CONSOLIDATED HAZARD ANALYSIS FOR MECHANICAL CLEANING OF WASTE TANKS 18 & 19

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TABLE OF CONTENTS

EXECUTIVE SUMMARY 1

1.0 INTRODUCTION 1

2.0 GENERAL PROCESS DESCRIPTION 2

3.0 OPEN ITEMS 4

4.0 INPUTS AND ASSUMPTIONS 4

4.1 INPUTS 4

4.2 ASSUMPTIONS 4

5.0 METHODOLOGY 7

5.1 HAZOP TECHNIQUE 7

5.2 IDENTIFY CAUSE(S), FREQUENCY, AND CONSEQUENCE(S) 8

5.3 IDENTIFY PREVENTIVE/MITIGATIVE CONTROL(S) 10

6.0 CONCLUSIONS 10

6.1 WASTE TANKS 12

6.2 WASTE REMOVAL EQUIPMENT 13

6.3 TRANSFER LINE 13

6.4 WASTE MIXING CHAMBER 13

6.5 PROCESS SKIDS 13

6.6 NPH EVENTS 14

REFERENCES 15

APPENDIX A METHODOLOGY AND INPUT TABLES 16

TABLE A-1. CONSEQUENCE EVALUATION LEVELS FOR HAZARD RECEPTORS 17

TABLE A-2. FREQUENCY EVALUATION LEVELS 18

TABLE A-3A. CONTROLS SELECTION CRITERIA MATRIX – OFFSITE PUBLIC, CO-LOCATED AND FACILITY WORKER 19

TABLE A-3B. PROCESS HAZARDS REVIEW ACCIDENT CRITERIA 20

APPENDIX B HAZARD EVALUATION TABLES 21

APPENDIX C SAND MANTIS AEROSOLIZATION CONCERNS 46

EXECUTIVE SUMMARY

The purpose of this Consolidated Hazard Analysis (CHA) report is to document the preparation and approval of the hazard analysis and control selection for the Mechanical Cleaning of Waste Tanks 18 and 19. The CHA is used to identify process safety and operational hazards, hazardous situations, and specific events that could produce undesirable consequences associated with mechanical cleaning of Waste Tanks 18 and 19. Although this CHA was performed for mechanical cleaning of Waste Tanks 18 and 19, the results are applicable to all the SRS Type IV Waste Tanks.

Waste Tanks 18 and 19 are currently in the Removed from Service (RFS) mode and will be placed into Mechanical Cleaning mode. The waste removal process involves using a mechanical crawler to remove and transfer the residual waste from a process tank, Waste Tanks 18 and 19, to the receipt tank, Waste Tank 7.

Table A-1, Consequence Evaluation Levels for Hazard Receptors was used to qualitatively determine the effects of the events on the three receptors of interest. The CHA identified one new unanalyzed event that would challenge the evaluation guidelines for the Co-Located Worker and Facility Worker. This event is a process tank aerosolization, caused by operation of the Sand Mantis lance with water pressure greater than 10,000 psi, leading to a release of process tank waste.

1.0 INTRODUCTION

This CHA identifies and evaluates potential accident conditions and events that have the potential to cause or contribute to the uncontrolled release of hazardous material from Waste Tanks 7, 18, and 19 as well as conditions during the process that might affect worker safety or have process impacts. Waste Tanks 18 and 19 are both categorized as Radiological HC-2 and Chemical HC-Moderate.

The HAZOP hazard evaluation technique was used for the CHA. The HAZOP hazard evaluation technique was used due to its efficient application to a discrete process i.e., the mechanical cleaning of Waste Tanks 18 and 19. The time and cost of the HAZOP evaluation is proportional to the cleaning process complexity and equipment that needed to be analyzed.

The HAZOP evaluation team consisted of HLW individuals who have experience with the hazard evaluation method and are knowledgeable with the proposed cleaning method and the equipment involved. The team identified thirty-four conditions or events that could challenge the consequence criteria applied to the three receptors of interest or have a detrimental effect on the successful completion of the cleaning process in a timely manner.

2.0 GENERAL PROCESS DESCRIPTION

The waste tank mechanical cleaning project is designed to remove the remaining waste in Tanks 18 and 19. The CSTF DSA (Ref. 1) and the CSTF Technical Safety Requirements (TSR) (Ref. 2) will be updated to reflect the Mechanical Cleaning process prior to operating the equipment in Type IV Waste Tanks (i.e., Tanks 18 and 19). The cleaning device, called a Sand Mantis, consists of a mechanical crawler and an eductor assembly that makes up a retrieval system utilizing an ultra high-pressure water eductor. The eductor operates with a working water pressure of approximately 17.5 kpsi (maximum of 36 kpsi) and flow of 4 to 6 gpm. The process system consists of a remotely controlled in-tank Sand Mantis, an umbilical hose containing hydraulic supply lines and the high-pressure water hoses, in-tank waste retrieval hose, a diesel driven ultra high-pressure (UHP) pump, a motor driven high pressure (HP) pump, hydraulic pump skid, a Diesel Generator, above ground hose-in-hose transfer lines, Waste Mixing Chamber, and support equipment. Operating controls for the process are located in a Water Treatment and Control Center skid which is continuously manned during the removal process. The Water Treatment and Control Center skid contains two, 2500 gallon water supply tanks and filters that pre-treat the water supplied to the UHP pump skids.

The Sand Mantis is remotely driven around the tank bottom by an operator located in the Control Center. The Sand Mantis has a high pressure (maximum 10 kpsi) hydro lance at its front that can be used to break up waste mounds and an eductor used to aspirate waste from the floor of the waste tank. The motive force for the movement of the Sand Mantis is high pressure hydraulic fluid (oil) operating at approximately 2150 psi with a maximum flow of 6 gpm. The hydraulic system operates the Sand Mantis drive wheels that have the capability to cut up reel tapes. The drive wheels are operated independently of each other allowing for precise control. The hydraulic fluid used for the Sand Mantis assembly is a small quantity. The type of fluid to be used will be evaluated by SRS. This evaluation will ensure that, in the event of a leak, the hydraulic fluid will not contribute significant flammable vapors to a waste tank and will contribute less than or equal to 5% organic contribution to the hydrogen LFL in waste tanks downstream of the process tanks. Operators will monitor the operation of the Sand Mantis using in-tank lighting, cameras and video surveillance equipment.

The eductor assembly operates using ultra high pressure water flowing through extremely small nozzles and exiting into an eductor. The eductor has a front mounted pickup elbow (on the crawler) that is in contact with the waste on the bottom of the tank. The pick up elbow has a screen on it to prevent picking up debris greater than ⅜ of an inch in diameter. Inside the eductor, initial particle size reduction of solid waste material occurs in an area called the Blast Zone. The educted waste travels through the eductor in-tank waste retrieval hose and up into a tee spool piece (called a riser cover) located on top of a riser. The eductor discharge hose is a flexible hose that is banded to the Sand Mantis umbilical line. The high pressure water lines, from the UHP pump skids to the Sand Mantis, are pressure-certified, double-wrapped, ultra high pressure hoses. They are designed with an outer covering to act as a barrier in the unlikely event of a leak of the primary hose. Any leakage from the primary hose to the outer covering will undergo a pressure drop through the leak point and 'weep' through the outer covering into the umbilical line. The umbilical line is an elastomer hose that contains the high-pressure water

lines and the hydraulic lines supplying the Sand Mantis. A ⅜ inch tether (cable) from the Sand Mantis to the tank top is part of the umbilical line.

The riser cover is the interface between the waste tank riser, mechanical cleaning equipment inside the tank, and the transfer line. The riser cover will be mounted on top of a riser in the tank being cleaned. The riser covers are an extension of the riser and have the same function of other riser covers, i.e., protect against aerosolization. The process tank riser cover contains disconnects for the high pressure water lines and hydraulic lines. Mounted inside the riser cover installed on the process tank is a winch assembly used to pay out/in the umbilical line and in-tank waste retrieval hose. The process tank riser cover contains a mechanical connection on its side wall for connecting the in-tank waste retrieval hose to the above ground transfer line.

Current process design has two separate above ground transfer lines, one from Tank 18 and one from Tank 19 routed to the receipt tank. The above ground transfer lines are a 'hose within a hose' design with appropriate shielding installed around the transfer lines. The waste flow through the transfer line from the eductor assembly consists of approximately 0 – 100 cfm (measured) entrained air, 2 gpm sludge slurry, and 4 – 6 gpm of water. The above ground waste transfer lines terminate inside a Waste Mixing Chamber (WMC) installed inside a riser on the receipt tank (Waste Tank 7). The bottom of the WMC hangs below the tank riser in the vapor space, above the waste level, of the receipt tank.

