic (i.e., agitated) environment has not been evaluated or tested.
P-3.1	No	The basic science has been validated at the laboratory scale	Use of these detectors in both a high radiation and a dynamic (i.e., agitated) environment has not been evaluated or tested.

T/P/M	Y/N (N/A)	Criteria	Basis
P-3.2	Yes	Preliminary system performance characteristics and measures have been identified and estimated	1. System Specification Document, K-Basins Sludge Assay System, BII-5184-SSD-001, Revision 8. 2. Preliminary system modeling completed by BIL Solutions, which is identified as reference No. 3 (G. Auchampaugh, K-Basin Sludge Assay System (KBSAS) Task 1 Memorandum, March 2005) in BII-5184-SSD-001, Revision 8. 3. BII-5184-TMU-001, KBSAS IPAN Total Measurement Uncertainty Document. 4. Application of the PAN/GHEA/AK method to the Non-Destructive Assay of Remote Handled TRU Waste., BNFL Instruments Inc. (various authors), presented at WM'04 Conference, Tucson, AZ. 5. High Sensitivity Assay of Cement Encapsulated Spent Nuclear Fuel Sludge using the Imaging Passive Active Neutron (IPAN™), Simpson A. (BIL Solutions), Abdurraham, N. (Fluor Hanford), presented at WM'07 Conference, Tucson, AZ.
M-3.1	No	No system components, just basic laboratory research equipment to verify physical principles	Use of these detectors in both a high radiation and a dynamic (i.e., agitated) environment has not been evaluated or tested.
M-3.2	N/A	Current manufacturability concepts assessed	
M-3.3	No	Sources of key components for laboratory testing identified	Use of these detectors in both a high radiation and a dynamic (i.e., agitated) environment has not been evaluated or tested. Location/Laboratories required to complete this testing have not been identified.

T - Technology, technical aspects
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N/A – Criteria which does not apply to the Sludge Treatment Process

Critical Technology Element

Technology Readiness Level Determination

CTE-06 Mixing

Applicable Critical Technology sub-Elements (CTsE)

CTsE-05E.1	**Feed stream preparation (Day Tank)**	(Enhanced) Ability to establish and maintain a homogeneous mixture (norm and off norm)
CTsE-08	**Corrosion Vessel Mechanical Agitation**	Is an agitator the correct tool for this application? Agitation capabilities sufficient for normal and off-normal conditions? Effects on/from other corrosion vessel components; Reliability/Maintainability; Baffle side effects (material buildup, etc); Ability to make well mixed product (IPAN Feed).
CTsE-14	**IPAN Agitation**	Agitation capabilities sufficient for norm and off-norm conditions; Effects on/from other vessel components; Reliability/Maintainability; Baffle side effects (material buildup, etc); Ability to make homogeneous product (IPAN Product).
CTsE-20	**Drum Mixing**	Container Homogenization; Hot Spot concerns.

Technology Readiness Level Established

TRL-02

Technology Concept
and/or
Application Formulated

TRL 2 Question Set

T/P/M	Y/N (N/A)	Criteria	Documentation
T-2.1	Yes	Potential system or components have been identified	White papers: 1. RPT-5477-PR-T-0001, Sludge Treatment System Description; 2. RPT-5477-EG-G-0009, Cavitation in Agitated Vessels. System Descriptions: 1. SD-5477-PR-P-0001, Packaging System Description; 2. SD-5477-PR-T-0001, Sludge Treatment System Description; 3. SD-5477-PR-R-0001, Sludge Retrieval and Transfer System Description. Test Reports: 1. PNNL-16643, Report on Expert Review of the Sludge Treatment Project Testing; 2. PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions; 3. PNNL-53451(Draft), Sludge Treatment Project Corrosion Process Chemistry Follow-on Testing Test Plan 53451-TP01, Rev. 0. Functional Criteria: 1. KBC-24540, Functional Design Criteria K Basin Closure Sludge Treatment Project.
T-2.2	Yes	Paper studies show that application is feasible	See T-2.1
T-2.3	Yes	An apparent theoretical or empirical design solution identified	See T-2.1
T-2.4	Yes	Basic elements of technology have been identified	See T-2.1
T-2.5	Yes	Desktop environment (paper studies)	See T-2.1
T-2.6	Yes	Components of technology have been partially characterized	See T-2.1
T-2.7	Yes	Performance predictions made for each element	See T-2.1
T-2.8	Yes	Initial analysis shows what major functions need to be done	See T-2.1
T-2.9	Yes	Modeling & Simulation used to verify physical principles	See T-2.1
T-2.10	Yes	Analytical studies confirm basic principles	See T-2.1
T-2.11	Yes	Analytical studies reported in scientific journals/conference proceedings/technical reports.	See T-2.1

T/P/M	Y/N (N/A)	Criteria	Documentation
T-2.12	Yes	Individual parts of the technology work (No real attempt at integration)	See T-2.1
T-2.13	N/A	Know what output devices are available	
T-2.14	Yes	The scope and scale of the waste problem has been determined	See T-2.1
T-2.15	Yes	Know what experiments are required (research approach)	See T-2.1
P-2.1	Yes	System architecture defined in terms of major functions to be performed	See T-2.1
P-2.2	Yes	Know capabilities and limitations of researchers and research facilities	See T-2.1

T - Technology, technical aspects
M - Manufacturing and quality
P - Programmatic, Customer Focus, Documentation
N/A – Criteria which does not apply to the Sludge Treatment Process

TRL 3 Question Set

T/P/M	Y/N (N/A*)	Criteria	Documentation
T-3.1	Yes	Some key process requirements are identified	CTsE-08: PNNL-16643, Report on Expert Review of the Sludge Treatment Project Testing All: KBC-24540, Functional Design Criteria K Basin Closure Sludge Treatment Project.
T-3.2	Yes	Predictions of elements of technology capability validated by analytical studies	CTsE-08: 1. PNNL-16643, Report on Expert Review of the Sludge Treatment Project Testing; 2. SD-5477-PR-T-0001, Sludge Treatment System Description.
T-3.3	Yes	Science known to extent that mathematical and/or computer models and simulations are possible	CTsE-08: PNNL-16643, Report on Expert Review of the Sludge Treatment Project Testing
T-3.4	No	Predictions of elements of technology capability validated by Modeling and Simulation (M&S)	CTsE-08: PNNL-53451(Draft), Sludge Treatment Project Corrosion Process Chemistry Follow-on Testing Test Plan 53451-TP01, Rev. 0.
T-3.5	No	Laboratory experiments verify feasibility of application	CTsE-08: 1. PNNL-53451(Draft), Sludge Treatment Project Corrosion Process Chemistry Follow-on Testing Test Plan 53451-TP01, Rev. 0; 2. PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions.
T-3.6	Yes	Predictions of elements of technology capability validated by laboratory experiments	CTsE-08: 1. PNNL-16643, Report on Expert Review of the Sludge Treatment Project Testing; 2. PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions.
T-3.7	Yes	Key process parameters/variables have begun to be identified.	CTsE-08: 1. PNNL-16643, Report on Expert Review of the Sludge Treatment Project Testing; 2. KBC-24540, Functional Design Criteria K Basin Closure Sludge Treatment Project.

T/P/M	Y/N (N/A*)	Criteria	Documentation
T-3.8	Yes	Paper studies indicate that system components ought to work together	White papers: RPT-5477-PR-T-0001, Sludge Treatment System Description; RPT-5477-EG-G-0009, Cavitation in Agitated Vessels. System Descriptions: 1. SD-5477-PR-P-0001, Packaging System Description; 2. SD-5477-PR-T-0001, Sludge Treatment System Description; 3. SD-5477-PR-R-0001, Sludge Retrieval and Transfer System Description.
T-3.9	Yes	Performance metrics for the system are established (What must it do)	CTsE-08: 1. PNNL-16643, Report on Expert Review of the Sludge Treatment Project Testing; 2. KBC-24540, Functional Design Criteria K Basin Closure Sludge Treatment Project.
T-3.10	Yes	Scaling studies have been started	CTsE-08: PNNL-53451(Draft), Sludge Treatment Project Corrosion Process Chemistry Follow-on Testing Test Plan 53451-TP01, Rev. 0
T-3.11	Yes	Scientific feasibility demonstrated	CTsE-08: 1. PNNL-16643, Report on Expert Review of the Sludge Treatment Project Testing; 2. PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions.
T-3.12	Yes	Key physical and chemical properties have been characterized for a number of waste samples	HNF-SD-SNF-TI-015, Spent Nuclear Fuel Project Technical Databook, Vol. 2, Sludge, provides the key physical and chemical properties for the waste. But, waste physical properties after processing are not well understood; see PNNL-16643, Report on Expert Review of the Sludge Treatment Project Testing; and PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions.

T/P/M	Y/N (N/A*)	Criteria	Documentation
T-3.13	No	A simulant has been developed that approximates key waste properties	CTsE-20: TSRT-5477-RT-00001, Test Report for Waste Drum Mixer Proof-of-Principle Test. Others: Representative simulant not developed since properties not fully understood; see PNNL-16643, Report on Expert Review of the Sludge Treatment Project Testing; and PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions.
T-3.14	Yes	Laboratory scale tests on a simulant have been completed	CTsE-20: TSRT-5477-RT-00001, Test Report for Waste Drum Mixer Proof-of-Principle Test. CTsE-08, 14: PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions.
T-3.15	Yes	Specific waste(s) and waste disposition site(s) has (have) been identified (WAC)	DOE/WIPP-02-3214, Remote-Handled Transuranic Waste Characterization Program Implementation Plan
T-3.16	No	The individual system components have been tested at the laboratory scale	CTsE-20: Full-scale drum mixing tests conducted and documented in TSRT-5477-RT-00001, Test Report for Waste Drum Mixer Proof-of-Principle Test. CTsE-08, 14: No lab scale testing completed.
P-3.1	Yes	The basic science has been validated at the laboratory scale	CTsE-08: 1. PNNL-53451(Draft), Sludge Treatment Project Corrosion Process Chemistry Follow-on Testing Test Plan 53451-TP01, Rev. 0; 2. PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions.
P-3.2	Yes	Preliminary system performance characteristics and measures have been identified and estimated	CTsE-08: 1. PNNL-16643, Report on Expert Review of the Sludge Treatment Project Testing; 2. PNNL-53451(Draft), Sludge Treatment Project Corrosion Process Chemistry Follow-on Testing Test Plan 53451-TP01, Rev. 0.

