Scientific Analysis/Calculation Administrative Change Notice

QA: QA

Complete only applicable items.

1. Document Number:	ANL-WIS-MD-000024	**2. Revision**:	01	**3. ACN**:	01
4. Title:	Postclosure Nuclear Safety Design Bases				
5. No. of Pages Attached:	51				

6. Approvals:

Preparer:	Roger J Henning Print Name and Sign	Roger J. Henning	3/14/2008 Date
Checker:	Peter Persoff Print name and sign	Peter Persoff	03/14/2008 Date
QCS/Lead Lab QA Reviewer:	John Devers Print name and sign	John K Devers	03/14/08 Date
Responsible Manager:	Palmer Vaughn Print name and sign	Palmer Vaughn	03/14/08 Date

7. Affected Pages	8. Description of Change:
	Changes are a result of OCRWM LP-7.5Q accepted with conditions, as documented on a Deliverable Review Comment Sheet dated 3/10/2008.
4-5	SNL 2007 [DIRS 178519], row for Section 6.4.4, after "Uncertainty in these corrosion rates", insert "has been included in the model."
4-7	SNL 2007 [DIRS 181953], delete the second occurrence of "Stress cracks are sufficiently small and tight to allow only the diffusive transport of radionuclides through the cracks" as a duplicate of two lines above.
4-7	SNL 2008 [DIRS 183478], correct from "The probability of igneous an igneous event…" to "The probability of an intrusive or eruptive igneous event…"
6-22, Table 6-4	Delete the extra cell in the last column for the EBS TH Environment Submodel line; merge the cells so the cited reference identifier covers both MSTHM Process Model and MSTHM Abstraction. EBS TH Environment Submodel | MSTHM Process Model | 6 EBS TH Environment Submodel | MSTHM Abstraction | 6
6-31	Delete the lines for core parameters "Closure Materials" and "Preclosure Ventilation"
6-36	The following changes are in Section 6.1.8 • Delete the last sentence in the first paragraph • In the second paragraph, the sentence starting with "The process presented herein, replace "presented herein" with "as it applies to postclosure activities" • Delete first sentence of third paragraph.

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6-37	Replace the first paragraph with: Processes and responsibilities for evaluating proposed changes to repository design, engineering, construction, and operations activities that could impact the postclosure safety analyses will be controlled through configuration management and change control processes. These controls may also be used to evaluate the potential inclusion of items in the *Q-List*, as necessary. In the second paragraph, delete "pursuant to this new procedure will" so paragraph reads: Evaluations conducted include programmatic decision activities, as defined in SCI-PRO-002, *Planning for Science Activities* as these evaluations consist of "what-if" studies of proposed changes to technical baseline parameters and processes. Approved design changes will be incorporated into the design and technical baseline using applicable procedures. Programmatic decision activities may involve alternative conceptual models, parametric changes, scientific analyses or calculations. Programmatic decision documentation shall fully describe the intended use of the product, and shall fully justify assumptions, inputs, and decisions with respect to its intended use. In the third paragraph after "concludes", delete "a report, which will include", and replace "report" with "evaluation" in two places so the paragraph reads: The evaluation concludes with documentation of the analysis supporting the results, as well as the results, justifications and conclusions that document the results of the evaluations and any subsequent impacts. Also, the evaluation will define, if warranted, a proposed path forward and any additional actions to be taken. The evaluation will be provided to lead lab senior management for any further action, which includes notification of BSC and/or DOE, as necessary.
7-1	Replace the first paragraph with the following paragraphs: Three barriers important to waste isolation (ITWI) have been identified (Section 6.1.2). These barriers are the Upper Natural Barrier, the Engineered Barrier System, and the Lower Natural Barrier. The specification of these barriers as ITWI is a result of an analysis conducted and documented in this report (Section 6.1.2 and 6.1.5). This analysis considers these barriers to be ITWI consistent with 10 CFR 63.2 and 10 CFR63.142(a) [DIRS 180319] because they have been determined to have one or more core parameter characteristics that either 1) prevent or substantially reduce the rate of movement of water from the repository to the accessible environment; 2) prevent the release or substantially reduce the release rate of radionuclides from the waste; 3) prevent or substantially reduce the rate of movement of radionuclides from the repository to the accessible environment, or 4) prevent or substantially reduce the potential for criticality. Table 7-1 provides a list of ITWI features / components supporting each of the three barriers as well as the barrier function for each feature/component (Output DTN: MO0801TABLITWI.000). A feature is classified as ITWI if it meets two conditions. The first condition is that the feature is associated with one or more parameter characteristic classified as important to barrier capability (ITBC). The second condition is that the feature is a significant contributor to the barrier capability relative to the other features of the barrier. Table 7-1 also identifies the relevant design control parameters related to the ITWI feature/component. These control parameters are quantities or variables that define or support a contribution to barrier capability or a model describing that capability (see Section 6.1). These design control parameters reflect the important aspect of the feature/component that must be controlled by either configuration management or procedural safety controls to ensure the postclosure performance assessment analytical bases are established during design, construction, procurement, operations, and closure. Most of these control parameters are identified as derived internal constraints in BSC 2008 [DIRS 183627] and Table 7-5. Other control parameters are related to specific constraints that are identified in other requirements documents such as the *Waste Acceptance Systems Requirements Document* (DOE 2007 [DIRS 169992]) and performance specifications documents such as *Transportation, Aging and Disposal Canister System Performance Specification*(DOE 2007 [DIRS 181403]).

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7-18	From the Waste Package Feature / Component: delete the line "Drip Shield Early Failure – Control – 2.1.03.10.0A …
7-33	Change the internal derived constraint for parameter 03-14 to say: "The waste package fabrication welds shall be conducted in accordance with standard industry requirements."
7-35	Change the internal derived constraint for parameter 03-23 to say: "The waste package surface finish shall be specified to be 125 roughness or better as defined in ASME B46.1-2002 [DIRS 166013]."
8-7	Update the TBV references for 183041 - DOC.20080307.0003, 184797- DOC.20080227.0003.
8-8	Update the reference 183478 - DOC.20080312.0001.
A-3	In Control Parameter "Emplacement Drift Diameter" replace "Diameter" with "Configuration".
A-9	In Core Parameter "Infiltration and Seepage processes" replace "processes" with "Properties".
A-11	In Control Parameter "Emplacement Drift Diameter" replace "Diameter" with "Configuration".
A-12	In Control Parameter "Standoff from Quaternary Faults" add "Repository" before "Standoff".
A-19	In Control Parameter "Emplacement Drift Diameter" replace "Diameter" with "Configuration".
A-29	In Control Parameter "Closure Boreholes" add "of" after "Closure".
A-34	In Control Parameter column add a line break between "Configuration" and "Emplacement".
A-42	Between "… to ensure correct implementation." and "Accordingly, these features are …" of the "Discussion of effect on barrier capability" column, insert: "The design addresses seals as closure of the shafts and ramps shall include backfilling for the entire depth of the opening. Site investigation boreholes within or near the footprint of the repository block will be backfilled with material compatible with the host rock and plugged. These design features are intended to meet the intrusion scenarios, and are not performance related."
A-43	In Control Parameter "Design of the Ground Support System" delete "the". In "Closure Boreholes" add "of" after "Closure".
A-50	In Control Parameter "Repository Elevation" add "—Standoff from Water Table".
A-52	In Core Parameter column add a line break between "Properties" and "Invert".
A-55	In Control Parameter column add a line break between "Limit" and "Drift".
A-65	In Control Parameter column add a line break between "Configuration" and "Verification".
A-66	Fix page break in table
A-67	Fix page break in table
A-68	In Control Parameter column add "Non-" to "ITBC", delete second "Non-ITBC".
A-77	In Control Parameter column add "Package" between "Waste" and "—Drip".
A-83	In Control Parameter column delete "Marring" after "Damage".
A-84	In Control Parameter column delete "Drip Shield Early Failure".
A-86	In Control Parameter column add a line break between "Configuration" and "Emplacement". Delete the hyphen at the end of "As-emplaced Waste Package-Drip Shield Configuration"-
A-88	In Control Parameter column add a line break between "Package" and "Drip".
A-92	In Control Parameter column add "In-drift" after "EBS" and change "Material" to "Materials".
A-111	In Control Parameter column add "Package" between "Waste" and "—Drip" Add "In-drift" after "EBS" and change "Material" to "Materials". In Core Parameter column, delete "Committed Materials".
A-112	In the Core Parameter column, add a line break between "Heat" and "Radionuclide".
A-115	In the Core Parameter column, after "In-Package Chemical Environment" delete "Parameter".
A-122	In the Core Parameter column, after "Waste Package Materials, Properties and Configuration" delete "Properties".

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A-123	In the Core Parameter column, after "Waste Form Degradation Corrosion Products" add "Properties" for FEP 2.1.09.08.0A.
A-130	In the Core Parameter column, add a line break between "Heat" and "Radionuclide".
A-135	In the Core Parameter column, add a line break between "Heat" and "Radionuclide".
A-140	In the Core Parameter column, after "Radionuclide Inventory and Source Term" add "Properties".
A-145	In Control Parameter column add "Emplacement" before "Pallet" and add "Function" after.
A-146	In Control Parameter column add "Emplacement" before "Pallet" and add "Function" after.
A-148	In Control Parameter column add a line break between "Function" and "Verification".
A-154	In the Core Parameter column, after "In-drift Chemical Environment" delete "Properties".
A-169	In the Control Parameter column, replace "Emplacement Drift Orientation" with "Orientation of Emplacement Drifts".
A-186	In Control Parameter "Standoff from Quaternary Faults" add "Repository" before "Standoff"
A-195	In the Core Parameter column, add "Non-ITBC" above parameters for 1.4.07.02.0A.

Table 4-1. Source of Inputs (Continued)

Citation	Source Title	Specifically Used From	Specifically Used In (this AMR)	Input Description
SNL 2007 [DIRS 177432]	Number of Waste Packages Hit by Igneous Events	Section 6	Table A-2	Potential consequence of an eruptive conduit, to the surface intersecting the repository is that waste packages entrained within a conduit may be breached, releasing radionuclides in an erupting ash plume where they can be dispersed downwind to the reasonably maximally exposed individual
		Section 7.2	Table A-3	Discussion of possibility of an eruptive conduit intersecting the repository and extending to surface
70 FR 53313 [DIRS 178394]	70 FR 53313. Implementation of a Dose Standard After 10,000 Years. Internet Accessible	10 CFR 63.305(b)	Table A-1	Future changes in agricultural and industrial activities are excluded based on regulatory requirements
SNL 2007 [DIRS 178519]	General Corrosion and Localized Corrosion of Waste Package Outer Barrier	Section 1	Table A-2	Stainless steel inner shell of waste package has been conservatively modeled to provide no delay of penetration of waste package once waste package Alloy 22 outer barrier has been breached
		Section 6.4.4	Table A-2	Possibility of localized corrosion also requires particular antecedent geochemical conditions that are generally not present
		Section 6.4	Table A-2	Uncertainty in corrosion rates has been included in the model
10 CFR 63. 2007 [DIRS 180319]	10 CFR 63	10 CFR 63.51(a)(3)(i−iii), 10 CFR 63.72(a), and 10 CFR 63.72(b)(1−11)	Table A-1	To preclude any potential deleterious effects, construction and operational management, and administrative controls will be developed
SNL 2007 [DIRS 180472]	Initial Radionuclide Inventories	Section 6	Table A-2	Within the waste package, radioactive decay and ingrowth contribute to the waste inventory, which defines the amount of different radionuclides present in different waste forms
		Section 6.1	Table A-2	Other radionuclides have moderate half-lives and decay to products that may be released from the waste
		Section 6.1	Table A-2	Waste inventory defines the amount of different radionuclides present in different waste forms
		Section 6.1.10	Table A-2	Any change to inventory will be managed by the change evaluation process
		Section 6.3	Table A-2	The process of decay and ingrowth of radionuclides is included in the TSPA
		Sections 6.4, 6.6.2 and 6.6	Table A-2	Differences in waste inventory of the different waste forms have been included in the evaluation of barrier capability
SNL 2007 [DIRS 180778]	General Corrosion and Localized Corrosion of the Drip Shield	Section 6	Table A-2	General corrosion rates of titanium in the range of likely environmental conditions are low during the regulatory period. This process has been included in models of drip shield degradation

Table 4-1. Source of Inputs (Continued)