The WMC contains flush water lines, waste transfer lines, and particle size reduction equipment (an immersion mill). The immersion mill, located near the bottom of the WMC, is designed to grind up and reduce solid waste particles to less than 38 microns. The immersion mill is shaft operated by an electric motor and reduction gear located outside the waste tank riser. The immersion mill continually re-circulates (via a propeller at the bottom of the shaft) the waste material until it is light enough for displacement upwards in the WMC. A cylindrical strainer basket is contained within the immersion mill. The grinding medium consists of small ceramic beads or balls. The ceramic grinding medium is much larger than the mesh size of the strainer. Cylindrical rods extending out from the rotating shaft mix the waste and ceramic grinding medium. The propeller at the bottom of the mill pulls waste material out of the strainer basket, and forces the waste back up along the outside of the mill. The lighter material continues up the WMC and out the overflow ports. The heavier material is pulled back into the immersion mill and goes back through the grinding process. The size of material that makes it to the overflow ports is determined by several factors including the height of the overflow holes above the mill, the mesh size of the strainer basket, the size of the grinding medium, and the propeller design and speed. The mill is designed to allow liquid and particles less than 38 microns to flow into Tank 7.

If later determined to be necessary, the capability exists to spray wash waste tanks undergoing mechanical cleaning. Waste tank spray washing will use current CSTF technology and equipment.

3.0 OPEN ITEMS

The following Open Items are associated with this CHA:

- None

4.0 INPUTS AND ASSUMPTIONS

The intent of the inputs and assumptions is to establish a baseline upon which the CHA was performed. Departures from this baseline may require re-evaluation.

4.1 Inputs

Input data to the CHA was obtained from the following:

- Facility and engineering personnel.
- Conceptual design diagrams (Ref. 3, 4).
- Manufacture's test report results (Ref. 5).
- Design testing data/recordings.

4.2 Assumptions

The following assumptions have been made for the performance of the CHA:

- Waste Tanks 18 and 19 are in the Removed from Service (RFS) mode and will be placed into Mechanical Cleaning mode prior to initiating mechanical cleaning/waste removal. No new waste will be transferred into Tanks 18 and 19 (i.e., isolated from waste transfers), therefore process waste tank overheating and wall failure are judged to be not credible events for the cleaning process. This does not prevent flushing the above ground process transfer lines back to Tank 18 or 19, as needed by the process.
- Waste Tank 18 and 19 tank overflow event from the mechanical cleaning process water additions is judged to be not credible because water for the process is supplied by two 2500 gallon (vender supplied) storage tanks. Makeup water to the storage tanks will be a manual, batched process controlled by facility personnel.
- To prevent backflow, the facility supplied water to the Water Treatment skid is physically separated from the Water Treatment skid storage tanks after completion of tank filling.
- The mechanical cleaning process does not introduce any new flammability concerns. (Reference 11, 12) The process equipment in contact with caustic liquid waste (e.g., Sand Mantis, umbilical line, Waste Mixing Chamber) will not generate flammable gases (i.e., hydrogen).

- Process tanks (Tks. 18 & 19) undergoing mechanical cleaning shall meet the definition of a Very Slow Generation Tank. The mechanical cleaning process does not cause a significant release of trapped gas in the waste tank being processed. (Reference 11, 12) Any trapped gas contained in the remaining waste heel in the tanks that can be impacted by the operation of the mechanical cleaning crawler is considered negligible.

- Based on previous cleaning/waste removal operations in Tanks 18 and 19, the mechanical cleaning process is not a Bulk Salt Dissolution activity.

- The Inhalation Dose Potential (IDP) for mechanical cleaning will be less than or equal to 9.8E+07 rem/gallon. The total effective Inhalation Dose Potentials (IDP) for any tank undergoing mechanical cleaning will be less than or equal to 1.0E+11 Rem. (Reference 2)

- A waste tank undergoing mechanical cleaning may be spray washed as needed. The Spray Wash process uses current CSTF technology/equipment and was not analyzed in the CHA. Spray washing water will be supplied from a limited/batch source.

- Total flow out of the Sand Mantis eductor will be less than or equal to 400 cfm. The receipt tank ventilation system is capable of handling this input flow into its vapor space.

- Only one crawler lancing device operating above 10,000 psi is allowed in a waste tank undergoing mechanical cleaning.

- Operation of the high pressure water lance will be limited to a maximum supply pressure of 33,000 psi with 6 gpm maximum supply flow.

- Maximum sludge slurry waste and process water flow through the transfer line is 10 gpm assuming a 1 to 4 ratio of sludge slurry to process water. Maximum supernate flow and process water flow through the transfer line is 40 gpm assuming a 6 to 1 ratio of supernate to process water.

- The waste tanks are not air tight and will not pressurize to point of failure.

- The high-pressure water supply lines from the process skids to the Sand Mantis will be double wrapped, ultra high pressure hoses. All the high pressure lines going to the Sand Mantis will be contained within an outer umbilical hose.

- A hydraulic leak will add less than or equal to 30 gallons of hydraulic fluid to the waste in the tank being processed, for subsequent transfer to the receipt tank. In the event of a leak into the process tank, the hydraulic oil will not contributed significant flammable vapors to the waste tank and will contribute less than or equal to 5% organic contribution to the hydrogen LFL in the downstream tank(s).

- The above ground transfer line will be less than 3 meters above ground level and will be able to be flushed with flush water.

- The Transfer Control Program does not apply to waste being removed from the process tanks.

- When not in use, the Flush Water system will be physically disconnected from the transfer system. Flush water supplied to the process system will be from a batch supply. The use of the DIWF system is prohibited for this process.

- The Control Center is continuously manned by at least one operator whenever a pump skid or hydraulic skid is in operation.

- The starting and stopping of the transfer of waste from the process tanks to the receipt tank will be under the direct supervision/control of CSTF personnel.

- Actual waste removal from a process tank and transfer to the receipt tank will be limited to only one process tank at any given time.

- The mechanical cleaning process introduces no cleaning chemicals.

- A siphon potential from the receipt tank (Tank 7) back to the process tank (Tank 18 or 19) does not exist. A siphon event is not credible based on design of the Waste Mixing Chamber. The Waste Mixing Chamber is an open vessel located in the vapor space of the tank above the operating level of the tank. Initial Condition that is verified by an Engineering Evaluation of the design.

- Residual liquid in Waste Tanks 18 and 19 maintain the tanks in a wet condition. Operation of the eductor in a local area of the waste tank does not remove enough water from the tank to make the tank a Dry Sludge Tank.

- Splashing of waste inside the waste tank due to drop of the Sand Mantis assembly does not cause significant airborne releases to the environment.

- The design of the Waste Mixing Chamber prevents the chamber from falling through the riser into the receipt tank.

- The Waste Mixing Chamber is an open vessel (e.g., has no top, has large overflow ports) that is located below the waste tank ceiling in the tank vapor space. This passive design feature makes overflow to the environment, overpressurization, and hydrogen buildup WMC events not credible.

- No waste will be transferred out of the Waste Mixing Chamber (when installed in Tank 7 riser) back to the process tanks.

- A criticality event is assumed to be not credible as a result of the proposed mechanical cleaning operation based on the current evaluations given in Chapter 6 of the CSTF DSA.

5.0 METHODOLOGY

This section describes the methodology used to perform the CHA for the Mechanical Cleaning of Waste Tanks 18 and 19. The CHA identifies the hazards of the process, loss of production, and equipment/facility damage. The CHA qualitatively evaluates the unmitigated and mitigated scenarios and bins the events according to risk.

The HAZOP Hazard Analysis technique was used to identify potential hazardous conditions or events and to select potential control strategies that reduce the likelihood of occurrence of the condition/event or mitigate the consequences of the event. The analysis includes the following steps:

- Identify nodes to be evaluated
- Utilizes HAZOP process parameters and guide words to identify potential hazardous events
- Identify Causes Frequency, and Consequences
- Identify Preventive/Mitigative Controls

5.1 HAZOP Technique

The CHA was performed by a multi–disciplinary team with representatives from different organizations. The primary team consisted of representatives from Engineering, Operations, and Regulatory Programs.

Reference 6 recognizes multiple methodologies and techniques for completing the CHA. Among these methodologies are the Hazard and Operability Study (HAZOP) process, the Failure Modes and Effects Analysis, the What-If Analysis, and others. The CHA methodology selected should be that which best supports the process being analyzed. The HAZOP analysis technique was selected because the time and cost of a HAZOP analysis were proportional to the Waste Tank 18 and 19 mechanical cleaning process.

The HA utilized the HAZOP technique to carefully review the process section by section, in a systematic fashion to identify process hazards and accident potentials that can lead to undesirable consequences. This technique forces the CHAP team to examine design configurations and specific points of the process or operation. This selection is in accordance with the guidance found in the CHAP Methodology Manual (Ref. 7).