T/P/M	Y/N (N/A*)	Criteria	Documentation
M-3.1	Yes	No system components, just basic laboratory research equipment to verify physical principles	CTsE-08: 1. PNNL-53451(Draft), Sludge Treatment Project Corrosion Process Chemistry Follow-on Testing Test Plan 53451-TP01, Rev. 0.; 2. PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions.
M-3.2	N/A	Current manufacturability concepts assessed	
M-3.3	Yes	Sources of key components for laboratory testing identified	CTsE-08: 1. PNNL-53451(Draft), Sludge Treatment Project Corrosion Process Chemistry Follow-on Testing Test Plan 53451-TP01, Rev. 0.; 2. PNNL-16496, Hydrothermal Testing of K Basin Sludge and N Reactor Fuel at Sludge Treatment Project Operating Conditions.

T - Technology, technical aspects
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P - Programmatic, Customer Focus, Documentation
N/A – Criteria which does not apply to the Sludge Treatment Process

Critical Technology Element

Technology Readiness Level Determination

CTE-07 Waste Package

Applicable Critical Technology sub-Elements (CTsE)

CTsE-19	**Product Container**	Material compatibility of waste package and ability to decontamination
CTsE-21	**Dosing Head (wet and dry)**	Contamination Control/Confinement; Demonstrate that ventilation pipe provides appropriate protection for the drum agitator shaft.
CTsE-22	**WIPP Certifiable Waste Form**	Verify ability to produce a WIPP certifiable waste package
CTsE-24	**Drum Decontamination**	Verify ability to perform remote decontamination to acceptable levels

Technology Readiness Level Established

TRL-04 **Component and/or System Validation in Laboratory Environment**

TRL 4 Question Set

T/P/M	Y/N (N/A)	Criteria	Documentation
T-4.1	Yes	Key process variables/parameters have been fully identified.	1. DOE/WIPP-02-3122 rev. 6.0, *WIPP-WAC.* 2. Contract 25147, Sect. 4.4.3, BWAC. 3. HNF-5173, *PHMC Radiological Control Manual*
T-4.2	Yes	Individual process equipment/components tested in laboratory or by supplier	1. Nexia Solutions (05)6826 (Submittal 22, v5), *Small-Scale POP Encapsulation Trials of Sludges using Ordinary Portland Cement* 2. TSRT-5477-RT-0001, *Waste Drum Mixer Proof of Principle Test*
T-4.3	Yes	Subsystems composed of multiple components tested at lab scale using simulants	1. TSRT-5477-RT-0001, *Waste Drum Mixer Proof of Principle Test* 2. VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*
T-4.4	Yes	Modeling & Simulation used to simulate some components and interfaces between components	Nexia Solutions (05)6826 (Submittal 22, v5), *Small-Scale POP Encapsulation Trials of Sludges using Ordinary Portland Cement*
T-4.5	Yes	Overall system requirements for end user's application are documented	1. KBC-24540, *STP Functional Design Criteria* 2. HNF-20135, *STP Functional Requirements Document*
T-4.6	Yes	System performance metrics measuring requirements have been established	1. FP-0603-BNGA-074-002, *MOSS Fabrication, Inspection, and Test Plan* 2. Letter Report 46683-RPT01, *Control Measures to Assure 'No Liquid' in Grouted KE NLOP sludge*, CH Delegard et al, 9/27/05. 3. RPT-5477-EG-G-0003, *Development Plan for the BWAC Acceptable Knowledge Package*
T-4.7	Yes	Laboratory testing requirements derived from system requirements are established	46857-RPT-04, *K-Basin Sludge Equipment Function and Design Testing at the APEL.*
T-4.8	Yes	Analysis completed to establish component compatibility (Do components work together)	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System* [via testing]
T-4.9	Yes	Technology demonstrates basic functionality in simulated environment	1. VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System* 2. Nexia Solutions (05)6826, (Submittal 22, v5), *Small-Scale POP Encapsulation Trials of Sludges using Ordinary Portland Cement*

T/P/M	Y/N (N/A)	Criteria	Documentation
T-4.10 M-4.1	Yes	Equipment scale-up relationships are understood/accounted for in technology development program	1. VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System* NOTE: During the MOSS FAT, visual observations indicated that the dry dosing head did not adequately contain dry particulate (cement) indicating potential contamination confinement issues. Design changes are being considered and validated in the future.
T-4.11	Yes	Integration studies have been started	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System* [via testing]
T-4.12	Yes	Scaling documents and designs of technology have been completed	1. Nexia Solutions (05)6826 (Submittal 22, v5), *Small-Scale POP Encapsulation Trials of Sludges using Ordinary Portland Cement* 2. VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*
T-4.13	Yes	Functional process description developed. (Systems/subsystems identified)	SD-5477-PR-P-0001, Packaging System Description
T-4.14	Yes	Low fidelity technology "system" integration and engineering completed in a lab environment	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System* [via testing]
T-4.15	Yes	Key physical and chemical properties have been characterized for a range of wastes	1. RPT-5477-PR-T-0006, *Determination of Corrosion Reaction Endpoint* 2. RPT-5477-PR-T-0008, *Potential Reactions that Might Modify the Reaction of Uranium Metal, Impact the Process, and Influence the Applicability of Hydrogen Concentration Measurements* 3. RPT-5477-PR-T-0009, *Total Measurement Uncertainty* 4. RPT-5477-EG-G-0003, *Development Plan for the BWAC Acceptable Knowledge Package* 5. RPT-5477-M-T-0003, *Overfilling of Drum with Flush Water* 6. RPT-5477-M-T-0004, *Drum Handling System Failures and Recovery Actions Strategy* 7. Nexia Solutions (05)6826 (Submittal 22, v5), *Small-Scale POP Encapsulation Trials of Sludges using Ordinary Portland Cement* 8. TSRT-5477-RT-0001, *Waste Drum Mixer Proof of Principle Test*

T/P/M	Y/N (N/A)	Criteria	Documentation
T-4.16	Yes	A limited number of simulants have been developed that approximate the range of waste properties	1. KBC-MO-041, *K Basin Containerized Sludge Rheological Simulants* (attachment to A21C-25147-RCI-065). 2. PNNL-14811, *Gas Generation Testing of Uranium Metal in Simulated K Basin Sludge and in Grouted Sludge Waste Forms.* 3. RPT-5477-PR-T-0013, *Evaluation of Simulants Specified for Design and Fabrication of the Assay Vessel Agitator.*
T-4.17	Yes	Laboratory scale tests on a range of simulants have been completed	Nexia Solutions (05)6826, (Submittal 22, v5), *Small-Scale POP Encapsulation Trials of Sludges using Ordinary Portland Cement*
T-4.18	Yes	Process/parameter limits are being explored	1. RPT-5477-PR-T-0006, *Determination of Corrosion Reaction Endpoint* 2. RPT-5477-PR-T-0008, *Potential Reactions that Might Modify the Reaction of Uranium Metal, Impact the Process, and Influence the Applicability of Hydrogen Concentration Measurements* 3. RPT-5477-PR-T-0009, *Total Measurement Uncertainty* 4. RPT-5477-EG-G-0003, *Development Plan for the BWAC Acceptable Knowledge Package*
T-4.19	Yes	Test results are analyzed and documented	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*
P-4.1	Yes	Draft conceptual designs have been documented	Final Design Complete, See BNG America Submittals 35 & 38
M-4.2	Yes	Laboratory components tested are prototypical of system components	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*
M-4.3	Yes	Available components assembled into laboratory scale system	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*
M-4.4	Yes	Scalable technology prototypes have been produced (Can components be made bigger than lab scale)	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*
M-4.5	Yes	Key manufacturing processes for equipment systems identified	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*
M-4.6	N/A	Key manufacturing processes assessed in laboratory	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*

T/P/M	Y/N (N/A)	Criteria	Documentation
M-4.7	N/A	Mitigation strategies identified to address manufacturability/producibility shortfalls	1. RPT-5477-M-T-0003, *Overfilling of Drum with Flush Water* 2. RPT-5477-M-T-0004, *Drum Handling System Failures and Recovery Actions Strategy* 3. RPT-5477-PR-T-0008, *Potential Reactions that Might Modify the Reaction of Uranium Metal, Impact the Process, and Influence the Applicability of Hydrogen Concentration Measurements* 4. RPT-5477-PR-T-0009, *Total Measurement Uncertainty*

T - Technology, technical aspects
M - Manufacturing and quality
P - Programmatic, Customer Focus, Documentation
N/A – Criteria which does not apply to the Sludge Treatment Process

