Note to: File

From: Hans Arlt, Sr. Systems Performance Analyst
Performance Assessment Branch
Division of Waste Management and Environmental Protection
Office of Federal and State Materials and Environmental Management Programs

Date: March 8, 2013

SUBJECT: Hanford Site Waste Management Area C Features, Events, and Processes List

The enclosed document is a draft report of features, events, and processes (FEPs) relevant to near-surface disposal of radioactive waste at the Waste Management Area (WMA) C, United States Department of Energy, Hanford Site. The list of FEPs was developed to support the WMA C performance assessment. The draft report was provided to the NRC via email dated August, 3, 2011.

Enclosure:

1. Email from Michael Connelly to Hans Arlt forwarding the WMA C FEPs.
2. WMA C FEPs list.

Enclosure 1

From:	Connelly, Michael
To:	Arlt, Hans
Subject:	FEPs Report from the Database
Date:	Wednesday, August 03, 2011 11:57:31 AM
Attachments:	FEP_Report_nrc.pdf

Hans

Here is the FEPs report you requested. The first nine pages is a list of all the FEPs we have in the database at this time, the remaining pages are how we have addressed the FEPs that are listed with a Yes for included in this report. This list will expand as we go through the FEPs, only FEPs in which we have reviewed are included.

Mike

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Enclosure 2

Complete FEPs List at this time 8/3/2011		
FEP_ID	FEP	Included in this Report
0	Assessment Context Factors	Yes
0.1	Assessment Purpose	Yes
0.1.01	Strategic Studies	Yes
0.1.02	Development of experience/understanding	Yes
0.1.03	Regulatory Development	Yes
0.1.04	Demonstrate Regulatory Compliance	Yes
0.1.05	Site Selection Guideline	Yes
0.1.06	Site Characterization Guidelines	Yes
0.1.07	Disposal concept design	Yes
0.1.08	Confidence Building	Yes
0.1.09	Waste acceptance criteria	Yes
0.1.10	Regulatory Review	Yes
0.1.11	Corrective action	Yes
0.1.12	Reassessment of safety	Yes
0.2	Regulatory Requirements and Criteria	Yes
0.2.01	Protection of Human Health and the Environment	Yes
0.2.01.01	Optimisation	Yes
0.2.01.02	Independence of safety from controls	Yes
0.2.01.03	Effects in the future	Yes
0.2.01.04	Radiological Protection Standards	Yes
0.2.01.05	Environmental protection standards	Yes
0.2.01.06	Non-radiological protection standards	Yes
0.2.02	Phases of Disposal	Yes
0.2.02.01	Pre-Operational Period	Yes
0.2.02.02	Operational period	Yes
0.2.02.03	Post-closure period	Yes
0.2.03	Technical Requirements	Yes
0.2.03.01	Multi-factor Safety Function	Yes
0.2.03.02	Isolation	Yes
0.2.03.03	Containment	Yes
0.2.03.04	Site Characterisation	Yes
0.2.03.05	Facility Design	Yes
0.2.03.06	Facility Construction	Yes
0.2.03.07	Waste Acceptance Requirements and Criteria	Yes
0.2.03.08	Monitoring	Yes
0.2.03.09	System of Records	Yes
0.2.03.10	Quality Assurance	Yes
0.2.03.11	Natural Analogues	Yes
0.2.03.12	Peer Review (Regulatory and International)	No
0.3	Assessment Philosophy	Yes
0.3.01	Assessment Approach	Yes
0.3.01.01	Iterative Approach	Yes
0.3.01.02	Systematic Approach	No
0.3.01.03	Prospective Evaluation Approach	No
0.3.01.04	Reasonable Assurance Approach	No
0.3.01.05	Realistic Approach	Yes
0.3.01.06	Cautious Approach	No
0.3.01.07	Transparent Approach	No
0.3.02	Uncertainties, treatment of	No
0.3.02.01	Future Uncertainties	No
0.3.02.02	Model Uncertainties	No
0.3.02.02.01	Conceptual Model Uncertainties	No

Complete FEPs List at this time 8/3/2011		
FEP_ID	FEP	Included in this Report
0.3.02.02.02	Mathematical Model Uncertainties	No
0.3.02.02.03	Computer Model Uncertainties	No
0.3.02.03	Parameter/Data Uncertainty	No
0.3.02.04	Subjective Uncertainty	No
0.3.03	Sensitivity Analysis, Performance of	No
0.3.04	Confidence, Model	Yes
0.3.04.01	Verification, performance of	No
0.3.04.02	Calibration, performance of	No
0.3.04.03	Validation, performance of	No
0.3.05	Modelling Approach	No
0.3.05.01	Scoping (screening) Calculations	No
0.3.05.02	Worst Case (Bounding) Calculations	No
0.3.05.03	Deterministic Calculations	No
0.3.05.04	Probabilistic Calculations	No
0.4	Assessment Conditions	No
0.4.01	Assessment Timeframe	No
0.4.01.01	Closure to end of Institutional Control	No
0.4.01.02	Institutional Control to 10,000 yrs	Yes
0.4.01.03	Beyond 10,000 yrs	No
0.4.01.04	Peak Impact	No
0.4.02	Assessment Domain	Yes
0.4.03	Future Human Action Assumptions	No
0.4.03.01	Present day technology	No
0.4.03.02	Past as a reflection of the future	Yes
0.4.03.03	Cure for cancer	No
0.4.03.04	Malicious act or acts of war	Yes
0.4.03.05	Deliberate human intrusion	Yes
0.4.04	Future Human Behaviour (target group) Assumptions	No
0.4.04.01	Basis for consideration of radiological impacts to human beings:	No
0.4.04.02	Future evolution of human beings and other species:	No
0.4.04.03	A priori approach to define exposure groups	No
0.4.04.04	A posteriori approach to define exposure groups	No
0.4.05	Target Audience (Stakeholders Involvement)	No
0.4.05.01	Developers:	No
0.4.05.02	Opinion formers:	No
0.4.05.03	Regulators	No
0.4.05.04	Wider Community	No
0.4.06	Assessment Endpoints	No
0.4.06.01	Annual individual dose	No
0.4.06.02	Annual individual risk	No
0.4.06.03	Lifetime individual dose	No
0.4.06.04	Lifetime individual risk	No
0.4.06.05	Collective dose	No
0.4.06.06	Collective risk	No
0.4.06.07	Dose to non-human biota	No
0.4.06.08	Radionuclide fluxes from the disposal facility	No
0.4.06.09	Radionuclide fluxes into the biosphere	No
0.4.06.10	Radionuclide concentration in the environment	No
0.4.06.11	Radionuclide inventory disposed and remaining in the disposal facility	No
0.4.06.12	Activity limits in disposed waste	No
0.4.06.13	Non-radiological assessment endpoints	No
0.4.07	Dose Response Assumptions	No

Complete FEPs List at this time 8/3/2011		
FEP_ID	FEP	Included in this Report
0.4.08	Results, Presentation of	No
0.4.08.01	Multiple lines of reasoning:	No
0.4.08.02	Performance of individual system components	No
0.4.08.03	Various safety indicators over a range of timeframes	No
0.4.08.04	Documentation, presentation and communication of the safety assessment	No
0.4.08.05	Supplement a sophisticated modelling approach with a less complex model	No
0.4.09	Disposal Facility Assumptions	No
1	EXTERNAL FACTORS	No
1.1	Disposal Facility Factors	Yes
1.1.01	Investigations, Site	Yes
1.1.01.01	Geology	Yes
1.1.01.02	Hydrogeology	Yes
1.1.01.03	Geochemistry	Yes
1.1.01.04	Tectonic and seismicity	Yes
1.1.01.05	Surface environment	Yes
1.1.01.06	Meteorology and climatology	Yes
1.1.01.07	Geography and demography	Yes
1.1.01.08	Natural resources and land use	Yes
1.1.02	Design, Disposal Facility	Yes
1.1.02.01	Description, Disposal facility type	Yes
1.1.02.02	Functional requirements and criteria	Yes
1.1.02.03	Design features (safety concept)	Yes
1.1.02.04	Design documentation	Yes
1.1.02.05	Alternative design conditions	Yes
1.1.03	Schedule and Planning	Yes
1.1.03.01	Construction, scope and schedule	Yes
1.1.03.02	Operation, scope and schedule	Yes
1.1.03.03	Closure, scope and schedule	Yes
1.1.03.04	Alternative schedule and planning conditions	Yes
1.1.04	Construction, Disposal Facility	Yes
1.1.04.01	Construction process (method)	Yes
1.1.04.02	Performance and verification of construction	Yes
1.1.04.03	Alternative construction conditions	Yes
1.1.05	Operation, Disposal Facility	Yes
1.1.05.01	Acceptance of waste	Yes
1.1.05.02	Waste repackaging	Yes
1.1.05.03	Waste allocation	Yes
1.1.05.04	Waste emplacement	Yes
1.1.05.05	Backfill preparation, handling and emplacement	Yes
1.1.05.06	Monitoring and surveillance	Yes
1.1.05.07	Remedial activities	Yes
1.1.05.08	Alternative operational conditions	Yes
1.1.06	Closure, Disposal Facility	Yes
1.1.06.01	Analysis of remedial alternatives	Yes
1.1.06.02	Closure plan	Yes
1.1.06.03	Performance requirements and criteria	Yes
1.1.06.04	Closure system features and materials	Yes
1.1.06.05	Failure mechanisms	Yes
1.1.06.06	Disposal facility preparation and clearance	Yes
1.1.06.07	Construction, closure system	Yes
1.1.06.08	Confirmation, closure system	Yes
1.1.06.09	Alternative closure conditions	Yes

Complete FEPs List at this time 8/3/2011		
FEP_ID	FEP	Included in this Report
1.1.07	Quality Assurance	Yes
1.1.07.01	Procurement of items and services	Yes
1.1.07.02	Manufacturing	Yes
1.1.07.03	Research and development	Yes
1.1.07.04	Siting	Yes
1.1.07.05	Design	Yes
1.1.07.06	Construction	Yes
1.1.07.07	Commissioning	Yes
1.1.07.08	Operation	Yes
1.1.07.09	Decommissioning (closure)	Yes
1.1.07.10	Failure of quality assurance/control	Yes
1.1.08	Administrative control, Disposal facility	Yes
1.1.08.01	Pre-operational period	Yes
1.1.08.02	Operational period	Yes
1.1.08.03	Post-closure period	Yes
1.1.08.04	Failure of administrative control	Yes
1.1.09	Accidents and unplanned events	Yes
1.1.09.01	Human induced accidents and unplanned events	Yes
1.1.09.02	Natural occurring accidents and unplanned events	Yes
1.1.10	Retrievability	Yes
1.1.11	Nuclear Criticality	Yes
1.2	Geological Processes and Effects	No
1.2.01	Tectonic movement	Yes
1.2.01.01	Plate boundaries	Yes
1.2.01.02	Tectonic cycle	Yes
1.2.01.03	Deformation of geological structures:	Yes
1.2.01.04	Oceanic-continental	Yes
1.2.01.05	Continental-continental:	Yes
1.2.02	Orogeny	Yes
1.2.03	Seismicity	Yes
1.2.04	Volcanic and magmatic activity	Yes
1.2.05	Metamorphism	Yes
1.2.06	Hydrothermal activity	Yes
1.2.07	Denudation and Deposition (large-scale)	Yes
1.2.07.01	Erosion	Yes
1.2.07.02	Corrasion	Yes
1.2.07.03	Weathering	Yes
1.2.07.04	Weathering rates and plate tectonics:	No
1.2.07.05	Fluvial erosion	Yes
1.2.07.06	Aeolian erosion	Yes
1.2.07.07	Glacier erosion	Yes
1.2.07.08	Glacier deposits	Yes
1.2.07.09	Coastal erosion	Yes
1.2.07.10	Mass-wasting	No
1.2.07.11	Mass wasting in cold climates	No
1.2.07.12	Events triggering mass wasting:	No
1.2.07.13	Sedimentation	No
1.2.07.14	Depositional environments	No
1.2.07.15	Sedimentation and tectonics	No
1.2.08	Diagenesis	Yes
1.2.09	Pedogenesis	Yes
1.2.10	Salt diapirism and dissolution	Yes

Complete FEPs List at this time 8/3/2011		
FEP_ID	FEP	Included in this Report
1.2.11	Undetected geological features	No
1.2.12	Hydrological/hydrogeological response to geological changes	No
1.2.12.01	Change in hydraulic boundary conditions	No
1.2.12.02	Change in hydraulic properties	No
1.2.12.03	Change in geochemical behaviour	No
1.2.12.04	Change in surface water flow path	No
1.2.12.05	Preferential flow paths	No
1.2.13	Geomorphologic responds to geological changes	No
1.2.13.01	Structural landforms	No
1.2.13.02	Weathering landforms	No
1.2.13.03	Erosional landforms	No
1.2.13.04	Depositional landforms	No
1.3	Climate Processes and Effects	No
1.3.01	Climate change, global	No
1.3.01.01	Climate reconstruction	No
1.3.01.02	Climate change theories	No
1.3.01.03	The carbon cycle	No
1.3.01.04	Greenhouse effect	No
1.3.01.05	Global warming	No
1.3.01.06	Environmental effects of global warming:	No
1.3.02	Climate change, regional and local	No
1.3.02.01	Climate fluctuations	No
1.3.02.02	Volcanic eruptions	No
1.3.02.03	Global climate change induced changes	No
1.3.03	Sea level change	Yes
1.3.04	Periglacial effects	Yes
1.3.05	Glacial and ice sheet effects, local	Yes
1.3.06	Warm climate effects (tropical and desert)	Yes
1.3.07	Hydrological/hydrogeological response to climate changes	No
1.3.07.01	Change in the driving forces for hydrological and hydrogeological flow regime:	No
1.3.07.02	Change in the hydrological and hydrogeological flow regime:	No
1.3.08	Ecological response to climate changes	No
1.3.08.01	Soil	No
1.3.08.02	Atmosphere	No
1.3.08.03	Solar radiation	No
1.3.08.04	Water	No
1.3.08.05	Living organisms	No
1.3.08.06	Ecological adaptation	No
1.3.09	Human behavioural response to climate changes	No
1.3.10	Geomorphologic responds to climate changes	No
1.3.10.01	Periglacial landforms	No
1.3.10.02	Warm climates	No
1.4	Future Human Actions (Active)	No
1.4.01	Human influences on climate	No
1.4.02	Social and institutional developments	No
1.4.02.01	Incomplete closure	No
1.4.02.02	Changes in planning controls and environmental legislation:	No
1.4.02.03	Demographic change and urban development:	No
1.4.02.04	Changes in land use:	No
1.4.02.05	Change in regulatory requirements:	No
1.4.02.06	Loss/degradation of societal memory:	No
1.4.02.07	Loss of archives/records	No

Complete FEPs List at this time 8/3/2011		
FEP_ID	FEP	Included in this Report
1.4.03	Knowledge and motivational issues (Disposal facility)	No
1.4.03.01	Knowledge of the disposal facility	No
1.4.03.02	Inadvertent human action	No
1.4.04	Drilling activities	No
1.4.04.01	Exploration drilling	No
1.4.04.02	Site characterisation	No
1.4.04.03	Exploitation drilling	No
1.4.04.04	Waste disposal	No
1.4.04.05	Deliberate intrusion drilling	No
1.4.04.06	Reuse of existing boreholes	No
1.4.04.07	Remedial action drilling	No
1.4.05	Mining and other underground activities	No
1.4.05.01	Mining and underground construction activities	No
1.4.05.02	Resource exploration and exploitation	No
1.4.05.03	Underground excavations	No
1.4.05.04	Solution mining	No
1.4.05.05	Underground dwelling	No
1.4.05.06	Waste retrieval, mining	No
1.4.05.07	Underground nuclear testing	Yes
1.4.05.08	Malicious intrusion	Yes
1.4.06	Un-intrusive site investigation	No
1.4.07	Surface excavations	No
1.4.07.01	Excavations for construction	No
1.4.07.02	Excavations as part of remedial actions	No
1.4.07.03	Geotechnical investigations	No
1.4.07.04	Waste disposal facility	No
1.4.07.05	Deliberate intrusion excavation	No
1.4.08	Site Development	No
1.4.08.01	Site development for construction	No
1.4.08.02	Site development for dam construction	No
1.4.08.03	Change in topography	No
1.4.08.04	Change in land use	No
1.4.09	Archaeology	No
1.4.10	Water management (groundwater and surface water)	No
1.4.10.01	Groundwater management	No
1.4.10.02	Surface water management	No
1.4.11	Explosions and crashes	No
1.4.11.01	Accidental human actions	No
1.4.11.02	Malicious human actions	No
1.4.12	Pollution	No
1.4.12.01	Soil pollution	No
1.4.12.02	Groundwater pollution	No
1.4.12.03	Air pollution	No
1.4.13	Remedial actions	No
1.4.13.01	Unsuccessful attempt to improve site conditions:	No
1.4.13.02	Retrieval of waste	No
1.4.13.03	Additional engineered barriers	No
1.4.14	Technological developments	No
1.4.14.01	Retrograde developments	No
1.4.14.02	No technological development	No
1.4.14.03	Biogas production	No
1.4.14.04	Cure for cancer	No

Complete FEPs List at this time 8/3/2011		
FEP_ID	FEP	Included in this Report
1.4.14.05	Technological advance in food production	No
2	DISPOSAL SYSTEM DOMAIN FACTORS	No
2.1	Waste, Waste Form & Engineered Features	No
2.1.01	Inventory, waste	No
2.1.01.01	Waste stream	No
2.1.01.02	Waste volume	No
2.1.01.03	Waste homogeneity:	No
2.1.01.04	Radiological content of waste:	No
2.1.01.05	Non-radiological (toxic) content of waste:	No
2.1.01.06	Waste classification:	No
2.1.01.07	Uncertainty in inventory:	No
2.1.02	Waste form, characteristics and degradation processes	No
2.1.03	Container, characteristics and degradation/failure processes	No
2.1.04	Buffer/backfill, characteristics and degradation processes	No
2.1.05	Other engineered features, characteristics and degradation processes	No
2.2	Geological Environment	No
2.2.01	Stratigraphy	No
2.2.01.01	Stratigraphic record:	No
2.2.01.02	Formation:	No
2.2.02	Host lithology	No
2.2.02.01	Geological properties:	No
2.2.02.02	Physical characteristics:	No
2.2.03	Disturbed zone, host lithology	No
2.2.03.01	Formation of cracks:	No
2.2.03.02	Interface (boundary condition):	No
2.2.03.03	Hydro mechanical effects:	No
2.2.03.04	Backfilling, effect on disturbed zone:	No
2.2.03.05	Contaminant migration, disturbed zone:	No
2.2.04	Discontinuities, large scale (in geosphere)	No
2.2.04.01	Fault (deformation by fracture):	No
2.2.04.02	Folds (deformation by bending):	No
2.2.04.03	Dykes:	No
2.2.04.04	Aquifer formation (layering of rocks):	No
4.05□2.2.04.05	Discontinuities, boundary conditions:	No
2.2.05	Contaminant migration path characteristics (in geosphere)	No
2.2.05.01	Hydrogeological zones:	No
2.2.05.02	Interstitial geometry:	No
2.2.05.03	Bypass flow:	No
2.2.05.04	Fracture infill:	No
2.2.05.05	Weathering, contaminant migration path:	No
2.2.06	Mechanical processes and conditions (in geosphere)	No
2.2.06.01	Change in stress field	No
2.2.06.02	Mechanical load, disposal facility:	No
2.2.06.03	Mechanical rapture:	No
2.2.06.04	Change in rock properties:	No
2.2.07	Hydraulic/hydrogeological processes and conditions (in geosphere)	No
2.2.08	Chemical/geochemical processes and conditions (in geosphere)	Yes
2.2.09	Biological/biochemical processes and conditions (in geosphere)	Yes
2.2.10	Thermal processes and conditions (in geosphere)	Yes
2.2.11	Gas sources and effects (in geosphere)	No
2.2.11.01	Effects of natural gasses	No
2.2.11.02	Gas induced groundwater flow	No

Complete FEPs List at this time 8/3/2011		
FEP_ID	FEP	Included in this Report
2.2.12	Geological resources (in geosphere)	No
2.2.12.01	Methane	No
2.2.12.02	Other uses of host lithology	No
2.2.12.03	Water resource exploration:	No
2.2.12.04	Deep deposit exploration	No
2.2.12.05	Near-surface deposit exploration:	No
2.3	Surface Environment	No
2.3.01	Topography and morphology	No
2.3.02	Biomes	No
2.3.03	Soil and sediment	No
2.3.04	Aquifers and water-bearing features, near surface	No
2.3.05	Terrestrial surface water bodies	No
2.3.06	Coastal features	Yes
2.3.07	Marine features	Yes
2.3.08	Atmosphere	No
2.3.09	Vegetation	No
2.3.10	Animal populations	No
2.3.11	Meteorology	No
2.3.12	Hydrological regime and water balance (near-surface)	No
2.3.13	Erosion and deposition	No
2.3.14	Ecological/biological/microbial systems	No
2.3.15	Animal/Plant intrusion	No
2.4	Human Behaviour	No
2.4.01	Human characteristics (physiology, metabolism)	No
2.4.02	Adults, children, infants and other variations	No
2.4.03	Diet and fluid intake	No
2.4.04	Habits (non-diet-related behaviour)	No
2.4.05	Community characteristics	No
2.4.06	Food preparation and water processing	No
2.4.07	Dwellings	No
2.4.08	Natural/semi-natural land and water use	No
2.4.09	Rural and agricultural land and water use	No
2.4.10	Urban and industrial land and water use	No
2.4.11	Leisure and other uses of environment	No
3	CONTAMINANT FACTORS	No
3.1	Contaminant Characteristics	No
3.1.01	Radioactive decay and in-growth	No
3.1.02	Radionuclide properties, other	No
3.1.03	Organics and potential for organic forms	No
3.1.04	Chemical/organic toxin stability	No
3.1.05	Inorganic solids/solutes	No
3.1.06	Volatiles and potential for volatility	No
3.1.07	Noble gases	No
3.2	Contaminant Release and Migration Factors	No
3.2.01	Contaminant release pathways	No
3.2.02	Chemical/geochemical-mediated processes, effects on contaminant release and migration	No
3.2.03	Microbial/biological-mediated processes, effects on contaminant release and migration	No
3.2.04	Water-mediated migration of contaminants	No
3.2.05	Solid-mediated migration of contaminants	No
3.2.06	Gas-mediated migration of contaminants	No
3.2.07	Atmospheric migration of contaminants	No
3.2.08	Animal, plant and microbe mediated migration of contaminants	No

Complete FEPs List at this time 8/3/2011		
FEP_ID	FEP	Included in this Report
3.2.09	Human-action-mediated migration of contaminants	No
3.2.10	Colloids mediated migration of contaminant	No
3.3	Exposure Factors	No
3.3.01	Food chains, uptake of contaminants in	No
3.3.02	Drinking water, foodstuffs and drugs, contaminant concentrations in	No
3.3.03	Environmental media, contaminant concentrations in	No
3.3.04	Non-food products, contaminant concentrations in	No
3.3.05	Exposure modes	No
3.3.06	Dosimetry	No
3.3.07	Radiological toxicity/effects	No
3.3.08	Chemical toxicity/effects	No
3.3.09	Radon and radon daughter exposure	No

Definition: Factors to consider in determining the scope or boundary conditions for the safety assessment of a near-surface disposal facility. These include factors related to the purpose for which the assessment is being performed, the regulatory requirements and criteria, the assessment philosophy that will be followed and the overall framework within which the assessment will be performed. Decisions at this point will affect the phenomenological scope of a particular phase of assessment, i.e. what "physical FEPs" will be included in the analysis.