The events are categorized according to the nature of the postulated release mechanism. A standard list of event categories is used. The CHA applied the basic event categories identified in Chapter 7 of Reference 7. They are listed as follows, along with a general description of the general consequence source:

E-1 Fire – Consequences typically due to inhalation/ingestion of hazardous material released by a fire.

E-2 Explosion – Consequences typically due to inhalation/ingestion of hazardous material released by an explosion.

E-3 Loss of Containment/Confinement – Consequences typically due to inhalation/ingestion of hazardous material released by mechanical (e.g. impact, spill) or other means.

E-4 Direct Radiological/Chemical Exposure – Consequences typically due to direct exposure (contact chemical exposure, radionuclide 'shine').

E-5 Nuclear Criticality – Consequences typically due to direct exposure and release of fission products from a criticality.

E-6 External Hazards – Consequences typically due to inhalation/ingestion of hazardous material released due to an external event. Depending on specific event, direct exposure consequences may also be applicable.

E-7 Natural Phenomena – Consequences typically due to inhalation/ingestion of hazardous material released due to natural phenomena hazards. Depending on specific event, direct exposure consequences may also be applicable.

E-8 Other – Consequences typically due to loss of production (i.e., loss of primary program capabilities), monetary loss including cleanup, equipment damage, product value, etc., with no hazardous material release, or impact to existing structure, system, component (SSCs) or administrative controls credited for current hazardous events in the DSA.

5.2 Identify Cause(s), Frequency, and Consequence(s)

Causes – The causes are developed from the existing hazards and process and the operational experience provided by the team members. Causes may be hardware failures, human errors, unanticipated process states (e.g., dry out of the sludge), external disruptions (e.g., impacts to lines/hoses external to the tank), etc. By identifying the cause(s) of the postulated event, the team is able to better determine the initiating frequency and achieves a better understanding of preventive and mitigative features. Because this process is a first-time application, preliminary events/causes may be developed by the regulatory team members prior to the meeting.

Unmitigated Frequency and Consequence – Unmitigated (no controls) frequency and consequence estimates are generally qualitative in nature, and may be based on any or all of the following: engineering judgment of the team or subject matter experts, supplier test data, or simple calculations. Due to the expected short duration of the cleaning process, the team applied a frequency (f) determination of either Anticipated ($f \geq 10^{-2}$/year) or Unlikely ($10^{-4} \leq f < 10^{-2}$/year) for the identified conditions/events. The unmitigated event frequency was determined through a qualitative process that involved assigning a frequency level to each event identified that could result in a release of hazardous energy and/or material, personnel injuries, loss of equipment or facilities, or loss of production. Table A-2 defines the available frequency evaluation levels. Further along in the process, additional frequency levels (e.g., extremely unlikely, not credible) are identified and applied to the events by the team.

The event consequence levels were qualitatively determined by the team members and documented in Appendix B tables. Event consequences are documented by specifying the

impact on the three receptors at specified receptor locations that have been determined without taking credit for barriers or controls, which could reduce the consequences. When evaluating event consequences, credit may be taken for items identified as initial conditions or assumptions. Consequences are a function of the type and characteristics of the hazard, the quantity released, the release mechanism, relative location of the release, and any relevant transport characteristics. Consequences can be determined from: (1) simple source term calculations, (2) existing safety documentation, and/or (3) qualitative assessment supported by simple calculations.

Unmitigated doses to the Occupationally Exposed Person (OEP) at 100 meters, and Facility Worker (FW) were initially estimated using existing Waste Tank HC-2 designation along with the CSTF DSA. For 95% meteorology and 3 cm surface roughness, an approximate multiplier of 10 and additional scaling factors (e.g., IDP ratio, volume ratio) are applied to the CSTF DSA calculations and radiological consequences, determine consequences to the OEP and facility worker. An approximate multiplier of 2 to the CSTF DSA calculations and radiological consequences was used to determine consequences to the Offsite Public. These qualitative assessments supported by simple calculations are then validated by engineering calculations, with changes made to Appendix B as appropriate.

Consequence evaluation is the process of determining which of the consequence levels in Table A-1 are relevant to the three receptors for a particular release event. Table A-1 gives the radiological and chemical consequence levels for the specified receptor locations. Receptors are as follows:

Facility Worker — Facility Workers (FW) are workers immediately adjacent to, or in, the occupied area of the hazard. The occupied area of the hazard is the area within the last possible means of physically controlling the hazard or controlling access to the hazard (e.g., building, fence, permanent chain with multiple warning signs). Note: a physical barrier credited to protect workers outside the area or prevent entrance of workers into the area is to be identified as an initial condition (IC).

Co-Located Worker — Co-Located Workers (CW) are workers outside the occupied area of the hazard. If there is no defined physical means of controlling the hazard or controlling access to the hazard, the location is assumed to be at the worst possible location, but no closer than 100 meters to the hazard. For this analysis, CW consequences were qualitatively determined from the dose at 100 meters.

Offsite Public — Everyone outside the site boundary at the time of the event. For this analysis, Offsite Public receptor consequences were qualitatively determined from the dose at 9.4 kilometers.

The unmitigated hazard analysis is concerned with the maximally exposed individual at each of the receptor locations.

Using event frequency and consequence levels, events are “binned” with respect to frequency and consequence to assess relative risk. The objective of risk binning (ranking) is to determine

those events that pose the greatest risk to the Offsite Public, CW, and the FW. Higher risk events might be candidates for additional analysis and/or functional classification evaluation. Once the unmitigated event frequency and consequence level were estimated, events were located on the appropriate Risk Criteria Matrix for the Offsite Public, CW, or FW, as shown in Tables A-3a and A-3b. The Risk Rank column of the unmitigated hazard analysis tables (Appendix B) provides the risk rank for each of the receptor locations.

For events with a production loss or facility/equipment loss consequence, a risk rank of B was assigned for those events with a frequency of "Anticipated" that could result in a loss of production of greater than six months or facility/equipment damages in excess of two million dollars (2003 dollars) including cleanup, equipment damage, product value, etc. (Ref. 7). If an event could result in a loss of production of greater than six months or facility/equipment damages in excess of two million dollars, but the frequency of the event was less than or equal to "Unlikely", then a risk rank of C was assigned.

A risk rank of C was assigned for events that result in a production loss of less than six months or facility/equipment damages less than two million dollars.

5.3 Identify Preventive/Mitigative Control(s)

During the CHA, preventive controls were identified which are passive/active engineered controls and the programmatic/specific administrative controls that reduce the frequency of an event from occurring. Mitigative controls are the passive/active engineered controls and the programmatic/specific administrative controls that reduce the consequences of an event. Control strategies were chosen using the following preferred selection strategy: prevention over mitigation, passive over active, and engineered controls over administrative controls (ACs). Factors such as cost, reliability, durability, life cycle cost, and process operating life, etc. were also considered during control selection.

The initiating frequency level, consequence level, and risk bin of the event (from the unmitigated HE) are modified with the reductions due to credited preventive features. The amount of reduction is dependent upon the control(s). Events having unmitigated frequencies and consequences in risk bin C do not require credited controls; therefore, the mitigated frequencies and consequences are shown as "N/A." While credited controls may not be required, possible facility controls, which are un-credited, were identified during the CHA meeting and are presented for consideration.

6.0 CONCLUSIONS

This HAZOP Analysis identified and evaluated conditions or events that have the potential to cause or contribute to the uncontrolled release of hazardous materials, cause personnel injury, or impact project operation from the Mechanical Cleaning (MC) of Waste Tanks 18 and 19.

Three events, HIHTL-1 *Above ground transfer line break*, HIHTL-5 *Hydrogen explosion in core hose*, and HIHTL-6 *Hydrogen explosion in the secondary hose* were initially recognized by the CHA team as being consistent with similar events in the current CSTF DSA. The CHA team qualitatively assessed these events as being the same as the current CSTF DSA and applied the

current DSA SS controls to these events. However, it was determined that applying SS functional classification to the mechanical cleaning process temporary components associated with these events was going to be cost and time prohibitive. Therefore, these events underwent a qualitative evaluation to determine the offsite and onsite radiological consequences and this evaluation was reviewed and approved by the Safety Input Review Committee (SIRC) process.