TRL 5 Question Set

T/P/M	Y/N (N/A)	Criteria	Documentation
T-5.1	Yes	The relationships between major system and sub-system parameters are understood on a laboratory scale.	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*
T-5.2	Yes	Plant size components available for testing	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*
T-5.3	Yes	System interface requirements known (How will system be integrated into the plant?)	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*
T-5.4	Yes	Preliminary design engineering begins	Final Design Complete, See BNG America Submittals 35 & 38
T-5.5	Yes	Requirements for technology verification established	1. FP-0603-BNGA-074-002, *MOSS Fabrication, Inspection, and Test Plan* 2. RPT-5477-EG-G-0003, *Development Plan for the BWAC Acceptable Knowledge Package*
T-5.6	Yes	Interfaces between components/subsystems in testing are realistic (benchtop with realistic interfaces)	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*
T-5.7	Yes	High fidelity lab integration of system completed, ready for test in relevant environments	1. Nexia Solutions (05)6826 (Submittal 22, v5), *Small-Scale POP Encapsulation Trials of Sludges using Ordinary Portland Cement.* 2. TSRT-5477-RT-0001, *Waste Drum Mixer Proof of Principle Test.* 3. VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*
T-5.8	Yes	Lab scale similar system tested with range of simulants	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*
T-5.9	Yes	Fidelity of system mock-up improves from laboratory to benchscale testing	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*
T-5.10	No	Laboratory environment for testing approximates operational environment	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System* NOTE: Contamination control failed during Factory Acceptance Tests. Resultant is currently under development but has yet to be tested and validated.
T-5.11	Yes	Component integration issues and requirements identified	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*

T/P/M	Y/N (N/A)	Criteria	Documentation
T-5.12	Yes	Requirements definition with performance thresholds and objectives established for final plant design	RPT-5477-EG-G-0014, *Preliminary Design Compliance Report.*
T-5.13	Yes	Preliminary technology feasibility engineering report completed	Final Design Complete, See BNG America Submittals 35 & 38
T-5.14	Yes	Integration of modules/functions demonstrated in a laboratory/bench scale environment	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*
T-5.15	No	The range of relevant physical and chemical properties has been determined	Sludge hot cell testing in progress. These tests will aid understanding the rheology of the corroded sludge and in development of a truly representative simulant.
T-5.16	No	Simulants have been developed that bound the relevant range of waste properties	Sludge hot cell testing in progress. These tests will aid understanding the rheology of the corroded sludge and in development of a truly representative simulant.
T-5.17	No	Testing has verified that the relevant properties/performance of the simulants match the properties/performance of the actual wastes	Sludge hot cell testing in progress. These tests will aid understanding the rheology of the corroded sludge and in development of a truly representative simulant.
T-5.18	No	Laboratory scale tests on the full range of simulants and/or real wastes using a high-fidelity system have been completed	Sludge hot cell testing in progress. These tests will aid understanding the rheology of the corroded sludge and in development of a truly representative simulant.
T-5.19	No	Test results for simulants and real waste are consistent	Sludge hot cell testing in progress. These tests will aid understanding the rheology of the corroded sludge and in development of a truly representative simulant.
T-5.20	No	Laboratory to engineering scale scale-up issues are understood and resolved	1. VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System* 2. Airborne Contamination Issues Remain. These Issues are still under development and resolution is pending.
T-5.21	Yes	Limits for process variables/parameters are being refined	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*
T-5.22	Yes	Test plan for high-fidelity lab scale tests executed – results validate design	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*
M-5.1	N/A	Tooling and machines demonstrated in lab for new manufacturing processes to make component	N/A

T/P/M	Y/N (N/A)	Criteria	Documentation
M-5.2	Yes	Manufacturing techniques have been defined to the point where largest problems defined	VS-6016-403, *Factory Acceptance Test for the MOSS Packaging System*
M-5.3	No	Reliability, availability, maintainability and inspectability (RAMI) target levels identified	1. RPT-5477-OR-G-0001, *Operational Research Model Throughput Assessment* 2. FHI Failure Modes and Effects Analysis (FMEA) in progress

T - Technology, technical aspects
M - Manufacturing and quality
P - Programmatic, Customer Focus, Documentation
N/A – Criteria which does not apply to the Sludge Treatment Process

Appendix C

Findings and Observations

The following Findings and Observations were identified by the STP TRA Team during their assessment of the maturity of the technology envisioned for use in the Sludge Treatment Process design. The Team believed that the following items were not related to technology maturity, but rather to equipment identification, design, testing, or fabrication/construction issues. Additionally, Observation 1 deals with the Team's concern for the difficulty in applying the NASA/DoD pre-manufacturing lines of inquiry to a DOE process development task.

<u>Observation 1</u> – TRA Process Not Tailored to DOE Processes and Practices

The STP TRA Team identified several concerns with the format and content of the NASA/DoD TRA process and especially with the TRL lines of inquiry and level descriptions. These concerns were associated with application of the TRA process to the DOE project management practices. In many cases the Team struggled to correlate the meaning or intent of a specific line of inquiry, which had been written to assess a specific NASA/DoD issue, to an appropriate issue for the STP process. The Team felt that this was due mainly to the fact that the NASA/DoD effort was focused on validating a process to allow manufacturing of several to many items, while the DOE is normally concerned with startup and operation of a single item.

The Team recognizes that the TRA process provides a useful methodology for determining the technology maturity levels for candidate technologies. Additionally, the resultant Technology Readiness Level that is determined is useful to provide relative comparisons between technologies and to identify technologies that need further efforts to reach an appropriate technology maturity level. However, as an absolute number it is not necessarily a valid, overall "grade" of the project. For example, a candidate technology may be at a TRL-2, but it could take a relatively small effort to take it to a TRL-6.

Additionally, the TRL questions sets and the TRL numbering system were developed and may be valid to evaluate a "production" system (i.e., validate a technology before manufacturing a thousand airplanes), however, it may not be suitable for a one-of-a-kind process system design which is typical of DOE projects.

Also, there were discussions which questioned the rationale and justification for requiring a TRL-6 prior to commencing construction. The Team questions the need to develop an engineering/pilot scale (prototypical) system for every system or sub-system. The Team believes that a graded approach should be instituted with regard to "required" TRL levels, based on costs, risks, uncertainty, etc., to allow flexibility and cost effectiveness.

Thus, although the idea of assessing technology maturity before committing procurement and construction funding is an appropriate objective, the STP TRA Team concludes that the NASA/DoD TRA process could to be modified to be a more effective and valid tool for DOE projects.

Observation 2 – Fines management and capture methodology needs to be identified and integrated into design

There is a very fine sludge fraction that does not settle readily, and redistributes itself every time it is disturbed. It has been observed to settle through out both K-East and K-West to significant levels. Capture and disposal of this sludge is not well understood, nor has any technology been identified at this late point in time. It is quite evident that at some point in time this fraction of sludge well need to be captured and put into a waste stream. The enhanced base line, which uses decanting of a day tank, will tend keep a large portion of this sludge out of the process stream.

Historically, very little attention has been paid to the control and management of the sludge fines. Although several engineered features, e.g., XXX, have been developed and integrated into the sludge retrieval, transfer and containerization systems, generally this stream has been allowed to freely resettle throughout the East and West Basins. Additionally, past retrieval and transfer operations have shown that the sludge material is fractured as it is pumped, this increasing the total amount of fines. Also, during operation of the Large Diameter Container system, it was shown that the fines were not easily filtered.

In the future, the K West Basin will not be available to serve as the "fines capture and containment" system, as it will be necessary to remove and treat all sludge current contained in the basin. Therefore, it will be imperative that the STP design incorporate functions and capabilities that ensure the fines can be removed and packaged.

Observation 3 – Valve Binding and/or Actuation

Binding of process valves is an acknowledged concern in remote applications in high radiation fields dealing with fluids containing abrasive solids. The Project's document SP-5477-EG-G-0112, *Process Integration – Special Valves Specification* addresses the issue in design space but there is no indication that critical valves will undergo testing prior to system commissioning.

Calculation CALC-5477-NS-T-0006, *Radiation Exposure for Sludge Treatment Process Valves* evaluated the impact of radiation on valve materials and, based on published data, concluded that the valve materials will withstand expected radiation exposure under normal operating without degradation in performance. The analysis was conservative as it did not credit line flushing as a means to reduce radiation exposure to valve materials. The analysis concluded there is sufficient margin (several orders of magnitude based on the cited reference) with respect to radiation exposure under normal operating conditions; testing may be warranted to validate valve performance following upset conditions that may result in additional, unanticipated radiation exposure.

Observation 4 – Demister Design Issues

Several concerns were identified by the STP TRA Team during its review of the corrosion vessel demister. These concerns included:

- The demister dip leg is likely to become plugged during the sludge corrosion process
- The dip leg design will not allow water to move out of the demister and down the dip leg. The density of the sludge will force the water to rise in the dip tube and flood the demister.
- The demister has been integrated into the corrosion vessel shell and incorporates no mechanism for either the physical cleanout or replacement of the demister in the event that it becomes plugged.
- The demister inlet (i.e., corrosion vessel outlet) is likely to be exposed to corroded sludge, due to foaming/frothing and/or agitator splashing. There is no provision for cleaning or clearing a plug in the inlet, should one occur.

These concerns should be addressed and resolved prior to initiating operation of the corrosion vessel.

Observation 5 – Contamination Mitigation

- **Overall Process**

The STP TRA Team had concerns with the lack of engineered barriers between the operations personnel and the operating systems. The use of the half-wall to separate the operations control area and the operating systems does not seem appropriate for the levels of radioactivity, and the resulting potential contamination, which is to be addressed.