Comment: Within a post-closure safety assessment of a near-surface disposal facility, the assessment context contains a high level description of the assumptions and constraints imposed on the system, with the purpose to identify what will be included or excluded from the assessment and a justification for these choices. In addition it provides clarity on the safety strategy and the approach to follow in the safety assessment.

The "Assessment Context Factors" layer of FEPs is divided into four categories: 1.1 Assessment Purpose, 1.2 Regulatory requirements and Exclusions, 1.3 Assessment Philosophy and 1.4 Assessment Bounding Conditions.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **3/31/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Section 2.5 of the Tri-Party Agreement HFFACO *Hanford Federal Facility Agreement and Consent Order* defines the scope of the Performance Assessment for Hanford.

> "*Ecology, as the lead agency for SST system closure, EPA, and DOE have elected to develop and maintain as part of the SST system closure plan one performance assessment for the purposes of evaluating whether SST system closure conditions are protective of human health and the environment for all contaminants of concern, both radiological and non-radiological. DOE intends that this performance assessment (PA) will document by reference relevant performance requirements defined by RCRA, HWMA, Clean Water Act, Safe Drinking Water Act, and the Atomic Energy Act of 1954 (AEA) and any other performance requirements that might be ARARs under CERCLA. The PA is of larger scope than a risk assessment required solely for non-radiological contaminants. The PA is expected to provide a single source of information that DOE can use to satisfy potentially duplicative functional and/or documentation requirements. A PA will be developed for each WMA and will incorporate the latest information available. These PAs will be approved by Ecology and DOE pursuant to their respective authorities. For Ecology approval means incorporation by reference, into the Site-Wide Permit through the closure plans.*
>
> *As individual components are retrieved or characterized, or other component closure activities are completed, the resulting component characterization information will be incorporated into the WMA PA to determine its relative risk compared to the entire WMA performance. In doing this, the Parties will be able to make interim closure decisions for individual components. Initially, the WMA PA will be based on assumptions and available data describing component characterization information. As each WMA proceeds toward closure, its respective PA will be updated to address all pertinent new results and findings – and*

will, as a minimum, incorporate the following results as they become available: actual volumes of tank waste residuals left after retrieval, results of leak investigations, new geologic and ancillary equipment waste characterization information, and the results of new barrier and tank residual stabilization and fill performance studies and tests. Final WMA closure decisions will be made after all components are retrieved and/or characterized, and all other component closure activities have been completed and a final WMA PA is complete."

Closure

Per *Hanford Federal Facility Agreement and Consent Order (HFFACO) Action Plan Milestone M-045-00* is to be closed in accordance with WAC-173-303-610, Closure and Post-Closure . Paragraph 2 of this specific milestone is given below

"For the purposes of this Agreement all units located within the boundary of each tank farm will be closed in accordance with WAC 173-303-610. This includes contaminated soil and ancillary equipment that were previously designated as RCRA past practice units. Adopting this approach will ensure efficient use of funding and will reduce potential duplication of effort via application of different regulatory requirements: WAC 173-303-610 for closure of the TSD units and RCRA Section 3004(U) for remediation of RCRA past practice units."

The two primary options for closure under WAC 173-303-610 call for a closed WMA that meets all regulatory requirements for 1) clean closure or 2) a landfill closure. Ecology is proposing to place the SST system under Part V Unit-Specific Conditions for Units Undergoing Closure of the Hanford Site-Wide Permit (Ecology Publication 08 05 007, Frequently Asked Questions - Hanford's Site-Wide Permit). The Tank Closure and Waste Management Environmental Impact Statement (TC&WM EIS) is evaluating various alternatives for closure including clean closure and landfill closure. The final EIS will identify DOE's preferred alternative; Ecology is participating in the TC&WM EIS as a cooperating agency.

For the purposes of analysis in this WMA C performance assessment, it is assumed that the Waste Management Area C will be landfill closed and meeting the requirements of both WAC 173-303-610 and DOE O 435.1. This assumption is subject to modification based on the final decision(s) resulting from the TC&WM EIS as documented in the ROD.

RCRA Corrective Action

This WMA is also under RCRA corrective action WAC-173-303-646. It should be noted that that unplanned releases of contaminants within the Waste Management Area C have already occurred from past operations and vadose soils contain contamination of approximately 10,000,000 pCi/g for Cs-137, 50 pCi/g of Tc-99, 22 ug/kg of chromium, and 6 ug/kg of nitrate. Additionally, groundwater beneath the site contains Tc-99 at 20 times the MCL and nitrate at approximately 2.5 times above the MCL.

There is presently a ongoing characterization program developed per RPP-RPT-38152 to address vadose zone contamination in and around WMA C to address evaluation of alternatives in a Corrective Measure Study (CMS) and in the selection ofa proposed remedy. The PA through the baseline risk assessment will support the CMS.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
HFFACO	M-045-00	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order
WAC-173-303	610	Washington Administr	Dangerous Waste Regulations: Closure and post-closure (610)
DOE/EIS-0391		Burandt, 2009	Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland WA
RPP-35485 Rev.	Executive Summa	Connelly, 2007	Field Investigation Report for Waste Management Areas C and A-AX
WAC-173-303	646	Washington Administr	RCRA Corrective Action

Related Features, Events, and Processes

Alternative Point of View

EnteredBy	DateEntered	POV
h0098182	4/4/2011	

Regulator Comments

EnteredBy	DateEntered	Comment
h0098182	6/30/2011	test

Definition: The purpose for which the safety assessment of a near-surface disposal facility is being undertaken.

Comment: A post-closure safety assessment can be performed for various purposes as part of the overall management of radioactive waste, which will most likely depends on the stage in the development of the near-surface disposal system. These assessments can be performed either on a generic/hypothetical basis (i.e. based on generic, academic, assumed or theoretical system conditions/specifications) or on a site-specific basis.

Key Concepts, Examples and Related FEPs

1) **Strategic studies:** Input in the determination of important strategic issues, for example the identification of feasible disposal concepts, the development of new disposal concepts or the choice of waste encapsulation technology so as not to prejudice final disposal.
2) **Development of experience/understanding**: Help develop an understanding of the safety assessment process in readiness for site-specific assessments, to develop their experience in the behaviour of the system or to identify and guide generic and site-specific research priorities.
3) **Regulatory development:** To support development of regulations for the management of radioactive waste. Although there is common reliance on international guidance such as the IAEA Principles of Radioactive Waste Management and International Commission on Radiological Protection (ICRP) Publications 77 and 81, the regulatory interpretation varies in terms of the details and may yet remain to be decided. The safety assessment objectives may therefore include provision of broader supporting analyses of safety issues and development of regulatory guidance, or even the development of the regulations themselves.
4) **Demonstrate regulatory compliance:** To support licence applications at various stages in the life cycle of the disposal facility (e.g. to help gain a licence to construct, operate or close the disposal facility, or whenever there are significant changes in the safety of the facility or revisions to the associated regulations). Some regulations are prescriptive in their form, giving relatively precise requirements and definitions, whereas others are more qualitative. In the latter case, the assessment context can be very important in helping to define how a quantitative assessment can be used to provide end-points to allow demonstration of compliance with qualitative criteria.
5) **Site selection guideline:** To help develop guidelines to restrict the geographical areas considered for a disposal site, and to identified and compared potential sites.
6) **Site characterisation guidelines:** To provide input to the site characterisation programme, when a particular site has been chosen for further investigation. Results from the assessments can help identify where better data are required for the site characterisation programme.
7) **Disposal concept design:** To develop and design the disposal concept that will optimise the cost but ensure sufficient levels of safety, following the identification of a suitable disposal site.
8) **Confidence building:** When performing a safety assessment as part of confidence building, there may be an increase focus on presentation of the types of results, which can be readily absorbed by a less technical audience. It may also be necessary to address the interests of local people with particular behaviour patterns, who wish to see the implications of those behaviour patterns addressed, whether they are critical or not. The key issue is that public interests may be wider than those of regulator bodies. It is therefore important to recognise which additional factors should be addressed to meet that interest at the outset of the safety assessment, not half way through the programme. In the case of policy makers and the scientific community, they may have specific and different interests from those of the general public. A more detailed assessment might be required to address concerns here.
9) **Waste acceptance criteria, derivation of quantitative:** One of the measures that can be implemented to ensure that living organisms are not adversely affected by radioactive waste disposed in near-surface disposal facilities is the specification of requirements for the acceptance of waste at a near-surface disposal facility as part of a comprehensive waste management system. Waste acceptance criteria can either be generically specified by the regulatory body or developed by the operator on the basis of either generic studies or site specific safety assessments, with account taken of appropriate radiological criteria, the conditions of operations, the planned duration of active institutional controls and the required characteristics of natural and engineered systems. Distinction can be made between qualitative and quantitative requirements for the acceptance of waste at a near-surface disposal facility. The derivation of quantitative waste acceptance requirement set limits on the total activity and the activity concentration of radioactive waste to be disposed in a disposal facility to ensure compliance

with regulatory criteria.

10) **Regulatory review:** The Regulatory Authority needs to be satisfied that good engineering practice has been used in developing proposals for design, construction, operation, closure or post-closure of the facility and that good science has been applied in investigating the suitability of the site, in supporting research and development work, in the interpretation of the resulting data and the safety assessment methodologies used. In assuring itself that all these various facets of safety have been adequately demonstrated to be in place, the Regulatory Authority must be in a position to understand the safety case presented and evaluate the adequacy of the supporting safety assessments. This requires a systematic evaluation of the safety case and supporting assessments. In addition to reviewing safety assessments for new facilities, the Regulatory Authority may require review of safety assessments for licensed radioactive waste disposal facilities in order to:

a) evaluate the current status of disposal facilities and make comparison with the original safety case, and in some cases with the purpose of upgrading the safety;

b) identify tendencies for the development of the facility;

c) update the safety case in compliance with the latest safety requirements and criteria, incorporating state of the art safety assessment methodologies, use of modelling approaches and computer codes; and

d) evaluate the impact on the safety of the facility of natural and human induced changes on the disposal facility system and its environment.

11) **Corrective action, support of:** To support corrective measures following facility or site failure and consequent decommissioning of the facility or site. This is slightly different application of the safety assessment process than for corrective action - where the focus is to improve the safety of the facility - mainly because the facility and its content will be removed to restore the site to a greenfields area. Safety assessment is used to decide to what levels the site should be cleaned to ensure regulatory compliance.

12) **Reassessment of safety**: A large number of near-surface disposal facilities have been developed during the last forty years. These facilities have been constructed, operated, upgraded or closed according to various safety standards, requirements and criteria, while safety assessments have been conducted at varying levels of completeness and quality. Other, often older facilities may have had assessments conducted that are no longer considered adequate by present day standards. Furthermore, at some of these facilities, disposal practices have been conducted that may not meet modern concepts of safety, and consideration must be given to corrective measures and the future use of these facilities. Examples of cases where reassessment will be performed include:

a) the safety of the existing facility has not yet been demonstrated;

b) no safety assessment has been performed;

c) the safety of the facility has been questioned because revisions to the operating conditions have been proposed; or

d) a periodic review and update of the safety assessment is required by the regulator.

Applies to WMA	**Yes**	Entered By:	**h0098182**	On:	**5/31/2011**	Reviewed By		On:	

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies:

Purpose: Given in Appendix I Section 2.5 of the Tri-Party Agreement HFFACO *Hanford Federal Facility Agreement and Consent Order;* and in RPP-RPT-41918 which states "provide an informational basis for long-term human health and environmental information and assessments that will be needed by each regulatory body (DOE, EPA, NRC, and Ecology) to approve eventual closure actions in an SST WMA"

As noted in the FEP 0, WMA C is also under RCRA Corrective Action. There is presently a ongoing characterization program developed per RPP-RPT-38152 to address vadose zone contamination in and around WMA C to address evaluation of alternatives in a Corrective Measure Study (CMS) and in the selection ofa proposed remedy. The PA through the baseline risk assessment will support the CMS.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
HFFACO	Appendix I Secti	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order
RPP-RPT-41918	Sections 3, 6, 5, and 7.2.4	Connelly, 2009	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
RPP-RPT-38152	Section 2.0	Seeley, 2008	Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation/Corrective Measures Study

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Input in the determination of important strategic issues,

Comment: The identification of feasible disposal concepts, the development of new disposal concepts or the choice of waste encapsulation technology so as not to prejudice final disposal.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Engineered Systems

How it Applies:

Major Issues:
Limited options for closure due to site selection in the 1940s
Buried Tanks, Pipelines, Ancillary Equipment with residual waste
Tanks Stabilized by grouting
If class C waste remains within 5 m of existing surface, requires either 5 m cap or an intruder barrier
Requires RCRA-compliant closure cap/barrier
Contamination in the vadose zone already present will continue to leach to groundwater

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918	Section 5	Connelly, 2009	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
RPP-RPT-44042	Section 4.4	Bergeron, et al. 2010	Recharge and Waste Release within the Engineered System in Waste Management Area C
RPP-RPT-46879	Section 4.3, 5.0	Fort et al. 2010	Corrosion and Structural Degradation within the Engineered System in Waste Management C

Related Features, Events, and Processes

Related FEP	Related FEP Title
2.1	Waste, Waste Form & Engineered Features
2.1.01	Inventory, waste
2.1.02	Waste form, characteristics and degradation processes

2.1.03	Container, characteristics and degradation/failure processes
2.1.04	Buffer/backfill, characteristics and degradation processes
2.1.05	Other engineered features, characteristics and degradation processes

Alternative Point of View

Regulator Comments

Definition: Develop an understanding of the safety assessment process

Comment: 1) Readiness for site-specific assessments
2) Experience in the behavior of the system
3) Identify and guide generic and site-specific research priorities

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Total System Perfomance

How it Applies: Total system performance
Phase 1 and Phase 2 characterization efforts
Retreival of Tank Waste

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-35484	Complete Docume	Connelly et. al.	Field Investigation Report for Waste Management Areas C and A-AX
RPP-PLAN-38777	Complete Document	Nguyen, D. M.	Sampling and Analysis Plan for Phase 2 Characterization of Vadose Zone Soil in Waste Management Area C
RPP-20699	Complete Docume	Nguyen, D. M.	Tank 241-C-106 Residual Waste Inventory Estimates for Component Closure Risk Assessment
RPP-RPT-29202	Complete Docume	Nguyen, D. M.	Tank 241-C-202 Residual Waste Inventory Estimates for Tank Component Closure Risk Assessment
RPP-RPT-29889	Complete Docume	Nguyen, D. M.	Tank 241-C-201 Residual Waste Inventory Estimates for Tank Component Closure Risk Assessment
RPP-RPT-32376	Complete Docume	Nguyen, D. M.	Tank 241-C-103 Residual Waste Inventory Estimates for Tank Component Closure Risk Assessment
RPP-RPT-33337	Complete Docume	Nguyen, D. M.	Tank 241-C-203 Residual Waste Inventory Estimates for Tank Component Closure Risk Assessment
RPP-PLAN-39114	Complete Document	Connelly et. al.	Phase 2 RCRA Facility Investigation/Corrective Measures Study Work Plan for Waste Management Area C
PNNL-14903	Complete Document	Deutsch, et. al.	Hanford Tanks 241-C-203 and 241-C-204: Residual Waste Contaminant Release Model and Supporting Data

PNNL-15187	Complete Docume	Deutsch, et. al.	Hanford Tank 241-C-106: Residual Waste Contaminant Release Model and Supporting Data
PNNL-15372	Complete Docume	Deutsch, et. al.	Advances in Geochemical Testing of Key Contaminants in Residual Hanford Tank Waste
PNNL-15544	Complete Docume	Deutsch, et. al.	: Impact of Cement Reactions on Release of Contaminants from Residual Waste
PNNL-16229	Complete Document	Deutsch, et. al.	Hanford Tanks 241-C-202 and 241-C-203: Residual Waste Contaminant Release Model and Supporting Data
PNNL-16738	Complete Docume	Cantrell, et. al.	Hanford Tank 241-C-103 Residual Waste Contaminant Release Models and Supporting Data
PNNL-19425	Complete Docume	Cantrell, et. al.	Hanford Site Tank 241-C-108 Residual Waste Contaminant Release Models and Supporting Data
DOE/ORP-2008	Complete Docume	Mann	RCRA Facility Investigation Report for Hanford Single-Shell Tank Waste Management Areas

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Support development of regulations for the management of radioactive waste

Comment: The safety assessment objectives may therefore include provision of broader supporting analyses of safety issues and development of regulatory guidance, or even the development of the regulations themselves.

Key Concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0098182** On: **6/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Does not apply, the WMA C PA will not be used to develop regulations or guidance

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Support permit and/or license application throughout the closure process

Comment: Some regulations are prescriptive in their form, giving relatively precise requirements and definitions, whereas others are more qualitative. In the latter case, the assessment context can be very important in helping to define how a quantitative assessment can be used to provide end-points to allow demonstration of compliance with qualitative criteria

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Total System Performance

How it Applies:
HFFACO Requirements
WAC 173-303 610 Closure Requirements
WAC 173-303 646 RCRA Corrective Action Requirements
WAC 173-340-700 to 760 Requirements Cleanup Levels
WAC 173-340-747 (8) Alternative Fate and Transport Models
DOE Order 435.1

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
HFFACO	Appendix I Secti	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order
WAC-173-303	610 (7)	Washington Administr	Dangerous Waste Regulations: Closure and post-closure (610)
WAC-173-303	646	Washington Administr	RCRA Corrective Action
WAC-173-340	700 - 760	Washington Administr	Cleanup Level Requirements
DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: To help develop guidelines to restrict the geographical areas considered for a disposal site, and to identified and compared potential sites

Comment:

Key Concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0098182** On: **6/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: Does not apply. Site selection was determined in the 1940's, cannot change the selection of the site today

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Provide input to the site characterisation programme, when a particular site has been chosen for further investigation.

Comment: Results from the assessments can help identify where better data are required for the site characterisation programme.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Engineering and Natural Systems

How it Applies: Site characterization has been ongoing for a number of years. This includes Phase 1 and Phase 2 vadose characterizations activities for RCRA Corrective Actions, routine monitoring of the groundwater, characterization of the residual waste (concentration and volume), and release rate studies.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-35484	Complete Docume	Connelly et. al.	Field Investigation Report for Waste Management Areas C and A-AX
RPP-PLAN-38777	Complete Document	Nguyen, D. M.	Sampling and Analysis Plan for Phase 2 Characterization of Vadose Zone Soil in Waste Management Area C
RPP-20699	Complete Docume	Nguyen, D. M.	Tank 241-C-106 Residual Waste Inventory Estimates for Component Closure Risk Assessment
RPP-RPT-29202	Complete Docume	Nguyen, D. M.	Tank 241-C-202 Residual Waste Inventory Estimates for Tank Component Closure Risk Assessment
RPP-RPT-29889	Complete Docume	Nguyen, D. M.	Tank 241-C-201 Residual Waste Inventory Estimates for Tank Component Closure Risk Assessment
RPP-RPT-32376	Complete Docume	Nguyen, D. M.	Tank 241-C-103 Residual Waste Inventory Estimates for Tank Component Closure Risk Assessment
RPP-RPT-33337	Complete Docume	Nguyen, D. M.	Tank 241-C-203 Residual Waste Inventory Estimates for Tank Component Closure Risk Assessment
RPP-PLAN-39114	Complete Document	Connelly et. al.	Phase 2 RCRA Facility Investigation/Corrective Measures Study Work Plan for Waste Management Area C
PNNL-14903	Complete Document	Deutsch, et. al.	Hanford Tanks 241-C-203 and 241-C-204: Residual Waste Contaminant Release Model and Supporting Data
PNNL-15187	Complete Docume	Deutsch, et. al.	Hanford Tank 241-C-106: Residual Waste Contaminant Release Model and Supporting Data
PNNL-15372	Complete Docume	Deutsch, et. al.	Advances in Geochemical Testing of Key Contaminants in Residual Hanford Tank Waste

PNNL-15544	Complete Docume	Deutsch, et. al.	: Impact of Cement Reactions on Release of Contaminants from Residual Waste
PNNL-16229	Complete Document	Deutsch, et. al.	Hanford Tanks 241-C-202 and 241-C-203: Residual Waste Contaminant Release Model and Supporting Data
PNNL-16738	Complete Docume	Cantrell, et. al.	Hanford Tank 241-C-103 Residual Waste Contaminant Release Models and Supporting Data
PNNL-19425	Complete Docume	Cantrell, et. al.	Hanford Site Tank 241-C-108 Residual Waste Contaminant Release Models and Supporting Data
DOE/ORP-2008	Complete Docume	Mann	RCRA Facility Investigation Report for Hanford Single-Shell Tank Waste Management Areas

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Develop and design the disposal concept that will optimise the cost but ensure sufficient levels of safety, following the identification of a suitable disposal site

Comment:

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: Closure Concepts

- Remove tank residual to the extent practicable
- Fill tanks and diversion boxes with grout
- Remove contaminated soil hot spots
- At a minimum, place a RCRA-compliant barrier or cap over the site, however lead agencies may decide on a more robust cap.
- Address Deep Vadose Contamination
- Other?

