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Preclosure Procedural Safety Controls

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ACRONYMS

BWR	boiling water reactor
CRCF	Canister Receipt and Closure Facility
GROA	geologic repository operations area
HFE	human failure event
IHF	Initial Handling Facility
ITS	important to safety
PCSA	preclosure safety analysis
PSC	procedural safety control
PWR	pressurized water reactor
RF	Receipt Facility
SSCs	structures, systems, and components
WHF	Wet Handling Facility

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1. PURPOSE

The purpose of this report is to define and document procedural safety controls (PSCs) for preventing or mitigating event sequences that are derived from the preclosure safety analysis (PCSA). The identified PSCs will provide the bases for developing licensing specifications, normal and emergency operating procedures, and administrative controls. The report also identifies administrative controls to be included as part of the support and management systems. These administrative controls are used to establish the normal operating configuration and environment to provide a basis for performing the PCSA.

2. QUALITY ASSURANCE

This report has been prepared in accordance with PA-PRO-0313, *Technical Reports* (Ref. 8.2.5), and LS-PRO-0201, *Preclosure Safety Analysis Process* (Ref. 8.2.4). Therefore, the approved version is designated as "QA: QA."

2.1 USE OF SOFTWARE

2.1.1 Level 1 Software

No Level 1 software, as defined in IT-PRO-0011, *Software Management* (Ref. 8.2.3, Attachment 12), is used in preparing this report.

2.1.2 Level 2 Software

Level 2 software, as defined in *Software Management* (Ref. 8.2.3, Attachment 12), used in preparing this report is limited to the commercially available Word 2003, which is a component of the Microsoft Office 2003 suite of programs. The program is used on a personal computer running either Windows XP Professional or Windows 2000.

3. APPLICABLE CRITERIA AND REQUIREMENTS

A PCSA is required per 10 CFR 63.112 (Ref. 8.2.1). As required per 10 CFR 63.112, in part, the PCSA must include a systematic analysis of natural and human-induced hazards at the geologic repository operations area (GROA) and the technical basis for including or excluding specific hazards in the safety analysis. Furthermore, the PCSA is required to evaluate the probability of the occurrence of event sequences during the operating period before permanent closure and to categorize them as either Category 1 or Category 2 event sequences, as described in 10 CFR 63.2. Event sequences that have less than one chance in 10,000 of occurring before permanent closure of the repository are considered beyond Category 2 event sequences.

The technical bases for including or excluding certain hazards or for determining the probability category for a given event sequence may rest on the geologic setting; the design or structures, systems, and components (SSCs) important to safety (ITS); or other controls that are relied upon to limit or prevent potential event sequences or to mitigate their consequences. The *Yucca Mountain Review Plan* (Ref. 8.1.15), Section 2.1.1.6.3, Acceptance Criterion 2, addresses "administrative or PSCs needed to prevent event sequences, mitigate their effects" and includes consideration of management systems and procedures that ensure that administrative or PSCs will function properly. This report is developed to identify PSCs. A companion report, *Preclosure Nuclear Safety Design Bases* (Ref. 8.1.13), identifies the SSCs that are ITS.

This report does not identify the subset of controls that will be identified as licensing specifications. The purpose of this report is to collect the PSCs identified through the PCSA process to provide input for further disposition as licensing specifications, operating procedures, or administrative controls.

4. ASSUMPTIONS

None used.

5. METHOD FOR IDENTIFYING AND COMPILING PROCEDURAL SAFETY CONTROLS

PSCs are documented and controlled specific actions, or series of actions, taken by the operating staff in preparation for or during the execution of waste handling and emplacement. PSCs implement human activities that:

1. For postclosure, are relied upon to ensure that the controlling parameters in the features, events, and processes and the total system performance assessment are satisfied

2. For preclosure, are relied upon to reduce the likelihood of an initiating event or an event sequence

3. For preclosure, are relied upon to mitigate the consequences of an event sequence.

By Items 1, 2, and 3, PSCs are not intended to substitute for normal operating practices, and there are no identified PSCs for manual action to terminate event sequences. However, they may be implemented as individual written procedures, or they may be subsumed into normal operating procedures (e.g., for alignment of heating, ventilation, and air-conditioning), administrative controls (e.g., fire protection program, reliability program), management controls, or the radiation protection program. Examples of how such programs support the PCSA are listed in Table 2.

This report is limited to development of preclosure PSCs.

Expanding on the above, preclosure PSCs are defined as procedures or administrative controls for implementation of human activities that reduce the chance of or mitigate the consequences of event sequences. PSCs may also control the amounts and type of radioactive waste present in repository operations or locations. A PSC is a formally documented and controlled specific action or series of actions taken by the operating staff in preparation for or during the execution of a particular GROA operation. A PSC may be a localized action that ensures that the prevention of or the proper execution of a given event is performed with the required reliability. A PSC may be a general requirement that ensures that the baseline operating conditions of repository SSCs used for PCSA screening and detailed analyses are in place prior to and during waste handling.

PSCs are derived from (1) event sequence quantification analyses where a human interaction or a required operating condition affects the probability of an initiating event, affects the probability of a pivotal event, or is the basis for screening out a particular human failure event (HFE); (2) supporting analyses that provide the basis for screening out a potential hazard from being an initiating event of an event sequence; (3) conditions necessary to prevent criticality scenarios; and (4) conditions necessary to ensure that the amounts and type of radioactive wastes are bounded by the source terms used in the radiological consequence analyses.

Units used in this report include the following:

- Limits on operating speeds are presented in both metric (mps) and engineering units (fps or mph)

- Limits on operating, exposure, or mission times are expressed in hours.