- **IPAN/MOSS Skid**

The sludge that is being grouted can cause extremely high surface contamination if even very small quantities contact the outside of the barrels. The sludge transfer mechanism from the IPAN to the dosing head is not designed to drain easily or completely, as a flex hose is utilized. This means that the dosing head may continue to drip for an indeterminate time with random quantities of sludge being released after a dosing operation. There is a drip tray that will deploy under the dosing head after a dosing operation, however, if a drip occurs prior to or during the deployment of the drip tray and it hits the side of the drum or tray this would lead to spreading the contamination to the MOSS transfer system and potentially to other barrels.

There are no provisions to properly decontaminate high surface-contaminated barrels. The Master Slave Manipulator decontamination station is envisioned to only address minimal contamination spread. High levels of surface contamination are highly probable due to current misting issues/contamination spread with the dosing head. The inability to properly decontaminate the drum could result to increase personnel exposure and may result in its not being acceptable for shipment to WIPP.

Observation 6 – ALARA/Dose Mitigation

- **Overall Process**

The STP TRA Team felt that several fundamental ALARA principles and practices had been overlooked in developing the plan for integrating the STP skids into the CVDF. The expected radiation levels and potential contamination levels which will be observed during the processing and packaging of the sludge would normally be managed in a Hot Cell or Canyon facility, totally isolated and separate from the operating personnel. The use of a half wall, with a common air space, seems totally inappropriate for the performance of these types of operations. Additionally, the need to routinely send personnel into the operations area, e.g., for the placement and pre-staging of the empty waste drums, does not seem to be consistent with ALARA principles and practices.

- **Drum Handling associated with Cask Loading**

ALARA concerns remain with the load-out, removal and handling of the grouted drums. Issues including drum handling, cask loading, crane operator and support personnel exposure, sky-shine and on-site personnel protection have not been adequately addressed.

Observation 7 – WIPP Certification Concerns

In order for the STP waste packages (drums) to be finally dispositioned, they must be in a form acceptable by WIPP. In general, there are two methods for certification of waste packages - 1) the process for packaging the waste can be WIPP certified and, 2) the individual packages themselves can be WIPP certified.

For a process to be WIPP certified, the process has to have built in methods to be calibrated on a regular basis. The STP project has determined that the system does not have the capability to perform the necessary calibrations required to certify the process. Instead, the STP project will focus on making sure the waste packages are in a form which can be "certifiable" by WIPP.

At the time the STP contract was issued, the certification requirements related to the STP packaging had not been developed. In order to proceed, the STP contract stated that the drum packages produced must be WIPP "Certifiable", but the project was not required to produce WIPP certified waste containers.

At present, the end state requirements for WIPP certified waste packages have been developed and identified, but these requirements have not been integrated into the project. As a result, there is no demonstrated capability that the packaging system can produce waste packages which can be certified for WIPP storage.

Observation 8 – Hydraulic calculations for sludge transfer assumptions/methodology may not be valid.

Transportable slurries are defined by the STP Technical Staff as being nearly homogenous. However, there are extreme variations in size and density of the particles making up the sludge, which means the transfer stream, is a mixed flow. The hydraulic calculations were not modeled for this type of mixed flow and therefore add very little to the understanding of sludge dynamics during transfer. The hydraulic calculations for HIH were essentially performed the same as those for STP, and provided little insight and were shown, during operation, to not be representative. Now that accurately maintaining a relatively high concentration of sludge during transfer without plugging is a requirement, better modeling is required for the hydraulic calculations. This sludge exhibits a granular nature and is prone to jamming which sometimes is made stronger or more pronounced as pressure is applied. A Bingham Plastic model, which was used, implies it could be dislodged by moderate pressure increases. IPAN vessel testing has already shown that jamming will occur.

Observation 9 – Identified transfer pumps have proven to fail in similar applications

Some of the under water pumps in K-West Basin that move sludge for retrieval or transfer are essentially the same as the pumps that were used under water in K-East Basin during the HIH transfer evolution. This is not satisfactory as those pumps experienced erosion to the point of failure multiple times requiring great expenditure of time and resources to change these pumps out. The concept that the pumps are under water therefore a leak is inconsequential is totally unacceptable. Materials and pump designs are available to fully eliminate this hazard with little to no increase in cost.

Observation 10 – Assumptions made in sludge transfer (e.g., 1 1/2 line volumes will adequate flush lines, etc) may not be accurate due to particulate size distribution

Currently, an assumption was made that the sludge transfer lines would be flushed with approximately 1 ½ line volumes following transfer of the sludge materials. There are two concerns associated with this item:

- This volume of flush may not be sufficient to clear the transfer lines of all sludge materials, especially in those cases where large or very high density particles are present.
- This volume may have significant effects in the operation of the STP process, especially in those cases where the downstream vessel is very small, e.g., IPAN and/or waste drum.

Observation 11 – Level Detection

The level detection systems utilized in both the corrosion and the IPAN vessels operate on the principle of Time Domain Reflectrometry (TDR). This works on the principle of measurement of the time of flight between a radar pulse being emitted from a transmitter to the time which it is received back at the transmitter. For the installations in the STP vessels, the radar pulse is guided to the surface level to be measured by means of a 2-inch pipe, which serves as the waveguide. It is very important that the interior of the waveguide be free from all obstructions, as these will cause false reflections of the radar pulse. Additionally, for the STP applications, the waveguide will also be slotted to allow venting, thereby serving as a stillwell.

The STP TRA Team has identified two concerns associated with this method of level detection for the corrosion and IPAN vessels.

- Reliability & effectiveness under process conditions -- due to the uncertainties associated with the rheology of the corroded sludge, there are concerns that the waveguide slots or waveguide itself may become caked or plugged, resulting in false readings.
- Effects from other in-vessel components -- due to the uncertainties associated with the rheology of the corroded sludge, there are concerns that other in-vessel components, e.g., the agitator, may create an environment that prohibits accurate measurement of the vessel level, either by creating a vortex or foaming which will result in an inaccurate reading.

Observation 12 – N2 Sparge Ring

The nitrogen sparge ring is currently envisioned to consist of a large circular pipe with four vertical "stand-pipe" sintered metal filters equally spaced around its diameter. These filters are each surrounded by a short piece of pipe, which is tack welded to the sparge ring. These pipes protect the filters from abrasion, due to impingement from the agitated sludge, and provided an annular space for nitrogen bubble formation to occur.

The STP TRA Team has identified several concerns associated with the use of this sparge ring and its sintered metal filters arrangement.

- Reliability & effectiveness under process conditions – due to the uncertainties associated with the rheology of the corroded sludge, there are concerns that the annular spaces may become plugged and/or the sludge may cake onto the filters. This will result in the nitrogen gas finding the path of least resistance into the sludge, which may result in extremely large bubble formation.
- Effects on/from other corrosion vessel components -- due to the uncertainties associated with the rheology of the corroded sludge, there are concerns that the interactions between various in-vessel components, e.g., the agitator, may produce undesirable results. Large bubble formation may cause sporadic agitator cavitation or may lead to increased bearing failure.

Appendix D

K Basin Sludge Treatment Process Technology Readiness Assessment Plan

U.S. Department of Energy, Richland Operations Office

K Basins Sludge Treatment Process

Technology Readiness Assessment Plan

Environmental Management

safety ✣ performance ✣ cleanup ✣ closure

www.em.doe.gov

1.0 INTRODUCTION

The U.S Department of Energy (DOE), Richland Operations Office (RL) is constructing a K Basins Sludge Treatment Process (STP) for the retrieval, treatment and packaging of the various sludge streams currently stored in the K West Basin at the Hanford Site in Washington State. The STP Project is comprised of seven (7) major sub-systems: sludge containerization, retrieval, transfer, oxidation (corrosion), assay, packaging and drum handling, as shown in Figure 1. The first 3 subsystems are planned to be located in the K West Basin, while the remaining four subsystems would be placed into the Cold Vacuum Drying Facility (CVDF), which is located about 500 feet to the West of the Basin. A hose-in-hose transfer system would be utilized to move the sludge streams from the K West Basin to the CVDF.

This Technology Readiness Assessment (TRA) will be conducted to document the technical maturity of sludge retrieval, transfer, treatment and packaging technologies in the current STP baseline; emerging enhancements to the baseline design will also be included in the review scope. Additional TRAs may be performed as the project moves forward.