Citation	Source Title	Specifically Used From	Specifically Used In (this AMR)	Input Description
SNL 2007 [DIRS 181648]	In-Drift Natural Convection and Condensation	Executive Summary	Table A-2	Thermal environment has a direct effect on temperature and humidity in the emplacement drifts, which control the corrosion environment, and the conditions for radionuclide mobilization and release
		Executive Summary, Table 6.1.2-1, Sections 6.1, 6.2, 6.3 and 6.4	Table A-2	Convective flow of air and moisture in the emplacement drifts has been included in models of in-drift thermal hydrology. However, it does not create an additional source of moisture
		Section 6.2.1	Table A-2	Flow diversion, when combined with the lack of advection through the waste package, results in only the potential for diffusive releases from the waste form and waste package if the waste package has degraded features
SNL 2007 [DIRS 181953]	Stress Corrosion Cracking of Waste Package Outer Barrier and Drip Shield Materials	Section 6.8.6	Table A-2	Stress cracks are sufficiently small and tight to allow only the diffusive transport of radionuclides through the cracks
		Section 6.2	Table A-2	The potential for and resultant consequences of early failure of the waste package by manufacturing defects or weld flaws exists, and has been considered in the TSPA Nominal Scenario Class
BSC 2007 [DIRS 182131]	Basis of Design for the TAD Canister-Based Repository Design Concept.	Section 8.2.3.1.1	Table A-2	Requirements for Naval waste packages emplacement standoff distance from mapped faults
		Section 8.2.3.1.1	Table A-2	Naval waste packages that requires an 8.2-ft (2.5-m) minimum emplacement standoff distance from mapped faults
SNL 2008 [DIRS 183041]	Features, Events, and Processes for the Total System Performance Assessment: Analyses	Section 6, by individual FEP	Table A-1	Discussion of FEP related to the Upper Natural Barrier as either an included or excluded screening decision.
		Section 6, by individual FEP	Table A-2	Discussion of FEP related to the Engineered Barrier System as either an included or excluded screening decision.
		Section 6, by individual FEP	Table A-3	Discussion of FEP related to the Lower Natural Barrier as either an included or excluded screening decision.
SNL 2008 [DIRS 183478]	Total System Performance Assessment Model /Analysis for the License Application	Section 6.5 and Table 6.5-2	Table A-2	The probability of an intrusive or eruptive igneous event compromising waste emplacement drifts is very small
SNL 2008 [DIRS 183750]	Saturated Zone Flow and Transport Model Abstraction	Section 6.7.2	Table A-2	Other radionuclides have moderate half-lives and decay to products that may be released from the waste
		Sections 7.4.2, 6.7.2	Table A-3	Radioactive decay and ingrowth

Table 6-4. Relationship among TSPA Model Components, Submodels, and Abstraction/Process Model(s)/Analysis(es)

Barrier	TSPA-LA Principal Model Components		Submodel for TSPA-LA	Abstraction/Process Model(s)/Analysis(es)	Reference[1]
Upper Natural Barrier	Unsaturated Zone Flow Model Component	Site-Scale UZ Flow	UZ Flow Fields Abstraction	UZ Flow Fields Abstraction	1
				Site-Scale UZ Flow Process Model	
				Active Fracture Model	
				Dual-Permeability UZ Flow Model	
		Infiltration Analysis	Infiltration Submodel	Infiltration Model Abstraction	2
				Infiltration Process Model	2
		Climate Analysis	Climate Submodel	Future Climate Analysis	3
		Drift Seepage	Drift Seepage Submodel	Drift Seepage Abstraction	4,5
				Drift Seepage Abstraction including Drift Collapse	
				TH Seepage Process Model	
Engineered Barrier System	EBS Environment Model Component	Drift Wall Condensation	Drift Wall Condensation Submodel	In-Drift Natural Convection and Condensation Process Model	7
				Drift Wall Condensation Abstraction	
		EBS Thermal-Hydrologic Environment	EBS TH Environment Submodel	MSTHM Process Model	6
				MSTHM Abstraction	
		EBS Chemical Environment	EBS Chemical Environment Submodel	EBS P&CE Abstraction	8
				IDPS Process Model	15
	WP and DS Degradation Model Component	WAPDEG	WP and DS Degradation Submodel	WP General Corrosion Abstraction	10,11,12
				WP MIC Abstraction	
				WP SCC Abstraction	
				DS General Corrosion Abstraction	
		Localized Corrosion on WP Outer Surface	Localized Corrosion Initiation Submodel	Localized Corrosion Initiation Abstraction	
				Localized Corrosion Penetration Rate Abstraction	

core parameter characteristic was essentially the same as a control parameter, the core parameter characteristic was eliminated and the control parameter characteristic retained.

Core parameter characteristics are listed in Table 6-5 and cited in Appendix A.

Core parameter characteristics are defined in Section 6.1.1. They are associated with core parameters that contribute to barrier capability, support the postclosure technical baseline, and are candidates for performance confirmation. They are related to the events and/or processes that act on a feature as described by a FEP screening justification or report. Core parameter characteristics are generalized, and they include the materials, properties, configurations, and/or orientations.

Table 6-5. Core Parameter Characteristics

Core Parameter Characteristic[1]
Characterization of Fault Displacement
Characterization of Igneous Events
Characterization of Seismic Events
Corrosion Products Properties
Criticality Characteristics
Drip Shield Corrosion
Drip Shield Materials, Properties, and Configuration
Drip Shield Seismic Performance
Emplacement Drift Configuration
Emplacement Pallet Materials, Properties, and Configuration
Extent of Saturated Zone
Extent of Unsaturated Zone
Geothermal Gradient
In-Drift Chemical Environment
In-Drift Chemical Environment Properties
In-Drift Thermal Environment, Convection, Condensation, and Evaporation
Infiltration and Seepage
Infiltration and Seepage Properties
In-Package Chemical Environment
In-Package Thermal Environment,
Inside Waste Package Waste Forms
Interpretation of Fault Displacement
Invert Materials Properties, and Configuration
Pallet Materials, Properties, and Configuration
Properties of corrosion products
Properties of the Host Rock Unit
Properties of Unsaturated Zone
Radionuclide Inventory and Source Term Properties
Radionuclide Properties
Repository: location and depth; layout and geometry; construction, operation, and closure
Saturated Zone Chemical Environment
Saturated Zone Flow

Confirmation Plan activities. Thus, PoNSDB identifies all barrier capabilities, whereas, TSPA identifies which of these capabilities are represented in risk and performance determinations.

The activities identified in the Performance Confirmation Plan have been compared to the assumptions, data, and information that comprise the performance assessment models and results of the TSPA and the PoNSDB document. This exercise has confirmed that the existing performance confirmation activities provide a breadth of investigations sufficient to evaluate the performance basis of the license application. None of these activities is identified for deletion at this time (SNL 2008 [DIRS 184797]).

6.1.8 Methodology for Postclosure Change Evaluation

Repository design, engineering, construction, and operations activities may result in changes to design, materials, configurations, and processes that differ from the analyzed technical bases. In addition, advances in scientific research may result in information (data, models, and methodologies) that is different than the analyzed bases. Finally, the regulator may dictate change(s). The evaluation of such changes with respect to the postclosure technical basis and performance assessment is a necessary part of change control management, which involves integration among the preclosure safety analyses of the design organization (currently Bechtel SAIC Company, LLC (BSC)), Postclosure Analysis Organization (currently Sandia National Laboratories), the Department of Energy (DOE), and the Naval Nuclear Propulsion Program.

10 CFR 63.44 [DIRS 180319] provides regulatory requirements associated with change control for the technical basis documented in the Safety Analysis Report, but is not invoked until after construction authorization is granted. It is prudent to design the preconstruction change evaluation process to be consistent with the information needs of the program that will be implemented to comply with 10 CFR 63.44 [DIRS 180319] when it is invoked. The process as it applies to postclosure activities is primarily intended to provide evaluations of changes to postclosure activities and/or SSCs that will be required during the postclosure period during the presubmittal and preconstruction authorization time periods, although the process could additionally be used to address some of the requirements for 10 CFR 63.44 [DIRS 180319]. The requirements related to change control processes in 10 CFR 63.44 [DIRS 180319] addresses preclosure and postclosure changes.

The process of evaluation remains the same regardless of the drivers for the change (e.g., design, operations, or science). Evaluations are made with respect to impacts on the postclosure compliance baseline and performance assessment. The technical basis is defined and documented in the TSPA analysis and/or model report, key supporting postclosure technical documents, the FEPs analysis and Database, and Total System Performance Assessment design interface documents that define the design input parameters and current ranges for those parameters as the required source for postclosure analyses. These documents summarize the postclosure technical bases and will be used as the basis from which to evaluate proposed changes.

Processes and responsibilities for evaluating proposed changes to repository design, engineering, construction, and operations activities that could impact the postclosure safety analyses will be controlled through configuration management and change control processes. These controls may also be used to evaluate the potential inclusion of items in the *Q-List*, as necessary.

Evaluations conducted include programmatic decision activities, as defined in SCI-PRO-002, *Planning for Science Activities* as these evaluations consist of “what-if” studies of proposed changes to technical baseline parameters and processes. Approved design changes will be incorporated into the design and technical baseline using applicable procedures. Programmatic decision activities may involve alternative conceptual models, parametric changes, scientific analyses or calculations. Programmatic decision documentation shall fully describe the intended use of the product, and shall fully justify assumptions, inputs, and decisions with respect to its intended use.

The evaluation concludes with documentation of the analysis supporting the results, as well as the results, justifications and conclusions that document the results of the evaluations and any subsequent impacts. Also, the evaluation will define, if warranted, a proposed path forward and any additional actions to be taken. The evaluation will be provided to lead lab senior management for any further action, which includes notification of BSC and/or DOE, as necessary.

6.2 SYSTEM DESCRIPTION AND DEMONSTRATION OF MULTIPLE BARRIERS

A critical element for repository safety is a site and system that provides multiple barriers to the movement of water and radionuclides. A barrier is defined in 10 CFR 63.2 as any material, structure, or feature that, for a period to be determined by the NRC, prevents or substantially reduces the rate of movement of water or radionuclides from the Yucca Mountain Repository to the accessible environment, or prevents the release or substantially reduces the release rate of radionuclides from the waste.

The repository system is composed of natural and engineered features that are combined into two natural barriers and an engineered barrier, designated as the UNB, the LNB, and the EBS. These three barriers provide the following principal barrier functions:

- The UNB, by preventing or substantially reducing the amount and the rate of water seeping into the drifts, prevents or substantially reduces the rate of movement of water from the repository to the accessible environment and prevents or substantially reduces the release rate of radionuclides from the waste

7. CONCLUSIONS

Three barriers important to waste isolation (ITWI) have been identified (Section 6.1.2). These barriers are the Upper Natural Barrier, the Engineered Barrier System, and the Lower Natural Barrier. The specification of these barriers as ITWI is a result of an analysis conducted and documented in this report (Section 6.1.2 and 6.1.5). This analysis considers these barriers to be ITWI consistent with 10 CFR 63.2 and 10 CFR63.142(a) [DIRS 180319] because they have been determined to have one or more core parameter characteristics that either 1) prevent or substantially reduce the rate of movement of water from the repository to the accessible environment; 2) prevent the release or substantially reduce the release rate of radionuclides from the waste; 3) prevent or substantially reduce the rate of movement of radionuclides from the repository to the accessible environment, or 4) prevent or substantially reduce the potential for criticality.

Table 7-1 provides a list of ITWI features / components supporting each of the three barriers as well as the barrier function for each feature/component (Output DTN: MO0801TABLITWI.000). A feature is classified as ITWI if it meets two conditions. The first condition is that the feature is associated with one or more parameter characteristic classified as important to barrier capability (ITBC). The second condition is that the feature is a significant contributor to the barrier capability relative to the other features of the barrier.

Table 7-1 also identifies the relevant design control parameters related to the ITWI feature/component. These control parameters are quantities or variables that define or support a contribution to barrier capability or a model describing that capability (see Section 6.1). These design control parameters reflect the important aspect of the feature/component that must be controlled by either configuration management or procedural safety controls to ensure the postclosure performance assessment analytical bases are established during design, construction, procurement, operations, and closure. Most of these control parameters are identified as derived internal constraints in BSC 2008 [DIRS 183627] and Table 7-5. Other control parameters are related to specific constraints that are identified in other requirements documents such as the *Waste Acceptance Systems Requirements Document* (DOE 2007 [DIRS 169992]) and performance specifications documents such as *Transportation, Aging and Disposal Canister System Performance Specification*(DOE 2007 [DIRS 181403]).

Consumable materials to be incorporated into any engineered item important to waste isolation during fabrication of that item are also included as items important to waste isolation. The control parameters that are related to this specific criteria include 02-03: Committed Materials and 04-09: Waste Package & TAD Canister Excluded Materials.

Additional constraints beyond the control parameters listed are placed on some features or SSCs. Table 7-1 lists these additional controlling mechanisms as control parameter characteristics for the features or SSCs where they apply. These include: the Transportation, Aging, and Disposal Canister System Performance Specification (DOE 2007 [DIRS 181403], and the Waste Acceptance System Requirements Document (DOE 2007 [DIRS 169992]) and information contained in Naval Nuclear Propulsion Program classified documents. In addition, for postclosure purposes, NUREG-1536 and NUREG-1567 are equivalent in their requirements for moisture removal and are therefore acceptable.