The qualitative evaluation of HIHTL-1 *Above ground transfer line break* consisted of scaling the current DSA Transfer Error progression and consequences to the MC transfer error event identified in the CHA. The estimated unmitigated consequences of the CHA event was determined by ratioing the bounding criteria associated with the Mechanical Cleaning Mode for Type IV tanks to the data from Reference 10 (DSA confirmed engineering calculation). The qualitative evaluation consisted of the following:

<u>From Reference 10:</u>

MAR = 15,000 gallon spill of Bounding Sludge Slurry
IDP = 1.5E+09 rem/gal; therefore the Total Effective IDP = MAR X IDP = 2.25E+13 Rem
Unmitigated Consequences: Onsite = 190 rem Offsite = 0.427 rem

<u>Mechanical Cleaning Mode for Type IV tanks bounding data:</u>
Total Effective IDP = 1.0E+11 Rem (Value is a limit for tanks in Mechanical Cleaning)

$$\left(\frac{1.0E+11}{2.25E+13}\right)(190rem) = 0.84 \text{ rem onsite (unmitigated)}$$

$$\left(\frac{1.0E+11}{2.25E+13}\right)(0.427rem) = 1.9E-03 \text{ rem offsite (unmitigated)}$$

Since Tank 18 and 19 radiological inventories (Ref. 9) are below the bounding criteria for Mechanical Cleaning mode, the consequences from an above ground core hose spill during mechanical cleaning of either of these tanks does not challenge onsite or offsite evaluation guidelines (EGs). Therefore, the functional classification of the controls for this event was classified as Production Support (PS).

The qualitative evaluation of HIHTL-5 *Hydrogen explosion in core hose*, and HIHTL-6 *Hydrogen explosion in the secondary hose* consisted of scaling the current DSA Transfer Line Jacket Explosion progression and consequences to the MC secondary hose explosion event (bounds the core hose explosion event) identified in the CHA. The estimated unmitigated consequences of the CHA event were determined by ratioing the bounding criteria associated with the Mechanical Cleaning Mode for Type IV tanks (and bounding MC design inputs) to the data from Reference 13 (DSA confirmed engineering calculation). The qualitative evaluation consisted of the following:

<u>From Reference 13:</u>

MAR = 15,000 gallon spill of Bounding Supernate from core pipe breach
IDP = 9.8E+07 rem/gal
Transfer Line Jacket Volume = 957 ft^3

Unmitigated Consequences:
Onsite = 6.64E+01 (from line explosion) + 1.88E+00 (from pipe breach & spill) = 6.82E+01 rem
Offsite = 1.54E-01 rem

Mechanical Cleaning Mode for Type IV tanks bounding data:
MAR = Spill rate of 10 gpm X 3 hours = 1,800 gallon spill
IDP = 9.8E+07 rem/gal
Secondary Hose Bounding Volume = 4 inch diameter hose X 700 feet = 61.1 ft^3

$$\left(\frac{61.1\,ft^3}{957\,ft^3}\right)(6.64E+01rem) = 4.25 \text{ rem from line explosion (unmitigated)}$$

$$\left(\frac{1800gal}{15000gal}\right)(1.88E+00rem) = 2.25E-01 \text{ rem from line break \& spill (unmitigated)}$$

4.25 rem + 0.225 rem = 4.48 rem onsite (unmitigated)

Offsite dose was determined by ratioing the change in onsite dose and multiplying the offsite dose from the engineering calculation by that ratio:

$$\left(\frac{4.48}{68.2}\right)(1.54E-01rem) = 1.01E-02 \text{ rem offsite (unmitigated)}$$

Since Tank 18 and 19 radiological inventories (Ref. 9) are below the bounding criteria for Mechanical Cleaning mode, the consequences from an explosion in the secondary hose (or core hose) during mechanical cleaning of either of these tanks does not challenge onsite or offsite evaluation guidelines (EGs). Therefore, the functional classification of the controls for these events was classified as Production Support (PS).

The HAZOP data tables in Appendix B address the conditions or events that have the potential to cause or contribute to the uncontrolled release of hazardous materials, cause personnel injury, or impact project operation from the Mechanical Cleaning (MC) of Waste Tanks 18 and 19. The results of Appendix B tables are summarized below in separate sections based on the five study nodes or process sections analyzed.

6.1 Waste Tanks

Thirteen events associated with the MC Waste Tanks (MCTK) were identified by the hazard evaluation. One event (MCTK-5) was determined to be not credible. One event (MCTK-7B) is a new event that posed a high radiological consequence to the Facility Worker and Co-located Worker. This event will require two levels of Safety Significant controls (to be applied whenever water lancing pressure is greater than 10 kpsi). Two events (MCTK-1, 2) are the same type of events covered by the CSTF DSA and will require the current DSA controls.

Nine other events (MCTK-3, 4, 6, 7A, 8, 9, 10, 11, and 12) were determined to have negligible effects on all three of the receptors and primarily affected the completion of tank cleaning in a cost effective and timely manner. Although these events are not normally considered for controls, in most cases the team identified controls for consideration because the occurrence of the uncontrolled event would be unacceptable for the timely completion of the process or is unacceptable for programmatic reasons.

6.2 Waste Removal Equipment

Six events associated with the Waste Removal Equipment (WRE) were identified by the hazard evaluation. These six events were determined to have no effects on all three of the receptors and primarily affected the completion of tank cleaning in a cost effective and timely manner. Although these events are not normally considered for controls, in most cases the team identified controls for consideration because the occurrence of the uncontrolled event would be unacceptable for the timely completion of the process or is unacceptable for programmatic reasons.

6.3 Transfer Line

Seven events associated with the Hose-in-Hose Transfer Line (HIHTL) were identified by the hazard evaluation. One event (HIHTL-3) poses a moderate or low radiological, chemical consequence or a moderate or low Non-radiological/Non-chemical injury to the Facility Worker and will require Facility Controls (FC).

Six other events (HIHTL-1, 2, 4, 5, 6, 7) were determined to have negligible effects on all three of the receptors and primarily affected the completion of tank cleaning in a cost effective and timely manner. Although these events are not normally considered for controls, in most cases the team identified controls for consideration because the occurrence of the uncontrolled event would be unacceptable for the timely completion of the process or is unacceptable for programmatic reasons.

6.4 Waste Mixing Chamber

Three events associated with the Waste Mixing Chamber (WMC) were identified by the hazard evaluation. These three events (WMC-1, 2, 3) were determined to have negligible effects on all three of the receptors and primarily affected the completion of tank cleaning in a cost effective and timely manner. Although these events are not normally considered for controls, the team identified controls for consideration because the occurrence of the uncontrolled event would be unacceptable for the timely completion of the process or is unacceptable for programmatic reasons.

6.5 Process Skids

Five events associated with the Process Skids (PS) were identified by the hazard evaluation. Two events (PS-4, 5) were determined to have negligible effects on all three of the receptors and primarily affected the completion of tank cleaning in a cost effective and timely manner. Although these events are not normally considered for controls, in most cases the team identified controls for consideration because the occurrence of the uncontrolled event would be

unacceptable for the timely completion of the process or is unacceptable for programmatic reasons. Three events (PS-1, 2, 3) were classified as a Standard Industrial Hazard (SIH) and are covered by national codes and standards.

6.6 NPH Events

None of the events identified in the CHA process would add to the cumulative effects of a seismic or tornado/high winds event.

The aerosolization event (MCTK-7B) is not included in the cumulative effects of an NPH event because an NPH event is not an initiator for this event. Additionally, the process will be shutdown on notification of Tornado/High Winds (i.e., Severe Weather Program). The aerosolization event is not included in the cumulative effects of a seismic event because, at the time of a seismic event, if high pressure lancing (i.e., > 10 kpsi) is in progress then significant aerosolization has not occurred such that the tank vapor spaced is filled with vapor and lancing operations had to be shutdown (i.e., normal operations) and immediately after the seismic event the process could be shutdown using a (safety significant) electrical disconnect switch to stop lancing operations.

An NPH event is an initiator for a transfer line break (HIHTL-1). However, because of the negligible onsite and offsite radiological consequences and the small volume of waste that could be spilled out of a hose break over an eight hour period no controls are required to prevent or mitigate the consequences of a mechanical cleaning transfer line break; therefore, the consequences are not included in the cumulative consequences for a seismic event. Additionally, the cumulative onsite seismic event consequences reflect ten tank top collapses (removed from service tanks) at 2.6 rem per tank. This dose bounds the dose (0.84 rem) that can be released from a transfer line break with a total waste inventory of ≤ 1.0E+11 rem. The bounding cumulative offsite seismic event consequences reflect fifteen tank top collapses (ten removed from service and five Type IV tanks) with < 0.1 rem per tank top collapse compared to <0.002 rem for the transfer error. The number of tanks assumed in removed from service mode will be reduced by the number of tanks in mechanical cleaning.

Additionally, the mechanical cleaning transfer will be shutdown on notification of Tornado/High Winds (i.e., Severe Weather Program).

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11. X-CLC-G-00047, Tank 18 Removed From Service Flammability Evaluation, Rev. 0, October 2003.