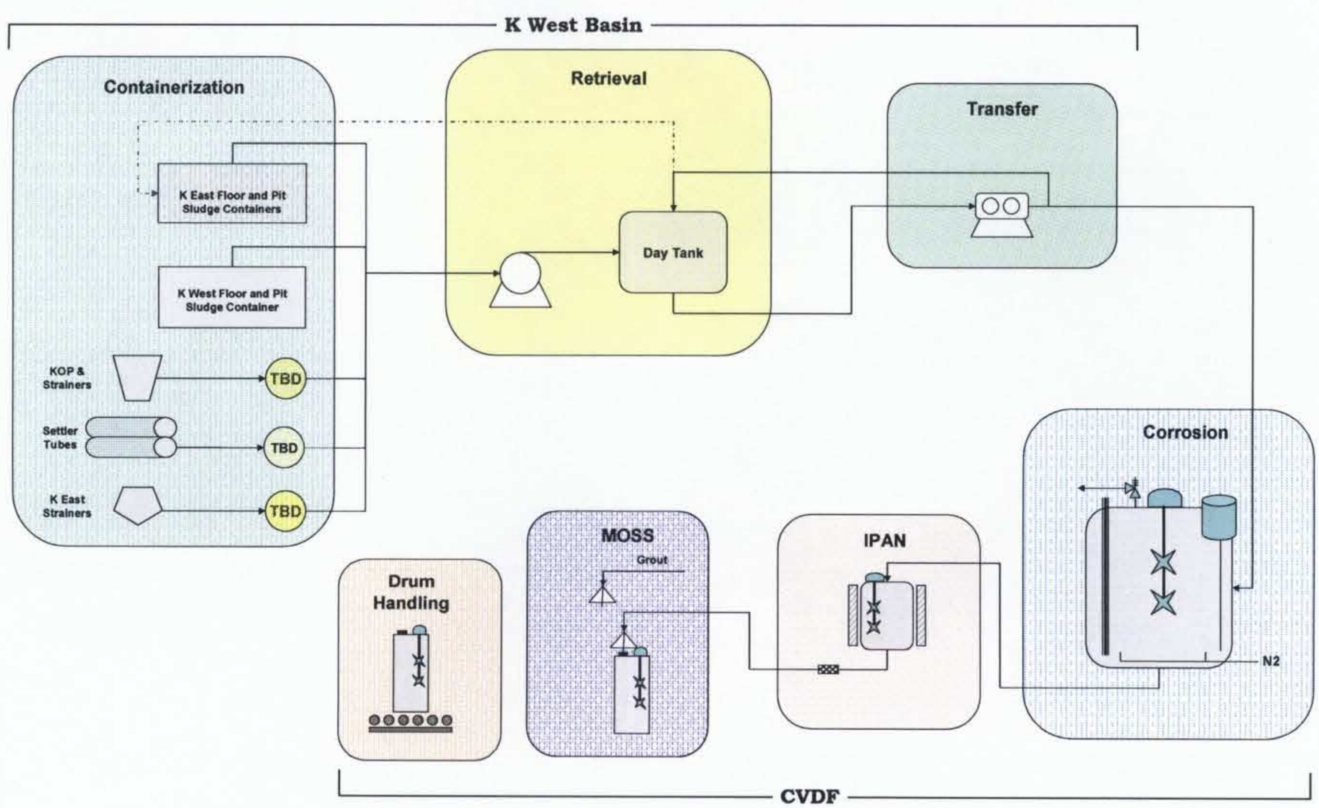

Figure 1. Sludge Treatment Process One-line Diagram

2.0 PURPOSE

The purpose of the STP TRA is to perform a "finding-of-fact" appraisal of the project's overall technical maturity. This is accomplished by first identifying individual technology elements utilized in the STP design. Then a systematic, metrics-based evaluation is performed to screen and assess the maturity of critical technology elements (CTEs) related to potential future deployment and operation in the sludge treatment process.

The TRA does not predict future system's performance nor does it assess the quality of the system's architecture, design, or integration plan(s). The TRA simply strives to identify any gaps which may exist between the current maturity of a CTE to that required for commencing construction of the overall processing system. The level of technical maturity, once determined, is assigned a numerical identifier, ranging from 1 to 9, based on specific, predetermined criteria. A maturity level of 6, as a minimum, is required to consider a CTE construction-ready. Any identified gaps, i.e., CTEs with a maturity level less than 6, along with specific plans for furthering the maturity of these individual CTEs, will be provided in a Technology Maturation Plan (TMP) to be developed by the Contractor (Fluor Hanford [FH]).

The TRA will be jointly performed by DOE-RL in collaboration with the Contractor. The STP TRA Team will be co-lead with the DOE-RL Chief Engineer, who reports to the Manager, Safety and Engineering Division and FH STP Chief Engineer. The STP TRA Team will be composed of technical experts and Contractor representatives, having experience in process operations, process engineering and system design. This STP TRA is viewed as an educational opportunity for both DOE-RL and FH and will serve as a pilot for subsequent TRAs, incorporating lessons learned from recent TRAs performed (e.g., Hanford's Waste Treatment Plant).

The results of this TRA and the subsequent TMP may be factored into a revised project baseline.

3.0 TRA BACKGROUND

In 1999, the U.S. General Accounting Office (GAO) produced a report (GAO/NSIAD-99-162) that examined the differences in technology transition between the DoD and private industry. The GAO concluded that the DoD took greater risks, and attempted to transition emerging technologies at lesser degrees of maturity compared to private industry. This resulted in the use of immature technology which increased overall program risk and led to substantial cost and schedule overruns. The GAO recommended that the DoD adopt the National Aeronautics and Space Administration's (NASA) Technology Readiness Levels (TRL) as a means of assessing technology maturity prior to design transition.

In 2001, the Deputy Undersecretary of Defense for Science and Technology issued a memorandum that endorsed the use of TRLs in new major programs. Guidance for assessing technology maturity was incorporated into the Defense Acquisition Guidebook (DODI 5000.2). Subsequently, the DoD developed detailed guidance for using TRLs in the 2003 DoD Technology Readiness Assessment

Deskbook (updated in May 2005 [DOD 2005]). The DoD Milestone Decision Authority must certify to Congress that the technology has been demonstrated in a relevant environment prior to transition of weapons system technologies to design or justify any waivers. TRL 6 is also used as the level required for technology insertion into design by NASA. The DOE-RL has decided to use the principles of the DoD TRA process for assessing STP technology readiness.

The TRA process as defined by the DoD consists of three parts: (1) identifying the Critical Technology Elements (CTEs); (2) assessing the TRLs of each CTE using an established readiness scale; and (3) preparing the TRA report. For those CTEs judged to be below the desired level of readiness, the TRA is followed by development of a Technology Maturation Plan that identifies the additional development required to attain the desired level of readiness.

4.0 SCOPE

The STP TRA Team is responsible for performing a review to determine the technical maturity of various critical components, subsystems and systems currently envisioned to be used in STP operation. The STP TRA Team will use methodology derived from the May 2005 Department of Defense Technology Readiness Assessment Handbook, as adapted for use by DOE, and will consider all major aspects of the STP design (excluding facility modification scope). A graded level of review detail will be applied depending on the significance of the CTE under consideration.

The STP TRA Team will systematically assess the STP process to establish the current maturity level of critical technology elements used in the baseline design. Additional recommendations have been documented (i.e., Murphy and Peres reviews) resulting in proposed enhancements to the baseline design; these enhancements will also be included in the review scope. The assessment scope will address the body of evidence available at the time of the review (i.e., planned/future development activities will not be reviewed or credited).

4.1 STP TRA Team Member Assignments

The STP TRA Team will be co-lead by DOE-RL and FH, with supporting technical experts and participation by select STP Project personnel. Contractor involvement is intended to promote effective integration of technology gaps into their technical baseline and project risk matrix.

Position	Title	Name
Lead	DOE-RL Chief Engineer	Burt Hill
Co-Lead	FH Chief Engineer	Neal Sullivan
Team member	Consultant/Technical Expert	Robbin Duncan
Team member	Consultant/Technical Expert	Dave Lowe
Team member	STP Project Test Authority	Mike Schliebe
Team member	Technical Support/Software SME	Scott Spencer

5.0 STP TRA METHODOLOGY

The STP TRA methodology was developed by the STP TRA Team. This methodology is modeled on the DOE TRAs that were previously conducted (e.g., Hanford WTP and SRS Tank 48) and the DoD TRA Deskbook (May 2005), as well as incorporating lessons learned from the previous DOE TRAs. These lessons learned were obtained via extensive process discussions with Pacific Northwest National Laboratories (PNNL) personnel that participated in previous TRAs and validated the TRA process methodology.

The STP TRA methodology is provided in the following sections. Figure 2 is a flow chart that depicts the STP TRA process steps and follow-on project activities.

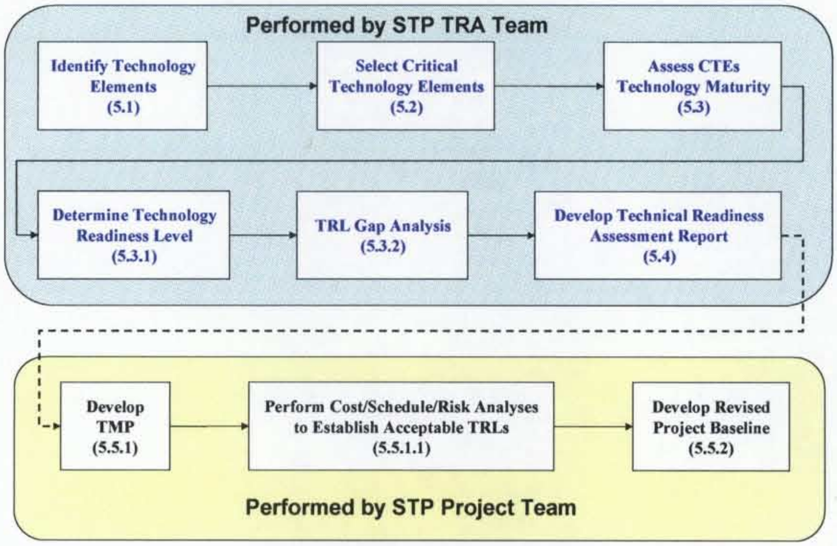

Figure 2. STP TRA Flow Chart

5.1 Identify Technology Elements

Technology Element (TE) identification is fundamental to the TRA and based on a comprehensive review of the STP design documents. The selection of the TEs is made by the STP TRA Team based on review of system plans, component lists, and operational requirements. The TEs may consist of systems, sub-systems, components, and/or concepts of use or function. After selection the list is given to the Contractor engineering technical staff to validate that the list is complete.

The TEs are the candidates that will be screened to determine if they are CTEs.