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Address the interests of local people with particular behaviour patterns, who wish to see the implications of those behaviour patterns addressed, whether they are critical or not.

Comment: The key issue is that public interests may be wider than those of regulator bodies. It is therefore important to recognise which additional factors should be addressed to meet that interest at the outset of the safety assessment, not half way through the programme. In the case of policy makers and the scientific community, they may have specific and different interests from those of the general public. A more detailed assessment might be required to address concerns here.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Total system performance

How it Applies: Scoping meetings which involve other interested parties besides the lead agencies and transparency in generating results

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Ensure that living organisms are not adversely affected by radioactive waste disposed in near-surface disposal facilities is the specification of requirements for the acceptance of waste at a near-surface disposal facility as part of a comprehensive waste management system.

Comment: Waste acceptance criteria can either be generically specified by the regulatory body or developed by the operator on the basis of either generic studies or site specific safety assessments, with account taken of appropriate radiological criteria, the conditions of operations, the planned duration of active institutional controls and the required characteristics of natural and engineered systems.

Distinction can be made between qualitative and quantitative requirements for the acceptance of waste at a near-surface disposal facility. The derivation of quantitative waste acceptance requirement set limits on the total activity and the activity concentration of radioactive waste to be disposed in a disposal facility to ensure compliance with regulatory criteria

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Inventory

How it Applies: The closed WMA C represents an operational facility being closed under RCRA and not a newly constructed disposal facility. Therefore the concept of waste acceptance critieria does not specifically apply. However, it might be said that it does apply through the use of Appendix H of HFFACO for the volume of material left in the single-shell tanks. This criteria is being considered to evaluate the amount of residuals left in tanks and ancillary equipment and other corrective measures related to existing soil contamination in the vadose zone and ground water.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
HFFACO	Appendix H	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Regulatory Authority needs to be satisfied that good engineering practice has been used in developing proposals for design, construction, operation, closure or post-closure of the facility and that good science has been applied in investigating the suitability of the site, in supporting research and development work, in the interpretation of the resulting data and the safety assessment methodologies used.

Comment: Regulatory Authority must be in a position to understand the safety case presented and evaluate the adequacy of the supporting safety assessments. This requires a systematic evaluation of the safety case and supporting assessments.

Key Concepts, Examples and Related FEPs

Regulatory Authority may require review of safety assessments for licensed radioactive waste disposal facilities in order to

- evaluate the current status of disposal facilities and make comparison with the original safety case, and in some cases with the purpose of upgrading the safety;
- identify tendencies for the development of the facility;
- update the safety case in compliance with the latest safety requirements and criteria, incorporating state of the art safety assessment methodologies, use of modelling approaches and computer codes; and
- evaluate the impact on the safety of the facility of natural and human induced changes on the disposal facility system and its environment.

Applies to WMA **Yes** Entered By: **h0098182** On: **6/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Total System Performance

How it Applies: Expected that the performance assessment will be reviewed by Ecology, EPA, and DOE. Comments will be received and addressed

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: To support corrective measures following facility or site failure and consequent decommissioning of the facility or site.

Comment: This is slightly different application of the safety assessment process than for corrective action - where the focus is to improve the safety of the facility - mainly because the facility and its content will be removed to restore the site to a greenfields area. Safety assessment is used to decide to what levels the site should be cleaned to ensure regulatory compliance

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: WMA C has contaminated hot spots, they may be removed prior to closure. This is being evaluated as part of the Phase 2 RCRA Facility Investigation/Corrective Measure Study

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Continue evaluation of the facility

Comment: A large number of near-surface disposal facilities have been developed during the last forty years. These facilities have been constructed, operated, upgraded or closed according to various safety standards, requirements and criteria, while safety assessments have been conducted at varying levels of completeness and quality.

Key Concepts, Examples and Related FEPs

Other, often older facilities may have had assessments conducted that are no longer considered adequate by present day standards. Furthermore, at some of these facilities, disposal practices have been conducted that may not meet modern concepts of safety, and consideration must be given to corrective measures and the future use of these facilities. Examples of cases where reassessment will be performed include:

- the safety of the existing facility has not yet been demonstrated;
- no safety assessment has been performed;
- the safety of the facility has been questioned because revisions to the operating conditions have been proposed; or
- a periodic review and update of the safety assessment is required by the regulator.

Applies to WMA **Yes** Entered By: **h0098182** On: **6/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Total System Performance

How it Applies: Post-closure monitoring of the facility following closure is required under both WAC 173-303 610 (7), DOE O 435.1 Chapter 4, and CERCLA Comprehensive Five-Year Review

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
WAC-173-303	610 (7)	Washington Administr	Dangerous Waste Regulations: Closure and post-closure (610)
DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual
OSWER No. 93	Complete Docume	EPA	Comprehensive Five-Year Review Guidance

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the regulatory requirements, conditions and criteria in national regulation or guidance associated with all stages of the development of near-surface radioactive waste disposal facilities that will have an influence on the post-closure safety assessment.

Comment: International guidance on the regulation of radioactive waste can be found in IAEA and ICRP related documents. In most cases, however, the regulatory framework will be based on national regulation. This includes regulations related to both the radiological component and the non-radiological component of a disposal system. Generally, the regulatory framework may be expressed in terms of the following:

1) Principles for the protection of human health and the environment
2) Measures to be taken during the different phases of disposal (e.g. pre-operation, operational, post-closure)
3) Assumptions regarding the definition of exposure groups and their behaviour, and
4) Technical requirements applicable to the development of a safety case for the disposal facility.

In some regulations, the exposure scenarios to be assessed are specified, or some scenarios or events are specifically ruled out of consideration.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **3/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: 1) Principals for the the protection of human health and the environment are given in the regulations from Washington Department of Ecology, EPA, and DOE

- WAC 173-303-610, CERCLA (RAGS), and DOE G 435.1 provide regulations and guidance on closure and post-closure activities.
- WAC 173-303-646 RCRA corrective actions invoke WAC-173-340 for selection of clean-up actions and standards that go along with the cleanup actions
- Summary of the regulations (Ecology), guidance (EPA, DOE) concening human health are given in RPP-RPT-47479 *Exposure Scenarios for the Waste Management Area C Performance Assessment* Section 3.0.

2) Measures to be take during the different phases of disposal (e.g. pre-operation, operational, post-closure)

- WMA C is presently an operating facility and management of short term risks to workers are required under 10 CFR 851 Worker Safety and Health Program; 10 CFR 830 Department of Energy Nuclear Safety Management; 10 CFR 835 Occupational Radiation Protection. These regulations are flow down into the contracts for DOE's contractors, because of these flow down requirements,

this performance assessment will no evaluate short-term risk to workers.

- Post-closure actions will be governed by the state permit, the RCRA Closure Plan, DOE Closure Plan, and the post-closure monitoring plan required under both WAC 173-303 Dangerous Regulations and DOE O 435.1

3) Assumptions regarding the definition of exposure groups and their behaviors is given in Chapters 3 and 5 of RPP-RPT-47479 and include

- WAC-173-340 Residential
- WAC-173-340 Industrial
- CERCLA to be consistent with what is being done elsewhere on the Central Plateau to meet CERCLA requirements
- Native American Umatilla
- Native American Yakama
- DOE All-Pathways Farmer
- DOE Inadvertent Intruder Well-Driller
- DOE Inadvertent Intruder Farmer with Pasture
- DOE Inadvertent Intruder Industrial Farmer
- DOE Air Pathway including Radon
- Other scenarios as they are provided to us

4) Technical Requirements (for purpose of analysis Landfill Closure is assumed)

- WAC 173-303-610 Closure and post-closure (7) Post-closure care and use of property
    1. Groundwater monitoring
    2. Maintenance and monitoring of waste containment systems
    3. Continuation of Security Requirements
    4. Closure Plan
    5. State Permit
- WAC 173-303-665 Landfills (6) Closure and Post-Closure
    1. Cover installation
    2. Maintenance and monitoring of cover
    3. Leak detection
    4. Groundwater monitoring
- WAC 173-303-646 RCRA Corrective Action
    1. WAC 173-340-350,-360 (State RI/FS, selection of cleanup action)
    2. WAC 173-340-400 (Site Cleanup and Monitoring)
    3. WAC 173-700 (Cleanup Standards)
- DOE 435.1 Requirements Chapter IV Low Level Waste Requirements
    1. Waste Characterization
    2. Site Evaluation and Facility Design
    3. Disposal
        - Performance Assessment
        - Composite Analysis
        - Performance Assessment and Composite Analysis Maintenance

- Disposal Authorization

4. Closure and Closure Plans
5. Post Closure Monitoring

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
WAC-173-303	610, 646, 665	Washington Administrative Code	Dangerous Waste Regulations: Closure and post-closure (610); Corrective Action (646); Landfills (665)
WAC-173-340	350, 360, 400 an	Washington Administr	Model Toxics Control Act Cleanup Regulation
DOE G 435.1	Chapter 4	DOE	Implementation Guide for use with DOE M 435.1-1 Chapter 4 Low-Level Waste Requirements
EPA/540/1 89/		EPA	Risk Assessment Guidance for Superfund Volume II Environmental Evaluation Manual Interim Final
EPA/540/1 89/		EPA	Risk Assessment Guidance for Superfund Volume I Environmental Evaluation Manual Interim Final
RPP-RPT-47479			Exposure Scenarios for the Waste Management Area C Performance Assessment

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the regulatory requirements and criteria for the protection of human health and the environment during the lifetime of the near-surface disposal facility and that would have an influence on the post-closure safety assessment.

Comment: Many of the hazards associated with the disposal of radioactive waste are similar to those associated with toxic waste forms (e.g. mining and chemical plant operations) and should be controlled. However, the nature of radioactive waste implies another hazard, namely the possibility of exposure to ionising radiation. An acceptable level of protection therefore needs to be provided, with particular attention to controlling the various ways by which humans might be exposed to radiation, and to ensure that such exposure is within established national requirements.

Generally, the regulatory body has the duty to ensure that all radioactive waste disposal activities are undertaken so as to safeguard the interest of present and future generations, as well as the wider environment. This requires the implementation of the basic components of radiation protection for practices (human activities that cause an increase in exposure), i.e.: justification of the practice; optimisation of protection; and limitation of individual doses. As waste management in general is an integral part of the practice generating the radioactive waste, it does not need to be justified separately.

Key Concepts, Examples and Related FEPs

1) **Optimisation:** A requirement that the radiological detriment to members of the public that may result from the near-surface disposal of radioactive waste should be as low as reasonably achievable (ALARA), economic and social factors being accounted for. Note, however, that ALARA principles cannot be rigorously applied to post-closure safety, since the notion of population dose is poorly defined for future populations.

2) **Independence of safety from controls:** A requirement that following the disposal of radioactive waste, the closure of the disposal facility and the withdrawal of controls, the continued isolation of the waste from the accessible environment should not depend on actions by future generations to maintain the integrity of the disposal system (see FEP 0.2.03). The practical implication of this principle is that the overall degree of containment provided by the near-surface disposal system after closure is such that the continued safety of future generations does not depend on control measures (e.g. monitoring, surveillance, preventative actions) after the time when control of the facility is withdrawn (see FEP 0.2.03).

3) **Effects in the future:** A requirement that radioactive waste should be managed in such a way that predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today. According to this principle, the risks to future individuals following the implementation of a near-surface disposal concept shall be limited on the same basis as are those to individuals living now. Therefore, the level of protection to be afforded to future generations should not be less than that provided today.

4) **Radiological protection standards:** Standards for the protection of human health following the closure of a near-surface radioactive waste disposal facility and that is consistent with the assessment endpoints (see FEP 0.4.06). Distinction can be made between radiological protection standards applied to scenarios representing natural processes and standards applied to human intrusion. The term "natural processes" includes all the processes that lead to the exposure of individuals other than human intrusion. For normal exposures the radiological protection standard is normally some fraction of the dose limit (1 mSv y-1), defined as the dose constraint (e.g. in the order of 0.1 mSv y-1 and 0.3 mSv y-1). Human intrusion exposures lower than 10 mSv y-1 should not warrant further consideration (e.g. intervention). Conversely, human intrusion exposures of around 100 mSv y-1 should almost always justified intervention.

5) **Environmental protection standards:** Standards that could be applied for the protection of the environment following the closure of a near-surface radioactive waste disposal facility and that is consistent with the assessment endpoints (see FEP 0.4.06). In the past no standards were set to control the undesirable build-up of radioactivity in the accessible environment. For this purpose, it was assumed that the standard of environmental control needed to protect human beings to the degree currently thought desirable would ensure that other species are not put at risk. Occasionally, individual members of non-human species might be harmed, but not to the extent of endangering whole species or creating imbalance between species. Whilst the above assertion is not necessarily incorrect, increased interest in

such measures has been shown internationally in recent years.
6) **Non-radiological protection standards:** Non-radiological protection standards that could be applied for the protection of human health and the environment following the closure of a near-surface radioactive waste disposal facility and that is consistent with the assessment endpoints (see FEP 0.4.06). Non-radiological protection standards are applicable to both the non-radiological components present in conventional radioactive waste disposal systems, as well as the non-radiological components associated with hazardous waste disposal systems, such as those for mining and mineral processing waste

Applies to WMA **Yes** Entered By: **h0098182** On: **6/2/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Exposure

How it Applies: Comparison against cleanup standards, risk, and dose.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
WAC 173-340	700	Washington Administr	Model Toxics Control Act Cleanup Regulation
DOE O 435.1	Chapter 4	DOE	Radioactive Waste Management
40 CFR Part 141	Sections 50 - 66	EPA	National Primary Drinking Water Regulations

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: A requirement that the radiological detriment to members of the public that may result from the near-surface disposal of radioactive waste should be as low as reasonably achievable (ALARA), economic and social factors being accounted for.

Comment: ALARA principles cannot be rigorously applied to post-closure safety, since the notion of population dose is poorly defined for future populations.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Engineering Systems

How it Applies:
1) Removal of tank residual to the extent practicable
2) possible removal of surface and near-surface contamination
3) possible deployment of deep vadose zone treatment technology provided source in deep vadose zone is found

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
HFFACO	Appendix H	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order
			Corrective Measure Study (awaiting results from the sampling)

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: A requirement that following the disposal of radioactive waste, the closure of the disposal facility and the withdrawal of controls, the continued isolation of the waste from the accessible environment should not depend on actions by future generations to maintain the integrity of the disposal system (see FEP 0.2.03).

Comment: The practical implication of this principle is that the overall degree of containment provided by the near-surface disposal system after closure is such that the continued safety of future generations does not depend on control measures (e.g. monitoring, surveillance, preventative actions) after the time when control of the facility is withdrawn (see FEP 0.2.03).

Key Concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0098182** On: **6/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: This does not apply at WMA C, because WMA C is already over regulatory standards and has to be monitored in perpetuity as long as waste remains at the site. The monitoring is required by
WAC 173-303-610 (7) Post Closure Care and Use of Property
DOE P 454.1 Institutional Controls
CERCLA Comprehensive Five-Year Review

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
WAC 173-303	610 (7)	Washington Administr	Dangerous Waste Regulations
DOE P 454.1	Page 4	DOE	Institutional Controls
OSWER No. 93	Complete Docume	EPA	Comprehensive Five-Year Review Guidance

Related Features, Events, and Processes

Related FEP	Related FEP Title
0.2.03	Technical Requirements

Alternative Point of View

Regulator Comments

Definition: Radioactive waste should be managed in such a way that predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today.

Comment: Risks to future individuals following the implementation of a near-surface disposal concept shall be limited on the same basis as are those to individuals living now. Therefore, the level of protection to be afforded to future generations should not be less than that provided today.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/2/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: WMA C will be evaluated against existing performance objectives as defined by WAC 173-340, EPA, and DOE O 435.1

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
WAC 173-340	700 - 760	Washington Administr	Model Toxics Control Act Cleanup Regulation
DOE O 435.1	Chapter 4	DOE	Radioactive Waste Management
40 CFR Part 141	Sections 50 - 66	EPA	National Primary Drinking Water Regulations

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Standards for the protection of human health following the closure of a near-surface radioactive waste disposal facility and that is consistent with the assessment endpoints

Comment: Distinction can be made between radiological protection standards applied to scenarios representing natural processes and standards applied to human intrusion. The term "natural processes" includes all the processes that lead to the exposure of individuals other than human intrusion. For normal exposures the radiological protection standard is normally some fraction of the dose limit (1 mSv y-1), defined as the dose constraint (e.g. in the order of 0.1 mSv y-1 and 0.3 mSv y-1). Human intrusion exposures lower than 10 mSv y-1 should not warrant further consideration (e.g. intervention). Conversely, human intrusion exposures of around 100 mSv y-1 should almost always justified intervention.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Exposure

How it Applies: Comparison is made against radiological standards protective of human health and the environment

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
DOE O 435.1	Chapter 4	DOE	Radioactive Waste Management
40 CFR Part 141	Sections 50 - 66	EPA	National Primary Drinking Water Regulations

Related Features, Events, and Processes

Related FEP	Related FEP Title
0.4.06	Assessment Endpoints

Alternative Point of View

Regulator Comments

Definition: Standards that could be applied for the protection of the environment following the closure of a near-surface radioactive waste disposal facility and that is consistent with the assessment endpoints

Comment: In the past no standards were set to control the undesirable build-up of radioactivity in the accessible environment. For this purpose, it was assumed that the standard of environmental control needed to protect human beings to the degree currently thought desirable would ensure that other species are not put at risk. Occasionally, individual members of non-human species might be harmed, but not to the extent of endangering whole species or creating imbalance between species. Whilst the above assertion is not necessarily incorrect, increased interest in such measures has been shown internationally in recent years.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Expsoure

How it Applies: Ecological Risk is a part of the baseline risk assessment and will be evaluated. See WAC 173-340 7490 through 7494.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
WAC 173-340	7490 - 7494	Washington Administr	Model Toxics Control Act Cleanup Regulation

Related Features, Events, and Processes

Related FEP	Related FEP Title
0.4.06	Assessment Endpoints

Alternative Point of View

Regulator Comments

Definition: Non-radiological protection standards for the protection of human health following the closure of a near-surface radioactive waste disposal facility and that is consistent with the assessment endpoints

Comment: Non-radiological protection standards are applicable to both the non-radiological components present in conventional radioactive waste disposal systems, as well as the non-radiological components associated with hazardous waste disposal systems, such as those for used to separate out isotopes for DOE

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/2/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Exposure

How it Applies: Hazardous waste was stored at WMA C and the non-radiological components have to be compared against the standards listed in WAC 173-340, clean water act, safe drinking water act, and clean air act.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
WAC 173-340	700 - 760	Washington Administr	Model Toxics Control Act Cleanup Regulation
40 CFR Part 141	Sections 50 - 66	EPA	National Primary Drinking Water Regulations

Related Features, Events, and Processes

Related FEP	Related FEP Title
0.4.06	Assessment Endpoints

Alternative Point of View

Regulator Comments

Definition: The different phases (time periods) associated with the disposal of radioactive waste in a near-surface disposal facility that will have a direct or indirect influence on the post-closure safety assessment.

Comment: The phases in the life-cycle of a near-surface radioactive waste disposal facility that could have direct or indirect influence on the post-closure safety assessment can be divided into a pre-operational period, operational period and a post-closure period, with interdependencies that exists between the different phases that need to be taken into consideration in the assessment.

Key Concepts, Examples and Related FEPs

1. **Pre-operational period**: Activities during the pre-operational period includes concept definition, environmental impact assessments, site selection, site investigation, design studies, the development of safety cases for operational and long term safety to obtain the authorization to proceed with the construction of the near-surface disposal facility and the initial construction activities.
2. **Operational period:** The operational period is the period from the moment the site is developed until it is closed. Although a post-closure safety assessment does not explicitly consider the activities of the operational period, interdependencies exists between the two period that need to be taken into consideration, since it might have an influence on the performance of the facility following the closure of the facility.
3. **Post-closure period:** The post-closure period is the period that begins the moment the site is closed. The post-closure period can be divided into the following periods:
    1. Institutional control period, when controls at the facility and its use are in place
    2. Post-institutional control period, when such controls are no longer in place

Applies to WMA **Yes** Entered By: **h0098182** On: **6/2/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Pre-Closure Conceptual Model

How it Applies: WMA C is different than most mixed LLW waste disposal facilities because it has been in use for nearly 70 years.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Activities during the pre-operational period includes concept definition, environmental impact assessments, site selection, site investigation, design studies, the development of safety cases for operational and long term safety to obtain the authorization to proceed with the construction of the near-surface disposal facility and the initial construction activities.