5.1 PROCESS

Per Step 4.1.6 of *Preclosure Safety Analysis Process* (Ref. 8.2.4), the contents of this report are developed from the results of the PCSA, performed using procedure Steps 4.1.1 through 4.1.4, or from other event sequence analyses or references, to include the following:

- Identify the human actions that contribute to Category 1, Category 2, or beyond Category 2 event sequences in concert with the ITS SSCs in the PCSA to comply with 10 CFR 63.111(c), and describe the associated PSCs.

- Identify the human actions that are relied upon in addition to the ITS SSCs for preventing criticality for Category 1 and Category 2 event sequences, and describe the associated PSCs.

- Identify the human actions that are relied upon for maintaining dose compliance with 10 CFR 63.111, and describe the associated PSCs.

- Assess and compile the operational and maintenance conditions required to ensure the level of performance and reliability of ITS SSCs incorporated into the PCSA.

- Prepare a PSC list.

In addition, analyses that support the screening out of certain external or internal events are examined for administrative controls that may be appropriate as PSCs. If it is determined that the administrative restrictions are appropriate as PSCs because they are derived from, or support, the PCSA, they are listed in Table 1, *Procedural Safety Controls*. However, if the administrative control is already contained in existing Project's Support and Management System and derived from the PCSA, the administrative control is included in Table 2, *Other Administrative or Management Controls That Support Preclosure Safety Analysis*.

5.2 COMPILATION OF PROCEDURAL SAFETY CONTROLS FROM PRECLOSURE SAFETY ANALYSIS AND SUPPORTING ANALYSES

PSCs are derived from several analyses that support the PCSA for the license application. The supporting analyses include the event sequence quantification for each of the GROA facilities, including the following:

- Canister Receipt and Closure Facility (CRCF)
- Initial Handling Facility (IHF)
- Receipt Facility (RF)
- Wet Handling Facility (WHF)
- Intra-Site Operations
- Subsurface Operations.

Each of the event sequence analysis documents includes analyses of event sequences initiated by mechanical failures or HFEs that cause malfunctions of mechanical handling equipment such as cranes, canister transfer machines, waste form transporters, and shield doors. The analyses also include initiating events caused by internal fires. Each of the documents also includes a facility-specific human reliability analysis that points to the need for a particular administrative control or procedure that is relied on for estimating the probability of an HFE. Other PSCs are identified to ensure that initial or boundary conditions for fire initiation or normal environmental conditions for equipment operations are maintained.

Specialized analyses include the following:

- External events screening
- Aircraft crash
- Seismic
- Industrial military hazards
- Criticality
- Consequences
- Construction hazards screening.

Each of the specialized analyses were reviewed to identify, where appropriate, PSCs that ensure that initial or boundary conditions are satisfied, that are required to screen out various hazards, or that ensure that the bases for PCSA radiological consequence analyses are maintained.

The following subsections provide a brief overview of the PSCs that are derived from each of the source documents. The overview also summarizes the bases or origins of the PSCs that are

documented in the source documents and, where appropriate, includes an identifier for a representative event sequence that employs the PSC. Statements of specific PSCs and their bases are presented in Table 1.

5.2.1 Internal Event Sequence Quantification for GROA Facilities

The internal event sequence categorization analysis of each facility that comprises the GROA (i.e., the CRCF, IHF, RF, WHF, Intra-Site Operations, and Subsurface Operations) identifies the design and operational features that establish the bases for the safety analysis. Included in these analyses are human reliability analyses that identify procedures that must be in place to support the quantification of the probabilities of HFEs incorporated into the overall event sequence quantification for a given facility. Each analysis also includes a comprehensive fire analysis that relies on the implementation of a fire protection program to control transient combustibles and ignition sources and that relies on maintenance of waste form exposure times to within the parameters used in the fire analyses. Such procedural controls are identified in Section 6.9.2 of the analysis for each facility:

- *CRCF Facility Reliability and Event Sequence Categorization Analysis* (BSC 2007 (Ref. 8.1.2))
- *IHF Reliability and Event Sequence Categorization Analysis* (BSC 2007 (Ref. 8.1.4))
- *RF Receipt Facility Reliability and Event Sequence Categorization Analysis* (BSC 2007 (Ref. 8.1.8))
- *WHF Reliability and Event Sequence Categorization Analysis* (BSC 2007 (Ref. 8.1.10))
- *Intra-Site Operations and Balance of Plant BOP Reliability and Event Sequence Categorization Analysis* (BSC 2007 (Ref. 8.1.6))
- *Subsurface Operations Reliability and Event Sequence Categorization Analysis* (BSC 2007 (Ref. 8.1.9)).

This report collects and consolidates the identical PSCs that have been identified in each facility analysis.

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Table 1. Procedural Safety Controls