The methodology for the determination of ITWI barriers is primarily based on the information contained in the screening justifications and screening dispositions of the Features, Events, and Processes (FEPs). As the FEPs form the bases of technical support for the TSPA, this approach is both efficient and comprehensive for ITWI barrier determination. The FEP screening justifications and dispositions can also be associated with specific parameter characteristics. The parameter characteristics associated with each FEP relevant to specific features/components of

Table 7-3 ITBC Features / Components and ITBC Parameter Characteristics of Engineered Barrier System (Continued)

Feature / Component	Characteristic	Type	Analysis Basis
Waste Package	As-Emplaced Waste Package-Drip Shield Configuration	Control	1.2.03.02.0A - Seismic Ground Motion Damages EBS Components (Included)
			2.1.03.03.0A - Localized Corrosion of Waste Packages (Included)
			2.1.03.11.0A - Physical Form of Waste Package and Drip Shield (Included)
	Characterization of Seismic Events	Core	1.2.03.02.0A - Seismic Ground Motion Damages EBS Components (Included)
	Committed Materials	Control	2.1.09.28.0A - Localized Corrosion on Waste Package Outer Surface due to Deliquescence (Excluded)
	Drip Shield Corrosion Allowance	Control	2.1.03.01.0A - General Corrosion of Waste Packages (Included)
			2.1.03.03.0A - Localized Corrosion of Waste Packages (Included)
			2.1.03.10.0A - Advection of Liquids and Solids through Cracks in the Waste Package (Excluded)
	Drip Shield Design	Control	2.1.03.01.0A - General Corrosion of Waste Packages (Included)
			2.1.03.03.0A - Localized Corrosion of Waste Packages (Included)
			2.1.03.10.0A - Advection of Liquids and Solids through Cracks in the Waste Package (Excluded)
	Drip Shield Design and Installation	Control	2.1.03.10.0A - Advection of Liquids and Solids through Cracks in the Waste Package (Excluded)
	Drip Shield Materials and Thicknesses	Control	2.1.03.01.0A - General Corrosion of Waste Packages (Included)
			2.1.03.10.0A - Advection of Liquids and Solids through Cracks in the Waste Package (Excluded)
	Drip Shield Materials, Properties, and Configuration	Core	1.2.03.02.0A - Seismic Ground Motion Damages EBS Components (Included)
			2.1.03.01.0A - General Corrosion of Waste Packages (Included)
			2.1.03.03.0A - Localized Corrosion of Waste Packages (Included)
			2.1.03.10.0A - Advection of Liquids and Solids through Cracks in the Waste Package (Excluded)

Table 7-5. Summary of Classification of Control Parameter Characteristics by Engineering Subsystem Categorization[1] (Continued)

Category	Number	Control Characteristic	Derived Internal Constraint	ITBC	ITWI Relevant
Waste Package	03-06	Waste Package Internal Pressurization	The waste package shall be designed to accommodate internal pressurization of the waste package including effects of a high temperature of 350°C and fuel rod gas release.	No	No
Waste Package	03-07	Waste Package Corrosion Allowance	For postclosure mechanical calculations and analysis, a corrosion allowance of at least 2 mm per side shall be accounted for on exposed waste package surfaces. Calculations will be performed using mechanical properties at 150°C or greater.	Yes	No
Waste Package	03-08	Seismic Design of Waste Package	The interface control mechanism for the seismic design spectra, time histories, and ground accelerations for the subsurface facilities is the Seismic Data IED.	Yes	No
Waste Package	03-09	Waste Package Worst-Case Dose Rate	The waste package containing the TAD canister with 21 PWR fuel assemblies shall represent the worst-case dose rate (80 GWd/MTU burnup, 5% U-235 enrichment and 5 years decay).	No	No
Waste Package	03-10	Waste Package Design Basis Bounding Dose Rate	The interface control mechanism for the design basis bounding dose rate calculations for waste packages and representative neutron flux is the Waste Package Radiation Characteristics IED.	No	No
Waste Package	03-11	Waste Package Decay Heat	The interface control mechanisms for the postclosure design basis waste package decay heat are the Waste Package Decay Heat Generation IEDs.	No	No
Waste Package	03-12	Waste Package Fabrication	The waste package outer corrosion barrier cylinder shall be fabricated from no more than 3 sections with longitudinal welds offset. The waste package will be inspected and evaluated per applicable criteria, e.g., Parameter 03-18, at the fabricator location and upon receipt at the repository location.	Yes	Yes
Waste Package	03-13	Waste Package Fabrication Weld Inspections	The waste package outer corrosion barrier fabrication welds shall be nondestructively examined by means of radiographic examination (RT) and ultrasonic testing (UT) for flaws equal to or greater than 1/16 inch. Outer corrosion barrier fabrication welds shall also be examined using liquid penetrant per the applicable specification.	Yes	Yes
Waste Package	03-14	Waste Package Welding Materials	The waste package fabrication welds shall be conducted in accordance with standard industry requirements.	Yes	Yes
Waste Package	03-15	Waste Package Fabrication Welding Flaws	The welding techniques for the fabrication welds shall be constrained to GMAW (gas metal arc welding) except for short-circuiting mode, and automated GTAW (gas tungsten arc welding) for Alloy 22 (UNS N06022) material, limited to <45 kJ/in. Welding flaws 1/16 inch and greater will be repaired for the outer corrosion barrier in accordance with written procedures that have been accepted by the design organization prior to their usage.	Yes	Yes

Table 7-5. Summary of Classification of Control Parameter Characteristics by Engineering Subsystem Categorization[1] (Continued)

Category	Number	Control Characteristic	Derived Internal Constraint	ITBC	ITWI Relevant
Waste Package	03-21	Waste Package Handling	The waste package shall be handled in a controlled manner during fabrication, handling, transport, storage, emplacement, installation, operation, and closure activities to minimize damage; surface contamination; and exposure to adverse substances.	Yes	Yes
Waste Package	03-22	Waste Package Handling & Emplacement	Waste package handling and emplacement activities shall be monitored through equipment with resolution capable of detecting waste package damage. An operator and an independent checker shall perform the operations. Records demonstrating compliance shall be maintained.	No	No
Waste Package	03-23	Waste Package Surface Finish	The waste package surface finish shall be specified to be 125 roughness as defined in ASME B46.1-2002 [DIRS 166013].	Yes	Yes
Waste Package	03-24	Waste Package Surface Damage Prior to Closure	The emplacement drift ground support system shall be inspected prior to drip shield installation. Waste packages that have come in contact with fallen rock or ground support materials will be inspected to ensure the damage to the waste package corrosion barrier that displace material (i.e. scratches), shall be limited to 1.6 mm (1/16 in) in depth. Modifications to the waste package corrosion barrier that deform the surface, but do not remove material (i.e. dents), shall not leave residual tensile stresses greater than 257 MPa.	Yes	Yes
Waste Package	03-26	Waste Package Moisture Removal & Inerting	All waste packages shall be vacuum dried and backfilled with helium in a manner consistent with that described in *Standard Review Plan for Dry Cask Storage Systems* (NUREG-1536) (NRC 1997 [DIRS 101903], Section 8.V.1).	Yes	Yes
Waste Form & TAD Canister	04-01	Loading of Waste Forms	To minimize waste form damage, waste package and TAD canister-loading activities shall be performed and monitored in accordance with industry standard practices including an operator and an independent checker. Records demonstrating compliance shall be maintained.	No	No
Waste Form & TAD Canister	04-02	Handling of Bare SNF	Bare SNF shall be handled in a standard industry fashion to limit damage and prevent unzipping of fuel rod cladding.	No	No
Waste Form & TAD Canister	04-03	Waste Form CSNF Fuel Rod Maximum Burnup Limit	The CSNF fuel rod or assembly maximum burnup shall be less than 80 GWd/MTU (this is bounded by the PWR burnup).	No	No
Waste Form & TAD Canister	04-04	Waste Form Moisture Removal & Inerting	All TAD canisters shall be vacuum dried and backfilled with helium in a manner consistent with that described in *Standard Review Plan for Dry Cask Storage Systems* (NUREG-1536) (NRC 1997 [DIRS 101903], Section 8.V.1). [Note: For postclosure moisture removal purposes, NUREG-1567 (NRC 2007 [DIRS 149756], Section 9.5.4.1) is equivalent to NUREG-1536 and is therefore acceptable.][2]	Yes	Yes
Waste Form & TAD Canister	04-05	Cladding Temperature Limit	The maximum temperature of the CSNF cladding upon emplacement shall not exceed 350°C (to prevent damage from creep or hydride reorientation).	No	No

179394 SNL 2007. *Total System Performance Assessment Data Input Package for Requirements Analysis for TAD Canister and Related Waste Package Overpack Physical Attributes Basis for Performance Assessment.* TDR-TDIP-ES-000006 REV 00. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070918.0005.

184614 SNL 2007. *UZ Flow Models and Submodels.* MDL-NBS-HS-000006 REV 03 AD 01. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080108.0003; DOC.20080114.0001.

177423 SNL 2007. *Waste Form and In-Drift Colloids-Associated Radionuclide Concentrations: Abstraction and Summary.* MDL-EBS-PA-000004 REV 03. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20071018.0019.

183041 SNL 2008. *Features, Events, and Processes for the Total System Performance Assessment: Analyses for the License Application: Analyses.* ANL-WIS-MD-000027 REV 00. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080307.0003.

182145 SNL 2008. *Simulation of Net Infiltration for Present-Day and Potential Future Climates.* MDL-NBS-HS-000023 REV 01 AD 01. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080201.0002.

179476 SNL 2008. *Features, Events, and Processes for the Total System Performance Assessment: Methods.* ANL-WIS-MD-000026 REV 00. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080211.0010.

184748 SNL 2008. *Particle Tracking Model and Abstraction of Transport Processes.* MDL-NBS-HS-000020 REV 02 AD 02. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080129.0008.

184797 SNL 2008. *Performance Confirmation Plan.* TDR-PCS-SE-000001 REV 05 AD 01. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080227.0003.

183750 SNL 2008. *Saturated Zone Flow and Transport Model Abstraction.* MDL-NBS-HS-000021 REV 03 AD 02. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080107.0006.

173869 SNL 2008. *Screening Analysis of Criticality Features, Events, and Processes for License Application*. ANL-DS0-NU-000001 REV 00. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080208.0001.

184806 SNL 2008. *Site-Scale Saturated Zone Transport*. MDL-NBS-HS-000010 REV 03 AD 01. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080121.0003.

183478 SNL 2008. *Total System Performance Assessment Model /Analysis for the License Application.* MDL-WIS-PA-000005 REV 00 AD 01. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080312.0001.

161058 Wu, Y-S.; Zhang, W.; Pan, L.; Hinds, J.; and Bodvarsson, G.S. 2002. "Modeling Capillary Barriers in Unsaturated Fractured Rock." *Water Resources Research, 38,* (11), 35-1 through 35-12. Washington, D.C.: American Geophysical Union. TIC: 253854.

154918 Wu, Y-S.; Zhang, W.; Pan, L.; Hinds, J.; and Bodvarsson, G.S. 2000. *Capillary Barriers in Unsaturated Fractured Rocks of Yucca Mountain, Nevada.* LBNL-46876. Berkeley, California: Lawrence Berkeley National Laboratory. TIC: 249912.

100520 YMP (Yucca Mountain Site Characterization Project) 1993. *Evaluation of the Potentially Adverse Condition "Evidence of Extreme Erosion During the Quaternary Period" at Yucca Mountain, Nevada.* Topical Report YMP/92-41-TPR. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: NNA.19930316.0208.

154386 YMP 2001. *Reclamation Implementation Plan.* YMP/91-14, Rev. 2. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: MOL.20010301.0238.

8.2 CODES, STANDARDS, REGULATIONS, AND PROCEDURES

180319 10 CFR 63. 2007. Energy: Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada. Internet Accessible.

177357 70 FR 49014. Public Health and Environmental Radiation Protection Standards for Yucca Mountain, NV. Internet Accessible.

178394 70 FR 53313. Implementation of a Dose Standard After 10,000 Years. Internet Accessible.

166013 ASME B46.1-2002. 2003. *Surface Texture (Surface Roughness, Waviness and Lay).* New York, New York: American Society of Mechanical Engineers. TIC: 257359.

147465 ASTM B 575-99a. 1999. *Standard Specification for Low-Carbon Nickel-Molybdenum-Chromium, Low-Carbon Nickel-Chromium-Molybdenum, Low-Carbon Nickel-Chromium-Molybdenum-Copper, Low-Carbon Nickel-Chromium-Molybdenum-Tantalum, and Low-Carbon Nickel-Chromium-Molybdenum-Tungsten Alloy Plate, Sheet, and Strip.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 247534.