Comment:

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/2/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Natural Systems

How it Applies: The pre-operational period at WMA C occurred before 1944. WMA C was built in 1944. The pre-operational period is used to set initial conditions for any modeling activity based on the available data collected before 1944.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: The operational period is the period from the moment the site is developed until it is closed. Although a post-closure safety assessment does not explicitly consider the activities of the operational period, interdependencies exists between the two period that need to be taken into consideration, since it might have an influence on the performance of the facility following the closure of the facility.

Comment:

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **7/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	Operational period will be covered by the Pre-Closure Period denominator/sensitivity cases as defined in Appendix B Section B.1

Conceptual Site Model Inventory

How it Applies: The operational period for WMA C is from 1945 to 2019? (the scheduled closure date). From the late 1940's to the 1980's, the tanks in WMA C received waste from the production facilities. During that period of time there have been a number of unplanned releases to the enviroment resulting in groundwater contamination. There is a ongoing effort to determine the volume and concentration (i.e. inventory) of contaminants in the fluids of those known unplanned releases. Additionally, there maybe releases in which there is no documentation (i.e. a buried pipeline).

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490	Section B.1	Bergeron, 2010	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: The post-closure period is the period that begins the moment the site is closed. The post-closure period can be divided into the following periods:

- Institutional control period, when controls at the facility and its use are in place
- Post-institutional control period, when such controls are no longer in place

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	Closure period will be covered by the Post-Closure denominator/sensitivity cases as defined in Section B.2 of RPP-RPT-48490

Conceptual Site Model

How it Applies: Because WMA C is already exceeding standards, controls will last as long as there is hazardous/radioactive waste in place.
Monitoring is required by
WAC 173-303-610 (7) Post Closure Care and Use of Property
DOE P 454.1 Institutional Controls
CERCLA 5 Year Review

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
OSWER No. 93	Complete Docume	EPA	Comprehensive Five-Year Review Guidance
WAC-173-303	610 (7)	Washington Administr	Dangerous Waste Regulations: Closure and post-closure (610)
DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual
RPP-RPT-48490	Section B.2	Bergeron, 2010	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to technical requirements to be considered in the development of a post-closure safety case for a near-surface radioactive waste disposal facility.

Comment: In the development of a safety case for a disposal system it is necessary to consider the overall system, comprising of the environmental system and its surrounding, the physical structures of the facility, the waste and their characteristics as well as a demonstration of good principles for managing the facility during the pre-closure period and post-closure institutional control period. The regulatory body might expect the developer to address these requirements in the safety case as a demonstration of good practice.

Key Concepts, Examples and Related FEPs

1. **Multi-factor safety function:** A requirement that the natural and engineered barriers shall be selected and designed to ensure long-term safety by means of multiple safety functions. That is, multiple barriers whose performance is achieved by diverse physical and chemical processes should provide the necessary safety for the facility. The implication of this requirement is that the strength of each component of the safety case must be demonstrated. It should be shown that, even with an adverse interpretation of any given aspect of the evidence taken in isolation, the overall system performance would still provide acceptable assurance of safety and not display "cliff-edge" effects (i.e. sudden or rapid deterioration).
2. **Isolation**: A requirement that the waste and its associated hazard should be kept away from the biosphere and resources used by humans, and also making it difficult for people to gain access to the waste. For disposal depths below those of normal human activities (typically 30 m) isolation is primarily provided by the geosphere. However, for depths closer to the surface, institutional control becomes increasingly important as a safety function. Near-surface disposal facilities can provide a period of isolation, which may be up to some tens of years or maybe hundreds to thousands of years. The degree of isolation required depends on the concentrations and half-lives of radionuclides present in the wastes, among other factors. The time at which peak doses appear depends not only on the half-life of the radionuclides, but also on the expected travel time.
3. **Containment**: A requirement that the combination of engineered and natural barriers should provide a high level of containment of the radionuclides for a period commensurate with the hazard posed by the waste. Containment refers to the prevention of radionuclide migration such that they remain within or close to the engineered barriers for a sufficient length of time. The containment of the waste over an initial period ensures that the majority of shorter-lived radionuclides will decay in situ.
4. **Site characterisation:** A requirement that the site shall be characterized at a sufficient level of detail to support both a general understanding of the site, its past evolution and likely future natural evolution over the period of interest for safety, and a specific understanding of the impact on safety of features, events and processes associated with the site and the disposal facility. The implication of this requirement is that the developer should establish a reasoned approach to investigation of the site in terms of, for example, the geological and hydrogeological environment, the chemical, geochemical and physio-chemical conditions, or any other site property that might influence the performance of the site.
5. **Facility design:** A requirement that the disposal facility and its engineered barriers should be designed to contain the waste and its associated hazard, to be physically and chemically compatible with the geological environment and to provide long term safety functions which complement those offered by the site. The facility and engineered barriers should also be designed with a view to ensuring safety in the operational period.
6. **Facility construction:** A requirement that the disposal facility should be constructed according to the assessed design and so as to preserve the long term safety functions of the natural barrier shown to be important by the safety case. The construction should also be carried with a view to ensuring safety during the operational period.
7. **Waste acceptance requirements and criteria:** A requirement that the waste and waste packages accepted for disposal should conform to requirements and criteria consistent with the operational and long-term safety cases for the disposal facility. The waste should be in a solid form with stable chemical and physical properties providing for the retention of radionuclides.

8. Distinction can be made between qualitative and quantitative waste acceptance criteria, both of which refer to waste form and characteristic factors that can affect the performance of the disposal system before and after disposal. Qualitative waste acceptance criteria specify the conditions and requirements on the thermal, physical, chemical, biological and mechanical properties of the waste, the waste form and the waste package. These criteria should ensure adequate performance during operational activities (e.g. handling and transport) and following the closure of the facility. Quantitative waste acceptance criteria sets limits on the total activity, the activity per waste package and activity per mass that can be accepted at a facility.
9. **Monitoring:** A requirement that, in support of the safety case, a programme of monitoring should be defined and carried out prior to and during the operation of the disposal facility. This should be designed to monitor for changes caused by construction of the facility and emplacement of the waste and also to confirm the conditions necessary for the safety of workers and members of the public and protection of environment during the operation of the disposal facility and to confirm the absence of conditions that would undermine the long term safety of the disposal facility. The implication of this requirement is that the developer will need to establish a reasoned approach to monitoring of the site and facility and a programme for its implementation. The monitoring programme should not compromise the long-term safety of the facility.
10. **System of records:** A requirement that the developer should set up and maintain a comprehensive system of records for the recording of detailed information on all aspects of the project affecting the safety case. The information to be recorded should include data and results from the site investigation and characterisation programme, design documents, drawings and detail of the engineering construction of the facility, records of waste emplacements and their location in the facility, operational information and results of monitoring at all stages of the project.
11. **Quality assurance**: A requirement that the developer should establish a comprehensive quality assurance programme for all activities affecting the safety case. This should include supporting activities such as research and assessment. All activities associated with a project to develop and operate a disposal facility will need to be planned carefully and implemented within a systematic programme of quality assurance in order to ensure that all the technical requirements will be met.
12. **Natural analogues**: A requirement that the information derived from natural analogue studies should be used to increase stakeholder confidence in the post-closure safety assessment results. Natural and man-made analogues to disposal systems and/or components of disposal systems have been studied so that the results of observations may be compared with the performance of disposal facility components or processes expected to take place in a disposal system. Analogues can be used for a number of purposes:
    1. Highlighting the similarity of materials, radionuclides and processes between the disposal system and analogue systems thereby demonstrating that none of the components of a disposal system are beyond man's experience.
    2. Presenting the expected evolution of the disposal system.
    3. Justifying the choice of features, events and processes (FEPs) and scenarios analysed in the assessment.
    4. Aiding in the development of conceptual models and associated processes because, by investigating the processes that operate in analogue systems, it is possible to learn about the key processes which can influence radionuclide behaviour, and which should therefore be represented in assessment models.
    5. Providing quantitative data to satisfy the parameter (data) requirements of the codes;
    6. Acting as test-beds for model validation by providing sites with relevant physico-chemical conditions where the codes can be used in a realistic fashion in attempts to simulate actual measured conditions.
13. **Peer review (regulatory and international)**: A requirement that the safety assessment should be subject to a rigorous peer review processes as part of developing a comprehensive and defensible safety case for a near-surface radioactive waste disposal facility. Peer review is a key component in building confidence. It should be undertaken to ensure that the assessment meets certain requirements such as the use of: good science; transparent and logical reasoning; factual data; appropriate quality assurance; multiple lines of reasoning; clear presentation of results. The most rigorous form of scrutiny is to carry out independent assessments and to use a variety of approaches and models. However, the necessary resources might not always be available to allow independent assessments, nor might it be appropriate for the purpose of the assessment. Distinction can be made between a regulatory peer review, international peer reviews and other (e.g. academic) peer reviews.

Applies to WMA	**Yes**	Entered By:	**h0006384**	On:	**6/1/2011**	Reviewed By		On:	

Denominator/Sensitivity Case(s):	At a high level, this will be covered by the Post-Closure denominator/sensitivity cases as defined in Section B.2 of RPP-RPT-484

Conceptual Site Model

How it Applies:

The initial WMA C PA will need to meet some aspects of all of the categories of requirements defined herein that include:

- Multi-safety Factor functions
- Isolation
- Containment
- Site characterization
- Facility Design
- Facility Construction
- Waste Acceptance Requirements and Criteria
- Monitoring
- System of Records
- Quality Assurnace
- Natural Analogues
- Peer Review (regulatory and international)

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490	Section B.2	Bergeron, 2010	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: A requirement that the natural and engineered barriers shall be selected and designed to ensure long-term safety by means of multiple safety functions.

Comment: That is, multiple barriers whose performance is achieved by diverse physical and chemical processes should provide the necessary safety for the facility. The implication of this requirement is that the strength of each component of the safety case must be demonstrated. It should be shown that, even with an adverse interpretation of any given aspect of the evidence taken in isolation, the overall system performance would still provide acceptable assurance of safety and not display "cliff-edge" effects (i.e. sudden or rapid deterioration).

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **6/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s): At a high level, this will be covered by the Post-Closure denominator/sensitivity cases as defined in Section B.2 of RPP-RPT-484

Conceptual Site Model Engineered System

How it Applies: Analysis of the closed WMA C will evaluate impacts of multiple components of both natural and engineered systems of long-term performance and closed facility safety. The components of the natural system were not necessarily selected and/or designed for the WMA C since it was an operational facility that is being closed under RCRA. However, the natural system is being considered in the selection of the engineered system components for the closed facilities.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5.0	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
RPP-RPT-44042	Sections 4 and 5	Bergeron et al. 2010	Recharge and Waste Release within Engineered System in Waste Management Area C
RPP-RPT-46879	Sections 3, 4, an	Fort et al 2010	Corrosion and Structural Degradation within Engineered System in Waste Management Area C
RPP-RPT-46088	Sections 3, 4, 5,	Bergeron et al. 2010	Flow and Transport in the Natural System at Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: A requirement that the waste and its associated hazard should be kept away from the biosphere and resources used by humans, and also making it difficult for people to gain access to the waste.

Comment: For disposal depths below those of normal human activities (typically 30 m) isolation is primarily provided by the geosphere. However, for depths closer to the surface, institutional control becomes increasingly important as a safety function. Near-surface disposal facilities can provide a period of isolation, which may be up to some tens of years or maybe hundreds to thousands of years. The degree of isolation required depends on the concentrations and half-lives of radionuclides present in the wastes, among other factors. The time at which peak doses appear depends not only on the half-life of the radionuclides, but also on the expected travel time.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **6/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Engineered System

How it Applies: The closure concepts being considered in WMA C include the both institutional controls and the isolation of the waste residuals left in tanks, pipelines, and ancillary facilities and surface soil contamination with a suitable engineered surface barrier thickness and design to preclude inadvertant intrusion by normal human activities. The engineered system will also consider the emplacement of grout in tanks and larger ancillary facilities to provide structural stability and to add further protection from human contact from waste residuals left in place.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5.0	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
RPP-RPT-44042	Section 4 and 5	Bergeron et al. 2010	Recharge and Waste Release within Engineered System in Waste Management Area C
RPP-RPT-46879	Sections 4, 5, an	Fort et al. 2010	Corrosion and Structural Degradation within Engineered System in Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: A requirement that the combination of engineered and natural barriers should provide a high level of containment of the radionuclides for a period commensurate with the hazard posed by the waste.

Comment: Containment refers to the prevention of radionuclide migration such that they remain within or close to the engineered barriers for a sufficient length of time. The containment of the waste over an initial period ensures that the majority of shorter-lived radionuclides will decay in situ.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **6/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Engineered System

How it Applies: Concepts being considered in the analysis of a closed WMA C include both institutional controls and the containment of the waste residuals left in tanks, pipelines, ad ancillary facilities and surface soil contamination with a suitable engineered surface barrier thickness and design to preclude or significantly delay an early release of contaminants from the closed facilities . The engineered system will also consider the emplacement of grout in tanks and larger ancillary facilities to provide structural stability and limit contaminant releases from waste residuals left in place until the majority of shorter-lived radionuclide inventories decay in situ.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0		Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
RPP-RPT-42042		Bergeron et al. 2010	Recharge and Waste Release within Engineered System in Waste Management Area C
RPP-RPT-46879		Fort et al 2010	Corrosion and Structural Degradation within Engineered System in Waste Management Area C
HFFACO	Appendix H	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: A requirement that the site shall be characterized at a sufficient level of detail to support both a general understanding of the site, its past evolution and likely future natural evolution over the period of interest for safety, and a specific understanding of the impact on safety of features, events and processes associated with the site and the disposal facility.

Comment: The implication of this requirement is that the developer should establish a reasoned approach to investigation of the site in terms of, for example, the geological and hydrogeological environment, the chemical, geochemical and physio-chemical conditions, or any other site property that might influence the performance of the site.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **6/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Natural System

How it Applies: Characterization of the geological and hydrogeological environment, the chemical, geochemical and physio-chemical conditions, or other site properties that might influence the performance of the closed WMA C has been ongoing. The work plan for the current Phase 2 Characterization efforts represents a reasoned apporach based on the DQO process that solicited input from DOE, regulators, other site contractors, and other stakeholder groups. This work is slated to be completed in FY 2013.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-38152	Section 2 through 8	Seeley 2008	Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation/Corrective Measures Study
RPP-RPT-39114	Entire Document	Connelly 2008	Phase 2 RCRA Facility Investigation/Corrective Measures Study Work Plan for Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: A requirement that the disposal facility and its engineered barriers should be designed to contain the waste and its associated hazard, to be physically and chemically compatible with the geological environment and to provide long term safety functions which complement those offered by the site.

Comment: The facility and engineered barriers should also be designed with a view to ensuring safety in the operational period.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **6/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Engineered System

How it Applies: The closure concepts being considered in WMA C include the both institutional controls and the isolation of the waste residuals left in tanks, pipelines, and ancillary facilities and surface soil contamination with a suitable engineered surface barrier thickness and design to preclude inadvertant intrusion by normal human activities. The engineered system will also consider the emplacement of grout in tanks and larger ancillary facilities to provide structural stability and to add further protection from human contact with waste residuals left in place.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0		Connelly et al 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
RPP-RPT-42042		Bergeron et al. 2010	Recharge and Waste Release within Engineered System in Waste Management Area C
RPP-RPT-46879		Fort et al. 2010	Corrosion and Structural Degradation within Engineered System in Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: A requirement that the disposal facility should be constructed according to the assessed design and so as to preserve the long term safety functions of the natural barrier shown to be important by the safety case.

Comment: The construction should also be carried with a view to ensuring safety during the operational period.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **6/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Engineered System

How it Applies: The closed WMA C represents an operational facility being closed under RCRA and, although some aspects of the closed WMA C will involve some construction, this facility is not considered in the same class as a newly constructed disposal facility. This specific aspect is not deemed to apply.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: A requirement that the waste and waste packages accepted for disposal should conform to requirements and criteria consistent with the operational and long-term safety cases for the disposal facility.

Comment: The waste should be in a solid form with stable chemical and physical properties providing for the retention of radionuclides. Distinction can be made between qualitative and quantitative waste acceptance criteria, both of which refer to waste form and characteristic factors that can affect the performance of the disposal system before and after disposal. Qualitative waste acceptance criteria specify the conditions and requirements on the thermal, physical, chemical, biological and mechanical properties of the waste, the waste form and the waste package. These criteria should ensure adequate performance during operational activities (e.g. handling and transport) and following the closure of the facility. Quantitative waste acceptance criteria sets limits on the total activity, the activity per waste package and activity per mass that can be accepted at a facility.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Engineered System

How it Applies: The closed WMA C represents an operational facility being closed under RCRA and not a newly constructed disposal facility. Therefore the concept of waste acceptance critieria does not specifically apply. However, it might be said that it does apply through the use of Appendix H of HFFACO for the volume of material left in the single-shell tanks. This criteria is being considered to evaluate the amount of residuals left in tanks and ancillary equipment and other corrective measures related to existing soil contamination in the vadose zone and ground water.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: A requirement that, in support of the safety case, a programme of monitoring should be defined and carried out prior to and during the operation of the disposal facility.

Comment: This should be designed to monitor for changes caused by construction of the facility and emplacement of the waste and also to confirm the conditions necessary for the safety of workers and members of the public and protection of environment during the operation of the disposal facility and to confirm the absence of conditions that would undermine the long term safety of the disposal facility. The implication of this requirement is that the developer will need to establish a reasoned approach to monitoring of the site and facility and a programme for its implementation. The monitoring programme should not compromise the long-term safety of the facility.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model Natural System

How it Applies: Ongoing RCRA permit requirements specify monitoring of the vadose zone and groundwater around WMA C during the pre-closure and post-closure periods. See WAC 173-303(7) and DOE Order/Guide 435.1 for post-closure monitoring requirements, as well as the CERCLA five year review.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
WAC-173-303	610 (7)	Washington Administr	Dangerous Waste Regulations: Closure and post-closure (610)
DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual
OSWER No. 93	Complete Docume	EPA	Comprehensive Five-Year Review Guidance

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: A requirement that the developer should set up and maintain a comprehensive system of records for the recording of detailed information on all aspects of the project affecting the safety case.

Comment: The information to be recorded should include data and results from the site investigation and characterisation programme, design documents, drawings and detail of the engineering construction of the facility, records of waste emplacements and their location in the facility, operational information and results of monitoring at all stages of the project.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **6/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Ongoing RCRA, DOE Order 435.1, and other regulatory and operational guidance and requirements specify the need to set up and maintain a comprehensive system of records for the recording of detailed information on all aspects of the project affecting the long-term performance assessment of a closed WMA C facility.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
WAC 173-303	610 (7)	Washington Administr	Dangerous Waste Regulations
WAC 173-340	702	Washington Administr	Model Toxics Control Act
DOE M 435.1	Chapter 4	DOE	Radioactive Waste Management Manual
OSWER No. 93	Complete Docume	EPA	Comprehensive Five-Year Review Guidance

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: A requirement that the developer should establish a comprehensive quality assurance programme for all activities affecting the safety case.

Comment: This should include supporting activities such as research and assessment. All activities associated with a project to develop and operate a disposal facility will need to be planned carefully and implemented within a systematic programme of quality assurance in order to ensure that all the technical requirements will be met.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **6/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Ongoing RCRA, DOE Order 435.1, and other regulatory and operational guidance requirements specify the need to establish a comprehensive quality assurance programme for all activities affecting the long-term performance assessment of a closed WMA C facility.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
WAC 173-303	610 (7)	Washington Administr	Dangerous Waste Regulations
WAC 173-340	702	Washington Administr	Model Toxics Control Act
DOE M 435.1	Chapter 4	DOE	Radioactive Waste Management Manual
OSWER No. 93	Complete Docume	EPA	Comprehensive Five-Year Review Guidance

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: A requirement that the information derived from natural analogue studies should be used to increase stakeholder confidence in the post-closure safety assessment results.

Comment: Natural and man-made analogues to disposal systems and/or components of disposal systems have been studied so that the results of observations may be compared with the performance of disposal facility components or processes expected to take place in a disposal system. Analogues can be used for a number of purposes:
Highlighting the similarity of materials, radionuclides and processes between the disposal system and analogue systems thereby demonstrating that none of the components of a disposal system are beyond man's experience.
Presenting the expected evolution of the disposal system.
Justifying the choice of features, events and processes (FEPs) and scenarios analysed in the assessment.
Aiding in the development of conceptual models and associated processes because, by investigating the processes that operate in analogue systems, it is possible to learn about the key processes which can influence radionuclide behaviour, and which should therefore be represented in assessment models.
Providing quantitative data to satisfy the parameter (data) requirements of the codes;
Acting as test-beds for model validation by providing sites with relevant physico-chemical conditions where the codes can be used in a realistic fashion in attempts to simulate actual measured conditions.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **6/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: The use of information derived from natural analogues is a not a specific requirement for this long-term performance assessment. However, information gained from natural analogues documented in technical reports and/or literature may be useful to assist the PA process in better understanding and predicting the long-term stability and degradation of concrete and grouts within a closed WMA C facility.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the philosophy applied in the post-closure safety assessment of the near-surface radioactive waste disposal facility.