Item	Facility/ Operations Area	SSC	Procedural Safety Controls	Basis	Representative Event Sequence (Sequence Number)	Reference
PSC-1	CRCF, IHF, RF, WHF	CTT	The CTT is deflated during loading of cask onto trolley, cask preparation activities, and during canister unloading or loading activities.	This control limits the probability of spurious movement of the CTT and resulting impact.	CRCF-ESD09-TAD (Seq. 4-3) IHF-ESD-04-NVL (Seq. 3-5) RF-ESD06-TAD (Seq. 6-3) WHF-ESD13-TAD (Seq. 6-3)	BSC 2008 (Ref. 8.1.2, Section 6.9.2); BSC 2008 (Ref. 8.1.4, Section 6.9.2); BSC 2008 (Ref. 8.1.8, Section 6.9.2); BSC 2008 (Ref. 8.1.10, Section 6.9.2).
PSC-2	CRCF, IHF, RF, WHF	ST Site prime mover Cask tractor	The ST is turned off during AO bolting and unbolting, and canister unloading or loading activities. The site prime mover and cask tractor are disconnected or secured to prevent motion before waste handling operations begin.	This control limits the probability of spurious movement of the ST, site prime mover, or cask tractor and resulting collision or tipover.	CRCF-ESD09-TAD (Seq. 4-3) IHF-ESD-01-HLW (Seq. 4-6) RF-ESD06-TAD (Seq. 6-3) WHF-ESD13-TAD (Seq. 6-3)	BSC 2008 (Ref. 8.1.2, Section 6.9.2); BSC 2008 (Ref. 8.1.4, Section 6.9.2); BSC 2008 (Ref. 8.1.8, Section 6.9.2); BSC 2008 (Ref. 8.1.10, Section 6.9.2).
PSC-3	CRCF, IHF	WPTT	Personnel are verified to be outside of the WP Positioning Room and the WP Loadout Room prior to movement of a loaded WP into the WP Positioning Room or the WP Loadout Room.	This control limits the probability of operators receiving a direct exposure during the loading of a WP into the TEV.	IHF-ESD-12C-NVL (Seq. 2) CRCF-ESD19-TAD (Seq. 3)	BSC 2008 (Ref. 8.1.2, Section 6.9.2); BSC 2008 (Ref. 8.1.4, Section 6.9.2).
PSC-4	IHF	CTM Naval SNF canister	Verify that the naval canister lifting adapter is fully detached from the naval SNF canister before using the CTM to remove the naval canister lifting adapter and shield ring.	Human reliability analysis quantification is based on this PSC being in place. This control protects the canister from a drop by the CTM during the removal of the naval canister lifting adaptor and shield ring.	IHF-ESD-07-NVL (Seq. 2-5)	BSC 2008 (Ref. 8.1.4, Section 6.9.2).
PSC-5	WHF	TAD canister/DPC shield ring	Prior to commencing operations that rely upon the TAD canister/DPC shield ring, the operating crew is to verify that the shield ring is installed.	This control limits the probability of operators receiving a direct exposure due to miscommunication between the operator and the crew regarding status of the shield ring. The crew that depends on the shield ring for their own safety will ensure its placement.	WHF-ESD29-TAD (Seq. 2)	BSC 2008 (Ref. 8.1.10, Section 6.9.2).
PSC-6	WHF	Transportation cask STC	Whenever a TAD canister or DPC is being moved in a shielded transfer cask or uncanistered SNF is being moved in a transportation cask, the shielded transfer cask or transportation cask will have a lid held in place with a minimum number of installed fasteners such that the stress on the fasteners as a result of a drop, is less than yield strength.	This control limits the probability that a drop or tipover of the STC or TC during movement will result in radiological release or criticality.	WHF-ESD19-DPC (Seq. 11-4)	BSC 2008 (Ref. 8.1.10, Section 6.9.2).
PSC-7	CRCF, WHF	Surface nuclear confinement HVAC, ITS exhaust subsystem serving ITS confinement areas and ITS subsystems serving ITS electrical and battery rooms	One train of HVAC is required to be operating and the second train is required to be in standby before commencing waste handling operations.	HVAC analysis uses this configuration. This control limits the probability that the HVAC system will fail to start when relied upon to mitigate the consequences of an event sequence.	CRCF-ESD09-TAD (Seq. 3-5) HF-ESD13-TAD (Seq. 2-5)	BSC 2008 (Ref. 8.1.2, Section 6.9.2); BSC 2008 (Ref. 8.1.10, Section 6.9.2).
PSC-8	EDGF	ITS diesel generators	Before commencing waste handling operations, two ITS diesel generators are aligned to start on detection of under voltage. Following the start of the diesel generators, the operator manages the operation of the ITS diesel generators to ensure continuous operation of a train of the Surface Nuclear Confinement HVAC, ITS exhaust subsystem serving ITS confinement areas and ITS subsystems serving ITS electrical and battery rooms in each of the waste handling facilities.	The PCSA models that both ITS diesel generators start and run 720 hours to support the operation of the surface nuclear confinement HVAC system.	CRCF-ESD09-TAD (Seq. 3-5) WHF-ESD13-TAD (Seq. 2-5)	BSC 2008 (Ref. 8.1.2, Section 6.9.2); BSC 2008 (Ref. 8.1.10, Section 6.9.2).