Table A-1. ITBC Analysis of Upper Natural Barrier FEPs (Continued)

Feature / Component	FEP Number Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Topography and Surficial Soils	2.2.03.02.0A Rock Properties of Host Rock and other Units **Included**	The hydrologic characteristics (e.g., permeability, porosity, capillarity, storage capacity) of the surficial soils and shallow bedrock above the repository are significant in affecting the amount of net infiltration following a precipitation event. The characteristics of the surficial soils also affect the soil retention and the time infiltrating water takes to pass below the root zone to become net infiltration (i.e., where it is not subject to further evapotranspiration processes). The hydrologic characteristics of the surface soils and shallow bedrock at Yucca Mountain, including associated uncertainty, most notably the permeability, are included in the assessment of the net infiltration and determined to be ITBC. **FEP Source:** SNL 2008 [DIRS 183041] — 2.2.03.02.0A	Yes	**ITBC:** Infiltration and Seepage Surface Soil Properties (including vegetation)	**None**
Topography and Surficial Soils	2.2.06.04.0A Effects of Subsidence **Excluded**	THM modeling showed that subsidence distances would be indistinguishable from natural variations in the ground surface, and are too small to affect run off or infiltration, or to create impoundments. In addition, corroborative mining data indicate no subsidence for the size of the drift opening relative to drift spacing. Stress relieved enhancements to fracture permeability and capillarity due to the excavation have been included in the uncertainty of permeability and capillarity used in the seepage models. The changes to fracture characteristics around emplacement drifts due to stress relief have been found to be too small to cause adverse effects on seepage. Subsidence induced stress effects on UZ flow are negligible. **FEP Source:** SNL 2008 [DIRS 183041] – 2.2.06.04.0A	No	**Non-ITBC:** Properties of the Host Rock Unit Unsaturated Zone Properties	**Non-ITBC:** Emplacement Drift Configuration Emplacement Drift Spacing Repository Layout Repository Elevation below the Surface Repository Geographic and Geologic Location
Topography and Surficial Soils	2.2.07.01.0A Locally Saturated flow at Bedrock/ Alluvium Contact **Excluded**	The possibility of locally saturated flow conditions at the bedrock–alluvium contact has been excluded in the assessment of net infiltration for two reasons. First, most of the infiltration model domain is characterized by relatively low slope, which corresponds to a small lateral hydraulic gradient. Second, bulk bedrock saturated hydraulic conductivity values are generally higher than the saturated hydraulic conductivity values in the overlying soil and, therefore, once water reaches the soil–bedrock interface, it would tend to enter bedrock instead of flowing laterally along the interface. **FEP Source:** SNL 2008 [DIRS 183041] – 2.2.07.01.0A	No	**Non-ITBC:** Surface Soil Properties (including vegetation) Infiltration and Seepage Unsaturated Zone Properties	**Non-ITBC:** Repository Geographic and Geologic Location

Table A-1. ITBC Analysis of Upper Natural Barrier FEPs (Continued)

Feature / Component	FEP Number Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Unsaturated Zone above the Repository	1.2.10.01.0A Hydrologic Response to Seismic Activity **Excluded**	Seismic activity may alter the rock, fracture, and fault characteristics, which may affect the hydrogeology of the unsaturated zone in the vicinity of the repository. Investigations focusing on the potentiometric hydrologic response, given changes in rock properties adjacent to a fault, demonstrate that the changes in water-table elevation are not expected to exceed 50 m and are transient and local in nature. Because the emplacement drifts are located at least 120 m above the current water table, such transient perturbations will not have any significant long-term effect to the unsaturated zone flowpaths or velocities above the repository. **FEP Source:** SNL 2008 [DIRS 183041] – 1.2.10.01.0A	No	**Non-ITBC:** Infiltration and Seepage Properties Properties of the Host Rock Unit Unsaturated Zone Properties Characterization of Seismic Events	**Non-ITBC:** Repository Geographic and Geologic Location Repository Elevation below the Surface
Unsaturated Zone above the Repository	1.2.10.02.0A Hydrologic Response to Igneous Activity **Excluded**	Igneous intrusions that might occur in the time frame of 10,000 years after closure would affect a relatively small volume of the host rock and are expected to be oriented subparallel to existing flow directions. Consequently, future intrusions would not have a significant effect on groundwater flow patterns or rates in the unsaturated zone above repository. Given the limited area of any thermal or geochemical alteration, and the consequent change of rock properties around an intrusion, any geochemical effects would be minimal. The potential development of a hydrothermal system from igneous activity is not expected based on analogue studies and would be of low consequence due to its limited size relative to the repository footprint. Any possible changes to topography and soils from extrusive activity are also of low consequence. **FEP Source:** SNL 2008 [DIRS 183041] – 1.2.10.02.0A	No	**Non-ITBC:** Infiltration and Seepage processes Properties of the Host Rock Unit Unsaturated Zone Properties Characterization of Igneous Events	**Non-ITBC:** Repository Geographic and Geologic Location

Table A-1. ITBC Analysis of Upper Natural Barrier FEPs (Continued)

Feature / Component	FEP Number Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Unsaturated Zone above the Repository	1.4.06.01.0A Altered Soil or Surface Water Chemistry **Excluded**	Human (e.g., agricultural or industrial) activities may affect soil and surface water chemistry, which in turn may impact the chemistry of infiltrating water. Current agricultural and industrial activities in the Yucca Mountain region are already included in the characterization of the unsaturated zone above the repository. Future changes in these activities are excluded based on regulatory requirements (10 CFR 63.305(b) [DIRS 178394]). Impacts of industrial activities associated with the repository itself on soil and water chemistry will be minor, and will have no significant adverse impacts on long-term repository performance **FEP Source:** SNL 2008 [DIRS 183041] – 1.4.06.01.0A	No	**Non-ITBC:** Seepage Water Chemistry	**Non-ITBC:** Repository Geographic and Geologic Location Reclamation of Lands Disturbed by Repository
Unsaturated Zone above the Repository	2.1.08.01.0A Water Influx at the Repository **Included**	Influx of liquid water is the same as seepage into the emplacement drifts. Seepage occurs when the downward percolation flux in the host rock is not completely diverted around underground openings by capillary flow processes. The principal factors that determine the occurrence and magnitude of seepage, in addition to the percolation flux, are the bulk permeability and the capillary strength of the fractured host rock. Uncertainty in these parameters, based on observations from in situ testing, is included in the performance assessment. Representativeness of the seepage parameter distributions used in the performance assessment (SNL 2007 [DIRS 181244], Section 6.6) within the repository host rock is considered important to capability of the upper natural barrier. Note that effects from rock excavation and committed materials are addressed for other FEPs (1.1.01.01.0B, 2.1.06.04.0A, 2.1.08.02.0A). **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.08.01.0A	Yes	**ITBC:** Unsaturated Zone Properties Infiltration and Seepage Properties of the Host Rock Unit	**Non-ITBC:** Emplacement Drift Configuration No Backfill in Emplacement Drifts Repository Elevation below the Surface Repository Geographic and Geologic Location Repository Layout Repository Standoff from Quaternary Fault Repository Standoff from Paintbrush Nonwelded

Table A-1. ITBC Analysis of Upper Natural Barrier FEPs (Continued)

Feature / Component	FEP Number Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Unsaturated Zone above the Repository (Continued)	2.1.08.01.0A Water Influx at the Repository **Included** (Continued)				Hydrogeologic Unit Verification of Design Rock Properties Minimum Thickness of PTn Unit Above the Repository
Unsaturated Zone above the Repository	2.1.08.01.0B Effects of Rapid Influx into the Repository **Excluded**	This FEP pertains to the potential quenching effect from rapid water influx during the thermal period. Transient pulses of water in the unsaturated zone at the repository horizon, whether caused by episodic infiltration events or transient effects associated with climate change, are not expected to significantly reduce drift wall temperature unless subject to strong episodic infiltration or focused flow. Sensitivity analyses of the Site-Scale UZ Flow Model show that the PTn unit dampens and homogenizes episodic infiltration pulses, resulting in a steady flow condition below. In addition, drift seepage studies also indicate that saturation buildup around the boiling zone is insignificant, and penetration of episodic and preferential flows originating from the condensation zone above drifts is not expected during the thermal period. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.08.01.0B	No	**Non-ITBC:** Unsaturated Zone Properties Infiltration and Seepage	**Non-ITBC:** Flood Protection Repository Elevation below the Surface Repository Geographic and Geologic Location Repository Standoff from Paintbrush Nonwelded Hydrogeologic Unit Minimum Thickness of PTn Unit above the Repository Repository Standoff from Quaternary Faults

Table A-1. ITBC Analysis of Upper Natural Barrier FEPs (Continued)

Feature / Component	FEP Number Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Unsaturated Zone above the Repository	2.2.06.03.0A Seismic Activity Alters Perched Water Zones **Excluded**	Perched water has only been found at Yucca Mountain near the TSw-CHn interface. In particular, the presence of perched water appears to be correlated with the presence of zeolitically altered minerals within the Calico Hills nonwelded (CHn). The fact that the perched water occurrence is strongly correlated with the zeolitic lithology indicates that the effects of seismic and tectonic processes do not play a significant role in the formation and persistence of perched water. Perched-water conditions do not presently exist in the unsaturated zone above the repository, and are not expected even under future climate changes (SNL 2007 [DIRS 184614], Sections 6.2.2.2 and 7.7.4.2. **FEP Source:** SNL 2008 [DIRS 183041] – 2.2.06.03.0A	No	**Non-ITBC:** Properties of the Host Rock Unit Infiltration and Seepage Unsaturated Zone Properties Characterization of Seismic Events	**Non-ITBC:** Repository Geographic and Geologic Location
Unsaturated Zone above the Repository	2.2.06.04.0A Effects of Subsidence **Excluded**	THM modeling showed that subsidence distances would be indistinguishable from natural variations in the ground surface, and are too small to affect run off or infiltration, or to create impoundments. In addition, corroborative mining data indicate no subsidence for the size of the drift opening relative to drift spacing. Stress relieved enhancements to fracture permeability and capillarity due to the excavation have been included in the uncertainty of permeability and capillarity used in the seepage models. The changes to fracture characteristics around emplacement drifts due to stress relief have been found to be too small to cause adverse effects on seepage. Subsidence induced stress effects on UZ flow are negligible. **FEP Source:** SNL 2008 [DIRS 183041] – 2.2.06.04.0A	No	**Non-ITBC:** Properties of the Host Rock Unit Unsaturated Zone Properties	**Non-ITBC:** Emplacement Drift Configuration Emplacement Drift Spacing Repository Layout Repository Elevation below the Surface Repository Geographic and Geologic Location
Unsaturated Zone above the Repository	2.2.07.01.0A Locally Saturated Flow at Bedrock/ Alluvium Contact **Excluded**	The possibility of locally saturated flow conditions at the bedrock–alluvium contact has been excluded in the assessment of net infiltration for two reasons. First, most of the infiltration model domain is characterized by relatively low slope, which corresponds to a small lateral hydraulic gradient. Second, bulk bedrock saturated hydraulic conductivity values are generally higher than the saturated hydraulic conductivity values in the overlying soil and, therefore, once water reaches the soil–bedrock interface, it would tend to enter bedrock instead of flowing laterally along the interface. **FEP Source:** SNL 2008 [DIRS 183041] – 2.2.07.01.0A	No	**Non-ITBC:** Surface Soil Properties (including vegetation) Infiltration and Seepage Unsaturated Zone Properties	**Non-ITBC:** Repository Geographic and Geologic Location

Table A-2. ITBC Analyses of Engineered Barrier System FEPs

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Emplacement Drift	1.1.01.01.0A Open Site Investigation Boreholes **Excluded**	Site investigation boreholes that have been left open, degraded, improperly sealed, or reopened, could modify flow and transport properties and produce enhanced pathways between the surface and the repository. This feature is excluded on the basis that: 1) existing boreholes from site characterization are known, 2) future drilling will be controlled, 3) the regulatory requirements for borehole sealing prior to repository closure will be met, and 4) administrative controls for repository construction and operations will be developed to ensure these outcomes. Accordingly, these features are considered not to be important to barrier capability. **FEP Source:** SNL 2008 [DIRS 183041] – 1.1.01.01.0A	No	**Non-ITBC:** Closure Materials, Properties, and Configuration	**Non-ITBC:** Repository Geographic and Geologic Location Closure of Boreholes
Emplacement Drift	1.1.02.00.0A Chemical Effects of Excavation and Construction in EBS **Excluded**	Administrative controls for repository construction and operations will be developed to assure that emplacement drifts are developed in accordance with the repository design. Materials used during drift excavation and development will be controlled to preclude any potential deleterious effects on engineered barriers. While excluded from further consideration in the postclosure analyzed basis, this exclusion is based on controls being in place. The placement of arbitrary materials in the drift could negatively impact barrier capability; however, it is unlikely that these impacts would substantially effect the release or transport of radionuclides since deviation from these controls are managed through the Corrective Action Program, which may require postclosure impact evaluation. **FEP Source:** SNL 2008 [DIRS 183041] – 1.1.02.00.0A	No	**Non-ITBC:** In-Drift Chemical Environment	**Non-ITBC:** Excavation Methods EBS Drip Shield Emplacement Drift Invert Materials Interactions Committed Materials

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Emplacement Drift	1.2.03.02.0A Seismic Ground Motion Damages EBS Components **Included**	Vibratory ground motion has the potential to cause seismically-induced rockfall that changes the cross-sectional shape and volume of the emplacement drifts (BSC 2004 [DIRS 166107], Sections 6.3.1.2 and 6.4.2.2) and changes the configuration of the EBS components within the emplacement drifts (SNL 2007 [DIRS 176828], Sections 6.1.2 and 6.1.3). A change in the cross section of the emplacement drifts can alter the seepage into the drifts, and the presence of rockfall about the drip shield can alter the mechanical response and temperature time history of the EBS components. The response of the emplacement drift configuration and processes to vibratory ground motion is important to barrier capability (ITBC). **FEP Source:** SNL 2008 [DIRS 183041] – 1.2.03.02.0A	Yes	**ITBC:** Properties of the Host Rock Unit Characterization of Seismic Events **Non-ITBC:** Pallet Materials, Properties, and Configuration Invert Materials, Properties, and Configuration Waste Form/Package Internals Materials, Properties, and Configuration Characterization of Seismic Events	**ITBC:** Repository Elevation - Overburden Thickness Repository Geographic and Geologic Location As-Emplaced Waste Package-Drip Shield Configuration Drip Shield Seismic Performance Seismic Design of Waste Package EBS Material Interactions - Copper Drip Shield Materials and Thicknesses **Non-ITBC:** Emplacement Pallet Fabrication and Corrosion Allowance Emplacement Drift Invert Configuration Emplacement Drift Invert Function Invert Materials Verification of Design Rock Properties