Comment: As used here, assessment philosophy refers to the use of reason, arguments and assumptions in the post-closure safety assessment to establish a comprehensive and defensible safety case for a near-surface disposal facility. The assessment philosophy adopted is determined by the assessment and modelling approach followed, the treatment of uncertainties in the assessment, performance of sensitivity analysis and establishing confidence in the computer models used.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: The initial WMA C PA will consider a range of assessment philosophies in the post-closure analysis of the Closed WMA C Facility.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the assessment approach applied in the post-closure safety assessment to establish a comprehensive and defensible safety case for a near-surface radioactive waste disposal facility.

Comment: Different assessment approaches can be applied to develop a post-closure safety case for a near-surface radioactive waste disposal facility. Which approach followed, will have an influence on the context of the assessment.

Key Concepts, Examples and Related FEPs

1) **Iterative approach:** In its nature, the post-closure safety assessment approach is an iterative approach, aiming at continual improvement of the safety case. This implies that a safety assessment process will have to go through two or more consecutive iterations. The advantage of such an approach is that it allows one to use information from the previous assessment to refine the design of the system and the collection of additional data. It also reduces the tendency that the assessment will focus on one component at the expense of others. As used here, the FEP refers to the different purposes of applying the iterative safety assessment approach to define a comprehensive and defensible safety case for a near-surface radioactive waste disposal facility.

2) **Systematic approach:** Different systematic or structured approaches can be followed to perform a post-closure safety assessment of a near-surface disposal facility, all aimed at improving the confidence in the assessment results. Factors to be considered in a systematic approach include:

a) Ensure that each stage of the assessment process and its associated decisions, are appropriately documented.

b) Be rigorous and based on methods that are scientifically and technically justifiable.

c) Allow multiple lines of reasoning (i.e. a diversity of arguments) to be used since no individual line of reasoning will necessarily be sufficient for any given assessment.

d) Allow iteration so that disposal facility plans can be implemented in a step-wise manner, thereby enhancing confidence.

e) At each step during the development of the disposal facility, an adequate understanding of the safety implications of the available options should be developed such that the ultimate goal of providing an acceptable level of long term and operational safety will be met.

3) **Prospective evaluation approach:** A prospective evaluation approach emphasises the fact that the intent of any modelling studies performed as part of the assessment is not to predict actual system behaviour as a function of time. Rather, the emphasis is to understand its behaviour better and to reflect the importance of specific components with respect to the regulatory compliance criteria.

4) **Reasonable assurance approach:** The safety assessment of a radioactive disposal system is not an exact procedure. Following a reasonable assurance approach in an assessment emphasizes this inexact nature. What one really wants to achieve in such an assessment is to reach defensible decisions on the extent to which the disposal system may comply with the regulatory criteria, i.e. to determine the conditions for which reasonable assurance of compliance with safety objectives can be provided. An assessment performed using a reasonable assurance approach is more a decision tool to determine the conditions for which reasonable assurance of compliance with safety objectives can be provided than a method to predict the actual behaviour of a disposal system into the future. The results will therefore be largely a function of the data, design and assumptions used in the analysis. Changes in any one of these conditions can change the conclusions of the assessment.

5) **Realistic approach:** In undertaking a post-closure safety assessment, various assumptions have to be adopted. Some assumption can be categorised as realistic or equitable, which is an assumption that is physically possible and quite likely to occur. A realistic approach is often used when some knowledge of the actual system condition are available. The disadvantage applying realistic assumptions in the assessment, it that the results might be underestimated. The key issue is therefore to document and justify the nature of each assumption in the assessment.

6) **Cautious assumptions:** In undertaking a post-closure safety assessment, various assumptions have to be adopted. Some assumption can be categorised as cautious or conservative, which is an assumption that will not result in the end-point(s) being underestimated. Using a cautious assumption approach, there is a danger that aggregation of large numbers of cautious assumptions, each of which may be appropriate in its own right, may result in an unrealistic estimate of potential impacts. The key issue is therefore to document and justify the nature of each assumption in the assessment.

7) **Transparent approach:** A transparent assessment approach ensures that all assumptions constraints and conditions imposed on the assessment and made within

the assessment, are communicated to all stakeholders in the assessment. For example,

a) a transparent scenario development approach will be followed, including the documentation and handling of expert judgement;
b) all assumptions and constraints imposed on model development will be justified and documented;
c) input parameter values will be justified and documented; and
d) a transparent approach to tread subjective uncertainties will be followed.

Applies to WMA **Yes** Entered By: **h0098182** On: **6/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: The initial WMA C PA will need to consider an approach that draws on the range of assessment approaches defined above in the post-closure analysis of the Closed WMA C Facility.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
DOE M 435.1	Chapter 4	DOE	Radioactive Waste Management Manual

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: In its nature, the post-closure safety assessment approach is an iterative approach, aiming at continual improvement of the safety case. This implies that a safety assessment process will have to go through two or more consecutive iterations.

Comment: The advantage of such an approach is that it allows one to use information from the previous assessment to refine the design of the system and the collection of additional data. It also reduces the tendency that the assessment will focus on one component at the expense of others. As used here, the FEP refers to the different purposes of applying the iterative safety assessment approach to define a comprehensive and defensible safety case for a near-surface radioactive waste disposal facility.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Following the philosophy of guidance on PAs in DOE Order 435.1 and in HFFACO Appendix I Section 2.5, the WMA C PA will use an iterative approach, aiming at continual improvement of the understanding of the long-term performance of a closed WMA C facility . This implies a performance assessment process that will go through a number of consecutive iterations as new information of site characterization, waste residual characterization, and the postulated closure state of WMA C becomes available. A document that is produced as part of the Performance Assessment is the maintenance plan which will identify specific data needs as part of the iterative process

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
DOE M 435.1	Chapter 4	DOE	Radioactive Waste Management Manual
HFFACO	Appendix I Secti	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: In undertaking a post-closure safety assessment, various assumptions have to be adopted. Some assumptions can be categorised as realistic or equitable, which is an assumption that is physically possible and quite likely to occur.

Comment: A realistic approach is often used when some knowledge of the actual system condition are available. The disadvantage applying realistic assumptions in the assessment, is that the results might be underestimated. The key issue is therefore to document and justify the nature of each assumption in the assessment.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: Because the initial WMA C PA will be done using both a deterministic and probabilisitic approach in assessing long-term performance of the Closed WMA C facility, the central tendency in the parameter distributions and related assumptions that provides the basis for the analysis will need to be selected to reflect, as closely as possible, the expected performance of the facility. In that regard, the central tendency of the analysis would be based on assumptions that are generally reflective of realistic assumptions of system performance.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the approach that will be followed to build confidence in the models used in the post-closure safety assessment, to establish a comprehensive and defensible safety case for a near-surface radioactive waste disposal facility.

Comment: Solution of the mathematical models is usually achieved by implementing one or more computer codes using analytic and/or numerical techniques. These codes may be proprietary codes, modified codes, and/or codes specifically developed for implementation of the chosen mathematical models.

The use of proprietary codes usually has the advantage that the codes have been previously developed and checked, and has a history of application to a range of cases. In contrast, modified or specifically developed codes need to be developed and checked, however they do have the advantage of being tailored to the needs of the specific problem to be addressed.
In all cases the associated process of software design need to be considered, based on a given mathematical specification. This involves giving consideration to relevant data and process structures and developing appropriate solution algorithms. Software design should be conducted within an appropriate software quality assurance system in order to provide an audit trail for the computer code that is ultimately developed. Confidence in the codes can be further developed through ensuring that an appropriate process of verification, calibration and validation has been undertaken.

Key Concepts, Examples and Related FEPs

Applies to WMA	**Yes**	Entered By:	**h0006384**	On:	**7/1/2011**	Reviewed By		On:	

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: The initial WMA C will need to consider model verification and validation as a part of the effort to build confidence in the models used in the long-term performance modeling. Part of model confidence building process will include:

- Proper STOMP code installation and testing with available verififcation problems
- Proper model abstraction of process-level model results based STOMP within the GoldSim system-level model software

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: 1. Institutional control is generally assumed not be reliable for periods in excess of a few hundred years and so loss of control of the site is assumed.

Comment: Over such timescales the engineered barriers will degrade. Depending upon the location of the disposal facility some major features of the disposal system might remain comparable to present-day conditions, although human behaviour may change significantly. It is often assumed that over such timescales major changes in climate, that might have a profound impact on the disposal system, would not occur.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: It should be noted that as long as dangerous/radioactive waste remains in place, that neither the Washington Administrative code (173-303 610 (7)) nor DOE Policy (454.1) nor CERCLA allows the removal of institutional controls, furthermore the site must remained monitored and maintained. Institutional controls are removed for calculational purposes only

After the initial 100 years of institutional control to 10,000 yrs post-clsoure. The specific changes that would have the potential to affect long-term recharge rates include the following.

- With loss of institutional control and increased possibility of human activities and intrusion, the cessation of use of water on-site may not expected to continue.

- Within SSTs and some of the ancillary equipment, the structural components of the engineered tank system and ancillary equipment, including the emplace grout, would be expected to continue to degrade and crack due to dissolution and other processes to a point where they would not offer any physical barrier for containing and/or controlling recharge into and contamimant releases from waste residuals.

- Degradation mechanisms would include
  - Continued long-term oxidation, corrosion, a:d degradation of steel liner system

- Continued long-term dissolution and degradation of:
  - grout/reinforced concrete base
  - reinforced concrete outer shell
  - grout emplaced in tank

- Continued degradation of the engineered surface barrier system would be expected but would continue to perform to the design recharge rate

through the expected design life of the barrier system (i.e. 500 yrs). After the barrier design life period of 500 yrs, effective recharge rates through the engineered surface barrier would be expected to return to higher recharge rates reflective of changing climatic conditons and associated vegetated surface conditions.

• Potential infiltration of water originating from the near-surface through the degraded reinforced concrete dome and the corroded steel liner system into emplaced grout and leach waste residuals

• Any instruments/structures needed to monitor barrier or site performance will not be expected to be maintained.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-42042	Section 4.2.4	Bergeron et al. 2010	Recharge and Waste Release within Engineered System in Waste Management Area C
WAC 173-303	610 (7)	Washington Administr	Dangerous Waste Regulations
DOE P 454.1	Page 4	DOE	Institutional Controls
OSWER No. 93	Complete Docume	EPA	Comprehensive Five-Year Review Guidance

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the domain over which the disposed wastes and disposal facility may present some significant human health or environmental hazard and that will be considered in the post-closure safety assessment to evaluate the performance of the disposal system (or components of the disposal system).

Comment: This may correspond to the spatial domain over which the safety of the disposed wastes and disposal facility is estimated, or the domain that is necessary to model in order to develop an understanding of the spatial movement of contaminants and resulting exposures.
The assessment domain may be limited by the purpose of the assessment, for example if the performance of only a component of the total system has to be assessed, oppose to the total system.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0098182** On: **6/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: The assessment of groundwater impacts at WMA C will be evaluated for two time periods consisting of the pre-closure conditions and post-closure conditions. The primary focus of the Initial PA will be on the post-closure analysis. The post-closure analysis will include process model results that will be synthesized into the system model using a data abstraction process. With the use of the system-level model, the post-closure analysis will include an evaluation of the total system uncertainty.

The pre-closure analysis of past releases using a process model using the STOMP© code, will be evaluated in the Initial PA to explore potential features, events and processes that provide insight into the flow and transport system at WMA C. The pre-closure analysis may provide insights for consideration in the development of the post-closure groundwater process model(s).

The pre-closure and post-closure analyses will be evaluated using two separate process model designs. The pre-closure analysis model design will be developed to explore alternative conceptual models, to evaluate viable interpretations of the environment important to the operational period. The post-closure model design will be developed based on the post-closure environment and will include viable features, events and processes identified from the pre-closure analyses.

Another important feature at WMA C that separates the pre-closure from the post-closure analysis is the differing flow directions in the unconfined aquifer during these two time periods of analysis. The pre-closure flow in the unconfined aquifer is from the northeast to southwest, while the post-closure flow direction is inferred to be toward the southeast (see section 5.5 of RPP-RPT-46088).

The groundwater analyses in the Initial PA will be focused on the local-scale impacts at WMA C and not for a regional scale. The groundwater impacts will be evaluated at the WMA C fence line.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	Section 4.0	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: 1. : Consider the past is an accurate reflection of future human action, i.e. technologies practiced in the past will be considered.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0098182** On: **6/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Does not apply at WMA C. The site was used for storage of nuclear waste. That waste is being removed to the extent practicable and the past is not an accurate reflection of the future.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Consideration of malicious human acts (e.g. terrorists acts) aimed at damaging the disposal facility.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0098182** On: **6/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Does not apply. It is along the same lines as NRC deliberate intrusion. See NUREG-0782 p 16

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
NUREG-0782 Vol 1	Page 16	NRC	Draft Environmental Impact Statement on 10 CFR Part 61 "Licensing Requirements for Land Disposal of Radioactive Waste"

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Consideration of deliberate human intrusion, taken with knowledge of the nature and content of the disposal facility.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0098182** On: **6/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Does not apply. Per NRC's guidance in NUREG-0782 Vol 1 Page 16 "NRC believes that deliberate intrusion into the disposal facility cannot reasonably be protected against, and it is not considered further."

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
NUREG-0782 Vol 1	Page 16	NRC	Draft Environmental Impact Statement on 10 CFR Part 61 "Licensing Requirements for Land Disposal of Radioactive Waste"

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to decisions taken, and events occurring during the life cycle of a near-surface radioactive waste disposal facility (e.g. design, construction, operation, closure and decommissioning) that could have an influence on the post-closure performance of the facility and therefore have to be considered in the safety assessment process.

Comment: The "Disposal Facility Factors" category of FEPs is outside the temporal boundary of the disposal system domain and predominantly associated with the pre-operational and operational period of the disposal facility. These factors are an example of the interdependencies that exists between these periods and the post-closure period and how to treat these interdependencies in the safety assessment process. Considering these factors in the post-closure safety assessment contribute to a demonstration of the principle of good practice.
"Disposal Facility Factors" is a category of External Factors in the Generic FEP List and is divided into individual FEPs.

Key Concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **6/14/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Relevant to Initial WMA C PA

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the investigations that are carried out at a potential near-surface disposal facility in order to characterise the site both prior and during the construction and operation of the facility.

Comment: This FEP can be used from two perspectives. Firstly, site investigation activities provide detailed site-specific performance assessment data and information necessary for the safety case to demonstrate the suitability of the site as a near-surface disposal facility and to establish baseline conditions.
Secondly, the possibilities exist that some of these investigations or past activities discovered during the investigations may compromise the performance of the disposal system in the post-closure period and consequently must be treated in the safety assessment as such.

Key Concepts, Examples and Related FEPs

1) **Geology:** As a natural barrier, the geological setting could contribute to the isolation of the waste and the limitation of releases of radionuclides to the biosphere. It could also contribute to the stability of the disposal system and provide sufficient volume and engineering properties favourable for implementing disposal. During geological investigations, efforts should be directed towards describing:

1. The basic geological characteristics of the region and site;
2. The geological history;
3. The lithology, stratigraphy, mineralogy and structural geological conditions of the region and the site;
4. Geological (tectonic) structures in the vicinity of the site; and
5. Geological features and conditions that could affect facility structures.

2) **Hydrogeology**: Groundwater serve as one of the major migration pathways of radionuclides released from a near-surface disposal facility. It is therefore preferable that the site should include low groundwater flow and long flow paths in order to restrict the transport of radionuclides. During hydrogeological investigations, efforts should be directed towards describing the following, for example:

a) Existing and projected water uses;
b) Location, extent and interrelationship of the important hydrogeological units in the region;
c) Recharge and discharge of the major hydrogeological units;
d) Regional and local water tables and their gradients and seasonal fluctuations,
e) An estimate of groundwater flow velocities and direction;
f) Radionuclides travel times along most likely flow paths from the disposal facility to the biosphere.

3) **Geochemistry:** The geochemistry of groundwater and the geological media could contribute to limiting the release of radionuclides from the disposal facility. Depending on its geochemical properties, it could extent the longlivity of engineered barriers, rather than reducing it. Conditions promoting sorption and precipitation/co-precipitation of radionuclides released from a disposal system are therefore preferable. During geochemical investigations, efforts should be directed towards describing the following, for example:

a) Corrosivity of groundwater towards the engineered barriers;
b) Processes or conditions influencing the solubility and the sorption of radionuclides;
c) Eh and pH of the groundwater, oxidation/reducing conditions, alkalinity, ionic strength, dissolved solids and density;
d) Processes or conditions involving the presence of natural colloids and organic materials;
e) Potential gas generation by the disposal system;
f) Mineralogical and petrographical composition of the groundwater flow system and its geochemical properties.

4) **Tectonic and seismicity:** It is preferable to locate a near-surface radioactive waste disposal facility in an area of low tectonic, volcanic and seismic activity such

that the isolation capacity of the disposal system will not be endangered. During tectonic and seismic investigations, efforts should be directed towards describing the following, for example:

a) Recent or historic evidence of active faulting, tectonic processes or igneous activity;

b) Historical earthquakes of such magnitude and intensity that, if they recurred, could adversely affect waste isolation;

c) Potential for natural events such as subsidence or volcanic activity that could change the regional hydrogeological system;

d) Evidence of soil liquefaction in seismic loads; and

e) Static and dynamic engineering properties of materials underlying the site.

5) **Surface environment:** Processes in the surface environment such as flooding of the disposal site, landsliding or erosion could alter the normal behaviour of the disposal system. These events should therefore not occur with such frequency or intensity that they could affect the ability of the disposal system to meet safety requirements. A well drained disposal site, free of areas of flooding or frequent ponding is preferable, while the accumulation of water in upstream drainage areas due to precipitation, snowmelt, failure of water control structures, channel obstruction or landsliding should be minimised so as to decrease the amount of runoff which could erode or inundate the facility. During surface environment investigations, efforts should be directed towards describing the following, for example:

a) Topography of the site, including actual drainage features;

b) Location of existing and planned water bodies (e.g. stream, rivers, lakes, reservoirs);

a) Definition of areas of landslides and other potentially unstable slopes, and of materials of low bearing strength or high liquefaction potential;

c) Definition of areas containing poorly drained materials;

d) Data on the flood history of the region;

e) The hydrologic responds of the catchment to precipitation; and

f) Upstream drainage areas.

6) **Meteorology and climatology:** The meteorology and climatology of a site are important considerations in the design and licensing of the near-surface radioactive waste disposal facility, including the occurrence of any extreme meteorological events. During meteorological and climatological investigations, efforts should be directed towards describing the following, for example:

a) Precipitation characteristics (e.g. rain and snow);

b) Wind and atmospheric dispersion characteristics;

c) Extreme meteorological phenomena, such as tropical and extratropical cyclones, tornadoes, severe winter storms and sandstorms; and

d) Normal and extreme values for meteorological parameters such as wind speed, and direction, temperature, humidity, precipitation, and atmospheric stability.

7) **Geography and demography:** There should be no ambiguity about the relation of other features to the location of the site investigated for the disposal of radioactive waste in a near-surface disposal facility. During geography and demography investigations, efforts should be directed towards describing the site and its boundaries, as well as areas beyond its boundaries that might be exposed to hazards from operations. For example:

a) The region in which the site is located;

b) Location of the site relative to prominent natural and manmade features, such as rivers and lakes, and nearby population centres;

c) Map of the site on a scale adequate to clearly define the boundary of the site and the distance of significant facility features from the boundary;

d) Population information based on the most recent census data (show population distribution as a function of distance and direction);

e) Location and population of nearby schools, prisons, hospitals, and other similar institutions;

f) The projected population by decade, if the population is expected to change significantly.

8) **Natural resources and land use:** Investigations into the natural resources in the area should demonstrate that there will be no adverse effect if resources such as mineral, hydrocarbons and water were exploited during construction, operation and after closure. A detailed description of the known natural resources at or near the site should therefore be included. Future uses of the land in the vicinity of the proposed site should be evaluated for potential impact on the performance of the disposal facility, and vice versa. During land use investigations, efforts should be directed towards describing the following, for example:

a) Existing land resources and uses and jurisdiction over them;

b) Foreseeable development of land in the area of interest.