Item	Facility/ Operations Area	SSC	Procedural Safety Controls	Basis	Representative Event Sequence (Sequence Number)	Reference
PSC-9	WHF	Spent fuel pool	With SNF in the pool, the concentration of soluble boron in the WHF pool and transportation cask/DPC fill water is maintained at a minimum of 2,500 mg/L, with the soluble boron enriched to a minimum of 90 wt% in the ^{10}B isotope.	This control provides the appropriate initial conditions in the WHF pool to ensure that a critical configuration cannot be created in the pool. For wet operations, the minimum required concentration of 2,500 mg/L of soluble boron (enriched to 90 wt % ^{10}B) in the WHF pool is sufficient to compensate for the complete omission of fixed neutron absorbers in the analyzed designs.	WHF-ESD21-CSNF (Seq. 2-3)	BSC 2008 (Ref. 8.1.11, Section 3); BSC 2008 (Ref. 8.1.10, Section 6.9.2).
PSC-10	IHF, CRCF, RF, WHF, Subsurface, Intra-Site	ITS SSCs	The amount of time that a waste form spends in each process area or in a given process operation, including total residence time in a facility, is periodically compared against the average exposure times used in the PCSA. Additionally, component failures per demand and component failures per time period are compared against the PCSA. Significant deviations will be analyzed for risk significance.	PCSA uses residence times and reliability data to calculate the probability of an initiating event. This control ensures that the average exposure times and reliability data are maintained consistent with those analyzed in the PCSA.	Applies to all event sequence and fault tree quantification that uses data from Att. C of the referenced analysis for each facility. Also applies to seismic PCSA analysis (Att. G of Ref. 8.1.14) and to fires analysis per Section 4.3 and Att. E of of the referenced analysis for each facility.	BSC 2008 (Ref. 8.1.14, Section 6.2.2.5); BSC 2008 (Ref. 8.1.2, Section 6.9.2); BSC 2008 (Ref. 8.1.4, Section 6.9.2); BSC 2008 (Ref. 8.1.8, Section 6.9.2); BSC 2008 (Ref. 8.1.10, Section 6.9.2); BSC 2008 (Ref. 8.1.6, Section 6.9.2); BSC 2008 (Ref. 8.1.9, Section 6.9.2).
PSC-11	IHF, CRCF, RF, WHF	Cask cranes	When transferring casks, the crane will remain connected to the cask until the proper seismic restraints are established.	The cask transfer trolley has built-in seismic restraints that prevent seismic interactions between the trolley frame and a cask. When so restrained, the cask is prevented from tipping by the cask transfer trolley design. During cask transfer, however, the crane must provide seismic stability until the cask transfer trolley seismic restraints are engaged.	No event sequences: potential cask tipover sequences due to seismic events are screened out (Section 6.2.2.5 of Ref. 8.1.14).	BSC 2008 (Ref. 8.1.14, Section 6.2.2.5)
PSC-12	IHF, CRCF, RF, WHF	Cask preparation platform	Transportation cask lid bolts are independently verified to have been removed prior to moving the cask from the cask preparation area to the unloading room or pool.	This control prevents the CTM from attempting to remove the cask lid with bolts still in place resulting in failure of the bolts and possible drop of the lid or cask.	CRCF-ESD09-TAD (Seq. 3-3) IHF-ESD07-HLW (Seq. 9-5) RF-ESD06-TAD (Seq. 3-3) WHF-ESD13-TAD (Seq. 2-3)	BSC 2008 (Ref. 8.1.2, Section 6.9.2); BSC 2008 (Ref. 8.1.4, Section 6.9.2); BSC 2008 (Ref. 8.1.8, Section 6.9.2); BSC 2008 (Ref. 8.1.10, Section 6.9.2).
PSC-13	IHF, CRCF, RF, WHF	CTM Port slide gates	At completion of a canister transfer operation, the port slide gates are verified to be closed	While the CTM is being used to perform transfer operations, the Operational Radiation Protection Program provides the necessary controls to ensure that workers are not present with the slide gates open. This control limits the probability of workers receiving a direct exposure by entering the transfer room with the CTM away from a port with a waste form present and the slide gate open.	CRCF-ESD18-TAD (Seq. 2) IHF-ESD-12A-NVL (Seq. 2) RF-ESD11 (Seq. 2) WHF-ESD29-TAD (Seq. 3)	BSC 2008 (Ref. 8.1.2, Section 6.9.2); BSC 2008 (Ref. 8.1.4, Section 6.9.2); BSC 2008 (Ref. 8.1.8, Section 6.9.2); BSC 2008 (Ref. 8.1.10, Section 6.9.2).
PSC-14	IHF, CRCF, RF, WHF	CTM	Prior to lifting or lowering a DPC, TAD canister, or naval canister, the CTM guide sleeve is to be verified to have been lowered.	This control limits the probability that a DPC, TAD canister, or naval canister is not in a vertical orientation during transfer such that any potential drops would be flat bottom drops.	CRCF-ESD09-TAD (Seq. 3-3) IHF-ESD-07-NVL (Seq. 4-5) RF-ESD06-TAD (Seq. 3-3) WHF-ESD13-TAD (Seq. 2-3)	BSC 2008 (Ref. 8.1.2, Section 6.9.2); BSC 2008 (Ref. 8.1.4, Section 6.9.2); BSC 2008 (Ref. 8.1.8, Section 6.9.2); BSC 2008 (Ref. 8.1.10, Section 6.9.2).
PSC-15	IHF, CRCF, RF, WHF, Intra-Site, Subsurface	Structure	Flights by fixed-wing aircraft in NTS or NTTR airspace within 4.9 NM (5.6 statute miles) of the North Portal and below 14,000 feet MSL are prohibited.	External event screening applied the results of the aircraft crash analysis, which assumes a flight restricted airspace around the North Portal.	No event sequences: initiating events screened out.	BSC 2008 (Ref. 8.1.3, Section 7).