5.2 Select Critical Technology Elements (CTEs)

The technology elements are then evaluated to determine their essential functional and operational characteristics required for the success of the STP project. This is accomplished through an evaluation of the STP system, subsystem, component, and/or process design and comparing it to the design input/requirements. The design input/requirements as identified in:

- Preliminary Documented Safety Analysis
- Safety Evaluation Report for the Preliminary Documented Safety Analysis for Sludge Treatment Project
- KBC-24540, Functional Design Criteria, K Basins Closure, Sludge Treatment Project
- DOE/WIPP-02-3214, Remote-Handled Transuranic Waste Characterization Program Implementation Plan

The technology elements and their associated critical functional and operational characteristics are then evaluated to identify the Critical Technology Elements (CTEs). A technology element is deemed "critical" if the system being acquired depends on the technology element to meet operational requirements, and the technology element or its application is either new or novel (Ref: DOD TRA Deskbook, May 2005). The decision logic that will be followed to select the CTEs is depicted in Figure 3. It consists of applying a series of questions to each of the technology elements, and the documented answers to those questions are used to determine if the technology element is identified as a CTE.

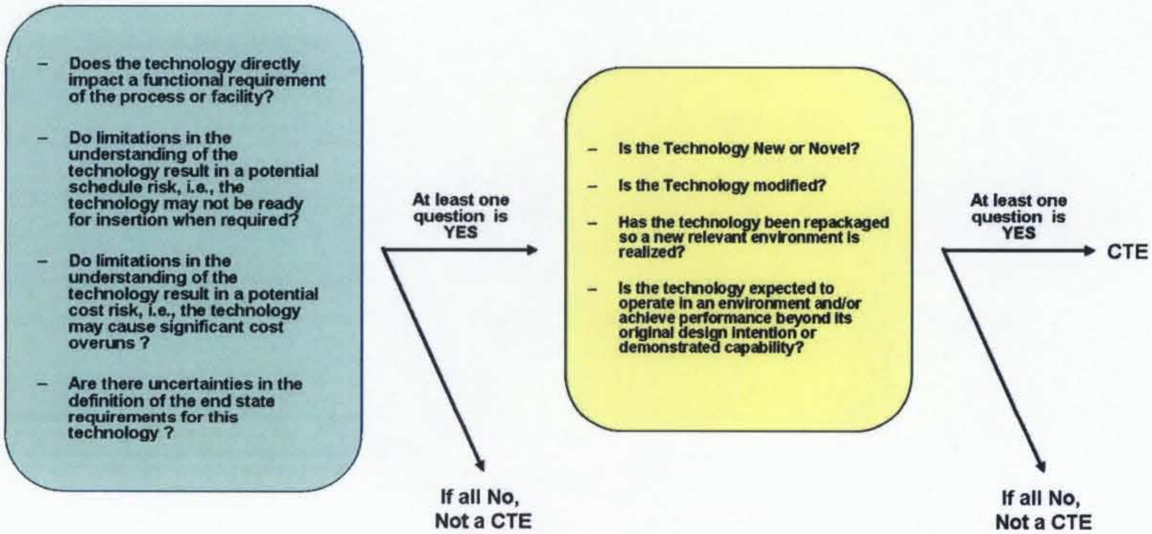

Figure 3. Critical Technology Elements Selection Methodology

5.3 Assess Critical Technology Element (CTE) Technical Maturity

Following identification of the CTEs, a "finding-of-fact" investigation will be preformed to establish each CTEs technical maturity. The desired TRL is 6, which equates to the technology having been proven in an engineering/pilot scale test or a similar technology having been validated in a relevant environment. The definitions and descriptions are provided in Figure 4 and Attachment A.

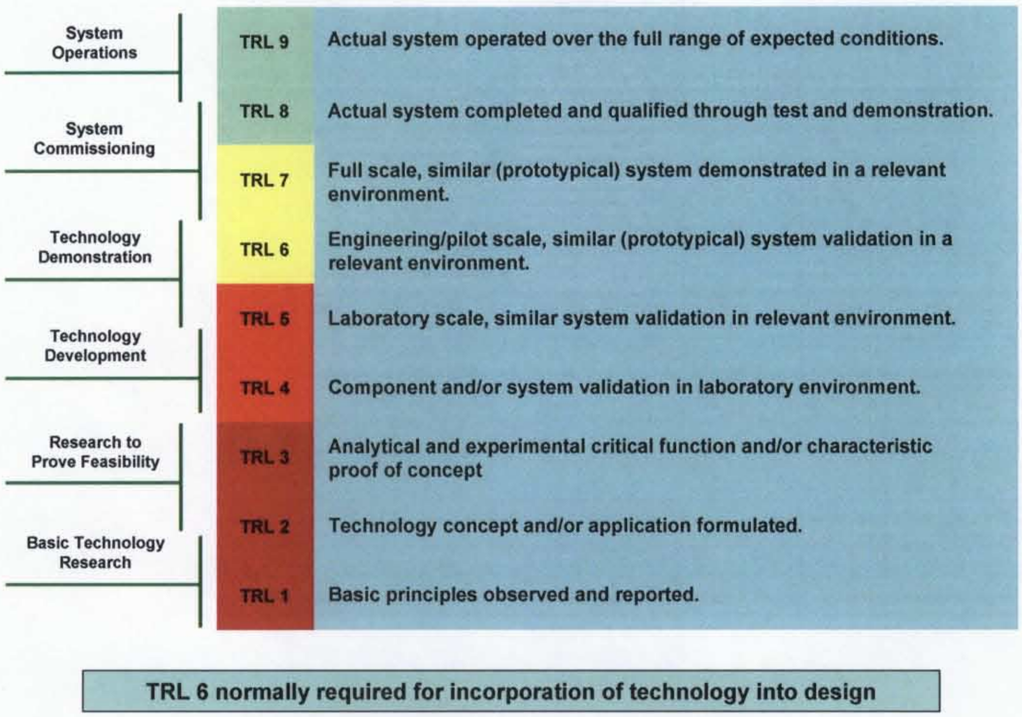

Figure 4. Technology Readiness Levels Definitions

5.3.1 Determine the Technology Readiness Levels (TRLs)

The STP TRA Team will use the WTP TRA question set, with minor refinements specific to the STP environment, as the basis for determining the TRL values of selected STP CTEs. The questions used by the WTP to establish a TRL values were derived from the TRL "calculator" (reference Nolte) and modified for fundamental applicability to the DOE environment. These questions will be further refined to incorporate lessons learned from previous TRAs to develop the STP lines of inquiry.

STP management will be provided with the list of CTEs and a request for supporting documentation to allow assessment of the technical maturity of each CTE. The STP TRA Team members will review the provided documentation in the context of the TRL lines of inquiry (Attachment C). Answers to the TRL lines of inquiry will be documented and used to establish a TRL value. Technical personnel from the STP will be queried during the TRL process to validate the STP TRA Team's interpretation of information used to establish the TRL value of the CTEs.

There may be several sub-systems or components integral to a given CTE which may result in multiple TRL values within the CTE under consideration. In the event of multiple TRLs for a given CTE, the lowest TRL value will be used as the value for the CTE and clarified in the TRA report.

The following table is a summary of the definition of Technology Readiness Levels (see Attachment A for a complete description).

5.3.2 Technology Readiness Level (TRL) Gap Analysis

Guidance provided to the STP TRA Team imposed a target TRL value of "6" as an acceptable technology maturity level to support a Critical Decision 3 (CD-3) review. Following selection of CTEs and determination of their corresponding TRL values, the STP TRA Team will develop a narrative description of the "delta" between the determined TRL value(s) and the target TRL value for the assessment (TRL 6). The STP TRA Team will use their collective expertise and experience to, in general terms, describe what they believe would be required to transition the CTE from its current TRL value to the target TRL 6 value. This portion of the assessment may be used as guidance for subsequent development of Technology Maturation Plans by the project.

5.4 Develop Technology Readiness Assessment (TRA) Report

The STP TRA Team will develop a report which fully describes the process methodology and results. Attachment B provides a proposed outline for the STP TRA Report.

5.5 Proposed Contractor Follow-on Activities

The TRA report may be utilized in support of Contractor follow-on activities may result in a revised project baseline, reflecting activities required to more fully mature the identified CTEs.

5.5.1 Develop Technology Maturation Plan (TMP)

The Contractor may utilize results from the TRA Final Report to develop a TMP. This TMP will focus on identifying the scope of work for maturing each CTEs to TRL.

5.5.1.1 Perform Cost/Schedule/Risk Analyses

A Cost/Schedule/Risk analyses would be performed for the scope identified to reach an acceptable TRL for each CTE (some TRLs less than 6 may be adequate with greater assumed risks). For those CTEs whose maturation to a TRL of 6 may result in either excessive costs and/or schedule, the TMP will identify the incremental maturation costs, schedule, and unaddressed risks for advancing the technology from its current TRL to higher TRLs. Ultimately, Contractor management will be responsible for defending TRLs less than 6.

5.5.2 Develop Revised Project Baseline

The TMP may be used to establish a revised project baseline.

6.0 SLUDGE TREATMENT PROCESS TRA SCHEDULE

The Technology Readiness Assessment will begin in June 25, 2007 and with projected final assessment documentation approval completed by the end of August 2007. A DOE-RL and Contractor management briefing on findings and conclusions will be conducted nominally one week after approval of the assessment report. The attached schedule provides relative timeframes anticipated for the review:

Task Number	Projected Duration	Task Description
1	2 weeks	Develop TRA Plan Development, Team Orientation and Pre-assessment Activities
2	2 weeks	Conduct TRA
3	1 week	Prepare Draft TRA Report
4	1 week	Brief Management, Internal DOE/Contractor Review
5	2 weeks	Finalize TRA Report

7.0 DEFINITIONS

Technology Elements (TEs): Technology elements of the STP Project that have been identified and which should be evaluated to determine if they are Critical Technology Elements.