12. X-CLC-F-00401, Tank 19 Removed From Service Flammability Evaluation, Rev. 0, April 2003.

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APPENDIX A

METHODOLOGY AND INPUT TABLES

Table A-1. Consequence Evaluation Levels for Hazard Receptors

Consequence Level (Abbreviations)		Offsite Public	Facility Worker	Co-Located Worker
High (H)	Non-rad/Non-chemical injury**		Prompt worker fatality, serious injury that is immediately life threatening or permanently disabling	Prompt worker fatality, serious injury that is immediately life threatening or permanently disabling
	Radiological	C ≥ 25 rem	C ≥ 100 rem; or radiological material quantity exceeds Hazard Category 3 threshold (per DOE-STD-1027); or high consequence injury due to radiological release or exposure	C ≥ 100 rem; or high consequence injury due to radiological release or exposure
	Chemical	C ≥ ERPG-2	Uniform distribution of total release C ≥ ERPG-3; or high consequence injury due to chemical release or exposure	C ≥ ERPG-3; or ≥ 29 CFR 1910.119 TQ released; or high consequence injury due to chemical release or exposure
*Moderate (M)	Non-rad/Non-chemical injury		Serious injury, no immediate loss of life, no permanent disabilities, hospitalization required	Serious injury, no immediate loss of life, no permanent disabilities, hospitalization required
	Radiological	5.0 ≤ C < 25 rem	25 ≤ C < 100 rem; or moderate consequence radiological related injury	25 ≤ C < 100 rem; or moderate consequence radiological related injury
	Chemical	ERPG-1 ≤ C < ERPG-2	Uniform distribution of total release ERPG-2 ≤ C < ERPG-3; or moderate consequence chemical related injury	ERPG-2 ≤ C < ERPG-3; or moderate consequence chemical related injury
Low (L)	Non-rad/Non-chemical injury		Minor injuries, no hospitalization	Minor injuries, no hospitalization
	Radiological	0.5 ≤ C < 5.0 rem	5.0 ≤ C < 25 rem; or low consequence radiological related injuries	5.0 ≤ C < 25 rem; or low consequence radiological related injuries
	Chemical	PEL-TWA ≤ C < ERPG-1	Uniform distribution of total release ERPG-1 ≤ C < ERPG-2; or low consequence chemical related injuries	ERPG-1 ≤ C < ERPG-2; or low consequence chemical related injuries
Negligible (N)	All	< Low	< Low	< Low

* SC or SS controls respectively are required if an event has moderate consequences that challenge (i.e., does not have to exceed) high radiological or chemical exposure/worker injury consequences. For events having moderate consequences that do not challenge the high range, facility controls and/or safety programs should be selected.

** SS required in nuclear facilities for prompt fatality, life threatening, or permanently disabling injuries for non-rad/non-chemical events that are not covered by national codes and standards.

Table A-2. Frequency Evaluation Levels

Acronym	Description	Frequency Level (f) (year^{-1})
A	Anticipated, Expected	$f \geq 10^{-2}$/yr
U	Unlikely	$10^{-4} \leq f < 10^{-2}$/yr
EU	Extremely Unlikely	$10^{-6} \leq f < 10^{-4}$/yr
BEU	Beyond Extremely Unlikely	$f < 10^{-6}$/yr

Table A-3A. Controls Selection Criteria Matrix – Offsite Public, Co-located and Facility Worker

Frequency → / Consequence ↓	Beyond Extremely Unlikely ($f < 10^{-6}$/yr)	Extremely Unlikely ($10^{-6} \leq f < 10^{-4}$/yr)	Unlikely ($10^{-4} \leq f < 10^{-2}$/yr)	Anticipated ($f \geq 10^{-2}$/yr)
High	**C/A3***	**A2**	**A1**	**A1**
Moderate	**C/B1****	**B1**	**B1**	**B1**
Low	**C**	**B**	**B**	**B**
Negligible	**C**	**C**	**C**	**C**

Key:

Region A1. Unmitigated events falling in Region "A1" due to radiological release require controls (SC for the public and SS for workers), and are **highly recommended** for additional Levels of Control (LOC) for all receptors per Ref. 8. Unmitigated events falling in Region "A1," due to chemical release or prompt fatality (etc.), require SS controls and **highly recommended** for additional LOC per Ref. 8. The goal is that the mitigated consequence is moved well into the B region, and possibly the "C" region or the event is prevented.***

Region A2. Unmitigated events falling in Region "A2" due to radiological release require controls (SC for the public and SS for workers), and are **recommended** for additional Levels of Control for all receptors per Ref. 8. Unmitigated events falling in Region "A2," due to chemical release or prompt fatality (etc.), require SS controls and **recommended** for additional Levels of Control per Ref. 8. The goal is that the mitigated consequence is moved well into the "B" region, and possibly the "C" region or the event is prevented.***

Region A3. Unmitigated events considered credible per E7, 2.25 falling in Region "A3" due to radiological release require controls (SC for the public and SS for workers), and are considered for additional LOC for CW or public per Ref. 8. Unmitigated events falling in Region "A3," due to chemical release or prompt fatality (etc.), require SS controls and consideration for additional LOC per Ref. 8. The desired result is that the mitigated consequence is moved into the "B" or "C" region, or the event is prevented.***

Region B1.

(a) Radiological events that have been evaluated using 50% meteorology and 100 cm surface roughness (for onsite receptors) or 95 % meteorology and 100 cm surface roughness (for offsite receptor) and have moderate "B1" consequences that challenge the high consequence criteria require SC controls for the public or SS controls for the workers.

(b) For offsite receptor (public), radiological events that have been evaluated using 95% meteorology and 3 cm surface roughness and have moderate "B1" consequences that challenge the high consequence criteria require SC controls.

(c) For onsite receptors (worker), radiological events that have been evaluated using 95% meteorology and 3 cm surface roughness and fall into Region "B1" (i.e., not exceed EG) require Facility Controls (FC).

(d) Unmitigated events that have moderate "B1" consequences to all receptors due to chemical release require SS controls; serious injury (etc.) to the worker requires Facility Controls (FC).

(e) For unmitigated events having moderate consequences that do not challenge the high consequence range, Facility Controls (FC) and/or safety programs should be selected. Documentation must be provided when facility controls or safety programs are not implemented.

Region B. Unmitigated events having low "B" consequences may require facility controls or safety programs. Justification must be provided when facility controls or safety programs are not implemented.

Region C. Events falling in Region "C" are not considered for controls. However, there may be events in this region that require the addition of Facility Controls because the frequency is higher than desired, the occurrence of the uncontrolled event is unacceptable to management in any event, or the uncontrolled event is unacceptable for programmatic or political reasons.

*** NPH, external events, and internal events in this frequency bin shall be addressed as required by E7, 2.25, Att. 8.8, Section 8.8.1.**

**** Moderate consequence "B1" events considered credible in this frequency bin that challenge high consequence criteria shall be treated the same as A3 events (i.e., consistent with E7, 2.25, Att. 8.8, Section 8.8.1). Moderate consequence events considered credible per E7, 2.25 in this frequency range that do not challenge high consequences should consider facility controls or safety programs.**

***** When a preventive control strategy is used, there is no requirement to make the event BEU. See E7, 2.25.**

Table A-3B. Process Hazards Review Accident Criteria

Frequency → / Consequence ↓	Beyond Extremely Unlikely ($f < 10^{-6}$/yr)	Extremely Unlikely ($10^{-6} \leq f < 10^{-4}$/yr)	Unlikely ($10^{-4} \leq f < 10^{-2}$/yr)	Anticipated ($f \geq 10^{-2}$/yr)
Loss of production *or* **Facility Damage > $ 2 million**	**C**	**C**	**C**	**B**
Loss of production < 6 mos *or* **Facility Damage < $ 2 million**	**C**	**C**	**C**	**C**

Key:

B	**Region B** Unmitigated events falling in Region B require Production Support (PS) controls. The desired result is that the mitigated combination of consequence and frequency is moved toward, and possibly into, the C region.
C	**Region C** Unmitigated events falling in Region C generally have negligible risk. However, there may be events in this region that require the addition of process controls because the frequency is higher than desired, or the occurrence of the uncontrolled event is unacceptable to management in any event, or the uncontrolled event is unacceptable for programmatic or political reasons.