Item	Facility/ Operations Area	SSC	Procedural Safety Controls	Basis	Representative Event Sequence (Sequence Number)	Reference
PSC-16	IHF, CRCF, RF, WHF, Intra-Site, Subsurface	Structure	The number of overflights by fixed-wing aircraft at altitudes greater than 14,000 feet MSL within the flight-restricted airspace (i.e., within 4.9 NM (5.6 statute miles) of the North Portal) is limited to 1,000 per year, and the overflights are limited to straight and level flights (i.e., maneuvering is not permitted).	External event screening applied the results of the aircraft crash analysis, which assumes that these operational controls are in place.	No event sequences: initiating events screened out.	BSC 2008 (Ref. 8.1.3, Section 7).
PSC-17	IHF, CRCF, RF, WHF, Intra-Site, Subsurface	Structure	Carrying ordnance or engaging in electronic jamming activities over the flight-restricted airspace (i.e., within 4.9 NM (5.6 statute miles) of the North Portal) is prohibited.	External event screening applied the results of the aircraft crash analysis, which assumes these operational controls are in place.	No event sequences: initiating events screened out.	BSC 2008 (Ref. 8.1.3, Section 7).
PSC-18	IHF, CRCF, RF, WHF, Intra-Site, Subsurface	Structure	Helicopter flights within 0.5 miles of surface facilities that process, stage, or age nuclear waste forms are prohibited.	External event screening applied the results of the aircraft crash analysis, which assumes that this flight restriction is in place.	No event sequences: initiating events screened out.	BSC 2008 (Ref. 8.1.3, Section 7).
PSC-19	Intra-Site (Aging Facility)	TAD canisters and DPCs	The surface contamination on TAD canisters and DPCs sent to the Aging Facility is less than 1.0×10^{-4} μCi/cm^2 for beta-gamma emitters and low-toxicity alpha emitters and 1.0×10^{-5} μCi/cm^2 for all other alpha emitters.	This control ensures that the dose consequences from airborne releases of contamination from the canisters on the aging pads are within the calculated values presented in the consequence analysis.	No event sequences: Potential event sequences screened out on basis of low consequences.	BSC 2008 (Ref. 8.1.7, Section 7 and Tables 45 and 70).
PSC-20	CRCF, RF, WHF, Intra-Site, Subsurface	Commercial SNF	Characteristics of commercial SNF received at the repository are verified to be within the following parameters: • The maximum burnup for commercial SNF is limited to 80 GWd/MTU for PWRs and 75 GWd/MTU for BWRs • The maximum initial enrichment for commercial SNF is limited to 5% ^{235}U • The minimum decay time of commercial SNF prior to shipment to the repository is 5 years.	This control ensures that the dose consequences from Category 2 event sequences involving these waste forms are within the values presented in the consequence analysis.	Applies to all event sequence end states result in release of radioactive from, or exposure to, commercial SNF.	BSC 2008 (Ref. 8.1.7, Section 7 and Tables 67, 68, and 70).
PSC-21	IHF, CRCF, Intra-Site, Subsurface	HLW	The individual radionuclide inventories per HLW canister are limited to the values presented in consequence analysis.	This control ensures that the dose consequences from Category 2 event sequences involving HLW are within the values presented in the consequence analysis.	Applies to all event sequence end states result in release of radioactive from, or exposure to, HLW.	BSC 2008 (Ref. 8.1.7, Tables 67, 68, and 70).
PSC-22	WHF	WHF pool	The height of water above the top of the active portions of commercial SNF assemblies in the WHF pool staging rack(s) and open TAD canisters, DPCs, and casks is maintained at or greater than 23 feet.	This control ensures that the pool leak path factors presented in the consequence analysis are maintained. Additionally, the water level is credited for preservation of shielding for workers.	WHF-ESD30-FUEL (Seq. 2)	BSC 2008 (Ref. 8.1.7, Tables 12 and 70); BSC 2008 (Ref. 8.1.10, Section 6.9.2).
PSC-23	Intra-Site (LLWF)		Dose rate measurements and associated conversions are performed to confirm that the following conditions are maintained in the LLWF: • Total radionuclide inventory on WHF pool resins and pool filters is at or below 2.3×10^3 Ci. • Total radionuclide inventory on the WHF stage 1 ITS HEPA filters is at or below 6,600 Ci. • Radionuclide concentration in the low-level liquid waste tanks is limited to dose equivalents of 1×10^{-3} Ci/m^3 of ^{60}Co and 1.5×10^{-3} Ci/m^3 of ^{137}Cs.	This control ensures that the dose consequences from Category 2 event sequences involving these waste forms are within the values presented in the consequence analysis.	No event sequences: Potential event sequences screened on basis of low consequences.	BSC 2008 (Ref. 8.1.7, Section 7; Tables 67, 68, and 70; and Appendix IV).

Item	Facility/ Operations Area	SSC	Procedural Safety Controls	Basis	Representative Event Sequence (Sequence Number)	Reference
PSC-24	IHF, CRCF, RF, WHF, Intra-Site, Subsurface	Cranes and handling equipment	When not in use, cranes, mobile platforms, and handling equipment are maintained in a location such that they cannot fall on a waste form.	The seismic analysis credits the exposure time of components over waste forms. This control ensures that the exposure time is limited to the time necessary to complete the waste handling operation.	Reduces the probability of potential 2-over-1 seismic interactions (Section 6.2.2.6 of referenced seismic PCSA).	BSC 2008 (Ref. 8.1.14, Section 6.10).
PSC-25	Subsurface	WP, emplacement drift	Rock condition is to be observed as emplacement drift boring is accomplished. Observed faults are to be specifically evaluated to ensure that conditions cannot credibly lead to a breach of the waste package during the preclosure period, or a standoff distance from the fault is to be established.	This control limits the potential for fault displacement (or related rockfall hazard) from a seismic event to induce a breach of the waste package at rest in an emplacement drift during the preclosure period.	For seismic PCSA, used to screen out potential fault displacement event sequences (Section 4.4.10, Ref. 8.1.14). SSO-ESD-03-SEQ-7-3	BSC 2008 (Ref. 8.1.14, Section 4.4.10); BSC 2008 (Ref. 8.1.9, Section 6.9.2).
PSC-26	CRCF	Cask Preparation Room equipment confinement doors	The Cask Preparation Room equipment confinement doors are to be closed when conducting operations with a potential for a drop involving a loaded cask.	This control ensures that the confinement boundary is intact when there is a potential for an event sequence that could result in radiological releases.	CRCF-ESD03-MCO (Seq. 2-6)	BSC 2008 (Ref. 8.1.2, Section 6.9.2).
PSC-27	WHF	Cask Preparation Room equipment confinement door	The Cask Preparation Room equipment confinement door is to be closed when waste handling operations are being conducted with a potential for a drop or collision involving a loaded cask or canister outside the WHF pool.	This control ensures that the confinement boundary is intact when there is a potential for an event sequence that could result in radiological releases outside the WHF pool.	WHF-ESD01-CSNF (Seq. 3-5)	BSC 2008 (Ref. 8.1.10, Section 6.9.2).