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Emplacement Drift	2.1.04.05.0A Thermal-Mechanical Properties and Evolution of Backfill **Excluded**	The physical properties of the backfill may affect groundwater flow, waste package and drip shield durability, and radionuclide transport in the waste disposal region. Properties of the backfill may change through time, due to processes such as silica cementation, thermal effects, and physical compaction. Since backfill is not to be placed in the drift this process is not relevant and does not contribute to barrier capability. Deviation from design could negatively impact barrier capability. Deviation from design is managed through the Corrective Action Program, which requires postclosure impact evaluation. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.04.05.0A	No	**None**	**Non-ITBC:** No Backfill in Emplacement Drifts
Emplacement Drift	2.1.05.02.0A Radionuclide transport through seals **Excluded**	Groundwater flow through seals in the access ramps, ventilation shafts, and exploratory boreholes could affect long-term performance of the disposal system. Sealing concepts have been identified for the License Application, but the designs of these seals have not been determined. The designs will be supported by evaluations of performance, and the application of construction and operational management and administrative controls to ensure correct implementation. The design addresses seals as closure of the shafts and ramps shall include backfilling for the entire depth of the opening. Site investigation boreholes within or near the footprint of the repository block will be backfilled with material compatible with the host rock and plugged. These design features are intended to meet the intrusion scenarios, and are not performance related. Accordingly, these features are considered not to be important to barrier capability. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.05.02.0A	No	**Non-ITBC:** Closure Materials, Properties, and Configuration	**Non-ITBC:** Repository Elevation - Overburden Thickness Repository Layout

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Emplacement Drift	2.1.06.01.0A Chemical Effects of Rock Reinforcement and Cementitious Materials in EBS **Excluded**	The effects of seepage water interacting with rock reinforcement and cementitious materials used in repository construction and operation, have been evaluated and determined to be insignificant with respect to postclosure performance. In addition, to prevent or limit potentially deleterious effects from rock reinforcement and cementitious materials, construction and operational management and administrative controls will be developed and implemented (SNL 2007 [DIRS 177412], Section 6.8). Therefore, these effects are considered not to be important to barrier capability. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.06.01.0A	No	**Non-ITBC:** In-Drift Chemical Environment Closure Materials, Properties, and Configuration	**Non-ITBC:** Committed Materials Excavation Methods Design of Ground Support System Closure of Shafts and Ramps Closure of Boreholes EBS Drip Shield / Emplacement Drift Invert Materials Interactions
Emplacement Drift	2.1.06.02.0A Mechanical Effects of Rock Reinforcement Materials in EBS **Excluded**	No postclosure barrier capability is attributed to the rock reinforcement materials used in the EBS. Postclosure models and analyses neglect the potential beneficial effects from rock reinforcement on the rock mass response to thermo-mechanical and seismic stresses. Therefore, these effects are considered not to be important to barrier capability. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.06.02.0A	No	**Non-ITBC:** Closure Materials, Properties, and Configuration Host Rock Properties	**Non-ITBC:** Committed Materials Excavation Methods Emplacement Drift Ground Support Design of Ground Support System

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Emplacement Drift	2.1.08.07.0A Unsaturated Flow in the EBS **Included**	Unsaturated flow occurs through the features of the EBS due to seepage or condensation processes. The nature of this flow has been included in the abstractions for flow and transport through the EBS features (SNL 2007 [DIRS 177407], Sections 5 and 6). Unsaturated flow is important to barrier capability, because it is driven by the downward gravitational potential, and makes possible certain key functions of the UNB and EBS. Accordingly, the parameters that describe and control unsaturated flow conditions are considered to be important to barrier capability. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.08.07.0A	Yes	**ITBC:** Infiltration and Seepage Properties **Non-ITBC:** Unsaturated Zone Properties Properties of the Host Rock Unit	**ITBC:** Repository Geographic and Geologic Location Repository Elevation - Overburden Thickness **Non-ITBC:** Verification of Design Rock Properties
Emplacement Drift	2.1.08.09.0A Saturated Flow in the EBS **Excluded**	The flow regime in the EBS does not result in a significant development of saturated flow conditions (i.e., the EBS remains free draining for all expected hydrologic conditions). The flow paths considered in the EBS transport abstraction are applicable to all possible flow conditions. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.08.09.0A	No	**Non-ITBC:** Properties of Unsaturated Zone	**Non-ITBC:** Repository Elevation–Standoff from Water Table

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Emplacement Drift (Continued)	2.1.09.01.0A Chemical Characteristics of Water in Drifts **Included** (Continued)	**FEP Source:** SNL 2008 [DIRS 183041] – 2.1.09.01.0A		**Non-ITBC:** Waste Form Degradation Corrosion Products Properties Invert Materials, Properties, and Configuration	
Emplacement Drift	2.1.09.02.0A Chemical Interaction with Corrosion Products **Included**	Just as the chemical characteristics of water in the drift are affected by the incoming water chemistry, they are also significantly affected by the water's interaction with the corrosion products in the drift (e.g., waste form, metallic portions of the waste package, rock bolts, steel in the invert, gantry rails). These chemical characteristics affect the likelihood of potential degradation, deterioration, and alteration of the other EBS components as well as affecting the transport characteristics of any radionuclides released from the waste package to the invert (SNL 2007 [DIRS 177412], Section 6.8). **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.09.02.0A	No	**Non-ITBC:** In-Drift Chemical Environment Waste Package Materials, Properties, and Configuration Waste Form/Package Internals Materials, Properties, and Configuration Pallet Materials, Properties, and Configuration Invert Materials, Properties, and Configuration Corrosion Products Properties Invert Materials, Properties, and Configuration Pallet Materials, Properties, and Configuration Invert Materials, Properties, and Configuration	**Non-ITBC:** Invert Materials Committed Materials

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Emplacement Drift	2.1.11.01.0A Heat Generation in EBS **Included**	The heat generated by radioactive decay has multiple effects on repository-relevant processes, including degradation, deterioration, and alteration of the EBS. The heat generation in the emplacement drifts affects the timing of the onset of seepage processes and the distribution of in-drift. Convection and condensation. The heat generation and resultant temperature also affect the water chemistry in the rock and emplacement drifts. The temperature resulting from heat generation, as well as seepage and condensation processes, affects the corrosion of the waste packages and drip shields. The temperature resulting from heat generation also affects the initiation of waste form alteration and radionuclide transport processes dependent on the presence of an aqueous film (SNL 2007 [DIRS 184433], Section 6.2.1[a]), SNL 2007 [DIRS 181648], Executive Summary). **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.11.01.0A	Yes	**ITBC:** In-Drift Thermal Environment Convection, Condensation, and Evaporation Drip Shield Materials, Properties, and Configuration Waste Package Materials, Properties, and Configuration Seepage Water Properties Waste Package Source Term, Inventory, Inventory Decay, and Decay Heat **Non-ITBC:** Invert Materials, Properties, and Configuration Waste Form Degradation Properties of the Host Rock Unit	**ITBC:** Drip Shield Materials and Thicknesses Waste Package Corrosion Allowance Waste Package Thermal Limits Waste Package Decay Heat Waste Package Spacing Waste Package Thermal Limits **Non-ITBC:** Waste Package Temperature Limit Drift Wall Temperature As-emplaced Waste Package-Drip Shield Configuration Waste Package Handling and Emplacement Verification of Design Rock properties

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Emplacement Drift	2.2.08.04.0A Re-Dissolution of Precipitates Directs more Corrosive Fluids to Waste Packages **Excluded**	Re-dissolution of precipitates in the host rock, and transport of affected waters to the in-drift environment, is excluded because this set of processes is a transient response that occurs only at the end of the boiling period. Seepage of affected waters into the drifts will be mitigated by the drip shields, which protect the waste packages from corrosive waters, and are made from titanium which exhibits no significant dependence of corrosion rates on water composition. Thermal-hydrologic-chemical and near-field chemistry models show that after the thermal period, the composition of seepage will closely resemble that of far-field and pre-heating formation waters. Accordingly, this transient response will have no significant impact on degradation of the engineered barrier. **FEP Source:** SNL 2008 [DIRS 183041] – 2.2.08.04.0A	No	**Non-ITBC:** Properties of the Host Rock Unit Unsaturated Zone Properties In-Drift Chemical Environment Seepage Water Properties	**Non-ITBC:** EBS Materials Interactions - Copper EBS Drip Shield / Emplacement Drift Invert Materials Interactions No Backfill in Emplacement Drifts Committed Materials Waste Package and TAD Canister Excluded Materials Drip Shield Design Drip Shield Design and Installation
Emplacement Drift	2.2.08.12.0A Chemistry of Water Flowing into the Drift **Included**	The chemistry of the seepage water is evaluated in the near-field chemistry model, and in supporting thermal-hydrologic-chemical models. These models have evaluated the range of expected water composition in the host rock, and how these waters change in response to repository heating. Seepage composition can affect corrosion of the waste package outer barrier, if the water contacts the waste package when other conditions such as temperature, promote initiation of localized corrosion. In addition, seepage composition and evaporative evolution in the drift environment can affect the transport of dissolved and colloid radionuclides in the invert. **FEP Source:** SNL 2008 [DIRS 183041] – 2.2.08.12.0A	Yes	**ITBC:** In-Drift Chemical Environment In-Drift Thermal Environment Convection, Condensation, and Evaporation Seepage Water Properties Radionuclide Inventory and Source-Term Properties Corrosion Products Properties Waste Package Source Term, Inventory, Inventory Decay, and Decay Heat	**Non-ITBC:** Waste Package Decay Heat Waste Package Thermal Limits Waste Package Spacing Waste Package Temperature Limit As-emplaced Waste Package-Drip Shield Configuration Verification of Design Rock Properties

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Drip Shield	1.2.02.03.0A Fault Displacement Damages EBS Components **Included**	The core and control parameter characteristics identified are not considered to be ITBC because with administrative controls in place, only a very small number of waste packages and drip shields would be impacted by undetected faults. It is not expected that faults will significantly affect the degradation of the EBS, at annual recurrence intervals of about 10^{-7} per year and less (SNL 2007 [DIRS 176828], Section 6.11.4), and only a small number of drip shields are affected. This degradation process is much less significant than the more likely seismically-induced ground motion effects (SNL 2007 [DIRS 176828], Section 6.7). **FEP Source:** SNL 2008 [DIRS 183041] – 1.2.02.03.0A	No	**Non-ITBC:** Characterization of Fault Displacement Drip Shield Materials, Properties, and Configuration	**Non-ITBC:** Repository Geographic and Geologic Location Repository Elevation - Overburden Thickness Repository Standoff from Quaternary Fault As-Emplaced Waste Package-Drip Shield Configuration
Drip Shield	1.2.03.02.0A Seismic Ground Motion Damages EBS Components **Included**	This damage mode substantially impacts the release of radionuclides from the repository. Vibratory ground motion has the potential to cause plastic deformation of drip shield components or separation of adjacent drip shields. Plastic deformation of drip shield components may result in residual stresses that exceed a tensile threshold for initiation and growth of stress corrosion cracks. However, the presence of a crack network in drip shield components does not compromise its ability to divert seepage away from the waste package because advective flow through stress corrosion cracks on the drip shield is excluded in FEP 2.1.03.10.0B, Advection of Liquids and Solids Through Cracks in the Drip Shield. Drip shield separation is defined as an axial or vertical gap between two adjacent drip shields that allows seepage to flow directly onto a waste package. Axial separation could occur during a ground motion because of high plastic deformation in the drip shield's connector subassemblies or because of large vertical displacements between adjacent drip shields. Axial separation of adjacent drip shields is excluded from the TSPA model because a kinematic	No	**Non-ITBC:** Properties of the Host Rock Unit Drip Shield Materials, Properties, and Configuration Characterization of Seismic Events Waste Package Materials, Properties, and Configuration Characterization of Igneous Events	**Non-ITBC:** Repository Elevation – Standoff from the Water Table Repository Geographic and Geologic Location As-Emplaced Waste Package-Drip Shield Configuration EBS Material Interactions -- Copper Drip Shield Seismic Performance Emplacement Pallet Function Seismic Design of Waste Package Waste Package Outer Barrier Material Specifications Waste Package Quantities Verification of Design Rock Properties

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Drip Shield (Continued)	1.2.03.02.0A Seismic Ground Motion Damages EBS Components **Included** (Continued)	study indicates that small static loads from rubble or frictional loads between EBS components are sufficient to eliminate axial separation of drip shields (SNL 2007 [DIRS 176828], Section 6.7.3.1). Significant vertical separation between adjacent drip shields is limited by the same physical mechanisms that limit axial separation, and the effects of a vertical separation are also mitigated by the presence of the drip shield connector subassembly which provides an overlap between adjacent drip shields (SNL 2007 [DIRS 176828, Section 6.7.3.2). Vibratory ground motion may also cause waste package-to-drip shield impacts. Lateral impacts of a waste package to the sidewalls of a drip shield do not cause catastrophic failure of the drip shields (SNL 2007 [DIRS 176828], Section 6.8.5). Longitudinal impacts of a waste package to an interior bulkhead on the underside of the drip shield have the potential to tear the bulkhead and rupture the welds that attach the plates to the bulkhead. High-velocity longitudinal impacts with the potential to damage the bulkhead support beams occur with much lower probability than the probability of buckling the sidewalls of the drip shield, as discussed in (SNL 2007 [DIRS 176828] Section 6.8.5). It follows that the drip shield sidewalls are likely to buckle before longitudinal impacts damage the bulkhead support beams and, after the sidewalls buckle, high-velocity longitudinal impacts are eliminated because the waste package can no longer move freely beneath the drip shield. It follows that the drip shield response to vibratory ground motion does not affect the release of radionuclides from the repository to the accessible environment, and is not important to barrier capability. **FEP Source:** SNL 2008 [DIRS 183041] – 1.2.03.02.0A			