Applies to WMA	Yes	Entered By:	h0006384	On:	6/14/2011	Reviewed By		On:	

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Past and ongoing Hanford site investigation activities provide regional and detailed site-specific characterization and monitoring data and information necessary for establishing baseline conditions and assessing post-closure performance of a closed WMA C. The WMA C site has about 70 dry wells on-site that are currently used for borehole logging and vadose zone monitoring in vicinity of the SSTs, 11 RCRA wells used for groundwater monitoring just outside of the WMA C fenceline, and numerous boreholes drilled for on-site and off-site characterization of hydrogeologic and contaminantion from past operational releases to the environment.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-46088	Sections 3, 4, an	Bergeron et al. 2010	Flow and Transport in the Natural System at Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: As a natural barrier, the geological setting could contribute to the isolation of the waste and the limitation of releases of radionuclides to the biosphere. It could also contribute to the stability of the disposal system and provide sufficient volume and engineering properties favourable for implementing disposal. During geological investigations, efforts should be directed towards describing:
a) The basic geological characteristics of the region and site;
b) The geological history;
c) The lithology, stratigraphy, mineralogy and structural geological conditions of the region and the site;
d) Geological (tectonic) structures in the vicinity of the site; and
e) Geological features and conditions that could affect facility structure

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s): Cases defined in Tables B-3 through B-5 (pre-closure analysis) and Tables B-14, B-16, and B-18 (post-closure analysis) in Appendi

Conceptual Site Model

How it Applies: Past and ongoing characterization efforts in the region and at the site have focused on describing the how the geologic setting contributes to the fate and transport of contaminants released from wastes and past contaminant to the environemtn. Efforts have been directed at defining:

- The geological history;
- The basic geological and stratigraphic characteristics of the region and site;
- The lithology, mineralogy and structural geological conditions of the region and the site;
- Geological (tectonic) structures in the vicinity of the site; and
- Geological features and conditions that could affect characteristics and related long-term performance of a closed WMA C

Due the uncertainty in effect of the geologic system to influence flow and transport contaminants of potential concern within the vadose zone, the initial WMA C will consider a number of alternative conceptual models that represent alternative intepretation of available geologic information and data on the vaodse zone These alternative models are described in a number of the data packages that prepared for the various working sessions provided below

The cases

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-46088	Section 3.0	Bergeron et al 2010	Flow and Transport in the Natural System at Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Groundwater serve as one of the major migration pathways of radionuclides released from a near-surface disposal facility. It is therefore preferable that the site should include low groundwater flow and long flow paths in order to restrict the transport of radionuclides. During hydrogeological investigations, efforts should be directed towards describing the following, for example:

a) Existing and projected water uses;
b) Location, extent and interrelationship of the important hydrogeological units in the region;
c) Recharge and discharge of the major hydrogeological units;
d) Regional and local water tables and their gradients and seasonal fluctuations,
e) An estimate of groundwater flow velocities and direction;
f) Radionuclides travel times along most likely flow paths from the disposal facility to the biosphere.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/5/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s): Cases defined in Tables B-3 through B-5 (pre-closure analysis) and Tables B-14, B-16, and B-18 (post-closure analysis) in Appendi

Conceptual Site Model

How it Applies: Past and ongoing characterization efforts in the region and at the site have focused on describing the how the hydrogeologic setting contributes to the fate and transport of contaminants released from wastes and past contaminant to the environment. Efforts have been directed at defining:

- Location, extent and interrelationship of the important hydrogeological units in the region and in the vicinity of the WMA C;
- Recharge and discharge relationships of the major hydrogeological units;
- Local- and regional-scale water table conditions including their hydraulic gradients and seasonal fluctuations,
- An estimate of groundwater flow velocities and direction in the underlying unconfined and confined aquifer systems;
- Estimates of the fate and transport of major radioactive and hazardous chemical constituents of concern from a closed WMA C facility to the biosphere.

The WMA C PA will incorporate information and data collected about the hydrogeologic conditons collected during past characterization efforts in its computation framework. The PA will evaluate a range of alternative models and model parameters used to represent the hydrogeologic system (combined vadose zone and groundwater systems) in a number of proposed sensitivity cases

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPT-RPP-46088	Sections 4 and 5	Bergeron et al 2010	Flow and Transport in the Natural System at Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: The geochemistry of groundwater and the geological media could contribute to limiting the release of radionuclides from the disposal facility. Depending on its geochemical properties, it could extent the longevity of engineered barriers, rather than reducing it. Conditions promoting sorption and precipitation/co-precipitation of radionuclides released from a disposal system are therefore preferable. During geochemical investigations, efforts should be directed towards describing the following, for example:

a) Corrosivity of groundwater towards the engineered barriers;
b) Processes or conditions influencing the solubility and the sorption of radionuclides;
c) Eh and pH of the groundwater, oxidation/reducing conditions, alkalinity, ionic strength, dissolved solids and density;
d) Processes or conditions involving the presence of natural colloids and organic materials;
e) Potential gas generation by the disposal system;
f) Mineralogical and petrographical composition of the groundwater flow system and its geochemical properties.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/5/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	See Table B-4 (Pre-closure analysis) and Table B-17 (psot-closure analysis) in Appendix B of RPP-RPT-48490, Rev. 1

Conceptual Site Model

How it Applies: Past and ongoing characterization efforts in the region and at the site have focused on describing how the geochemistry on the underlying sediments, porewaters in the vadose zone , and groundwater that could influence the fate and transport of contaminants released from wastes and past contamination to the environment. Efforts have been directed at defining a number of geochemistry- related factors:

- Processes or conditions influencing the solubility and the sorption of radionuclides;
- Eh and pH, oxidation/reducing conditions, alkalinity, ionic strength, dissolved solids and density
- Mineralogical and petrographical composition of the sediments in the vadose zone and groundwater flow system
- Geochemical properties of pore water in the vadose zone and in groundwater;
- Potential influence on contaminant mobility of the presence of colloids
- Potential influence on contaminant mobility of the presence of organics and/or complexing agents
- Potential gas generation by the disposal system;

The scope of geochemical factors related to the underlying sediments, porewaters in the vadose zone and groundwater that could influence the fate and transport of key constituents of concern will be limited to evalauting the mobility of constituents affected by adsorption using either a linear (kd) or non-linear (Fruendlich or Langmeir) adsorption isotherm. Recommended values of values for most of the constituents are provided in Table B-4 (Pre-closure analysis) and Table B-17 (psot-closure analysis) in Appendix B of RPP-RPT-48490, Rev. 1. More sophisticated treatment of geochemical effects may potentially be a subject of interest under the WMA C PA maintenance program.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See section B.1.4 and B.2.2.26	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: It is preferable to locate a near-surface radioactive waste disposal facility in an area of low tectonic, volcanic and seismic activity such that the isolation capacity of the disposal system will not be endangered. During tectonic and seismic investigations, efforts should be directed towards describing the following, for example:

a) Recent or historic evidence of active faulting, tectonic processes or igneous activity;
b) Historical earthquakes of such magnitude and intensity that, if they recurred, could adversely affect waste isolation;
c) Potential for natural events such as subsidence or volcanic activity that could change the regional hydrogeological system;
d) Evidence of soil liquefaction in seismic loads; and
e) Static and dynamic engineering properties of materials underlying the site.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/5/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	Contaminant release related sensitivity cases 1a, 1b, 1c, and 1 d. See Table B.13, Appendix B, RPP=RPT-

Conceptual Site Model

How it Applies: Defining the locations, magnitudes, and seismic interpretations of earthquakes recorded for the Hanford monitoring area of south-central Washington has been ongoing since the late 1960's. Studies have concluded that earthquakes can occur in the following six different tectonic environments (earthquake sources) at the Hanford Site (Geomatrix 1996):

· **Major Geologic Structures**. Reverse/thrust faults in the CRBG associated with major anticlinal ridges such as Rattlesnake Mountain, Yakima Ridge, and Umtanum Ridge could produce some of the largest earthquakes.

· **Secondary Faults**. These faults are typically smaller (1 to 20 km in length) than the main reverse/thrust faults that occur along the major anticlinal ridges (up to 100 km in length). Secondary faults can be segment boundaries (tear faults) and small faults of any orientation that formed along with the main structure.

· **Swarm Areas**. Small geographic areas not known to contain any geologic structures produce clusters of events (swarms), usually located in synclinal valleys. These clusters consist of a series of small shocks with no outstanding principal event. Swarms occur over a period of days or months, and the events may number into the hundreds and then quit, only to start again at a later date. This differs from the sequence of foreshocks, mainshock, and trailing-off aftershocks that have the same epicenter or are associated with the same fault system. In the past, swarms were thought to occur only in the CRBG. Most swarm areas are in the basalt, but swarm events also appear to occur in all geologic layers. However, typically a swarm event at a specific time is usually restricted to one layer. Seven earthquake swarm areas are recognized in the HSN area, but this list will be updated as new swarm areas develop. The Saddle Mountains, Wooded Island, Wahluke, Coyote Rapids, and Horse Heaven Hills swarm areas are typically active at one time or another during the year. The other earthquake swarm areas are active less frequently.

· **Entire Columbia Basin**. The entire basin, including the Hanford Site, could produce a "floating" earthquake. A floating earthquake is one that, for seismic design purposes, can happen anywhere in a tectonic province and is not associated with any known geologic structure. Seismic interpretation classifies it as a random event for purposes of seismic design and vibratory ground motion studies.

· **Basement Source Structures**. Studies (Geomatrix 1996) suggest that major earthquakes can originate in tectonic structures in the basement. Because little is known about geologic structures in
the basement beneath the Hanford Site, earthquakes cannot be directly tied to a mapped fault. Earthquakes occurring in the basement without known sources are treated as random events.

During FY 2009, the Hanford Seismic Network recorded nearly 3000 triggers on the seismometer system, which included over 1700 seismic events in the southeast Washington area and an additional
370 regional and teleseismic events. There were 1648 events determined to be local earthquakes relevant to the Hanford Site. Nearly all of these earthquakes were detected in the vicinity of Wooded Island,
located about eight miles north of Richland just west of the Columbia River. Recording of the Wooded Island events began in January with over 250 events per month through June 2009. The frequency of
events decreased starting in July 2009 to approximately 10-15 events per month through September 2009.

Most of the events were considered minor (coda-length magnitude [Mc] less than 1.0) with 47 events in the 2.0-3.0 range. The estimated depths of the Wooded Island events are shallow (averaging less than 1.0 km deep) with a maximum depth estimated at 2.3 km. This places the Wooded Island events within the Columbia River Basalt Group (CRBG). The highest-magnitude event (3.0Mc) occurred on May 13, 2009 within the Wooded Island swarm at depth 1.8 km. With regard to the depth distribution, 1613 earthquakes were located at shallow depths (less than 4 km, most likely in the Columbia River basalts), 16 earthquakes were located at intermediate depths (between 4 and 9 km, most likely in the pre-basalt sediments), and 19 earthquakes were located at depths greater than 9 km, within the crystalline basement. Geographically, 1630 earthquakes were located in swarm areas and 18 earthquakes were classified as random events.

Based on the frequency and magnitude of the majority of earthquakes that have been recently detected in the Hanford region, we would not expect the potential impacts from seismic activity on a closed WMA C facility to be significant. However, the potential for larger magnitude earthquakes that could affect some of the structural features of engineered systems, does exist because of the proximity of the Hanford site to the **Cascadia Subduction Zone**. This source has been postulated to be capable of producing large (i.e. magnitude 9) earthquakes.

While the potential impact of a large magnitude is not being considered in any specific denominator or sensitivity cases in the PA, the potential effects of this type of event on enhancing cracking of emplaced grout or the tank strucuture and the associated enhanced contaminant release is likely to be bounded by contaminant release cases that assumaed an advection-controlled release

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490	Table B-13	Bergeron et al 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Processes in the surface environment such as flooding of the disposal site, landsliding or erosion could alter the normal behaviour of the disposal system. These events should therefore not occur with such frequency or intensity that they could affect the ability of the disposal system to meet safety requirements. A well drained disposal site, free of areas of flooding or frequent ponding is preferable, while the accumulation of water in upstream drainage areas due to precipitation, snowmelt, failure of water control structures, channel obstruction or landsliding should be minimised so as to decrease the amount of runoff which could erode or inundate the facility. During surface environment investigations, efforts should be directed towards describing the following, for example:

a) Topography of the site, including actual drainage features;
b) Location of existing and planned water bodies (e.g. stream, rivers, lakes, reservoirs);
a) Definition of areas of landslides and other potentially unstable slopes, and of materials of low bearing strength or high liquefaction potential;
c) Definition of areas containing poorly drained materials;
d) Data on the flood history of the region;
e) The hydrologic responds of the catchment to precipitation; and
f) Upstream drainage areas.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	Case 3 in Table B-11, Barrier Design Life Evaluation, Multiple What-Ifs for design life sensitivities related to early failure and e

Conceptual Site Model Near-surface environment

How it Applies: Processes in the surface environment such as flooding or local erosion from rapid snow-melt combined with the bare-gravel surface conditons in the WMA C have in the past had some effect in increasing the effective overall recharge in vicinity of the farm during the peirod of operation. However, during the post-closure period, the WMA C will be covered with a surface engineered barrier that will components in its design to handle the frequency or intensity of these period events. Conceptual design analysis of the barrier components of the closed WMA C will consider the current topography and other surficial features in its final design to ensure that intermittent flooding and erosion events will have a minimal impact on recharge through and along side slope of the engineered cover system.

The effects of potential increased recharge or drainage caused any potential breach of the surface engineered barrier flooding or erosion will be considered in post-closure period in the initial WMA C PA in a number of sensitivity cases defined in:

Case 3 Table B-11, Appendix B, RPP-RPT-48490

Barrier Design Life Evaluation, Multiple What-Ifs for design life sensitivities related to early failure and extended life, Table B-12, Appendix B, RPP-RPT-48490

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-44042	Section 4.7	Bergeron et al. 2010	Recharge and Waste Release within Engineered System in Waste Management Area C
RPP-RPT-48490, Rev. 1	Section B.2.2.2.1	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C
RPP_RPT-4608	Section 4 and 5	Bergeron et al. 2010	Flow and Transport in the Natural System at Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: The meteorology and climatology of a site are important considerations in the design and licensing of the near-surface radioactive waste disposal facility, including the occurrence of any extreme meteorological events. During meteorological and climatological investigations, efforts should be directed towards describing the following, for example:

a) Precipitation characteristics (e.g. rain and snow);
b) Wind and atmospheric dispersion characteristics;
c) Extreme meteorological phenomena, such as tropical and extratropical cyclones, tornadoes, severe winter storms and sandstorms; and
d) Normal and extreme values for meteorological parameters such as wind speed, and direction, temperature, humidity, precipitation, and atmospheric stability.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/5/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s): See the proposed denominator and sensitivity cases being proposed for long-term post-closure recharge that reflect a range of

Conceptual Site Model

How it Applies: Understanding the meteorologic and climatalogical characterisitics of the site have been an important aspect of past studies aimed at estimating net long-term recharge. Recharge is one of the principal factors controlling the long-term fate and transport of constituents of potential concern through the vadose zone to the underlying groundwater. A discussion of meteorological and climatic affecting recharge are described in section 4.3.1 and 4.32 in RPP-RPT-44042- Rev. 0.

A range of recharge conditions reflecting a variety of meteorological and climatic conditions are being evaluated in the initial WMA C PA. See the proposed denominator and sensiviti\y cases being proposed for the initial WMA C PA in Tables B-11 and B-13 in Appendix B of RPP-RPOT-48490, Rev. 1

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	Section B.2.2.2.1,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C
RPP-RPT-44042	Sections 4.3.1 an	Bergeron et al 2010	Recharge and Waste Release within Engineered System in Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: There should be no ambiguity about the relation of other features to the location of the site investigated for the disposal of radioactive waste in a near-surface disposal facility. During geography and demography investigations, efforts should be directed towards describing the site and its boundaries, as well as areas beyond its boundaries that might be exposed to hazards from operations. For example:

a) The region in which the site is located;
b) Location of the site relative to prominent natural and manmade features, such as rivers and lakes, and nearby population centres;
c) Map of the site on a scale adequate to clearly define the boundary of the site and the distance of significant facility features from the boundary;
d) Population information based on the most recent census data (show population distribution as a function of distance and direction);
e) Location and population of nearby schools, prisons, hospitals, and other similar institutions;
f) The projected population by decade, if the population is expected to change significantly.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/5/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Numerous studies and related reports have described the geographic setting of the WMA C and its boundaries, as well as areas beyond its boundaries that might be exposed to hazards from releases from a closed WMA C. This includes:

a) The region in which the site is located;
b) Location of the site relative to prominent natural and manmade features, such as Columbia and Yakima rivers, and nearby population centres (Richland, Kennewick and Pasco);
c) Map of the site on a scale adequate to clearly define the boundary of the site and the distance of significant facility features from the boundary;
d) Population information based on the most recent census data (show population distribution as a function of distance and direction);

The initial WMA C PA will be focused on assessing the impacts of a closed WMA C at the facility fence and will be evaluate in detail impacts to downstream locations. The scope of this analysis is provided in Section

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Investigations into the natural resources in the area should demonstrate that there will be no adverse effect if resources such as mineral, hydrocarbons and water were exploited during construction, operation and after closure. A detailed description of the known natural resources at or near the site should therefore be included. Future uses of the land in the vicinity of the proposed site should be evaluated for potential impact on the performance of the disposal facility, and vice versa. During land use investigations, efforts should be directed towards describing the following, for example:

a) Existing land resources and uses and jurisdiction over them;
b) Foreseeable development of land in the area of interest.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/13/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	See Sensitivity cases defined for enhanced recharge in Table B-12 and preferential pathways in Table B-14 in RPP-RPT-48490,

Conceptual Site Model

How it Applies: The WMA C PA will be considering the impacts of a range of potential land uses that could possibly include natural resource exploration and exploitation. The types of activities that have been identified in the WMA C PA working sessions have included:

- Drilling and other natural resource exploration and exploitation (i.e. water, natural gas, sand and gravel, etc)
- Land uses involving increased water uses or releases or contaminant releases due the following land uses:
  - Agricultural
  - Residential
  - Industrial
  - Recreational (i.e. golf course)
- Reservoir development and operation or failure (i.e. Black Rock Reservoir)
- Dam removal

While these specific land uses or events may not be specifically evaluated, their overall impacts of these typers of events on contaminant releases are anticipated to be bounded by planned sensitivity cases evaluating the effects of changing recharge, preferential pathways, and contaminant transport pathways. Exposure scenarios specified in regulatory guidance that meet WAC, and DOE Order 435.1 and CERCLA requirements will be evaluated to examine the effects of range of exposure pathways. Other risk management scenarios have been identified in WMA C PA working sessions that will also be considered.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-46088	Table A-4 (Appen	Bergeron et al., 2010	Flow and Transport in the Natural System at Waste Management Area C
RPP-RPT-48490, Rev. 1	See Table B-12 and B-14	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C
RPT-RPT-4747	See Section 3	Connelly et al . 2011	Exposure Scenarios for the Waste Management Area C Performance Assessment

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the design of the disposal facility including the functional requirements and criteria the disposal facility has to met, the principle design features included in the safety concept of the facility to ensure the functional requirements are met, and the more detailed engineering design specification (design documentation) for excavation, construction and operation.

Comment: The disposal facility design and construction is established in a general way in the disposal concept for the disposal facility, which is based on expected host lithology characteristics, waste and backfill characteristics, construction technology, and economics. Disposal facility design includes the principle design features that are designed to provide long-term isolation of disposed waste, minimise the need for continued active maintenance after site closure, and improve the site's natural characteristics in order to protect human health and the environment. There may, nevertheless, be a range of engineering design and construction options still open. As the disposal facility project proceeds and more detailed site-specific information becomes available, the range of options may be constrained and decisions will be made. At any stage, disposal facility safety assessments may only analyse a subset of the total range of option.

Key Concepts, Examples and Related FEPs

1) **Description, Disposal facility type:** A summary description of the type of near-surface disposal facility and the main associated features. Generally, distinction can be made between minimum engineered type facilities (e.g. trenches), engineered type facilities (e.g. below or above ground vault), borehole type facilities (e.g. RADON type facilities, Greater Confinement type disposal facilities, BOSS type disposal facility), mining and mineral processing waste disposal facilities (e.g. waste rock, tailings dam, lake type facility, stockpiles, etc.), and rock cavities (e.g. abandoned mines).

2) **Functional requirements and criteria:** Factors related to the functional requirements and criteria that have to be considered and comply with in the design of the facility. Examples include:

a) Minimise infiltration of water into the disposal units
b) Ensuring the integrity of disposal unit covers
c) Providing the structural stability of backfill, waste and covers
d) Minimise contact of waste with standing water
e) Providing adequate site drainage
f) Minimise the need for long-term maintenance.
g) Providing a barrier against inadvertent intrusion
h) Maintaining occupational exposure as low as reasonable achievable (ALARA), social and economic factors being taken into consideration
i) Restrict the loss of radionuclides from the disposal facility

3) **Design features (safety concept):** Factors related to the design features, upon which the safety concept of the disposal facility is built to ensure that the functional requirements and criteria are met. The design features should ensure that under normal, abnormal or accident conditions, sufficient isolation and containment for radioactive materials are provided, the need for continued active maintenance after facility decommissioning are minimised, and the site's natural characteristics are improved in order to protect human health and the environment.

Factors related to the design features for a near-surface radioactive waste disposal facility can be divided into the following categories:

a) Engineering design considerations
b) Geotechnical design considerations
c) Structural design considerations
d) Seismic design considerations
e) Design features for long-term integrity (e.g. containment and isolation)

f) Fire protection design considerations

4) **Design documentation:** Factors related to the engineering design documentation available for the disposal facility, including procedures for the preparation, review, approval, issue, modification and control of documents and how it is included in the overall quality assurance programme.

5) **Alternative design** conditions: Factors relate to alternative disposal facility design conditions than those in the approved schedule and planning. Included in this FEP is the poor design of the disposal facility. Not all near-surface disposal facilities are well designed and some of the functional requirements and design features do not necessarily contribute to the safety of the facility.

Applies to WMA	**Yes**	Entered By:	**h0006384**	On:	**7/15/2011**	Reviewed By		On:	

Denominator/Sensitivity Case(s):	Table B-11 and B-12 (effect of barrier performance) in RPP-RPT-48490, Table B-13(effect of emplaced grout performance) in R

Conceptual Site Model

How it Applies:

The conceptual design of the closed WMA C that will be evalauted in the initial PA incliudes the following elements:

- The 100-series and 200-series SSTs will be filled with grout following maximum retrieval of tank wastes acheivable with current technologies. Selected ancillary facilities and equipment (catch tanks, diversion boxes, pits, and vaults) will be filled with grout following maximum retrieval of tank wastes acheivable with current technologies. The emplaced grout would provided:
  - added structural stability and integrity
  - minimize subsidence
  - minize contact of residual wastes with water
  - restrict the release of contaminants of concern from residual wastes

The range of sensitivity cases related to the effects of grout performance in controlling release of contaminants from residual wastes are defined in Table B-13 in RPP-RPT-48490.