NOTE: μ = (micro) 10^{-6}; AO = aging overpack; BWR = boiling water reactor; Ci = curie; cm^2 = centimeter squared; CRCF = Canister Receipt and Closure Facility; CTM = canister transfer machine; CTT = cask transfer trolley; DHLW = defense high-level (radioactive) waste; DOE = U.S. Department of Energy; DPC = dual-purpose canister; GROA = geologic repository operations area; GWd/MTU = gigawatt day per metric ton of uranium; HEPA = high-efficiency particulate air (filter); HLW = high-level radioactive waste; HVAC = heating, ventilation, and air-conditioning; IE = initiating event; IHF = Initial Handling Facility; ITS = important to safety; J = joule; m = meter; LLWF = Low-Level Waste Facility; mg/L = milligrams per liter; mph = miles per hour; mi = mile; MSL = mean sea level; NM = nautical mile; NTS = Nevada Test Site; NTTR = Nevada Test and Training Range; PCSA = preclosure safety analysis; PSC = procedural safety control; PWR = pressurized water reactor; RF = Receipt Facility; SNF = spent nuclear fuel; SSC = structure, system, or component; ST = site transporter; STC = shielded transfer canister; TAD = transportation, aging, and disposal; TC = transportation cask; TEV = transportation and emplacement vehicle; WHF = Wet Handling Facility; WP = waste package; WPTT = waste package transfer trolley; wt% = weight-weight percentage.

Source: Original

Table 2. Other Administrative or Management Controls That Support Preclosure Safety Analysis

Item	Facility/ Operations Area	Elements to be Addressed in Administrative or Management Control	Basis	Representative Event Sequence	Reference	Affected Support and Management System
1	Intra-Site, Subsurface, ST, TEV	A traffic control program is established that includes the following elements: • Speed limits for vehicles other than waste-form transporters or conveyances that operating in the vicinity of routes used by waste-form transit • Restrictions on the number of TEVs containing a WP (i.e., a "loaded" TEV) in transit at one time in the GROA and on the operation of an unloaded TEV on the surface or in the subsurface at the same time a loaded TEV is in transit • Closure of vehicular crossings over the TEV railway whenever a TEV is in transit on the surface to or from the subsurface • In the subsurface drifts, traffic will be restricted from being in the same area as a loaded TEV. On the surface, all site roads crossing the path of a waste form transfer vehicle will be closed while a waste form is in transit.	• To protect against energetic collisions or impacts on a waste form. A nuclear safety design basis restricts the operational speed of ITS waste form conveyances to 2.5 mph. This administrative program will provide an additional level of prevention. • To reduce the potential for a TEV containing a WP colliding with another loaded or unloaded TEV by restricting the number of TEVs in operation at one time in the same vicinity. • To reduce the potential for a loaded TEV collision with another vehicle stalled or otherwise halted at a rail crossing, inducing a derailment of the TEV.	Other potential initiating events screened out.	BSC 2008 (Ref. 8.1.6, Section 6.0); BSC 2008 (Ref. 8.1.9, Sections 6.0 and 6.9.2).	Conduct of normal activities, including maintenance, surveillance, and periodic testing. Training and certification of personnel.
2	IHF, CRCF, RF, WHF, Intra-Site, Subsurface	A fire protection program is established that includes the following elements: • Combustible material control • Ignition source control • Mobile firefighting service • Requirements that fire barriers between designated fire zones, such as doorways, windows, and dampers, be in place during waste handling operations.	• These requirements reduce the probability and intensity for a fire that could affect a waste form. • Models of fire propagation and probability analyses account for presence of fire barriers between zones.	Accounted for in fire analyses presented in Section 6.5 and Att. F of referenced analysis for each facility. (Ref. 8.1.9, Section 6.9.2)	BSC 2008 (Ref. 8.1.2, Section 6.5 and Att. F); BSC 2008 (Ref. 8.1.4, Section 6.5 and Att. F); BSC 2008 (Ref. 8.1.8, Section 6.5 and Att. F); BSC 2008 (Ref. 8.1.10, Section 6.5 and Att. F); BSC 2008 (Ref. 8.1.6, Section 6.5 and Att. F); BSC 2008 (Ref. 8.1.9, Sections 6.5, 6.9.2 and Att. F).	Conduct of normal activities, including maintenance, surveillance, and periodic testing. Records, reports, tests and inspections Training and certification of personnel. Quality Assurance Program
3	IHF, CRCF, RF, WHF, Intra-Site, Subsurface, ST, TEV, AO, STC	A maintenance program is established that includes the following elements: • Ensuring that the separation distance between combustible vegetation and the nearest structures containing radiological materials is maintained at 10 m (32.8 ft) or greater. • Inspection and maintenance of water diversion channels and levees to protect against potential flooding of areas near the repository, including the North Portal pad and the aging pads. • Inspection and maintenance of aging overpacks and horizontal aging modules to ensure ventilation ports are clear of debris.	These administrative controls provide the bases for screening out external fire and external floods as initiating events.	No event sequences: initiating events screened out.	BSC 2008 (Ref. 8.1.2, Section 6.5); BSC 2008 (Ref. 8.1.4, Section 6.0); BSC 2008 (Ref. 8.1.8, Section 6.0); BSC 2008 (Ref. 8.1.10, Section 6.0); BSC 2008 (Ref. 8.1.9, Section 6.0).	Conduct of normal activities, including maintenance, surveillance, and periodic testing. Records, reports, tests and inspections Training and certification of personnel. Quality Assurance Program
4	Structure of CRCF, IHF, RF, WHF, Aging Pad, ST, TEV, AO, STC	Land usage within the repository withdrawal area is verified to exclude the following: • Liquid petroleum or natural gas pipelines • Large explosive resources and/or sources of toxic or hazardous chemicals • Roads used by shipments of hazardous material, other than those associated with repository operations, nearer than approximately 11 km (7 mi).	These administrative controls provide the bases for screening out external man-made hazards as initiating events.	No event sequences: initiating events screened out.	BSC 2008 (Ref. 8.1.12, Section 6.12) BSC 2008 (Ref. 8.1.5, Section 6.3.3).	Configuration management system