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Drip Shield	1.2.03.02.0B Seismic-Induced Rockfall Damages Drip Shield **Excluded**	This FEP deals with large block rock fall. Rubble rock fall is dealt with separately under FEP 1.2.03.02.0C. The range of seismic effects encompasses a range of probabilities (both likely and unlikely). _For unlikely peak ground velocities above about 2 m/s, the lithophysal host rock is expected to collapse into the emplacement drifts. (SNL 2007 [DIRS 176828], Section 6.11.1.3). The parameter characteristics associated with this FEP and failure mode are not considered ITBC because seismically induced rockfall calculations demonstrate that rockfall does not damage the drip shield enough to impair its mechanical or hydrological performance. Seismically-induced rockfall in the emplacement drifts has the potential to damage or rupture the drip shields as barriers to flow and as barriers to rockfall. Large rock blocks, primarily in the nonlithophysal units of the repository, may fall out of the roof and walls of an emplacement drift during a seismic event. The impact of these blocks on the drip shields may cause plastic deformation of the drip shield plates, rupture of the drip shield plates, or rupture of the axial stiffeners beneath the crown of the drip shield. Plastic deformation of drip shield plates may result in residual stresses that exceed a tensile threshold for initiation and growth of stress corrosion cracks. However, the presence of a crack network in the plates does not compromise the drip shields' capability to divert seepage away from the waste package because advective flow through stress corrosion cracks on the drip shield plates is excluded in FEP 2.1.03.10.0B, Advection of Liquids and Solids Through Cracks in the Drip Shield.	No	**Non-ITBC:** Properties of the Host Rock Unit Drip Shield Materials, Properties, and Configuration Characterization of Seismic Events	**Non-ITBC:** Repository Elevation - Overburden Thickness Repository Geographic and Geologic Location As-Emplaced Waste Package-Drip Shield Configuration Drip Shield Seismic Performance Drip Shield Design Drip Shield Design and Installation Drip Shield Materials and Thicknesses Verification of Design Rock Properties

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Drip Shield	2.1.11.06.0B Thermal Sensitization of Drip Shields **Excluded**	Thermal sensitization of titanium is not expected for the range of likely thermal conditions in the emplacement. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.11.06.0B	No	**Non-ITBC:** In-Drift Thermal Environment Convection, Condensation, and Evaporation Drip Shield Materials, Properties, and Configuration Waste Package Source Term, Inventory, Inventory Decay, and Decay Heat	**Non-ITBC:** Drip Shield Materials and Thicknesses Waste Package Temperature Limit As-emplaced Waste Package-Drip Shield Configuration Waste Package Spacing Waste Package Thermal Limit Waste Package Decay Heat Verification of Design Rock Properties
Drip Shield	2.1.11.07.0A Thermal Expansion/ Stress of In-drift EBS Components **Excluded**	Repository heat at Yucca Mountain could result in thermally-induced stresses. These stresses could affect the EBS components, thus causing the formation of pathways for groundwater flow through the EBS or altering and/or enhancing existing pathways. Although thermal expansion of the drip shield occurs, this expansion is not significant under repository conditions and the design of the drip shield accommodates thermal expansion up to a 300°C temperature, which is higher than calculated postclosure temperatures. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.11.07.0A	No	**Non-ITBC:** In-Drift Thermal Environment Drip Shield Materials, Properties, and Configuration Waste Package Source Term, Inventory, Inventory Decay, and Decay Heat	**Non-ITBC:** Drip Shield Design Drip Shield Materials and Thicknesses Drip Shield Thermal Expansion Constraint Waste Package Spacing Waste Package Decay Heat Waste Package Thermal Limits Verification of Design Rock Properties As-emplaced Waste Package-Drip Shield Configuration
Drip Shield	2.1.13.02.0A Radiation Damage in EBS **Excluded**	Because the estimated neutron fluence is significantly below the waste package metals' damage thresholds, the mechanical properties of the EBS features will not be altered by radiation damage. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.13.02.0A	No	**Non-ITBC:** Radionuclide Inventory and Source-Term Properties Waste Package Source Term, Inventory, Inventory Decay, and Decay Heat	**Non-ITBC:** Waste Package Design Basis Bounding Dose Rate Waste Package Worst-Case Dose Rate Waste Package Decay Heat

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Waste Package	2.1.03.07.0A Mechanical Impact on Waste Package **Excluded**	Mechanical degradation of the waste package can lead to increased stresses and increased likelihood of stress corrosion cracking. Such mechanical degradation due to vibratory ground motion is included in the TSPA Model. In the absence of vibratory ground motions, mechanical impacts are insignificant to waste package degradation. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.03.07.0A	No	**Non-ITBC:** Drip Shield Materials, Properties, and Configuration Waste Package Materials, Properties, and Configuration Properties of the Host Rock Unit Pallet Materials, Properties, and Configuration	**Non-ITBC:** Waste Package Internal Pressurization Waste Package Surface Damage Prior to Closure Waste Package Radial Gap Waste Package Surface Marring Prior to Emplacement Waste Package Quantities Materials Contacting the Waste Package Waste Package Outer Barrier Material Specifications EBS Drip Shield / Emplacement Drift Invert Materials Interactions Drip Shield Corrosion Allowance Drip Shield Design Drip Shield Handling Drip Shield Design and Installation Drip Shield Materials and Thicknesses

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Waste Package	2.1.03.08.0A Early Failure of Waste Packages **Included**	The potential for and resultant consequences of early failure of the waste package by manufacturing defects or weld flaws exists, and has been considered in the TSPA Nominal Scenario Class (SNL [DIRS 181953], Section 6.2). Because of the very limited number of waste packages expected to be damaged by the early failure mechanisms, the impact is not substantial. It is ITBC because the design and handling must remain as analyzed for the number of early failures to stay insignificant. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.03.08.0A	Yes	**Non-ITBC:** Waste Package Materials, Properties, and Configuration	**ITBC:** Waste Package Annealing Waste Package Closure Waste Package Fabrication Waste Package Handling Waste Package Surface Damage Prior to Closure Waste Package Surface Finish Waste Package Fabrication Weld Inspections Waste Package Welding Materials Waste Package Fabrication Welding Flaws Non-ITBC Emplacement Drift Ground Support
Waste Package	2.1.03.10.0A Advection of Liquids and Solids through Cracks in the Waste Package **Excluded**	Cracks in the waste package, which may result from mechanical degradation associated with seismic activity, are of insufficient size to allow significant advective flux of water, and therefore this process is excluded from the performance assessment. However, cracks can allow moisture to enter the waste package via diffusion in sufficient amounts to initiate degradation and alteration of the materials and waste forms inside the waste package. In addition, diffusive transport through these cracks is the dominant transport process for radionuclides released from the waste. The lack of significant advection through cracks in the waste package is an important beneficial characteristic of the waste package feature. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.03.10.0A	Yes	**ITBC:** Infiltration and Seepage Properties Waste Package Materials, Properties, and Configuration Drip Shield Materials, Properties, and Configuration Waste Form Degradation Waste Form/Package Internals Materials, Properties, and Configuration	**ITBC:** Seismic Design of Waste Package Waste Package Corrosion Allowance Drip Shield Corrosion Allowance Drip Shield Design Drip Shield Design and Installation Drip Shield Materials and Thicknesses Drip Shield Seismic Performance

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Waste Package	2.1.07.01.0A Rockfall **Excluded**	Rockfall resulting from gravitational stresses, excavation-induced stresses, and thermally-induced stresses have been evaluated. The lithophysal rock units generally result in small blocks, while larger rock blocks are possible in the nonlithophysal rock units. In either case, the effects of rockfall on drip shields, have been considered and determined to be insignificant due to the limited extent of the rockfall, the limited stress-induced cracking of the drip shield, the preclusion of flux through the cracked drip shield, and the limited deformation of the drip shield such that it does not contact the waste package due to rockfall. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.07.01.0A	No	**Non-ITBC:** Properties of the Host Rock Unit Drip Shield Materials, Properties, and Configuration Waste Package Materials, Properties, and Configuration Drip Shield Materials, Properties, and Configuration	**Non-ITBC:** Seismic Design of Waste Package As-emplaced Waste Package-Drip Shield Configuration Waste Package Dimensions and Component Masses Waste Package Quantities Drip Shield Corrosion Allowance Drip Shield Design Drip Shield Design and Installation Drip Shield Materials and Thicknesses Drip Shield Seismic Performance Verification of Design Rock Properties EBS Drip Shield / Emplacement Drift Invert Materials Interactions Waste Package Surface Damage Prior to Closure Design of Ground Support System Emplacement Drift Configuration Emplacement Drift Ground Support

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Waste Package (Continued)	2.1.08.15.0A Consolidation of EBS Components **Excluded** (Continued)				Seismic Design of Waste Package Drip Shield Seismic Performance Verification of Design Rock Properties
Waste Package	2.1.09.03.0B Volume Increase of Corrosion Products Impacts waste Package **Excluded**	Volume increases associated with degradation of Alloy 22 are not expected to have any deleterious effect on the waste package because these volumes are small and there is limited possibility of such corrosion products forming between the Alloy 22 and stainless steel shells of the waste packages. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.09.03.0B	No	**Non-ITBC:** Waste Package Materials, Properties, and Configuration Corrosion Products Properties	**Non-ITBC:** Waste Package Radial Gap Waste Package Corrosion Allowance Waste Package Outer Barrier Material Specifications Waste Package Quantities
Waste Package	2.1.09.28.0A Localized Corrosion on Waste Package Outer Surface due to Deliquescence **Excluded**	The potential for salts to deliquesce on the waste package outer surface has been evaluated. Although the potential for salts to deliquesce exists, the effects of such deliquescence have been determined to be insignificant to performance, localized corrosion processes are not expected to be initiated. Even if localized corrosion was initiated, due to the limited volumes, it is likely that the process would not propagate through the waste package outer surface. The lack of significant degradation by this process is an important characteristic contributing to the barrier capability of the drip shield feature of the EBS. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.09.28.0A	Yes	**ITBC**: Waste Package Materials, Properties, and Configuration Seepage Water Properties In-Drift Chemical Environment **Non-ITBC:** In-Drift Thermal Environment Convection, Condensation, and Evaporation	**ITBC**: Committed Materials Waste Package Quantities Waste Package Outer Barrier Material Specifications Materials Contacting the Waste Package EBS Materials Interactions - Copper EBS Drip Shield / Emplacement Drift Invert Materials Interactions Repository Geographic and Geologic Location
Waste Package	2.1.11.03.0A Exothermic Reactions in the EBS **Excluded**	Exothermic reactions that could liberate heat in the waste and EBS, are insignificant in comparison to the heat generated by radioactive decay. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.11.03.0A	No	**Non-ITBC:** In-Drift Thermal Environment Waste Package Source Term, Inventory, Inventory Decay, and Decay Heat	**Non-ITBC:** Drip Shield Corrosion Allowance Waste Package Corrosion Allowance EBS Drip Shield / Emplacement Drift Invert Materials Interactions Committed Materials Waste Package & TAD Canister Excluded Materials

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Cladding (Continued)	1.2.02.03.0A Fault Displacement Damages EBS Components **Included** (Continued)	Naval SNF canisters have additional requirements related to emplacement away from faults. For naval SNF packages, these emplacement requirements are important to waste isolation. There is a specific criterion for naval waste packages that requires an 8.2-ft (2.5-m) minimum emplacement standoff distance from mapped faults with vertical displacements greater than 6.5 ft (2 m) (BSC 2007 [DIRS 182131], Section 8.2.3.1.1). Based on this evaluation, this is ITBC (and also ITWI) specifically for naval waste packages. **FEP Source:** SNL 2008 [DIRS 183041] – 1.2.02.03.0A			
Cladding	1.2.03.02.0A Seismic Ground Motion Damages EBS Components **Included**	This FEP does not consider Naval cladding. FEP 2.1.02.25.0B: Naval SNF structure (including cladding) deals with Navy cladding separately. Seismic effects are included in the Seismic Ground Motion Modeling Case of the Seismic Scenario Class. Except for Naval SNF, no credit is taken for cladding integrity in the TSPA. However, cladding provides barrier capability and thus has core and control parameters characteristics that limit its degradation at high temperatures or from mechanical loads. The core and control parameter characteristics identified are not considered to be ITBC because this barrier feature/component is not accounted for in the technical basis. **FEP Source:** SNL 2008 [DIRS 183041] – 1.2.03.02.0A	Yes	**ITBC:** Waste Package Materials, Properties, and Configuration Characterization of Seismic Events **Non-ITBC:** Waste Form/Package Internals Materials, Properties, and Configuration Properties of the Host Rock Unit	**ITBC**: Seismic Design of Waste Package Drip Shield Seismic Performance Waste Package Outer Barrier Material Specifications EBS In-Drift Materials Interactions **Non-ITBC:** As-emplaced Waste Package-Drip Shield Configuration Emplacement Pallet Function Emplacement Pallet Fabrication and Corrosion Allowance