APPENDIX B

HAZARD EVALUATION TABLES

Table B-1. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
MCTK -1	E-3	Receipt tank overflow results in radiological release to environment. MAR: Tank 7 – 0.75 M gallons	1. Transfer of waste material from process tank 2. Flushing of transfer line 3. Flushing of the Waste Mixing Chamber	A (1)	Rad/Chem: DSA Section 3.4.2.9 Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	Same as in DSA	Design: • Instrumentation to detect level increase and equipment to stop level increase (SS 1st LOC) Note: Equipment to stop level increase not needed for batch transfers <15 k gallons (Same as DSA) Administrative: • Tank Fill Limit Program (SS 1st LOC) (Same as DSA)	Design: None Administrative: None	Prevented (1)	NA	NA
MCTK -2	E-2	Explosion in the receipt tank due to hydrogen buildup results in radiological release to environment. MAR: Tank 7 – 0.75 M gallons	1. Vapor transfer from process tank into receipt tank 2. Process tank waste added to receipt tank increases hydrogen generation	BEU (1)	Rad/Chem: DSA Section 3.4.2.11 Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	Same as in DSA	Design: • Waste tank ventilation system operation (SC 1st LOC) • Periodic hydrogen monitoring (SS 2nd LOC) • Waste tank structure (SS 3rd LOC) • High level conductivity probes with CR alarm (Same as DSA)	Design: None Administrative: None	Prevented (1)	NA	NA

Table B-1. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
							Administrative: • Tank Fill Limit Program (SC 1st LOC) • Flammability control program (SS 2nd LOC) (Same as DSA)				
MCTK -3	E-3	Process tank is over pressurized by hot water from the sand mantis lance operation resulting in tank top contamination (radiological release) from tank vapor space pressurization. MAR: Vapor space contamination	1. Lance supply water temperature high due to heat of compression from UHP pumps 2. Lance supply water temperature high from high ambient temperatures sprayed into a cooler temperature tank	EU (1) Lance flow limited to 6 gpm Process tk. vapor space is very large compared to volume of remaining waste	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 C C C NA C C	Design: • By design, lance flow limited to < 6 gpm Administrative: • Monitor process tank vacuum	Design: None Administrative: None	NA	NA	NA

Table B-1. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
MCTK-4	E-3	Receipt tank over pressurized due to process high air flow rate resulting in tank top contamination (radiological release) from tank vapor space pressurization. MAR: Vapor space contamination	1. High air flow from sand mantis eductor 2. Eductor nozzle failure 3. Operator error 4. Receipt tank ventilation system failure	EU (1) Assumption: Process limits flow to < 400 cfm	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million > 6 months loss of production	 C C C NA C C	Design: • Receipt tank ventilation system maintains tank at negative pressure • Integrity of Eductor components • Designed UHP pump low flow rates • Design flow of mechanical cleaning operation to ≤ 400 cfm Administrative: • Operating procedures	Design: • Waste tank structural integrity Administrative: None	NA	NA	NA
MCTK-5		High temperature of waste material from process tank leads to boiling of waste in the receipt tank resulting in radiological release to environment. MAR: Tank 7 – 0.75 M gallons	1. UHP pumps add heat of compression to transfer medium (water)	Not Credible Transfer medium is less than 100˚ C	NA	NA	NA	NA	NA	NA	NA

Table B-1. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
MCTK -6		High pressure lance operation erodes hole in process tank wall/bottom resulting in sub-surface radiological release of tank contents (Environmental hazard). MAR: Tank 18 – 4,300 gallons sludge/zeolite Tank 19 – 15,100 gallons sludge/zeolite	1. Lance positioned too close to tank liner during operation and left in position for prolonged period of time	U (1)	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 C C C NA C C	Design: • Design of sand mantis keep lance minimum distance from tank wall or floor • Lance shoots forward and does not impinge on tank floor Administrative: • Operating procedures	Design: None Administrative: None	Prevented (1)	NA	NA
MCTK -7A	E-3	Process tank aerosolization leading to radiological release MAR: Tank 18 – 4,300 gallons sludge Tank 19 – 15,100 gallons sludge/zeolite	1. Operation of the Sand Mantis water lance with less than 10,000 psi operating water pressure directly impacts waste causing aerosolization	A (1)	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 C C C NA C C	Design: • Pump/motor designed to delivered < 10 kpsi operating pressure • Pressure protection device Administrative: • Operating procedures	Design: • Ventilation system with HEPA filters and waste tank design configuration • Tank top ARMs with alarms • Electrical disconnect to interrupt power supply to HP pump motor (stop lancing operation) Administrative: • Ventilation system performance monitoring	NA	NA	NA

Table B-1. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
MCTK -7B	E-3	Process tank aerosolization leading to radiological release MAR: Tank 18 – 4,300 gallons sludge Tank 19 – 15,100 gallons sludge/zeolite	1. Operation of the Sand Mantis water lance with greater than 10,000 psi operating water pressure directly impacts waste causing aerosolization 2. Above ground transfer line becomes plugged (2) 3. Eductor discharge line leaks/breaks inside the process tank (2) 4. High pressure water supply line leaks/breaks inside the process tank (3) 5. Eductor discharge line becomes plugged (2) 6. Connection of the high pressure supply line to the Sand Mantis/eductor fails/separates (3) (2) (3) - See notes at end of section.	A (1)	Rad/Chem: Offsite: N CW: H FW:H Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	C A1 A1 NA C C	Design: • Discharge Line Integrity • Over pressurization protection at UHP pump skid • High pressure line integrity • Over pressurization protection at hydraulic pump skid • Robust design of the high pressure connection from the HP supply line to the Sand Mantis Administrative: • Operating procedures (normal, abnormal, emergency) • Pressure protection requirements for high pressure system	Design: • Ventilation system with HEPA filters and waste tank design configuration (SS 1st LOC) • Tank top ARMs with alarms (SS 2nd LOC) • Electrical disconnect to interrupt power supply to HP pump motor (stop lancing operation) (SS 2nd LOC) • Capability to flush the transfer line • Ultra high pressure hose design (pressure certified, double wrapped hose designed such that outer wrap acts as barrier in event hose leaks) • Sand Mantis pickup tube screen Administrative: • Ventilation system performance monitoring (SS 1st LOC)	A (1)	Rad/Chem: CW: L FW: L	B B

Table B-1. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
								• Operating procedures (normal, abnormal, emergency) •			
MCTK -8	E-3	The process/receipt tank ventilation system fails during cleaning activities resulting in contamination (radiological release) of tank top from vapor space venting. MAR: Vapor space contamination	1. Equipment failure 2. Loss of electrical power 3. Support system failure 4. HEPA filter failure 5. Tornado/high winds, lightning	A (1)	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 C C C NA C C	Design: • Ventilation system integrity (FC) Administrative: • Ventilation system performance monitoring (FC) • Severe weather response program (FC)	Design: • Cameras used to monitor in-tank operation will allow operators to detect increase in misting • Tank top ARM with alarm Administrative: • Operating procedures (normal, abnormal, emergency)	Prevented (1)	NA	NA

Table B-1. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
MCTK -9	E-3	The hydraulic supply line to the Sand Mantis leaks/breaks inside the process tank resulting in an addition of organics to the waste tank. MAR: None	1. Material degradation 2. Line fatigue 3. Over pressurization 4. Sand Mantis cuts line lying on tank floor	A (1)	Rad/Chem: Offsite: None CW: None FW: None Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 NA NA NA NA C C	Design: • High pressure line integrity • Over pressurization protection at hydraulic pump skid • Hose management system Administrative: • Flammability Control Program • SRS evaluation of type and allowable amount of hydraulic fluid that can be added to the tanks	Design: • Ventilation system removes vapors • Limit on quantity of hydraulic fluid Administrative: • Skid operator responds to pressure drop and shuts down pump • Operating procedures (normal, abnormal, emergency)	NA	NA	NA
MCTK -10	E-3	Leaking hydraulic fluid is transferred to the receipt tank resulting in an increase of organics in the receipt tank. MAR: None	1. Hydraulic fluid leaking into waste tank being processed	U (1)	Rad/Chem: Offsite: None CW: None FW: None Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 NA NA NA NA C C	Design: • High pressure line integrity • Over pressurization protection at hydraulic pump skid Administrative: • SRS evaluation of type and allowable amount of hydraulic fluid that can be added to the tanks	Design: • Limited quantity of hydraulic fluid Administrative: • Skid operator responds to fluid loss and shuts down hydraulic unit • Operating procedures (normal, abnormal, emergency)	NA	NA	NA

Table B-1. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
MCTK -11	E-4	The sludge dries out from operation of the Sand Mantis eductor resulting in creation of a dry sludge tank. MAR: Tank 18 – 4,300 gallons sludge Tank 19 – 15,100 gallons sludge/zeolite	1. Eductor operation	BEU (1)	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 C C C NA C C	Design: • Eductor operation is localized • Lance operation erodes mounds and adds water to tank Administrative: • Operator actions maintain tank wetted • Operating procedures (normal, abnormal, emergency) • Inherent nature of waste has high % of interstitial liquid	Design: None Administrative: • Operating procedures (normal, abnormal, emergency)	BEU (1)	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 C C C NA C C
MCTK -12	E-8	Sand Mantis is dropped into tank causing damage to the tank bottom (hole) resulting in sub-surface radiological release of tank contents. MAR: Tank 18 – 4,300 gallons sludge Tank 19 – 15,100 gallons sludge/zeolite	1. Tether failure 2. Operator error	U (1)	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million > 6 months loss of production	 C C C NA C C	Design: • Dedicated lifting cable • Integrity of the Sand Mantis tether connection Administrative: • Critical lift program (FC)	Design: None Administrative: • Operating procedures (normal, abnormal, emergency)	Prevented (1)	NA	NA

(1) Engineering judgment/discussions with cognizant engineers.