Critical Technology Elements (CTEs): Technology components which are essential to the successful function and operation the STP. A CTE may be comprised of a single component, a subsystem, a system, or a concept of use or function.

A technology element is "critical" if the functionality, operability, reliability or maintainability of the system depends on this technology element and/or if the technology element or its application is either new or novel. An element that is new or novel or is being used in a new or novel way is critical if it is necessary to achieve the successful development of a system, its acquisition, or its operation utility.

Technology Readiness Level (TRL): Numerical value/ranking system describing the maturity of a given technology element relative to the intended application in the deployment and operation of the STP project.

Technology Maturation Plan (TMP): Planned activities, including estimated costs, schedule and predecessors/successors required to mature a given technology element to an acceptable level for deployment in the proposed environment.

8.0 REFERENCES

L. Holton, et al., *Technology Readiness Assessment for the Waste Treatment and Immolization Plant (WTP) Analytical Laboratory, Balance of Facilities, and LAW Waste Vitrification Facilities*, 07-Design-042, March 2007

Deputy Under Secretary of Defense for Science and Technology, *Technology Readiness Assessment (TRA) Deskbook*, May 2005

General Accounting Office, *Better Management of Technology Development Can Improve Weapon Systems Outcomes*, GAO/NSIAD-99-162, July 1999

General Accounting Office, Department of Energy, *Major Construction Projects Need a Consistent Approach for Assessing Technology Readiness to Help Avoid Cost Increases and Delays,* GAO-07-336, March 2007

General Accounting Office, Department of Energy, *Consistent Application of Requirements Needed to Improve Project Management,* GAO-07-518, May 2007

William L. Nolte, P.E., CQE, et al., *Technology Readiness Level Calculator*, NDIA Systems Engineering Conference, October 20, 2003

9.0 STP TRA TEAM DELIVERABLES

The STP TRA Team will provide a final report within 30 days of completion of the review. A draft of the report will be available to support Contractor follow-on activities, if needed. In preparing the final report, the following items will be developed:

- Prepare Draft Report
- Prepare DOE and FH Management Presentation
- Issue Final Report

Attachment A

Technology Readiness Levels

Relative Level of Technology Development	Technology Readiness Level	TRL Definition	Description
System Operations	TRL 9	Actual system operated over the full range of expected conditions.	Actual operation of the technology in its final form, under the full range of operating conditions. Examples include using the actual system with the full range of wastes.
System Commissioning	TRL8	Actual system completed and qualified through test and demonstration.	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental testing and evaluation of the system with real waste in hot commissioning.
	TRL 7	Full scale, similar (prototypical) system demonstrated in a relevant environment.	Prototype full scale system. Represents a major step up from TRL 6, requiring demonstration of an actual system prototype in a relevant environment. Examples include testing the prototype in the field with a range of simulants and/or real waste and cold commissioning.
Technology Demonstration	TRL 6	Engineering/pilot scale, similar (prototypical) system validation in a relevant environment.	Representative engineering scale model or prototype system, which is well beyond the lab scale tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype with real waste and/or a range of simulants.
	TRL 5	Laboratory scale, similar system validation in relevant environment	The basic technological components are integrated so that the system configuration is similar to (matches) the final application in almost all respects. Examples include testing a high-fidelity system in a simulated environment and/or with a range of real waste and simulants.
Technology Development	TRL 4	Component and/or system validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared with the eventual system. Examples include integration of "ad hoc" hardware in a laboratory and testing with a range of simulants.
Research to Prove Feasibility	TRL 3	Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory scale studies to physically validate the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative. Components may be tested with simulants.
	TRL 2	Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are still limited to analytic studies.
Basic Technology Research	TRL 1	Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development (R&D). Examples might include paper studies of a technology's basic properties.

Attachment B

Technology Readiness Assessment Report Outline

Technology Readiness Assessment
for
the Sludge Treatment Process Project

Attachment C

Technology Readiness Level
Lines of Inquiry

TRL 1 Question Set

T/P/M	Y/N (N/A)	Criteria	Basis
T-1.1		"Back of envelope" environment	
T-1.2		Physical laws and assumptions used in new technologies defined	
T-1.3		Paper studies confirm basic principles	
T-1.4		Initial scientific observations reported in journals/conference proceedings/technical reports.	
T-1.5		Basic scientific principles observed and understood.	
T-1.6		Research hypothesis formulated	
T-1.7		Basic characterization data exists	
P-1.1		Capabilities identified to perform needed research	

T - Technology, technical aspects
M - Manufacturing and quality
P - Programmatic, Customer Focus, Documentation
N/A – Criteria which does not apply to the Sludge Treatment Process

TRL 2 Question Set

T/P/M	Y/N (N/A)	Criteria	Basis
T-2.1		Potential system or components have been identified	
T-2.2		Paper studies show that application is feasible	
T-2.3		An apparent theoretical or empirical design solution identified	
T-2.4		Basic elements of technology have been identified	
T-2.5		Desktop environment (paper studies)	
T-2.6		Components of technology have been partially characterized	
T-2.7		Performance predictions made for each element	
T-2.8		Initial analysis shows what major functions need to be done	
T-2.9		Modeling & Simulation only used to verify physical principles	
T-2.10		Rigorous analytical studies confirm basic principles	
T-2.11		Analytical studies reported in scientific journals/conference proceedings/technical reports.	
T-2.12		Individual parts of the technology work (No real attempt at integration)	
T-2.13		Know what output devices are available	
T-2.14		The scope and scale of the waste problem has been determined	
T-2.15		Know what experiments are required (research approach)	
P-2.1		System architecture defined in terms of major functions to be performed	
P-2.2		Know capabilities and limitations of researchers and research facilities	

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N/A – Criteria which does not apply to the Sludge Treatment Process

TRL 3 Question Set

T/P/M	Y/N (N/A)	Criteria	Basis
T-3.1		Some key process requirements are identified	
T-3.2		Predictions of elements of technology capability validated by analytical studies	
T-3.3		Science known to extent that mathematical and/or computer models and simulations are possible	
T-3.4		Predictions of elements of technology capability validated by Modeling and Simulation (M&S)	
T-3.5		Laboratory experiments verify feasibility of application	
T-3.6		Predictions of elements of technology capability validated by laboratory experiments	
T-3.7		Key process parameters/variables have begun to be identified.	
T-3.8		Paper studies indicate that system components ought to work together	
T-3.9		Performance metrics for the system are established (What must it do)	
T-3.10		Scaling studies have been started	
T-3.11		Scientific feasibility fully demonstrated	
T-3.12		Key physical and chemical properties have been characterized for a number of waste samples	
T-3.13		A simulant has been developed that approximates key waste properties	
T-3.14		Laboratory scale tests on a simulant have been completed	
T-3.15		Specific waste(s) and waste disposition site(s) has (have) been identified (WAC)	
T-3.16		The individual system components have been tested at the laboratory scale	
P-3.1		The basic science has been validated at the laboratory scale	
P-3.2		Preliminary system performance characteristics and measures have been identified and estimated	
M-3.1		No system components, just basic laboratory research equipment to verify physical principles	
M-3.2		Current manufacturability concepts assessed	
M-3.3		Sources of key components for laboratory testing identified	

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N/A – Criteria which does not apply to the Sludge Treatment Process

TRL 4 Question Set

T/P/M	Y/N (N/A)	Criteria	Basis
T-4.1		Key process variables/parameters have been fully identified.	
T-4.2		Individual process equipment/components tested in laboratory or by supplier	
T-4.3		Subsystems composed of multiple components tested at lab scale using simulants	
T-4.4		Modeling & Simulation used to simulate some components and interfaces between components	
T-4.5		Overall system requirements for end user's application are documented	
T-4.6		System performance metrics measuring requirements have been established	
T-4.7		Laboratory testing requirements derived from system requirements are established	
T-4.8		Analysis completed to establish component compatibility (Do components work together)	
T-4.9		Technology demonstrates basic functionality in simulated environment	
T-4.10 M-4.1		Equipment scale-up relationships are understood/accounted for in technology development program	
T-4.11		Integration studies have been started	
T-4.12		Scaling documents and designs of technology have been completed	
T-4.13		Functional process description developed. (Systems/subsystems identified)	
T-4.14		Low fidelity technology "system" integration and engineering completed in a lab environment	
T-4.15		Key physical and chemical properties have been characterized for a range of wastes	
T-4.16		A limited number of simulants have been developed that approximate the range of waste properties	
T-4.17		Laboratory scale tests on a range of simulants have been completed	
T-4.18		Process/parameter limits are being explored	
T-4.19		Test results are analyzed and documented	
P-4.1		Draft conceptual designs have been documented	
M-4.2		Laboratory components tested are prototypical of system components	
M-4.3		Available components assembled into laboratory scale system	
M-4.4		Scalable technology prototypes have been produced (Can components be made bigger than lab scale)	
M-4.5		Key manufacturing processes for equipment systems identified	
M-4.6		Key manufacturing processes assessed in laboratory	
M-4.7		Mitigation strategies identified to address manufacturability/producibility shortfalls	