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Waste Form and Waste Package Internals	1.2.03.02.0A Seismic Ground Motion Damages EBS Components **Included**	Vibratory ground motion has the potential to damage the waste forms and waste package internals from waste package-to-waste package impacts and from waste package-to-pallet impacts that may occur during a seismic event. These impacts may cause axial and lateral accelerations of the spent fuel assemblies that are large enough to buckle the waste form and the waste package internals. These impacts may also cause plastic deformation of waste package OCB. Plastic deformation of the OCB may result in residual stresses that exceed a tensile threshold for initiation and growth of stress corrosion cracks. Once the OCB is breached by a crack network, corrosion of the waste form and waste package internals will compromise their capacity to support structural loads and to isolate the waste form during vibratory ground motion. The response of the waste form and waste package internals to vibratory ground motion is ITBC. **FEP Source:** SNL 2008 [DIRS 183041] – 1.2.03.02.0A	Yes	**ITBC:** Drip Shield Materials, Properties, and Configuration Waste Package Materials, Properties, and Configuration Properties of the Host Rock Unit Characterization of Seismic Events **Non-ITBC:** Pallet Materials, Properties, and Configuration Invert Materials, Properties, and Configuration Waste Form/Package Internals Materials, Properties, and Configuration	**ITBC:** Repository Elevation - Overburden Thickness Repository Geographic and Geologic Location As-Emplaced Waste Package-Drip Shield Configuration Drip Shield Seismic Performance Seismic Design of Waste Package EBS In-Drift Materials Interactions **Non-ITBC:** Emplacement Pallet Function Emplacement Pallet Fabrication and Corrosion Allowance Emplacement Drift Invert Configuration Emplacement Drift Invert Function Invert Materials Verification of Design Rock Properties Emplacement Pallet Design

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Waste Form and Waste Package Internals	2.1.01.01.0A Waste Inventory **Included**	The waste inventory defines the amount of different radionuclides present in different waste forms (SNL 2007 [DIRS 180472], Section 6.1). While inventory controls the initial conditions in waste form, which is important to the release of radionuclide inventory, it is well characterized and any change to inventory will be managed by the change-evaluation process Additionally, in the evaluation of barrier capability, transport of radionuclides from the waste inventory are evaluated separately in transport-related FEPs. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.01.01.0A	No	**Non-ITBC:** Radionuclide Inventory and Source-Term Properties Waste Form/Package Internals Materials, Properties, and Configuration Criticality Characteristics Waste Package Source Term, Inventory, Inventory Decay, and Decay Heat Radionuclide Inventory and Source-Term Properties	**Non-ITBC:** Waste Package Decay Heat Waste Package Thermal Limits Waste Form CSNF Fuel Rod Maximum Burnup Limit Waste Package Design Basis Bounding Dose Rate Waste Package Temperature Limit Cladding Temperature Limit - - Ventilation
Waste Form and Waste Package Internals	2.1.01.02.0A Interactions Between Co-located Waste **Excluded**	Although different waste forms have different inventories, and chemical and thermal characteristics (e.g., HLW glass waste forms versus SNF waste forms), these differences do not significantly affect the capability of the EBS. The models consider these differences in the evaluation of the releases from the waste form. However, there is no significant interaction between the co-located wastes and barrier capability is not substantially impacted. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.01.02.0A	No	**Non-ITBC:** Waste Form Degradation Waste Form/Package Internals Materials, Properties, and Configuration In-Package Chemical Environment Waste Package Source Term, Inventory, Inventory Decay, and Decay Heat In-Package Thermal Environment Criticality Characteristics	**Non-ITBC:** Waste Package Capacities Waste Package Decay Heat Waste Package Thermal Limits Waste Package Temperature Limit Cladding Temperature Limit - - Ventilation

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Waste Form and Waste Package Internals	2.1.02.02.0A CSNF Degradation (alteration, dissolution, and radionuclide release) **Included**	This FEP not only encompasses the structure and composition of the CSNF, it also addresses alteration, degradation, and dissolution of the waste form. These processes can influence the mobilization of radionuclides (BSC 2004 [DIRS 169987], Sections 6.1 and 6.2). This FEP defines the essence of the CSNF waste form. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.02.02.0A	Yes	**ITBC:** In-Package Chemical Environment In-Package Thermal Environment Waste Form Degradation Waste Form/Package Internals Materials, Properties, and Configuration	**ITBC:** Waste Form CSNF Fuel Rod Maximum Burnup Limit **Non-ITBC:** Waste Package Moisture Removal and Inerting Waste Package & TAD Canister Excluded Materials Loading of Waste Forms Handling of Bare SNF
Waste Form and Waste Package Internals	2.1.02.03.0A HLW Glass Degradation (alteration, dissolution, and radionuclide release) **Included**	This FEP not only encompasses the structure and composition of the high level waste glass waste form, it also addresses alteration and degradation of the waste form. These processes, along with phase separation, congruent dissolution, precipitation of silicates, co-precipitation of other minerals, and selective leaching, substantially impacts the mobilization of radionuclides. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.02.03.0A	Yes	**ITBC:** In-Package Chemical Environment In-Package Thermal Environment Waste Form Degradation Waste Form/Package Internals Materials, Properties, and Configuration	**ITBC:** Waste Package Moisture Removal and Inerting Loading of Waste Forms **Non-ITBC:** Handling of Bare SNF Waste Package and TAD Canister Excluded Materials

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Waste Form and Waste Package Internals	2.1.09.07.0A Reaction Kinetics in Waste Package **Included**	Reaction kinetics, limit the transport of a host of radionuclides and are implicitly accounted for in the In-Package Chemistry Model, the Dissolved Concentrations Model, and the EBS RTA. The parameter characteristics associated with this process substantially impact the transport of radionuclides from the waste form. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.09.07.0A	Yes	**ITBC:** In-Package Chemical Environment Waste Package Source Term, Inventory, Inventory Decay, and Decay Heat In-Package Thermal Environment Radionuclide Inventory and Source-Term Properties	**ITBC:** Waste Package Thermal Limits Waste Package and TAD Canister Excluded Materials
Waste Form and Waste Package Internals	2.1.09.08.0A Diffusion of Dissolved Radionuclides in EBS **Included**	Diffusion is an important transport mechanism for dissolved radionuclides from the waste form surface to the waste package internals and then through the degraded waste package to the invert. Diffusion is controlled by the degree of degradation of the waste package and the hydrologic characteristics within the waste package, which in turn, is a function of the type of waste. The diffusive transport is conservatively specified to occur through a continuous water film on the surfaces of the EBS features (SNL 2007 [DIRS 177407], Section 6.3.4). **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.09.08.0A	Yes	**ITBC:** In-Package Chemical Environment Waste Package Source Term, Inventory, Inventory Decay, and Decay Heat In-Package Thermal Environment Radionuclide Inventory and Source-Term Properties Waste Form/Package Internals Materials, Properties, and Configuration Waste Package Materials, Properties, and Configuration	**Non-ITBC:** Waste Package Outer Barrier Material Specifications Waste Package Quantities Waste Package Decay Heat Waste Package Thermal Limits

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Waste Form and Waste Package Internals (Continued)	2.1.09.08.0A Diffusion of Dissolved Radionuclides in EBS **Included** (Continued)			**Non-ITBC:** Waste Form Degradation Corrosion Products Properties	
Waste Form and Waste Package Internals	2.1.09.08.0B Advection of Dissolved Radionuclides in EBS **Included**	Advection is an important transport mechanism for dissolved radionuclides from the waste form surface to the waste package internals and then through the degraded waste package to the invert. Advection is controlled by the degree of degradation of the waste package and the hydrologic characteristics within the waste package, which in turn, is a function of the type of waste. The conditions required for advective transport through a waste package are less likely to occur than those conditions required for diffusion. However, when advective transport through the waste package does occur its consequences are more significant compared to that from diffusion mechanisms because of the amount of water involved. Therefore, advection trough the waste package is identified as ITBC. **FEP Source:** SNL 2008 [DIRS 183041]- 2.1.09.08.0B	Yes	**ITBC:** In-Package Chemical Environment Waste Package Source Term, Inventory, Inventory Decay, and Decay Heat In-Package Thermal Environment Radionuclide Inventory and Source-Term Properties Waste Form/Package Internals Materials, Properties, and Configuration Waste Package Materials, Properties, and Configuration **Non-ITBC:** Waste Form Degradation Corrosion Products Properties	**Non-ITBC:** Waste Package Outer Barrier Material Specifications Waste Package Quantities Waste Package Decay Heat Waste Package Thermal Limits

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Waste Form and Waste Package Internals	2.1.09.23.0A Stability of Colloids in EBS **Included**	The stability of colloids is a function of the chemical environment in the waste package internal environment (SNL 2007 [DIRS 177423], Sections 4.1.2 and 6.5.1) and determines how many colloids remain suspended in water Although considered and accounted for in the postclosure analyzed basis, the contribution of colloid transport processes is less significant than that associated with the transport of dissolved radionuclides and parameter characteristics associated with the transport of colloids are not considered ITBC. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.09.23.0A	No	**Non-ITBC:** In-Package Chemical Environment Waste Package Source Term, Inventory, Inventory Decay, and Decay Heat In-Package Thermal Environment Radionuclide Inventory and Source-Term Properties Waste Form Degradation Waste Form/Package Internals Materials, Properties, and Configuration Waste Package Source Term, Inventory, Inventory Decay, and Decay Heat Radionuclide Inventory and Source-Term Properties	**None**

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Waste Form and Waste Package Internals	2.1.14.16.0A In-Package Criticality (degraded configurations) **Excluded**	It has been determined that the conditions required to lead to in-package criticality are not likely to occur and the parameter characteristics associated with this process and feature do not substantially effect the release of radionuclides or impact the barrier capability of this feature(SNL 2007 [DIRS 173869], Section 6.3). **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.14.16.0A	No	**Non-ITBC:** Criticality Characteristics Waste Form/Package Internals Materials, Properties, and Configuration Waste Form Degradation Waste Package Materials, Properties, and Configuration Drip Shield Materials, Properties, and Configuration Infiltration and Seepage Properties Radionuclide Inventory and Source-Term Properties Drip Shield Seismic Performance Properties of the Host Rock Unit Waste Package Source Term, Inventory, Inventory Decay, and Decay Heat Radionuclide Inventory and Source-Term Properties	**Non-ITBC:** Drip Shield Seismic Performance Drip Shield Corrosion Allowance Seismic Design of Waste Package As-emplaced Waste Package-Drip Shield Configuration Loading of Waste Forms Repository Layout Waste Package and TAD Canister Excluded Materials Waste Package Moisture Removal and Inerting Waste Package Spacing Waste Package Capacities

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Waste Form and Waste Package Internals	2.1.14.24.0A In-package Criticality Resulting from an Igneous Event (intact configuration) **Excluded**	It has been determined that the conditions required to lead to in-package criticality are not likely to occur and the parameter characteristics associated with this process and feature do not substantially effect the release of radionuclides or impact the barrier capability of this feature(SNL 2007 [DIRS 173869], Section 6.6). **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.14.24.0A	No	**Non-ITBC:** Criticality Characteristics Waste Form Properties, and Configuration Waste Package Materials, Properties, and Configuration Radionuclide Inventory and Source Term Properties Waste Package Source Term, Inventory, Inventory Decay, and Decay Heat	**Non-ITBC:** Loading of Waste Forms Waste Package and TAD Canister Excluded Materials Waste Package Moisture Removal and Inerting

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Waste Package Pallet	1.2.03.02.0A Seismic Ground Motion Damages EBS Components **Included**	Vibratory ground motion has the potential to damage the emplacement pallets from waste package-to-pallet impacts that may occur during a seismic event. These impacts may deform or even crush the emplacement pallets once general corrosion of Alloy 22 reduces the thickness of the cradles that support the waste package. The impact loads may also fail the stainless steel connector rods in the pallet, allowing the two cradles to move independently during a seismic event. While the cradles remain intact and can support the waste package above the invert, the presence of the pallet can delay diffusive releases of radionuclides from the waste package to the invert, thereby providing a significant barrier to the release of radionuclides. **FEP Source:** SNL 2008 [DIRS 183041] – 1.2.03.02.0A	Yes	**ITBC:** Emplacement Pallet Materials, Properties, and Configuration Properties of the Host Rock Unit Characterization of Seismic Events	**ITBC:** As-emplaced Waste Package-Drip Shield Configuration Emplacement Pallet Fabrication and Corrosion Allowance Emplacement Pallet Design Emplacement Pallet Function EBS Drip Shield / Emplacement Drift Invert Materials Interactions Materials Contacting the Waste Package
Waste Package Pallet	2.1.06.05.0A Mechanical Degradation of Emplacement Pallet **Excluded**	The waste package emplacement pallet provides mechanical stability for the waste package given ground motions associated with a potential seismic event. The potential mechanical degradation of the waste package emplacement pallet has been evaluated and determined to not significantly affect the ability of the pallet to maintain its function of keeping the waste package stable and above the invert. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.06.05.0A	No	**Non-ITBC:** Emplacement Pallet Materials, Properties, and Configuration	**Non-ITBC:** Emplacement Pallet Design Emplacement Pallet Function Emplacement Pallet Fabrication and Corrosion Allowance Waste Package and Emplacement Pallet Static Stresses EBS Drip Shield / Emplacement Drift Invert Materials Interactions EBS Materials Interactions - Emplacement Pallet Function