- Pipelines with residual wastes left in place
- Selective corrective measures involving potential areas of local contamination or removal of selected pieces of near surface equipment
- D & D of surface facilities and buildings
- Emplacement of an enginered surface barrier to
  - adequately provide site drainage and minimize infiltration of water through the closed WMA C and
  - protect against inadvertant intrusion

The range of sensitivity cases related to the effects of engineered surface barrier performance in controlling recharge and release of contaminants from residual wastes are defined in Table B-11 and B-12 in RPP-RPT-48490.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure

RPP-RPT-48490 Rev. 1	Section 2.0, 4.3, and Appendix B	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C
RPP-RPT-42042	Section 3.0, 4.0,	Bergeron et al 2010	Recharge and Waste Release within Engineered System in Waste Management Area C
RPP-RPT-46879	Section 4, 5, and	Fort et al, 2010	Corrosion and Structural Degradation within Engineered System in Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: A summary description of the type of near-surface disposal facility and the main associated features. Generally, distinction can be made between minimum engineered type facilities (e.g. trenches), engineered type facilities (e.g. below or above ground vault), borehole type facilities (e.g. RADON type facilities, Greater Confinement type disposal facilities, BOSS type disposal facility), mining and mineral processing waste disposal facilities (e.g. waste rock, tailings dam, lake type facility, stockpiles, etc.), and rock cavities (e.g. abandoned mines).

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/15/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	No specific cases are identified with this specifc FEP

Conceptual Site Model

How it Applies: The conceptual design of the closed WMA C that will be evalauted in the initial PA can be described as a near-surface facility consisting of the following engineered elements:

- The 100-series and 200-series SSTs will be filled with grout following maximum retrieval of tank wastes acheivable with current technologies. Selected ancillary facilities and equipment (catch tanks, diversion boxes, pits, and vaults) will be filled with grout following maximum retrieval of tank wastes acheivable with current technologies. The emplaced grout would provided:
  - added structural stability and integrity
  - minimize subsidence
  - minize contact of residual wastes with water
  - restrict the release of contaminants of concern from residual wastes
- Pipelines with residual wastes left in place
- Selective corrective measures involving potential areas of local contamination or removal of selected pieces of near surface equipment
- D & D of surface facilities and buildings
- Emplacement of an enginered surface barrier to
  - adequately provide site drainage and minimize infiltration of water through the closed WMA C and
  - protect against inadvertant intrusion

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the functional requirements and criteria that have to be considered and comply with in the design of the facility. Examples include:

a) Minimise infiltration of water into the disposal units
b) Ensuring the integrity of disposal unit covers
c) Providing the structural stability of backfill, waste and covers
d) Minimise contact of waste with standing water
e) Providing adequate site drainage
f) Minimise the need for long-term maintenance.
g) Providing a barrier against inadvertent intrusion
h) Maintaining occupational exposure as low as reasonable achievable (ALARA), social and economic factors being taken into consideration
i) Restrict the loss of radionuclides from the disposal facility

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/15/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	No specifcally identified for the specific FEP

Conceptual Site Model

How it Applies: A conceptual design of the closed WMA C facilities is now being developed and will be available in FY 2012. This conceptual design defines the functional requirements and criteria that have to be considered and complied with in the design. These requirements and criteria include:Minimise infiltration of water into the disposal units
b) Ensuring the integrity of closed facility covers
c) Providing the structural stability of backfill, waste and covers
d) Minimizing contact of waste with standing water
e) Providing adequate site drainage
f) Minimizing the need for long-term maintenance.
g) Providing a barrier against inadvertent intrusion
h) Maintaining occupational exposure as low as reasonable achievable (ALARA), social and economic factors being taken into consideration
i) Restricting the loss of radionuclides and hazardous chemicals of concern from the closed WMA C facility

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-xxxxx		Quigley et al. (in proc	Conceptual Design of the WMA C facility at Closure.

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the design features, upon which the safety concept of the disposal facility is built to ensure that the functional requirements and criteria are met. The design features should ensure that under normal, abnormal or accident conditions, sufficient isolation and containment for radioactive materials are provided, the need for continued active maintenance after facility decommissioning are minimised, and the site's natural characteristics are improved in order to protect human health and the environment.

Factors related to the design features for a near-surface radioactive waste disposal facility can be divided into the following categories:

a) Engineering design considerations
b) Geotechnical design considerations
c) Structural design considerations
d) Seismic design considerations
e) Design features for long-term integrity (e.g. containment and isolation)
f) Fire protection design considerations

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/15/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	No specifc cases are identified for this FEP

Conceptual Site Model

How it Applies: Factors related to the design features for a closed WMA C facility are being developed as a part of the conceptual desing study and can be divided into the following categories:

a) Engineering design considerations
b) Geotechnical design considerations
c) Structural design considerations
d) Seismic design considerations
e) Design features for long-term integrity (e.g. containment and isolation)

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-xxxxx		Quigley et al. (in proc	Conceptual Design of the WMA C facility at Closure.

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the engineering design documentation available for the disposal facility, including procedures for the preparation, review, approval, issue, modification and control of documents and how it is included in the overall quality assurance programme.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/15/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	No specific cases are identified for this FEP

Conceptual Site Model

How it Applies: Procedures for the preparation, review, approval, issue, modification and control of facility design documents and how it is included in the overall quality assurance programs are described in WRPS Qualty Assurance program.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors relate to alternative disposal facility design conditions than those in the approved schedule and planning. Included in this FEP is the poor design of the disposal facility. Not all near-surface disposal facilities are well designed and some of the functional requirements and design features do not necessarily contribute to the safety of the facility.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/15/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	No specific cases are identified for this FEP

Conceptual Site Model

How it Applies: The initial WMA C PA will assume a single closure configuration that is consistent with the conceptual design. Under PA maintenance required by DOIE Order 453.1, the PA will need to be rerun if changes are identified in the closure documentation review cycles.

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The specific functional requirements and design features will need to be well described in DOE Tier 1 closure documentation and RCRA Teir II and II documention. Given the regulatory review planned for closure of WMA C through the HFFACO process (Closure documentation and review required for DOE Order 435.1 and RCRA), we anticipate that the closed WMA C facility will be well-designed facility.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
HFFACO	M-045-00	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order
DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the sequence of events and activities occurring during disposal facility construction (e.g. excavation, drilling), operation (e.g. waste emplacement, backfilling) and closure (e.g. sealing, cover emplacement).

Comment: Relevant events may include phased construction of units and emplacement of wastes, backfilling, sealing, capping and closure of sections of the disposal facility after wastes are emplaced and monitoring activities to provide data on the transient behaviour of the system or to provide input to the final assessment. The sequence of events and time between events may have implications for long term performance, e.g. decline of activity and heat production from the wastes, material degradation, chemical and hydraulic changes during a prolonged "open" phase.

Key Concepts, Examples and Related FEPs

1) **Construction, scope and schedule:** A detailed description of the major activities associated with the construction of the disposal facility and the schedule and resources required to construct the disposal facility. All this can be included in a construction plan, which may include an outline of the construction activities based on the construction drawings, specifications and related documents produced in the design phase of the project. The construction plan could also indicate a division of responsibilities between operators of the facility and outside contractors.

2) **Operation, scope and schedule:** A detailed description of the major activities associated with the operation of the disposal facility and the schedule and resources required for that purpose. All this can be included in a operation plan, which may include an outline of operations such as for the acceptance of waste, emplacement of waste, backfilling operations, monitoring and surveillance, and remedial activities where necessary. The operation plan could also indicate a division of responsibilities between operators of the facility and outside contractors.

3) **Closure, scope and schedule:** A detailed description of the major activities associated with the closure of the disposal facility and the schedule and resources required for that purpose. All this can be included in a closure plan, which may include an outline of the closure activities. The closure plan could also indicate a division of responsibilities between operators of the facility and outside contractors.

4) **Alternative schedule and planning conditions:** Factors related to alternative schedule and planning conditions assumed for the construction, operation and closure of the near-surface disposal facility. Included in this FEP is poor planning and scheduling of activities.

Applies to WMA	**Yes**	Entered By:	**h0006384**	On:	**7/21/2011**	Reviewed By		On:	

Denominator/Sensitivity Case(s):	See Tables B-1 through B-5 (for pre-closure period analysis) and Table B-12 for a specific case that will evaluated alternative ti

Conceptual Site Model

How it Applies: The initial WMA C PA will consider a pre-closure (1943 to present) flow and transport analyses that investigates the relationship between observed contaminant data in the vadose zone and groundwater. The uncertainty in the data and information related to the timing and location of past releases in the vadose zone have led to the need to consider a number of alternative conceptual models that include either 1) the potential effect of additional known or unknown sources of water or waste fluids, or 2) preferential pathway of flow and transport in the vadose zone, to explain current groundwater observations in the vicinity of the WMA in relation to the vadose zone observations of contaminant distributions. The evaluation of a number of alternative conceptual models consisting of a combination of these factors will allow for the evaluation of viable features, events, and processes (FEPs) that

provide insight into the flow and transport system at WMA C in relation to past releases. The viable FEPs identified during the pre−closure analysis will be evaluated for consideration in the post-closure analysis based on their relevance to the post-closure condition.

The initial WMA C PA will evaluate conditions consistent with a landfill closure of the WMA C in 2019. Alternative closure time frames will be considered in an alternative delayed closure at 2100 (See Table B-12, Appendix B, RPP-RPT-48490, Rev. 1)

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Table B-12, Appendix B	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: A detailed description of the major activities associated with the construction of the disposal facility and the schedule and resources required to construct the disposal facility. All this can be included in a construction plan, which may include an outline of the construction activities based on the construction drawings, specifications and related documents produced in the design phase of the project. The construction plan could also indicate a division of responsibilities between operators of the facility and outside contractors.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Major activities associated with the construction of the disposal facility and the schedule and resources required to construct the disposal facility will not be specifically evaluated in the Initial WMA C PA. Only the final end state of activities and actions taken as a part of closing WMA C will be considered in the post-closure analysis.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Table B-12 and B-13	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: A detailed description of the major activities associated with the operation of the disposal facility and the schedule and resources required for that purpose. All this can be included in a operation plan, which may include an outline of operations such as for the acceptance of waste, emplacement of waste, backfilling operations, monitoring and surveillance, and remedial activities where necessary. The operation plan could also indicate a division of responsibilities between operators of the facility and outside contractors.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Operations leading up to closure of the WMA C will not be evlauated in detail in the initial PA effort.

A set of pre-closure flow and transport analyses that investigates the relationship between observed contaminant data in the vadose zone and groundwater. The uncertainty in the data and information related to the timing and location of past releases in the vadose zone have led to the need to consider a number of alternative conceptual models that include either 1) the potential effect of additional known or unknown sources of water or waste fluids, or 2) preferential pathway of flow and transport in the vadose zone, to explain current groundwater observations in the vicinity of the WMA in relation to the vadose zone observations of contaminant distributions. The evaluation of a number of alternative conceptual models consisting of a combination of these factors will allow for the evaluation of viable features, events, and processes (FEPs) that provide insight into the flow and transport system at WMA C in relation to past releases. The viable FEPs identified during the pre−closure analysis will be evaluated for consideration in the post-closure analysis based on their relevance to the post-closure condition.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Table B-12 and B-13	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: A detailed description of the major activities associated with the closure of the disposal facility and the schedule and resources required for that purpose. All this can be included in a closure plan, which may include an outline of the closure activities. The closure plan could also indicate a division of responsibilities between operators of the facility and outside contractors.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: The post-closure analysis will only consider the assumed end state of the closed WMA C and not the specific major activities associated with the closure of the disposal facility and the schedule and resources required for that purpose.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Appendix B	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to alternative schedule and planning conditions assumed for the construction, operation and closure of the near-surface disposal facility. Included in this FEP is poor planning and scheduling of activities.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s): See Table B-13, Appendix B, RPP-RPT-48490, Rev. 1

Conceptual Site Model

How it Applies: The initial WMA C PA will evaluate conditions consistent with a landfill closure of the WMA C in 2019. Alternative closure time frames will be considered in an alternative delayed closure at 2100 (See Table B-13, Appendix B, RPP-RPT-48490, Rev. 1)

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Table B-12 and B-13,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the construction (e.g., excavation) of trenches, vaults, boreholes, etc., as well as the stabilisation of these facilities and installation/assembly of structural elements according to the approved schedule and planning.

Comment: As used here, construction includes those activities that are required to bring the disposal facility into fully operational state, i.e. the implementation of the design considerations and specifically to the construction of features of the disposal facility necessary to provide long-term isolation of disposed waste, minimise the need for continued active maintenance after site closure, and improve the site's natural characteristics in order to protect public health and the environment. In addition, it includes the construction methods. (See FEP 1.102).

Key Concepts, Examples and Related FEPs

1) **Construction process (method):** The construction process or method provides information on the process that will be followed to construct the disposal facility and its sub-components, according to the construction plan. It includes, amongst others

a) Information on the preparation of the site
b) Construction (e.g. blasting, excavation, drilling of borehole, etc.) of the disposal facility
c) Construction of steel or concrete structures,
d) Backfilling methods that will be used
e) The equipment required.

2) **Performance and verification of construction:** Performance and verification activities should be carried out according to the quality control procedures. Examples of items that would be subjected to the quality control procedures are:

a) Soil excavation and foundation preparation
b) Materials such as reinforcing steel, concrete ingredients, buffer materials, etc.,
c) Trail batching and concrete manufacturing at site
d) Concrete placing ad curing
e) Welding consumables and quality of welments
f) Building services including power distribution, lighting, fire detection, communication, crane control system, radiation monitoring system, etc.

3) **Alternative construction conditions:** Factors relate to alternative disposal facility construction conditions than those in the approved schedule and planning. Included in this FEP is the poor construction of the disposal facility. Not all near-surface disposal facilities are well constructed, while some of the construction activities might alter disposal system conditions.

Applies to WMA	**Yes**	Entered By:	**h0006384**	On:	**7/21/2011**	Reviewed By		On:	

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: Major activities associated with the construction of the disposal facility and the schedule and resources required to construct the disposal facility will not be specifically evaluated in the Initial WMA C PA. Only the final end state of activities and actions taken as a part of closing WMA C will be

considered in the post-closure analysis.

The PA analysis will be based on assumptions of performance with regards to specific elements of the engioneered part of the closed system. The analysis will not specifically consider any construction defects and issuesother than the potential impacts for a range of alternative performance levels for:

- grout emplaced in tanks and ancillary equipment (higher and lower diffusion levels and shorter and longer effective design lives) (See Table 13, Appendix B, RPP-RPT-48490, rev. 1)
- the engineered surface barrier placed on the closed WMA C (i.e. higher and lower recharge levels and shorter and longer design lives) (See Table 12, Appendix B, RPP-RPT-48490, rev. 1)

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Table B-12 and B-13 ,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: The construction process or method provides information on the process that will be followed to construct the disposal facility and its sub-components, according to the construction plan. It includes, amongst others

a) Information on the preparation of the site
b) Construction (e.g. blasting, excavation, drilling of borehole, etc.) of the disposal facility
c) Construction of steel or concrete structures,
d) Backfilling methods that will be used
e) The equipment required.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: The initial WMA C PA will evaluate the end state assumed at closure will not specifically consider construction processes or methods used to get to closure.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Table B-12 and B-13 ,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Performance and verification activities should be carried out according to the quality control procedures. Examples of items that would be subjected to the quality control procedures are:

a) Soil excavation and foundation preparation
b) Materials such as reinforcing steel, concrete ingredients, buffer materials, etc.,
c) Trail batching and concrete manufacturing at site
d) Concrete placing ad curing
e) Welding consumables and quality of welments
f) Building services including power distribution, lighting, fire detection, communication, crane control system, radiation monitoring system, etc.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	Tables B

Conceptual Site Model

How it Applies: The PA analysis will be based on assumptions of performance with regards to specific elements of the engioneered part of the closed system. The analysis will not specifically consider any construction defects and issuesother than the potential impacts for a range of alternative performance levels for:

- grout emplaced in tanks and ancillary equipment (higher and lower diffusion levels and shorter and longer effective design lives) (See Table B-13, Appendix B, RPP-RPT-48490, rev. 1)
- the engineered surface barrier placed on the closed WMA C (i.e. higher and lower recharge levels and shorter and longer design lives) (See Table B-12, Appendix B, RPP-RPT-48490, rev. 1)

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Table B-12 and B-14	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors relate to alternative disposal facility construction conditions than those in the approved schedule and planning. Included in this FEP is the poor construction of the disposal facility. Not all near-surface disposal facilities are well constructed, while some of the construction activities might alter disposal system conditions.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/21/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s): Tables B-12 and B-13, Appendix B, RPP-RPT-48490, Rev. 1

Conceptual Site Model

How it Applies: The PA analysis will be based on assumptions of performance with regards to specific elements of the engioneered part of the closed system. The analysis will not specifically consider any construction defects and issuesother than the potential impacts for a range of alternative performance levels for:

- grout emplaced in tanks and ancillary equipment (higher and lower diffusion levels and shorter and longer effective design lives) (See Table B-13, Appendix B, RPP-RPT-48490, rev. 1)
- the engineered surface barrier placed on the closed WMA C (i.e. higher and lower recharge levels and shorter and longer design lives) (See Table B-12, Appendix B, RPP-RPT-48490, rev. 1)

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Table B-12 and B-13,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the operation (waste acceptance, waste emplacement, backfilling, monitoring and surveillance, remedial activities) of the near-surface radioactive waste disposal facility, according to the approved schedule and planning for the facility.

Comment: As used here, disposal facility operation is the period between the construction of the disposal facility and the closure of the disposal facility (i.e. it exclude actions associated with the closure of the disposal facility). Although the post-closure safety assessment is not directly associated with these operational activities, interdependencies exist between the two periods that need to be considered. Actions taken during the operational period may thus have an influence on the performance of the facility during the post-closure period.

Key Concepts, Examples and Related FEPs

1) **Acceptance of waste:** Factors related to the acceptance of radioactive waste at the near-surface disposal facility. Distinction can be made between qualitative and quantitative requirements for the acceptance of waste at a near-surface disposal facility. Qualitative waste acceptance requirements sets limits on activities and concentration to be accepted for disposal at the facility. Qualitative waste acceptance requirement could, for example, be used to specify criteria for:

a) The transport and delivery of waste packages to the disposal facility;
b) The physical, chemical and biological properties of the radioactive waste;
c) Items and substances that are prohibited in the waste;
d) The characteristics of the waste packages;
e) Labelling of the waste package; and
f) Documentation to accompanying the waste shipment.

2) **Waste repackaging:** Factors related to the repackaging of waste or waste containers in new or larger waste packages before emplacement at their final position within the disposal facility. Upon receipt and inspection of waste at the disposal facility, some waste may be judged to be unsuitable for the disposal handling operations due to the condition of the packaging. Repackaging of these waste may be done at the disposal facility, normally by placing the waste in an overpack, if it does not pose any radiation hazard or contamination risk.

3) **Waste allocation:** Factors related to the choices on allocation of wastes to the disposal facility or separate units of the disposal facility, including waste type(s) and amount(s).

4) The waste type and waste allocation are established in a general way in the disposal facility concept. There may, however, be a number of options concerning these factors. Final decisions may not be made until the disposal facility is operating and will be subject to regulation. In safety assessments, assumptions may need to be made about future waste arisings and future waste allocation strategies.

5) **Waste emplacement:** Factors related to the placing of wastes (usually in containers) at their final position within the disposal facility. Some waste types and inventories may require special waste emplacement arrangements to simplify the disposal practice, to ensure safety or to ensure structure stability in the disposal zone.

6) **Backfill preparation, handling and emplacement:** Factors related to the preparation, handling and emplacement of backfill materials in the disposal zone of the disposal facility.

7) Backfill material is used to refill excavated portions of the disposal facility or any void spaces left unfilled after waste has been emplaced, or provide a stable base for the placement of the next package layers. It may also provide some shielding and serve as a fire retardant. The fill voids, most often a free-flowing backfill material in a dry state is required. Different methods can be used to handle and emplace the backfill material to reduce radiation hazards and homogeneity.

8) **Monitoring and surveillance:** Factors related to the monitoring and surveillance that is carried out during operations, or following closure of sections to the total disposal facility. This includes monitoring and surveillance for operational safety and also of parameters related to long-term safety and performance.

9) Disposal facility design, host lithology, national regulations, confidence building or public pressure may determine the extent and requirement for such a

monitoring and surveillance programme.
10) **Remedial activities:** Factors related to remedial activities carried out at the disposal facility to improve the safety of the facility.
11) **Alternative operational conditions:** Factors relate to alternative operational activities at the disposal facility than those in the approved schedule and planning. Included in this FEP is the poor operation of the disposal facility (e.g. waste acceptance, waste emplacement, waste allocation, backfilling etc.). Not all near-surface disposal facilities are well operated, while some of the operational activities might alter disposal system conditions.

Applies to WMA **Yes** Entered By: **h0006384** On: **7/26/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: The majority of these FEPS would not apply since the closed WMA C ia not a disposal facility. Tow concepts that would apply would include:

- Monitoring and surveillance after closure
- The potential for remedial actions (i. e. corrective measures performed on existing contamination) that may be undertaken prior to closure

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
HFFACO	M-045-00	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order
DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the acceptance of radioactive waste at the near-surface disposal facility. Distinction can be made between qualitative and quantitative requirements for the acceptance of waste at a near-surface disposal facility. Qualitative waste acceptance requirements sets limits on activities and concentration to be accepted for disposal at the facility. Qualitative waste acceptance requirement could, for example, be used to specify criteria for:

a) The transport and delivery of waste packages to the disposal facility;
b) The physical, chemical and biological properties of the radioactive waste;
c) Items and substances that are prohibited in the waste;
d) The characteristics of the waste packages;
e) Labelling of the waste package; and
f) Documentation to accompanying the waste shipment.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/26/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: This specific factors related to waste in the following does not apply per se.