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TRL 5 Question Set

T/P/M	Y/N (N/A)	Criteria	Basis
T-5.1		The relationships between major system and sub-system parameters are understood on a laboratory scale.	
T-5.2		Plant size components available for testing	
T-5.3		System interface requirements known (How will system be integrated into the plant?)	
T-5.4		Preliminary design engineering begins	
T-5.5		Requirements for technology verification established	
T-5.6		Interfaces between components/subsystems in testing are realistic (benchtop with realistic interfaces)	
T-5.7		High fidelity lab integration of system completed, ready for test in relevant environments	
T-5.8		Lab scale similar system tested with range of simulants	
T-5.9		Fidelity of system mock-up improves from laboratory to benchscale testing	
T-5.10		Laboratory environment for testing approximates operational environment	
T-5.11		Component integration issues and requirements identified	
T-5.12		Requirements definition with performance thresholds and objectives established for final plant design	
T-5.13		Preliminary technology feasibility engineering report completed	
T-5.14		Integration of modules/functions demonstrated in a laboratory/bench scale environment	
T-5.15		The range of relevant physical and chemical properties has been determined	
T-5.16		Simulants have been developed that bound the relevant range of waste properties	
T-5.17		Testing has verified that the relevant properties/performance of the simulants match the properties/performance of the actual wastes	
T-5.18		Laboratory scale tests on the full range of simulants and/or real wastes using a high-fidelity system have been completed	
T-5.19		Test results for simulants and real waste are consistent	
T-5.20		Laboratory to engineering scale scale-up issues are understood and resolved	
T-5.21		Limits for process variables/parameters are being refined	
T-5.22		Test plan for high-fidelity lab scale tests executed – results validate design	
M-5.1		Tooling and machines demonstrated in lab for new manufacturing processes to make component	
M-5.2		Manufacturing techniques have been defined to the point where largest problems defined	
M-5.3		Reliability, availability, maintainability and inspectability (RAMI) target levels identified	

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TRL 6 Question Set

T/P/M	Y/N (N/A)	Criteria	Basis
T-6.1		The relationships between system and sub-system parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	
T-6.2		Operating environment for final system known	
T-6.3		Collection of actual maintainability, reliability, and supportability data has been started	
T-6.4		Design, safety and environmental compliance operating limits for components are practicable	
T-6.5		Off-normal operating conditions evaluated during engineering scale system	
T-6.6		System technical interfaces defined	
T-6.7		Component integration demonstrated at an engineering scale	
T-6.8		Scaling issues that remain are identified and understood. Supporting analysis is complete	
T-6.9		Engineering feasibility fully demonstrated (e.g. will it work)	
T-6.10		Technology "system" design specifications complete and ready for detailed design	
T-6.12		Engineering scale tests on the full range of simulants (or real wastes) using a prototypical system have been completed	
T-6.13		Engineering to full scale scale-up issues are understood and resolved	
T-6.14		Laboratory and engineering scale experimental results are consistent	
T-6.15		Limits for process variables/parameters are defined	
T-6.16		Plan for engineering scale testing executed - results validate design	
P-6.1		Have begun to establish an interface control process	
P-6.2		Formal configuration management program defined to control change process to ensure test results remain valid	
M-6.1		Reliability, availability, maintainability and inspectability (RAMI) levels established	
M-6.2		Critical manufacturing processes prototyped	
M-6.3		Most pre-production hardware is available to support fabrication of the system	
M-6.4		Materials, process, design, and integration methods have been employed (e.g. can design be produced?)	
M-6.5		Components are functionally compatible with operational system	
T-6.11		Engineering scale system is high-fidelity functional prototype of operational system	
M-6.6		Process and tooling are mature to support fabrication of components/system	
M-6.7		Production demonstrations/evaluations are complete	

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N/A – Criteria which does not apply to the Sludge Treatment Process

Appendix E

Sludge Treatment Process Technology Readiness Assessment Team Member Bios

Burt Hill, Chief Engineer, DOE-RL

Mr. Hill is the DOE-RL Chief Engineer for sludge treatment, and the RL team lead for Engineering. He has 16 years experience with DOE in Nuclear Engineering, Maintenance, Operational Readiness Reviews, and Safety and Oversight programs. He has 24 years experience in the Nuclear Navy where he supervised the operation and maintenance of submarine Naval Reactor Plants. Leader of a Nav Sea Code 390 team that tracked and trended all mechanical and electrical systems for the West Coast Trident Submarine Fleet saving 100s of millions by scheduling maintenance prior to failure, and rescheduling maintenance that was not needed. Mechanical Engineering interface between the Navy and Electric Boat during construction and Engineering Officer of the Watch during initial start up of the natural circulation S8G Trident Submarine Reactor and Engine Room Prototype in up state New York. He was Leading Crew Chief and Training Coordinator during two Naval Nuclear Prototype tours, developed and implemented the position of refit coordinator for submarines in both the Pacific and Atlantic. He served as a crew member aboard two ballistic missile submarines and one 688 class fast attack submarine.

David Lowe, CH2M Hill

Mr. Lowe is the CH2M HILL Nuclear Business Group Chief Engineer. He previously served in the following positions: Senior Vice President for Nuclear Operations Technical Services for CH2M HILL Hanford Group (Tank Farms), Site Chief Engineer and the Deputy Director for Safety, Engineering, and Quality Programs for the Kaiser-Hill Company, LLC at the Rocky Flats Environmental Technology Site, Chief Engineer for CH2M HILL Hanford Group (Tank Farms), Assistant Manager for Engineering for the Department of Energy Rocky Flats Field Office (DOE-RFFO), and Assistant Director for Process Engineering at the Defense Nuclear Facilities Safety Board (DNFSB). He started his career in the Nuclear Navy as a submarine officer, and was qualified as Engineer by Naval Reactors. He has a Master of Engineering (ME) and Bachelor of Science (BS) degrees in Chemical Engineering, a Master of Business Administration (MBA), and is a Registered Professional Engineer (Chemical Engineering).

Michael J. Schliebe, Fluor Hanford

Mr. Schliebe has 32 years experience in process development, troubleshooting and verification. He directed process support and chemical engineering development laboratory activities for over 18 years. He was responsible for expedited prototyping and deployment of unique engineered systems and components used in high hazard radioactive work environments. Mr. Schliebe also has extensive working experience in pilot plant design, construction and operation. He directed implementation of technology relevant to solvent extraction purification, crystallization, calcinations, hydro fluorination, and "bomb reduction" production of plutonium metal. He has a strong theoretical and working knowledge in the fundamentals of chemical engineering unit operations and associated hardware, particularly crystallization, solid/liquid separation, dissolution, fluid transfer, solvent extraction and ion exchange. Mr. Schliebe has a Bachelor of Science in Chemical Engineering from South Dakota School of Mines and Technology.

Scott Spencer, Fluor Hanford

Mr. Spencer has more than 20 years experience performing various engineering, management, and project management roles at the Hanford nuclear reservation. As a Battelle employee working for the Pacific Northwest National Laboratory, Mr. Spencer held positions in Quality Engineering, Facilities Engineering, Project Management, and also managed a large Design and Drafting organization. Under the PHMC contract, Mr. Spencer transferred to the 300 Area D&D Project managed by Babcock and Wilcox, originally working as a system Design Authority before transferring into the B&W Central Engineering Group. With consolidation of the PHMC contractors under Fluor Hanford, Mr. Spencer joined the FH Central Engineering group and is currently serving as the Engineering Resource Manager, Design and Drafting Discipline Manager, and Software Subject Matter Expert for engineering software. Mr. Spencer is also the interpretive authority for numerous FH engineering and configuration management processes and procedures. He holds a Bachelor of Science degree in Mechanical Engineering and a Masters in Business Administration.

Robbin A. Duncan, TRUTech L.L.C.

Mr. Duncan has more than 25 years of diverse and progressive experience in the areas of project and operations management; technology identification and deployment; chemical processing; nuclear reactor and steam plant operations; and facility/equipment shutdown, deactivation, decontamination, decommissioning and demolition (D4). For the past 12 years, Mr. Duncan has been intimately involved with a number of projects across the Hanford site, including K Basins Sludge Retrieval/Disposition and Facility Closure, Plutonium Finishing Plant D4, 324/327 Facilities Shutdown and D4, and CH2M Hill's Tank Farms Heat Stress Mitigation Program. Mr. Duncan has extensive experience in the identification, evaluation, and deployment of new and emergent technologies for various projects across the U.S. Department of Energy (DOE) complex. Mr. Duncan served as the technical representative to the DOE National Facility Deactivation Initiative (NFDI) for new and emergent technology reviews and for plutonium-contaminated facilities deactivation and closure. Mr. Duncan holds a Bachelor of Science in Chemical Engineering from Montana State University.

Task# DOE-SED-C-2007-0369

E-STARS[R] Report
Task Detail Report
08/29/2007 1053

TASK INFORMATION

Task#	DOE-SED-C-2007-0369		
Subject	Memo-M. McCormick - K Basins Sludge Treatment Project Technology Readiness Assessment		
Parent Task#		**Status**	Open
Reference		**Due**	
Originator	Mercado, Sally C (Mercado, Sally C)	**Priority**	High
Originator Phone	(509) 376-7597	**Category**	None
Origination Date	08/28/2007 1313	**Generic1**	
Remote Task#		**Generic2**	
Deliverable	None	**Generic3**	
Class	None	**View Permissions**	Normal
Instructions	bcc: SED Rdg File SED Off File D. Faulkner, KBC P. Garcia, SED P. Pak, KBC D. Shoop, AMSE Record Note: Attachment is big (168 pages).		

ROUTING LISTS

1 Route List Active

- Hill, Burt E - Approve - Approved - 08/28/2007 1555
  Instructions:
- Garcia, Pete J - Approve - Approved with comments - 08/29/2007 1052
  Instructions:

ATTACHMENTS

Attachments 1. 0369 - K Basins SLudge Readiness Assessment Ltr.doc

COLLABORATION

COMMENTS

Poster Garcia, Pete J (Mercado, Sally C) - 08/29/2007 1008

Approve

Concur per PG scm 8/29/07

TASK DUE DATE HISTORY

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SUB TASK HISTORY

No Subtasks

-- end of report --