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Waste Package Pallet	2.1.06.05.0C Chemical Degradation of Emplacement Pallet **Included**	The waste package emplacement pallet provides chemical stability for the waste package and a uniform chemical boundary condition for evaluation of waste package degradation, in that the waste package does not come into direct contact with the invert. The potential chemical degradation of the waste package emplacement pallet has been evaluated and determined to not significantly affect the ability of the pallet to maintain its function of keeping the waste package stable and above the invert. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.06.05.0C	No	**Non-ITBC:** Emplacement Pallet Materials, Properties, and Configuration Waste Package Materials, Properties, and Configuration	**Non-ITBC:** Emplacement Pallet Design Emplacement Pallet Function Emplacement Pallet Fabrication and Corrosion Allowance EBS In-drift Materials Interactions As-emplaced Waste Package-Drip Shield Configuration Waste Package Outer Barrier Material Specifications
Waste Package Pallet	2.1.06.07.0A Chemical Effects at EBS Component Interface **Excluded**	Solid-to-solid interactions at the interfaces between the various features of the EBS have been considered in the design and analysis of the in-drift chemical environment such that galvanic coupling and other chemical interactions are insignificant to postclosure performance assessment. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.06.07.0A	No	**Non-ITBC:** Emplacement Pallet Materials, Properties, and Configuration Waste Package Materials, Properties, and Configuration	**Non-ITBC:** EBS Materials Interactions – Copper EBS Drip Shield / Emplacement Drift Invert Materials Interactions EBS Materials Interactions - Emplacement Pallet Function
Waste Package Pallet	2.1.06.07.0B Mechanical Effects at EBS Component Interfaces **Excluded**	Administrative controls for the repository construction and operations will be developed to assure that waste packages and drip shields are placed in accordance with the repository design. Physical effects of steady-state contact (static loading) that occur at the interfaces between materials in the drift may affect the performance of the system. The mechanical effects of static loading that occur at interfaces between materials in the emplacement drift are not significant to the postclosure performance of the repository. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.06.07.0B	No	**Non-ITBC:** Emplacement Pallet Materials, Properties, and Configuration Waste Package Materials, Properties, and Configuration	**Non-ITBC:** Emplacement Pallet Design Emplacement Pallet Function Emplacement Pallet Fabrication and Corrosion Allowance Waste Package and Emplacement Pallet Static Stresses As-Emplaced Waste Configuration / Waste Package Outer Barrier Material Specifications

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Invert	1.2.03.02.0A Seismic Ground Motion Damages EBS Components **Included**	Vibratory ground motion has the potential to damage the steel framework and ballast in the invert. The framework in the invert is carbon steel that is expected to corrode quickly in the moist, in-drift environment. The response of the steel framework is therefore not ITBC, with or without seismic events. The ballast in the invert is an engineered material that will be produced from crushed tuff generated during mining operations. This crushed tuff is a highly porous material that may settle or compact during a seismic event, but is not considered to provide a significant barrier capability in comparison to the intact tuff in the unsaturated zone surrounding the emplacement drifts. The response of invert to vibratory ground motion is therefore not ITBC. **FEP Source:** SNL 2008 [DIRS 183041] – 1.2.03.02.0A	No	**Non-ITBC:** Invert Materials, Properties, and Configuration Properties of the Host Rock Unit Characterization of Igneous Events	**Non-ITBC:** Invert Materials Emplacement Drift Invert Configuration Emplacement Drift Invert Function Verification of Design Rock Properties Repository Geographic and Geologic Location Repository Elevation - Overburden Thickness
Invert	2.1.06.05.0B Mechanical Degradation of Invert **Excluded**	Mechanical degradation of the invert does not significantly affect the capability of the other EBS features, nor would such changes affect the radionuclide migration rate through the invert to the edge of the EBS, because changes in invert ballast porosity do not significantly affect the radionuclide transport characteristics. Seismically induced changes to the invert, and the effect from dead loading due to drift collapse, are considered separately (see FEP 1.2.03.02.0A). **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.06.05.0B	No	**Non-ITBC:** Invert Materials, Properties, and Configuration	**Non-ITBC:** As-emplaced Waste Package-Drip Shield Configuration Invert and EBS Components in Situ Stress and Thermal Response Emplacement Drift Invert Configuration Emplacement Drift Invert Function Invert Materials
Invert	2.1.06.05.0D Chemical Degradation of Invert **Excluded**	The crushed tuff invert ballast material is not subject to dissolution or weathering processes that could significantly change its hydrological, mechanical, or radionuclide transport characteristics. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.06.05.0D	No	**Non-ITBC:** Invert Materials, Properties, and Configuration	**Non-ITBC:** EBS Drip Shield / Emplacement Drift Invert Materials Interactions Invert Materials Emplacement Drift Invert Configuration

Table A-2. ITBC Analyses of Engineered Barrier System FEPs (Continued)

Feature	FEP Number, Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Invert	2.1.09.13.0A Complexation in EBS **Excluded**	Chemical and biological conditions that could contribute to complexation of radionuclides in the invert will not occur or will be present to such limited extent as to not enhance the rates of transport of radionuclides released from the waste package. Therefore, complexation effects in the invert are negligible from a barrier capability perspective. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.09.13.0A	No	**Non-ITBC:** In-drift Chemical Environment Waste Package Source Term, Inventory, Inventory Decay, and Decay Heat Invert Materials Properties, and Configuration Radionuclide Inventory and Source-Term Properties	**Non-ITBC:** Waste Package and TAD Canister Excluded Materials Committed Materials
Invert	2.1.09.19.0A Sorption of Colloids in EBS **Excluded**	Although colloids could potentially sorb on invert ballast materials, thus reducing the rate of radionuclide release, this sorption is small and, because the travel path through the invert is short compared with that through the unsaturated zone below the repository, is relatively insignificant. For pseudo-colloids to which radionuclides are reversibly sorbed, sorption of the carrier particles has limited effect on radionuclide transport. Because of the limited affect on barrier performance, colloid sorption is excluded from the TSPA (SNL 2008 [DIRS 183041] – 2.1.09.19.0A) and the process is not ITBC. **FEP Source:** SNL 2008 [DIRS 183041] – 2.1.09.19.0A	No	**Non-ITBC:** In-Drift Chemical Environment In-Drift Thermal Environment Convection, Condensation, and Evaporation Radionuclide Inventory and Source-Term Properties Invert Materials Properties, and Configuration Waste Form Degradation Corrosion Products Properties Waste Form/Package Internals Materials, Properties, and Configuration	**None**

Table A-3. ITBC Analysis of Lower Natural Barrier FEPs (Continued)

Feature / Component	FEP Number Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Unsaturated Zone Below the Repository	1.2.04.02.0A Igneous Activity Changes Rock Properties **Excluded**	Studies of natural analogue sites show that the effect of unlikely intrusive igneous events is generally to alter the properties in the immediate vicinity (a few meters) from the intrusive sill or dike. These changes (which may be increases or decreases in permeability and porosity) are of such limited spatial extent. In addition, because dikes would be nearly vertical, the formation of a significant perched water zone associated with a dike is not expected. Furthermore, although lateral diversion and formation of perched water occurs where the TSw contacts the zeolitic CHn, transport sensitivity analyses indicate that most of the delay in radionuclide movement to the water table occurs within the TSw and above the zone of strong lateral diversion. Hence, any changes in potential lateral diversion resulting from dikes would have negligible effects on radionuclide transport times. Other unsaturated zone flow and transport sensitivity analyses provide additional support that radionuclide transport between the repository and the water table is insensitive to changes in fault properties. Therefore, igneous activity-induced rock property changes do not significantly affect the capabilities of the unsaturated zone below the repository. **FEP Source:** SNL 2008 [DIRS 183041] – 1.2.04.02.0A	No	**Non-ITBC:** Characterization of Igneous Events Unsaturated Zone Properties	**Non-ITBC:** Repository Geographic and Geologic Location
Unsaturated Zone Below the Repository	1.2.04.05.0A Magma or Pyroclastic Base Surge Transports Waste **Excluded**	The transport of waste through the UZ by magma or pyroclastic base surge following an unlikely eruptive igneous event is insignificant compared to areal transport of the waste resulting from ash and tephra eruption that is included in performance assessment. **FEP Source:** SNL 2008 [DIRS 183041] – 1.2.04.05.0A	No	**Non-ITBC:** Characterization of Igneous Events	**Non-ITBC:** Repository Geographic and Geologic Location
Unsaturated Zone Below the Repository	1.2.04.06.0A Eruptive Conduit to Surface Intersects Repository **Included**	Even though the possibility of an eruptive conduit intersecting the repository and extending to the surface has been included in the performance assessment, the number of waste packages potentially intersected by such an event (SNL 2007 [DIRS 177432], Section 7.2) is considered an insignificant contributor to the dose to the reasonably maximally exposed individual (RMEI). **FEP Source:** SNL 2008 [DIRS 183041] – 1.2.04.06.0A	No	**Non-ITBC:** Characterization of Igneous Events	**Non-ITBC:** Repository Geographic and Geologic Location Orientation of Emplacement Drifts Emplacement Drift Spacing

Table A-3. ITBC Analysis of Lower Natural Barrier FEPs (Continued)

Unsaturated Zone Below the Repository	2.2.10.07.0A Thermo-chemical Alteration of the Calico Hills Unit **Excluded**	Thermo-chemical alteration of the Calico Hills unit could affect unsaturated zone flow and transport by: (1) mineral dissolution and precipitation, which would change the fracture porosity and permeability of the fracture network; (2) changing the fracture-matrix interaction through the Active Fracture Model □; or (3) changing the sorption coefficient (K_d) through mineral dissolution and precipitation on the fracture wall surfaces. However, sensitivity analyses indicate that: (a) changes to fracture permeability of the CHn have a much less effect than variations in infiltration rates; and (b) changes in γ or K_d values of the CHn do not significantly affect radionuclide breakthrough, as transport in the unsaturated zone is controlled by the overlying TSw unit. Models show that elevation of the repository above the CHn ensures that the CHn will not be heated to temperature ranges that would cause significant dewatering of zeolites (see description of FEP 2.2.10.14.0A, Mineralogic Dehydration Reactions). **FEP Source:** SNL 2008 [DIRS 183041] – 2.2.10.07.0A	No	**Non-ITBC:** Unsaturated Zone Chemical Environment In-Drift Thermal Environment, Convection, Condensation, and Evaporation Unsaturated Zone Properties Unsaturated Zone Transport Waste Package Source Term, Inventory, Inventory Decay, and Decay Heat	**Non-ITBC:** Drift Wall Temperature Waste Package Spacing Repository Standoff from the CHn Unit
Unsaturated Zone Below the Repository	2.2.10.09.0A Thermo-chemical Alteration of the Topopah Spring Basal Vitrophyre **Excluded**	Fluid inclusion data and thermal history analysis show that the current degree of alteration in TSw basal vitrophere resulted from exposure to temperatures of up to 80-95ºC for a long period of time (a million years). In comparison, the postclosure thermal pulse will be very brief relative to the extended thermal history of the mountain, and drift wall temperatures drop below 50ºC in less than 20,000 years, and will have little effect on the abundance of secondary minerals in the TSw basal vitrophyre. Therefore, thermally-induced alteration of this unit will be limited and will not significantly affect the sorptive or hydrologic properties of the units. **FEP Source:** SNL 2008 [DIRS 183041] – 2.2.10.09.0A	No	**Non-ITBC:** Unsaturated Zone Chemical Environment In-Drift Thermal Environment, Convection, Condensation, and Evaporation Unsaturated Zone Properties Unsaturated Zone Transport Waste Package Source Term, Inventory, Inventory Decay, and Decay Heat	**Non-ITBC:** Drift Wall Temperature Waste Package Spacing

Table A-3. ITBC Analysis of Lower Natural Barrier FEPs (Continued)

Feature / Component	FEP Number Name, and Screening Decision	Discussion of Effect on Barrier Capability	Relates to ITBC[1]	Core Parameter Characteristic[2]	Control Parameter Characteristic[3]
Saturated Zone	1.4.01.01.0A Climate Modification Increases Recharge **Included**	The increase in recharge associated with future climate states significantly increases the groundwater flux through the tuff and alluvial water-conducting features, which reduces the effectiveness of the barrier capability of this feature. This effect is incorporated into the saturated zone flow and transport model, and is determined to be ITBC because of its significant contribution to the barrier capability of the saturated zone. **FEP Source:** SNL 2008 [DIRS 183041] – 1.4.01.01.0A	Yes	**ITBC:** Saturated Zone Properties Saturated Zone Flow Extent of Saturated Zone	**Non-ITBC:** Repository Geographic and Geologic Location Repository Elevation above the Water Table
Saturated Zone	1.4.07.02.0A Wells **Included**	The effect of pumping wells on saturated zone groundwater flow has been incorporated into the Site-Scale SZ Flow Model via the configuration of the water table used as an upper boundary and the flow rates across the model boundaries as provided by the Death Valley regional model. The regional model specifically incorporated the irrigation wells located south of Yucca Mountain in Amargosa Valley. In addition, measured water levels from these existing wells are used in the calibration of the Site-Scale SZ Flow Model. Furthermore, the effects of wells on the dose to the RMEI are included into the TSPA by assuming all of the radionuclide mass that reaches the 18-km accessible environment, is contained in the representative volume of groundwater from which the RMEI obtains all required water. The effects of wells are not ITBC for the saturated zone because wells drilled for domestic or agricultural use are not anticipated to significantly affect groundwater flow or radionuclide movement due to the their large distances away from the predominant flow paths. **FEP Source:** SNL 2008 [DIRS 183041] – 1.4.07.02.0A	No	**Non-ITBC:** Saturated Zone properties Saturated Zone Flow	**Non-ITBC:** **None**