Table B-1. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

(2) Negligible consequences to all receptors based on visual test results modeling this cause. See Appendix C.

(3) The cause of the event has been shown to be not credible. See Appendix C.

Table B-2. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source)	Consequence Level	Risk Rank	Preventive Controls	Mitigative Controls	Freq. Level (Source)	Consequence Level	Risk Rank
WRE-1	E-8	Low flow/low pressure through eductor results in loss of production MAR: None	1. Equipment failure/wear 2. Debris plugs UHP water system 3. Debris plugs eductor suction	A (1)	Rad/Chem: Offsite: None CW: None FW: None Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 NA NA NA NA C C	Design: • Design of equipment • Process water supply filters • Eductor suction tube inlet screen Administrative: • Operating procedures	Design: • Back flushing capability • Replace faulty equipment Administrative: None	NA	NA	NA
WRE-2	E-8	High flow/high pressure thru the eductor leads to loss of production MAR: None	1. Equipment failure/wear	A (1)	Rad/Chem: Offsite: None CW: None FW: None Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 NA NA NA NA C C	Design: • Design/testing of equipment Administrative: • Operating procedures	Design: • Replace faulty equipment Administrative: None	NA	NA	NA

Table B-2. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source)	Consequence Level	Risk Rank	Preventive Controls	Mitigative Controls	Freq. Level (Source)	Consequence Level	Risk Rank
WRE-3	E-8	Low hydraulic pressure at the hydraulic motors leads to loss of production. MAR: None	1. Hydraulic equipment failure/wear	A (1)	Rad/Chem: Offsite: None CW: None FW: None Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 NA NA NA NA C C	Design: • Design of equipment Administrative: • Operating procedures	Design: None Administrative: None	NA	NA	NA
WRE-4	E-8	The Sand Mantis becomes stuck inside the tank resulting in a loss of production. MAR: None	1. Operator error 2. Unexpected interference	U (1)	Rad/Chem: Offsite: None CW: None FW: None Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 NA NA NA NA C C	Design: • Very slow speed of Sand Mantis assembly • Lights and video camera • Separate hydraulic drive motors Administrative: • Operating procedures (normal, abnormal, emergency)	Design: • Sand Mantis tether to retrieve equipment Administrative: • Operating procedures (normal, abnormal, emergency)	NA	NA	NA

Table B-2. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source)	Consequence Level	Risk Rank	Preventive Controls	Mitigative Controls	Freq. Level (Source)	Consequence Level	Risk Rank
WRE-5	E-8	The incorrect type of hydraulic fluid is used in the Sand Mantis operating system resulting in a loss of production. MAR: None	1. Operator error	U (1)	Rad/Chem: Offsite: None CW: None FW: None Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 NA NA NA NA C C	Design: None Administrative: • QC program • Operating procedures (normal, abnormal, emergency) • Facility control of hydraulic makeup capability	Design: None Administrative: None	NA	NA	NA
WRE-6	E-8	The tether/umbilical cord becomes disconnected from the Sand Mantis resulting in a loss of production. MAR: None	1. Material degradation 2. Line fatigue 3. Sand Mantis cuts line lying on tank floor	U (1)	Rad/Chem: Offsite: None CW: None FW: None Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 NA NA NA NA C C	Design: • Robust design (multiple connection points) • Dedicated lifting cable attached to Sand Mantis • Tether management system Administrative: • Operating procedures (normal, abnormal, emergency)	Design: None Administrative: • Operating procedures (normal, abnormal, emergency)	NA	NA	NA

(1) Engineering judgment/discussions with cognizant engineers.

Table B-3. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
HIHTL -1	E-3 E-7	The above ground transfer line leaks/breaks resulting in a release of radioactive materials to the environment. (Spill height is assumed to be less than 3 meters.) MAR: 1800 gallons (10 gpm X 3 hr)	1. Material degradation (wall thinning, thermal stress, metal fatigue, ground vibration, cycling) 2. Core pipe over pressurization 3. Vehicle crash, crane and load impacts 4. Operator error 5. External events (gas bottle missile, nearby fire/explosion) 6. Water hammer 7. Tornado/high wind, seismic, lightning	A (1)	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 C C C NA C C	Design: • Core pipe integrity • Secondary containment around core pipe (with leak detection as required for any low spots in transfer line) Administrative: • Controls supporting pipe integrity 1. Transfer controls 2. Traffic controls 3. Critical lift controls 4. Structural integrity controls 5. Severe weather response	Design: • Instrumentation to detect leaks (ARMs, Leak detection system) • Equipment to stop release Administrative: • ARM location program • Facility personnel able to shut down transfer process	NA	NA	NA

Table B-3. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
HIHTL -2	E-3	Radioactive tank waste is pushed into flush water system resulting in a release of radioactive material to the environment. MAR: 1800 gallons (10 gpm X 3 hr)	1. Operator error 2. Valve misalignment 3. Flush water system failure	A (1)	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 C C C NA C C	Design: • Flush water system connections designed to prevent pushback • Permanently installed flush water line requires double block and bleed on flush water valves and flush lines on exterior of tank up to the valves is a jacketed line Administrative: • Administratively restrict Sand Mantis operation during flushing operation	Design: • Area radiation monitoring instruments Administrative: • Operating procedures (normal, abnormal, emergency)	NA	NA	NA

Table B-3. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
HIHTL -3	E-8	Low flow of waste through transfer line results in increased radiation levels (shine). MAR: 266 gallons (700 ft of 3 inch line @ 0.38 gpf)	1. Eductor wear 2. Line plugging 3. Excessive particles in transfer path 4. Waste held up in transfer line low spots	A (1)	Rad/Chem: Offsite: N CW: N FW: L Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 C C B NA C C	Design: • Screen on suction head limits particle size to ≤ ⅜ inch Administrative: None	Design: • Shielding installed for bounding conditions (FC) • ARMs • Transfer line flushing • WMC temperature monitor (increasing temp indicates loss of transfer line flow) Administrative: • Radiation protection periodically monitors transfer line (using teletrix)	A	Rad/Chem: FW: N	 C

Table B-3. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
HIHTL -4	E-3	High temperature waste flow in transfer line causes line failure resulting in radioactive leak to the environment MAR: 1800 gallons (10 gpm X 3 hr)	1. UHP pump operation 2. High ambient temperature for process supply water	A (1)	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 C C C NA C C	Design: • Core pipe integrity • Secondary containment around core pipe with leak detection Administrative: • Controls supporting pipe integrity 1. Transfer controls 2. Traffic controls 3. Critical lift controls 4. Structural integrity controls 5. Severe weather response	Design: • Instrumentation to detect leaks (ARMs) • Equipment to stop release Administrative: • ARM Location controls • Facility personnel able to shut down transfer process	NA	NA	NA

Table B-3. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
HIHTL -5	E-2	Core hose explosion results in radioactive release. MAR: 11.9 gallons (10% of 2" core hose capacity [700' x 0.17 gpf])	1. Waste holdup in core line after shutdown results in hydrogen buildup	A (1)	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 C C C NA C C	Design: None Administrative: • Line flushing	Design: • Secondary containment surrounding core pipe Administrative: • Emergency Response Program	NA	NA	NA
HIHTL -6	E-2	Secondary hose explosion results in radioactive release. MAR: 30.8 gallons (10% of 4" secondary hose capacity [700' x 0.66 gpf])	1. Leakage from core hose into secondary hose causes waste hold up and subsequent hydrogen build up in secondary hose.	A (1)	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 C C C NA C C	Design: • Core hose integrity • Leak detection system Administrative: • Core hose flushing	Design: • Venting of secondary hose through connection at toadstool on Process tank Administrative: • Emergency Response Program	NA	NA	NA

Table B-3. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
HIHTL -7	E-3	Movement of transfer line causes wear of transfer line resulting in release of radioactive material to the environment MAR: 1800 gallons (10 gpm X 3 hr) Same as HIHTL-1	1. Surge flow through transfer line	A (1)	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 C C C NA C C	Design: • Core pipe integrity • Transfer line supported/braced to resist movement Administrative: • Controls supporting pipe integrity 1. Transfer controls 2. Traffic controls 3. Critical lift controls 4. Structural integrity controls 5. Severe weather response	Design: • Instrumentation to detect leaks (ARMs) • Equipment to stop release Administrative: • ARM Location controls • Facility personnel able to shut down transfer process	NA	NA	NA

(1) Engineering judgment/discussions with cognizant engineers.