Table 2. Other Administrative or Management Controls That Support Preclosure Safety Analysis (Continued)

Item	Facility/ Operations Area	Elements to be Addressed in Administrative or Management Control	Basis	Representative Event Sequence	Reference	Affected Support and Management System
5	Intra-Site, Subsurface	A radiation protection program is established that includes the following elements: • Workers are prevented from being in proximity to a TEV while the TEV contains a WP • Control of access to emplacement drifts after a WP has been placed • Control of access to waste handling operations areas when a waste form is present • Verification of safe working environments, such as closure of shield doors or shield ports, by radiation technicians.	• The first control is to reduce the probability of radiation exposure to a worker in proximity to the TEV during normal operations or in the event that a TEV system failure occurs during transit on the surface or in the subsurface. • The second control is to reduce the probability of radiation exposure to a worker in proximity to an emplacement drift containing one or more WPs. • The third and fourth controls provided to reduce the probability of radiation exposure to a worker during processing of a waste form container in a waste handling facility.		BSC 2008 (Ref. 8.1.2, Section 6.9.2); BSC 2008 (Ref. 8.1.4, Section 6.9.2); BSC 2008 (Ref. 8.1.8, Section 6.9.2); BSC 2008 (Ref. 8.1.10, Section 6.9.2); BSC 2008 (Ref. 8.1.9, Section 6.9.2); BSC 2008 (Ref. 8.1.6, Section 6.9.2).	Operational radiation protection program Records, reports, tests and inspections Training and certification of personnel. Quality Assurance Program
6	Structure of CRCF, IHF, RF, WHF, Aging Pad, ST, TEV, AO, STC	A construction control program is established that includes the following elements: • Control of the installation and configuration of the isolation barriers between emplacement drifts and subsurface construction areas such that development operations do not impact on emplacement operations. • Control, storage, and use of explosives to ensure that there are no adverse effects on the structure of waste handling facilities, emplacement areas, or waste form conveyances. Timing of explosive blasts will be coordinated to not coincide with repository emplacement operations.	These controls protect against construction hazards from adversely affecting ITS SSCs and potentially initiating an event sequence.	No event sequences: initiating events screened out.	BSC 2007 (Ref. 8.1.1)	Configuration management system
7	IHF, CRCF, RF, WHF, Intra-Site, Subsurface	Operating procedures are established that includes the following requirement: • When not in use, each non-ITS components (such as maintenance cranes) listed in the referenced analysis is verified to be secured in a location such that it cannot fall on or interfere with the safety function of an ITS SSC during waste handling operations.	This control protects against non-ITS SSCs from adversely affecting ITS SSCs.	No event sequences: initiating events screened out.	BSC 2008 (Ref 8.1.16, Tables B-1 through G-1).	Conduct of normal activities, including maintenance, surveillance, and periodic testing Training and certification of personnel Quality Assurance Program

NOTE: AO = aging overpack; CRCF = Canister Receipt and Closure Facility; IHF = Initial Handling Facility; ITS = important to safety; PCSA = preclosure safety analysis; PSC = procedural safety control; PWR = pressurized water reactor; RF = Receipt Facility; SSC = structure, system, or component; ST = site transporter; STC = shielded transfer canister; TAD = transportation, aging, and disposal; TC = transportation cask; TEV = transportation and emplacement vehicle; WHF = Wet Handling Facility; WP = waste package.

Source: Original

5.2.2 Seismic Event Sequence Analysis for GROA Facilities

Seismic Event Sequence Quantification and Categorization (Ref. 8.1.14) includes all of the facilities and operations that comprise the GROA (i.e., the CRCF, IHF, RF, WHF, Intra-Site Operations, and Subsurface Operations). The seismic analysis identifies the design and operational features that establish the bases for the nuclear safety design bases. Included in these analyses are expressions of the average time that a waste form is exposed to a seismic event during the preclosure period. A PSC is defined to control and verify the average exposure times so as to validate the preclosure seismic analysis. Other PSCs derived from the seismic analysis ensure that waste forms are seismically stable at each step in the waste handling process. The procedural controls are identified in the analysis and are incorporated into Table 1.

5.2.3 Criticality Analysis

The *Preclosure Criticality Safety Analysis* (Ref. 8.1.11) identifies component design requirements, material properties, and operational conditions that must be controlled to validate that criticality does not occur in any Category 1 or Category 2 event sequences. The analysis includes all facilities in the GROA and identifies required PSCs for each facility. This report collects these PSCs in Table 1.