Table B-4. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
WMC-1	E-3	Pushback/siphon of waste from WMC into flushing lines resulting in release of radioactive material to the environment MAR: 4800 gallons (10 gpm X 8 hr)	1. Operator error 2. Valve misalignment 3. Flush water system failure	A (1)	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 C C C NA C C	Design: • Flush water line connections designed to prevent pushback/siphon • Siphon break at WMC • Permanently installed flush water line requires double block and bleed on flush water valves and flush lines on exterior of tank up to the valves is a jacketed line Administrative: • Administratively restrict UHP pump operation during flushing operation	Design: • Area radiation monitoring instruments Administrative: • Operating procedures (normal, abnormal, emergency)	NA	NA	NA

Table B-4. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
WMC-2	E-3	Foam/froth released out the mechanical seal for the immersion mill results in contamination on the tank top. MAR 10 gallons	1. Mechanical seal failure	A (1)	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 C C C NA C C	Design: • WMC overflow holes • Tank 7 ventilation Administrative: None	Design: • ARMs with control room alarms Administrative: None	NA	NA	NA
WMC-3	E-3	Boiling of the waste in the WMC results in a radiological release MAR: 155 gallons	1. Excessive operation of the immersion mill without transfer flow through it results in waste temperature increase	A (1)	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 C C C NA C C	Design: • Immersion mill temperature monitor • Flush water supply to the WMC Administrative: • Operating procedures	Design: • Tank 7 active ventilation system with HEPAs • Waste tank containment Administrative: • HEPA filter monitoring	NA	NA	NA

(1) Engineering judgment/discussions with cognizant engineers.

Table B-5. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
PS-1	E-3	The high pressure water supply line leaks/breaks outside the process tank resulting in personnel injury. MAR: None Standard Industrial Hazard (SIH) covered by national codes and standards	1. Material degradation 2. Line fatigue 3. Over pressurization 4. Impact cuts line lying on ground	A (1)	Rad/Chem: Offsite: None CW: None FW: None Personnel Injury: Low Process Impact: Loss of production < $2 million < 6 months loss of production	 NA NA NA B C C	Design: • Over pressurization protection at HP pump skid (FC) • High pressure line integrity Administrative: • High pressure system protection requirements per codes/standards	Design: • High pressure line design (double wall causes pressure drop and weepage through outer covering) Administrative: • Whipping protection program • Skid operator responds to pressure drop and shuts down pump • Personnel access around umbilical line restricted when lines are pressurized • Operating procedures (normal, abnormal, emergency)	Prevented (1)	NA	NA

Table B-5. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
PS-2	E-3	The hydraulic supply line to the Sand Mantis leaks/breaks outside the process tank resulting in personnel injury and a release of hydraulic oil to the environment. MAR: None Standard Industrial Hazard (SIH) covered by national codes and standards	1. Material degradation 2. Line fatigue 3. Over-pressurization 4. Impact cuts line lying on ground	A (1)	Rad/Chem: Offsite: None CW: None FW: None Personnel Injury: Low Process Impact: Loss of production < $2 million < 6 months loss of production	 NA NA NA B C C	Design: • Over pressurization protection at hydraulic pump skid (FC) • High pressure line integrity Administrative: • High pressure system protection requirements per codes/standards	Design: • Portable eye wash station for personnel Administrative: • Whipping Protection Program • Skid operator responds to pressure drop and shuts down pump • Personnel access around umbilical line restricted when lines are pressurized • Operating procedures (normal, abnormal, emergency)	Prevented (1)	NA	NA

Table B-5. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
PS-3	E-1	Fire at the control station during clean out operations resulting in personnel injury and a loss of production. MAR: None Standard Industrial Hazard (SIH) covered by national codes and standards	1. Misting of hydraulic oil from high pressure leak 2. High combustible loading 3. Diesel fuel leak 4. Electrical component failure/shorting	A (1)	Rad/Chem: Offsite: None CW: None FW: None Personnel Injury: N Process Impact: Loss of production < $2 million < 6 months loss of production	 NA NA NA C C C	Design: • Hydraulic fluid has low flammability rating Administrative: • Fire protection program	Design: • Fire protection equipment Administrative: • Event Response	NA	NA	NA
PS-4	E-3	Severe movement of a process skid impacts the process waste tank resulting in a radioactive release to the environment. MAR: Tank 18 – 4,300 gallons sludge Tank 19 – 15,100 gallons sludge/zeolite	1. Tornado/high winds 2. Seismic event	A (1)	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production > $2 million > 6 months loss of production	 C C C NA B B	Design: • Waste tank structural integrity • Hold down straps Administrative: • Severe weather response • Structural Integrity program	Design: None Administrative: None	NA	NA	NA

Table B-5. Hazard Evaluation Table for Mechanical Cleaning of Waste Tanks 18 & 19

Event No.	Event Cat.	Event Description	Causes	Freq. Level (Source) Init.	Consequence Level Unmitigated	Risk Rank Unmit.	Preventive Controls	Mitigative Controls	Freq. Level (Source) Prev.	Consequence Level Mitigated	Risk Rank Mit.
PS-5	E-3	Pushback of waste through the UHP supply lines results in a release of radioactive material to the environment MAR 1 gallon	1. Flushing of the transfer line from receipt tank to the process tank to clear the transfer line	U (1)	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 C C C NA C C	Design: • Isolation valve on UHP unit prevents pushback Administrative: None	Design: • Orifices in nozzle preclude/restrict any significant amount of waste getting pushed back through the UHP supply lines • ARMs with alarms Administrative: • Alarm response procedure	U (1)	Rad/Chem: Offsite: N CW: N FW: N Personnel Injury: None Process Impact: Loss of production < $2 million < 6 months loss of production	 C C C NA C C

(1) Engineering judgment/discussions with cognizant engineers.

APPENDIX C

SAND MANTIS AEROSOLIZATION CONCERNS

Sand Mantis Aerosolization Concerns

Aerosolization accidents are analyzed in the CST Documented Safety Analysis report. A portion of these events are due to pressurized steam or air directly impinging on the waste surface resulting in an airborne waste release.

The sand mantis works on similar principles as a steam jet in the tank farm. The sand mantis has a high pressure water lance that has the potential (i.e., operation with > 10 kpsi water pressure) to cause a similar aerosolization event as the steam jets used in the tank farm. Operation of the high pressure water lance with greater than 10 kpsi supply pressure will require safety related controls to mitigate the consequences of aerosolization.

During the cold/simulant testing of the sand mantis, some of the aerosolization scenarios were simulated. These scenarios include:

- Pluggage of the transfer line,
- Pluggage of the suction line
- Leak of the waste being transferred, and
- Water lancing operations.

The results of these tests, as documented in the test videos, indicate little to no aerosol being produced. Aerosolization of tank waste from high pressure flow out the suction line of the eductor (i.e., plugged transfer line) has been shown by testing (with test video records) to be not credible. The pressure drop through the eductor nozzle, the change in flow direction through the eductor, and the pressure drop in the suction liner of the eductor results in an extremely large drop in pressure at the outlet of the suction line. The supply water drains out the suction line without any aerosolization effects. As evidence in the vendor test videos, even impinging on a tank wall did not result in airborne waste from exiting the immediate location. Previous testing and WSRC site water lancing operations has shown that using a water lance at less than or equal to 10 kpsi supply pressure produces negligible aerosols in the waste tanks. Based on these results, these scenarios have been determined to result in negligible consequences to all receptors for this application.

The two remaining scenarios of concern for aerosolization with the sand mantis are leaks in the high pressure water feed line or a leak at the feed line connection to the mantis. The ultra-high pressure water hose is a pressure certified, double wrapped hose, which is then contained within the umbilical hose. The outer wrap acts as a barrier to contain any leakage from the inner high pressure hose, swell, and than weep the water to the inside of the umbilical hose. The umbilical hose contains the high-pressure water and hydraulic lines. It would take three passive failures of the high pressure feed hose, its outer wrap, and the umbilical hose to result in an impingement that might possibly cause an aerosolization of waste tank contents. There are no common mode failures in the waste tank which will cause all of the hoses to fail at the waste surface. Therefore, it is not credible for a leak in the high pressure supply hose to cause an aerosolization event.

The umbilical hose will have a mechanical connection to the Sand Mantis. This outer hose will contain any leakage from the high pressure Sand Mantis connections (i.e., high pressure supply line and high pressure hydraulic lines). There are no common mode failures in the waste tank which will cause the mechanical connection of the umbilical hose and a high pressure connection to fail at the waste surface. Therefore, it is not credible for a high pressure Sand Mantis connection point failure to cause an aerosolization event.