5.2.4 Consequences

Preclosure Consequence Analyses (Ref. 8.1.7) identifies waste form material properties and GROA operating conditions that must be controlled to validate the doses calculated for Category 1 or Category 2 event sequences. The analysis includes all facilities and operations in the GROA and identifies required PSCs for each facility. This report collects these PSCs in Table 1.

5.2.5 External Events Screening

The *External Events Screening Analysis* (Ref. 8.1.12) applies considerations of site location and characteristics to screen out potential hazards. For a few hazards, the screening relies on the performance of some maintenance activities to ensure that the technical basis for screening is realized over the preclosure period. For example, the screening out of external fires from the land surrounding the GROA is based on maintaining a separation distance of 10 m (32.8 ft) or greater between combustible vegetation and the nearest structures containing radiological materials. This requirement was considered as a potential PSC. After review, it was determined that the restriction is inappropriate to be listed as a PSC as it is contained in existing Support and Management Systems. Specifically, it was determined that this administrative control is part of the fire protection program and therefore, it was included in Table 2.

For other hazards, the external events screening analysis incorporates results of more detailed analyses such as the *Frequency Analysis of Aircraft Hazards for License Application* (Ref. 8.1.3) or the *Industrial/Military Activity-Initiated Accident Screening Analysis* (Ref. 8.1.5). These analyses identify certain administrative restrictions that are relied upon as a basis for screening out hazards, as identified in the respective reports. These administrative restrictions were considered as potential PSCs as described in Sections 5.2.6 and 5.2.7.

5.2.6 Aircraft Crash

The *Frequency Analysis of Aircraft Hazards for License Application* (Ref. 8.1.3) is based on maintaining a buffer zone around and over the GROA that excludes flights by fixed-wing aircraft and protects against helicopters flying close to waste handling facilities. The analysis specifies several PSCs that must be incorporated into the operations of the GROA. Such PSCs are incorporated into Table 1.

5.2.7 Industrial Military Hazards

The *Industrial/Military Activity-Initiated Accident Screening Analysis* (Ref. 8.1.5) evaluates the proximity of hazards that currently exist at the Yucca Mountain site due to nearby military activities, including the Nevada Test Site and the Nevada Test and Training Range, and due to commercial activities, primarily transportation. Such hazards have been screened out because no hazard exists within a 5-mile radius of the GROA. It is stated that the land withdrawal area, and the U.S. Department of Energy management of that area, provides a buffer from current military and industrial hazards, which will ensure that the 5-mile standoff radius will be maintained for the preclosure period. It is determined that the administrative restrictions are inappropriate as PSCs since they are contained in existing Project's Support and Management Systems. However, such administrative controls are identified in external event screening analyses and therefore are included in Table 2.

5.2.8 Construction Hazards Screening

The *Construction Hazards Screening Analysis* (Ref. 8.1.1) is a systematic examination of various categories of hazards from surface and subsurface construction activities that could potentially interact with waste forms or waste handling operations and lead to an exposure to radiation. The analysis includes consideration of physical impact (e.g., collision, crushing) such as construction cranes falling onto a waste form, chemical contamination, flooding, fires, explosions/implosions, radiation, and thermal effects. The analysis identifies several administrative measures that allow such hazards to be screened out as potential initiating events from the event sequence analyses for the surface and subsurface facilities. Those administrative measures were considered as potential PSCs. Such practices maintain separation distances and barriers and dictate how construction materials, including explosives, are controlled. It is determined that the administrative restrictions are contained in existing Project's Support and Management Systems, and therefore are included in Table 2.

6. SUPPORT AND MANAGEMENT SYSTEMS

In the course of analyzing means to prevent or mitigate event sequences, several support and management systems were implicitly relied on to ensure that the GROA is operated and maintained in accordance with regulatory and usual practices for nuclear facilities. With these management systems in place, it is unnecessary to identify specific practices as PSCs in the context of this report. Such management systems that are relied upon to implement administrative and PSCs include the following:

- **Quality Assurance Program**—Requirements will be applied to appropriate SSCs, and management controls will be applied to other SSCs.

- **Records, reports, tests and inspections**—Records will be created and maintained to describe the construction and the resulting as-built configuration of the repository surface and subsurface facilities.

- **Training and certification of personnel**—The training program will identify tasks and personnel classifications that require training before personnel can operate, maintain, engineer, manage, or perform quality-affecting activities.

- **Startup activities and testing**—This program will be applied to ITS SSCs and SSCs important to waste isolation and their operational processes prior to receipt of waste.

- **Conduct of normal activities, including maintenance, surveillance, and periodic testing**—Prior to the receipt of waste, plans will be developed and implemented for the conduct of normal activities, including operations, maintenance, surveillance, and periodic testing of SSCs and related processes.

- **Emergency planning**—This plan will establish the basis for written procedures and practices for the control of emergency events that may occur at the repository.

- **License specifications**—License specifications will be used to set limiting conditions for operations to ensure the safety bases of the PCSA.

- **Operational radiation protection program**—This program will be implemented through procedures and work controls to ensure that radiation protection measures are employed for the protection of workers, the public, and the environment, commensurate with the scope and extent of licensed activities.

- **Configuration management system**—This system will maintain design bases and will be integrated with repository procedures to ensure that design and operation within the design bases of SSCs occurs.

7. RESULTS

Table 1 lists the PSCs, the basis for identifying the requirement as a PSC, and the source document(s). Table 2 lists items that are also derived from the PCSA and will be included in administrative controls as part of the support and management systems that establish the normal operating configuration and environment that provide a foundation for performing the PCSA.

8. REFERENCES

8.1 DOCUMENTS CITED

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8.2 CODES, STANDARDS, REGULATIONS, AND PROCEDURES

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