- The transport and delivery of waste packages to the disposal facility;
- Items and substances that are prohibited in the waste;
- The characteristics of the waste packages;
- Labelling of the waste package; and
- Documentation to accompanying the waste shipment.

Acceptance of existing soil contamination and waste residual left in tanks and ancillary facilities as a part of the closed WMA C will be evaluated in detail as a part of the baseline risk assessment and the long-term performance assessment of the closed facility.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
HFFACO	M-045-00	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the repackaging of waste or waste containers in new or larger waste packages before emplacement at their final position within the disposal facility. Upon receipt and inspection of waste at the disposal facility, some waste may be judged to be unsuitable for the disposal handling operations due to the condition of the packaging. Repackaging of these waste may be done at the disposal facility, normally by placing the waste in an overpack, if it does not pose any radiation hazard or contamination risk.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0006384** On: **7/26/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Does not apply.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
HFFACO	M-045-00	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order
DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the choices on allocation of wastes to the disposal facility or separate units of the disposal facility, including waste type(s) and amount(s).

The waste type and waste allocation are established in a general way in the disposal facility concept. There may, however, be a number of options concerning these factors. Final decisions may not be made until the disposal facility is operating and will be subject to regulation. In safety assessments, assumptions may need to be made about future waste arisings and future waste allocation strategies.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/26/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Does not apply as described above. Some part of the existing soil contamination in the subsurface and waste residuals in retrieved tanks and ancillary equipment including pipelines will likely be left behind as a part of the configuration but will not be allocated into the closed WMA C like it would be within a closed LLW disposal facility.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
HFFACO	M-045-00	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order
DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the placing of wastes (usually in containers) at their final position within the disposal facility. Some waste types and inventories may require special waste emplacement arrangements to simplify the disposal practice, to ensure safety or to ensure structure stability in the disposal zone.

Comment:

Applies to WMA **Yes** Entered By: **h0006384** On: **7/26/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Does not apply as described for a disposal facility as above. Some part of the existing soil contamination in the subsurface and waste residuals in retrieved tanks and ancillary equipment including pipelines will likely be left behind as a part of the configuration but will not be placed into the closed WMA C like it would be within closed LLW disposal facility. The use of grout and concrete will likely be used as a part of enhancing long-term safety and performance and enhancing structural stability for tanks and some of the ancillary equipment.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
HFFACO	M-045-00	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order
DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the preparation, handling and emplacement of backfill materials in the disposal zone of the disposal facility.
7) Backfill material is used to refill excavated portions of the disposal facility or any void spaces left unfilled after waste has been emplaced, or provide a stable base for the placement of the next package layers. It may also provide some shielding and serve as a fire retardant. The fill voids, most often a free-flowing backfill material in a dry state is required. Different methods can be used to handle and emplace the backfill material to reduce radiation hazards and homogeneity.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/26/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Does not apply per se. Closure ofWMA C may likely involve the use of a grading fill to establish a stable base for place of the final engineered surface barrier.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the monitoring and surveillance that is carried out during operations, or following closure of sections to the total disposal facility. This includes monitoring and surveillance for operational safety and also of parameters related to long-term safety and performance.
9) Disposal facility design, host lithology, national regulations, confidence building or public pressure may determine the extent and requirement for such a monitoring and surveillance programme.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/26/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Monitoring and surveillance is carried out during current site operations for operational safety and will be expected to continue following closure of the WMA C to ensure long-term safety and performance.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to remedial activities carried out at the disposal facility to improve the safety of the facility.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: The closure process will include an evaluation of a baseline risk assessment of current conditions and will consider and possibly implement a variety of potential remedial activities (i.e. use of corrective measures) to reduce the long-term risk of a closed WMA C facility.

The initital WMA C PA will be based on the most corrent assumptions about corrective measures. Deviations from assumed corrective measures prior to actual closure will need to factored into susequent PA interations and maintenance.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors relate to alternative operational activities at the disposal facility than those in the approved schedule and planning. Included in this FEP is the poor operation of the disposal facility (e.g. waste acceptance, waste emplacement, waste allocation, backfilling etc.). Not all near-surface disposal facilities are well operated, while some of the operational activities might alter disposal system conditions.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s): See Table B-12, Appendix B, RPP-RPT-48490, rev. 1

Conceptual Site Model

How it Applies: The denominator case for the initial WMA C will evaluate a site closure at 2019. Additional sensitivity cases will examine alternative operational periods and other aspects of site closure (See Table B-12, Appendix B, RPP-RPT-48490, rev. 1) that include:

- The effects of delaying closure by 50 yrs.
- The effects of loss of institutional control 50 yrs after closure.
- The effects of alternative barrier design lives and
- The effects of other events and processes that could affect recharge rates after loss of institutional control and/or barrier design life

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Table B-12, Appendix B	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the closure operations of the near-surface radioactive waste disposal facility, according to the approved schedule and planning for the facility.

Comment: Closure of a disposal facility is the last major operational step in completing the disposal system. It is defined as a *systematic action that is conducted after the receipt of waste ceases and waste emplacement operations have been completed with the intention of providing a final configuration for the disposal system*.

Closure phase activities need to complement the design of the disposal system because the entire system is intended to contain and isolate harmful constituents for a sufficiently long period so that risks posed to humans and ecosystems are acceptable. Disposal facility closure requires consideration of a combination of scientific, engineering, regulatory, and socio-economic factors that are integrated and optimised to select cost-effective alternatives acceptable to all interested parties.

Key Concepts, Examples and Related FEPs

1) **Analysis of remedial alternatives:** Factors related to an analysis of remedial alternatives (including a baseline, no-action alternative) for the closure of a near-surface radioactive waste disposal facility. Some countries have LILW disposal facilities that were filled, and in some cases covered, before systematic methods of safety analysis were developed. Many of the "legacy" disposal facilities may require remedial actions that are more extensive than simply the installation of a cover. Examples of the type of facilities that might require more extensive remedial action include unlined trenches and seepage pits. An analysis of the no-action alternative identifies the need for remedial action and provides a baseline for comparative purposes. If the disposal facility is designed and operated taking into account the complete life cycle of the facility, the need for remedial alternatives analysis would probably not be required is not required.

2) **Closure plan:** Factors related to a detailed and regulatory approved closure plan developed for the near-surface radioactive waste disposal facility. The first step in the process of disposal facility closure (for both current and legacy facilities) is the requirement that the facility operator submits a detailed closure plan to regulatory authorities and obtains approval prior to its execution. Closure plans for the facility have to reflect any "as built" modifications to the original facility or operational practices that would affect the results of the safety assessment. The primary objective of the closure plan is to satisfy regulatory requirements and address public concerns to achieve safety isolation of the waste in a cost-effective manner. The detailed project plan usually include the following:

a) Roles and responsibilities for organisations involved with closure and post-closure care of the facility
b) A detailed description of the closure method
c) An updated safety assessment of the facility
d) A monitoring and surveillance plan
e) A description of the record keeping and record preservation system
f) Long-term controls that will be implemented during the post-closure phase

3) **Performance requirements and criteria:** Factors related to performance requirements and criteria to be considered in the development of closure systems for a near-surface radioactive waste at the disposal facility. Closure systems are designed to satisfy a number of requirements to ensure the long-term safety of the disposal facility. The design requirements for a closure system are derived from regulatory input, public consultation, economic considerations and technical analyses. There are a number of general requirements that all closure systems are expected to meet to ensure the long-term integrity of the facility:

❑

4) **Closure system features and materials:** Factors related to features included in a closure system of near-surface radioactive waste at the disposal facility and the materials used for that purpose. There are several engineering features or components that may be used for closure of near-surface radioactive waste at the disposal facilities:

a) A cap (cover) with or without a low permeability (resistive) layer.
b) Cut-off walls designed to minimize lateral migration of either leachate out of groundwater into the disposal facility

c) Drainage features to conduct surface and subsurface water and potential leachate away from the disposal facility

Markers to indicate the presence of a closed disposal facility to future generations. A wide variety of materials can be employed as barrier material in the construction of disposal facilities. These materials can be used either individually or in combination to provide the overall system with the required properties. Examples include:

- 1. Clay
- 2. Concrete and cement
- 3. Asphalt
- 4. Synthetic materials
- 5. Rock and aggregates
- 6. Vegetation

5) **Failure mechanisms:** Factors related to failure mechanisms that will influence the performance of closure systems designed for near-surface radioactive waste at the disposal facility. All engineered features and structures will at some point fail to carry out the function they were designed to perform. This failure may be a sudden catastrophic one, resulting from stresses outside the design envelope and tolerances of the structure or it may be a gradual reduction in performance over a period of time. There are a number of mechanisms by which closure features may fail, the major ones being:

a) Erosion
b) Intrusion (human, animal and plant)
c) Weathering
d) Differential settlement and subsidence
e) Clogging
f) Pressurization due to gas generation
g) Chemical and microbial attack
h) Ecological succession

6) **Disposal facility preparation and clearance:** Factors related to the preparation and clearance for closure of near-surface radioactive waste at the disposal facilities.

In preparation for disposal facility closure, there are a number of technical operations that are required. These include:

a) Clearance and decommissioning of existing building and other structures
b) If necessary, removal of interim measures such as temporary caps
c) Selection of materials and provisions of materials handling areas
d) Infrastructure changes to allow the delivery of construction materials
e) Scheduling

7) **Construction, closure system:** Factors related to the construction of closure systems for near-surface radioactive waste at the disposal facilities. The major tasks of construction of a closure system for near-surface radioactive waste at the disposal facilities are:

a) Verification by soil testing that underlying materials are ready to be capped
b) Excavation and preparation of soil material
c) Placement of monitoring systems
d) Placement of engineered barrier systems (e.g. soil placement, soil compaction, Geomembrane installation, drainage systems)
e) Installation of drainage control features
f) Revegetation
g) Quality control

8) **Confirmation, closure system:** Factors related to the confirmation of a closure system implemented for a near-surface radioactive waste at the disposal facility. The confirmation process consists of several activities that include disposal facility inspections, data collection and management, and presentation of information to the appropriate regulatory body to gain final approval for disposal facility closure. If the disposal facility performs as designed during this short period following operation, it is then placed into an institutional control phase. An important part of the institutional control period is to demonstrate by periodic monitoring and observation that the facility is functioning as intended to contain and isolate waste from the biosphere. The level of activity decreases at latter stages of the institutional control period as confidence in the facility's performance increases based on the results of post-closure monitoring and observation. The eventual goal of closure is to have enough confidence that the disposal facility will not ever represent a significant risk to human health so that the land may eventually be used for other purposes.
9) **Alternative closure conditions:** Factors relate to alternative closure condition implemented at the disposal facility than those in the approved schedule and planning. Included in this FEP is the poor closure of the disposal facility. These poorly closed conditions will influence disposal system performance.

Applies to WMA **Yes** Entered By: **h0006384** On: **7/26/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Closure of WMA C will consider:

- Analysis of remedial alternatives (use of corrective measures)
- Closure plan
- Performance requirements and criteria
- Closure system features and materials
- Failure mechanisms
- Facility preparation and clearance:
- Construction of closure system
- Confirmation of closure system
- Alternative closure system

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
HFFACO	M-045-00	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order
DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to an analysis of remedial alternatives (including a baseline, no-action alternative) for the closure of a near-surface radioactive waste disposal facility. Some countries have LILW disposal facilities that were filled, and in some cases covered, before systematic methods of safety analysis were developed. Many of the "legacy" disposal facilities may require remedial actions that are more extensive than simply the installation of a cover. Examples of the type of facilities that might require more extensive remedial action include unlined trenches and seepage pits. An analysis of the no-action alternative identifies the need for remedial action and provides a baseline for comparative purposes. If the disposal facility is designed and operated taking into account the complete life cycle of the facility, the need for remedial alternatives analysis would probably not be required is not required.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	See Table B-7 through B-17, Appendix B, RPP-RPT-48490, Rev. 1

Conceptual Site Model

How it Applies: The initial PA will assume a specific landfill closure condition with an associated set of remedial actions implemented prior to site closure. No specific analysis of remedial alternatives are planned. A variety of sensitivity cases will be examined to evaluate different aspects of engineered components and source terms left within the closed WMA C that include:

- expected performance of the engineered surface barrier
- diffusion characteristics of the emplace grout and concrete.
- uncertainty in residual inventory in unretrieved tanks
- uncertainty in inventories of past waste releases to the vadose zone.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Table B-7 through B-17,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to a detailed and regulatory approved closure plan developed for the near-surface radioactive waste disposal facility. The first step in the process of disposal facility closure (for both current and legacy facilities) is the requirement that the facility operator submits a detailed closure plan to regulatory authorities and obtains approval prior to its execution. Closure plans for the facility have to reflect any "as built" modifications to the original facility or operational practices that would affect the results of the safety assessment. The primary objective of the closure plan is to satisfy regulatory requirements and address public concerns to achieve safety isolation of the waste in a cost-effective manner. The detailed project plan usually include the following:

a) Roles and responsibilities for organisations involved with closure and post-closure care of the facility
b) A detailed description of the closure method
c) An updated safety assessment of the facility
d) A monitoring and surveillance plan
e) A description of the record keeping and record preservation system
f) Long-term controls that will be implemented during the post-closure phase

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Closure of WMA C will require preparation of:

- Tier 1 closure plans to meet requirements for closure in DOE-Order 435.1
- Tier 2 and 3 closure plans to meet requirements for closure under RCRA as specified in
  - WAC 173-303 610 Closure Requirements
  - WAC 173-303 646 RCRA Corrective Action Requirements

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
HFFACO	M-045-00	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order

DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual
WAC-173-303	610	Washington Administr	Dangerous Waste Regulations: Closure and post-closure (610)
WAC-173-303	646	Washington Administr	RCRA Corrective Action

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to performance requirements and criteria to be considered in the development of closure systems for a near-surface radioactive waste at the disposal facility. Closure systems are designed to satisfy a number of requirements to ensure the long-term safety of the disposal facility. The design requirements for a closure system are derived from regulatory input, public consultation, economic considerations and technical analyses. There are a number of general requirements that all closure systems are expected to meet to ensure the long-term integrity of the facility:

- a) Impermeability
- b) Integrity
- c) Resistance to degradation
- d) Reparability

Criteria specific to closure system design can be performance driven (derived from site and facility-specific models) or prescriptive (i.e. regulatory criteria that apply to an entire class of facility). The detailed criteria required for design and evaluation of a multi-layer cover incorporating resistive and capillary barriers, or the criteria required for design and evaluation of a surface water drainage system are seldom included in models used to evaluate the performance of closure systems. Examples of performance criteria needed for detailed design calculations are:

- a) Infiltration rate into the cap
- b) Freeze-thaw depth
- c) Runoff and erosion
- d) Compactness and strength of cap layers
- e) Compactness and strength of waste layers

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: The PA will be focused on assessing the long-term impacts of a closed WMA C. The closed WMA C will designed to meet the specific performance requirements and criteria defined in Hanford Federal Facility Agreement and Consent Order (HFFACO) that include :

- Appendix H and I in HFFACO
- WAC 173-303 610 Closure Requirements
- WAC 173-303 646 RCRA Corrective Action Requirements
- WAC 173-340-700 to 760 Requirements Cleanup Levels
- DOE Order 435.1

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
HFFACO	M-045-00	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order
DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual
WAC-173-303	610	Washington Administr	Dangerous Waste Regulations: Closure and post-closure (610)
WAC-173-303	646	Washington Administr	RCRA Corrective Action
WAC-173-340	700 to 760	Washington Administr	Model Toxics Control Act -- Cleanup
DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to features included in a closure system of near-surface radioactive waste at the disposal facility and the materials used for that purpose. There are several engineering features or components that may be used for closure of near-surface radioactive waste at the disposal facilities:

a) A cap (cover) with or without a low permeability (resistive) layer.
b) Cut-off walls designed to minimize lateral migration of either leachate out of groundwater into the disposal facility
c) Drainage features to conduct surface and subsurface water and potential leachate away from the disposal facility

Markers to indicate the presence of a closed disposal facility to future generations. A wide variety of materials can be employed as barrier material in the construction of disposal facilities. These materials can be used either individually or in combination to provide the overall system with the required properties. Examples include:

- ❑
  1. Clay
  2. Concrete and cement
  3. Asphalt
  4. Synthetic materials
  5. Rock and aggregates
  6. Vegetation

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	See Tables B-12 and B-13 in Appendix B of RPP-RPT-48490, Rev. 1

Conceptual Site Model

How it Applies: The PA will be focused on assessing a closed WMA C facility that will include the following two engineered features and components:

- emplaced grout and concrete in retrieved tanks ad ancillary equipment and pipeline encasements and
- an engineered surface barrier that will include:
  - an surface layer to maximize evapo-transpiration of infitrating precipitation
  - a capillary break and drainage system to maximize lateral drainage away from the facility and to minimize water infitration through the cover system and the waste residual and contamination below,
  - an intrusion barrier to minimize inadvertant intrusion or contact with soil contamination and waste residuals at depth below the barrier system.

A range of sensitivity cases will be examined to evaluate a range of expected long-term performance of these engineered components (see Tables B-11 and B-13 in Appendix B of RPP-RPT-48490, Rev. 1)

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Table B-7 through B-17,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to failure mechanisms that will influence the performance of closure systems designed for near-surface radioactive waste at the disposal facility. All engineered features and structures will at some point fail to carry out the function they were designed to perform. This failure may be a sudden catastrophic one, resulting from stresses outside the design envelope and tolerances of the structure or it may be a gradual reduction in performance over a period of time. There are a number of mechanisms by which closure features may fail, the major ones being:

- a) Erosion
- b) Intrusion (human, animal and plant)
- c) Weathering
- d) Differential settlement and subsidence
- e) Clogging
- f) Pressurization due to gas generation
- g) Chemical and microbial attack
- h) Ecological succession

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **8/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	See Table B-11 through B-14, Appendix B in RPP-RPT-48490, Rev. 1

Conceptual Site Model

How it Applies: Failure mechanisms from natural processes (erosion, weathering, subsidence, chemical attack or degradation) or biological induced events (Human or ecological system intrusion) will not be specifically evaluated in WMA C but a range of sensitivity cases designed to look at a range of expected performances for the engineered components and the natural ystem as impacted by these failure mechanisms will be considered.

The range of sensitivity cases being considered in the initial PA are defined in Table B-11 through B-14, Appendix B in RPP-RPT-48490, Rev. 1

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Table B-7 through B-17,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the preparation and clearance for closure of near-surface radioactive waste at the disposal facilities.

In preparation for disposal facility closure, there are a number of technical operations that are required. These include:

a) Clearance and decommissioning of existing building and other structures
b) If necessary, removal of interim measures such as temporary caps
c) Selection of materials and provisions of materials handling areas
d) Infrastructure changes to allow the delivery of construction materials
e) Scheduling

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: The closure configuration that will be evaluated in the WMA C PA will assume:

a) Clearance and decommissioning of existing building and other surface structures
b) the potential use of corrective measures to remove or to contain localized areas of contaminantion or waste resdiuals
c) the emplacement of grout in retireed tanks and ancillary equipment and encasements containing pipelines to enhance the strucutural stability of these facilities and to isolate remaining waste residuals
c) the construction of an engineered surface barrier designed to minimize infiltration and inadvertant intrusion into contamination and waste residuals left in the closed facility

A range of sensitivity cases will be examined to evaluate a range of expected long-term performance of these engineered components (see Tables B-11 and B-13 in Appendix B of RPP-RPT-48490, Rev. 1)

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
RPP-RPT-48490, Rev. 1	See Table B-7 through B-17,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the construction of closure systems for near-surface radioactive waste at the disposal facilities. The major tasks of construction of a closure system for near-surface radioactive waste at the disposal facilities are:

a) Verification by soil testing that underlying materials are ready to be capped
b) Excavation and preparation of soil material
c) Placement of monitoring systems
d) Placement of engineered barrier systems (e.g. soil placement, soil compaction, Geomembrane installation, drainage systems)
e) Installation of drainage control features
f) Revegetation
g) Quality control

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: The closure process and associated requirements defined in HFFACO, the Washington Administrative code, and the DOE Order 435.1 will include:

a) Verification by soil testing that underlying materials are ready to be capped
b) Excavation and preparation of soil material
c) Placement of monitoring systems
d) Placement of engineered barrier systems (e.g. soil placement, soil compaction, intruder barrier installation, drainage systems)
e) Installation of drainage control features
f) Revegetation
g) Quality control

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the confirmation of a closure system implemented for a near-surface radioactive waste at the disposal facility. The confirmation process consists of several activities that include disposal facility inspections, data collection and management, and presentation of information to the appropriate regulatory body to gain final approval for disposal facility closure. If the disposal facility performs as designed during this short period following operation, it is then placed into an institutional control phase. An important part of the institutional control period is to demonstrate by periodic monitoring and observation that the facility is functioning as intended to contain and isolate waste from the biosphere. The level of activity decreases at latter stages of the institutional control period as confidence in the facility's performance increases based on the results of post-closure monitoring and observation. The eventual goal of closure is to have enough confidence that the disposal facility will not ever represent a significant risk to human health so that the land may eventually be used for other purposes.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: The closure process and requirements will include confirmation of a closure system performancer as implemented at the WMA C. The confirmation process will consist of several activities that include closed facility inspections, data collection and management, and presentation of information to the WA State Department of Ecology (per WAC requirements) and DOE (per DOE Order 435.1 requirements) to gain final approval for a closure permit from Ecology and closure authroization from DOE. The closed WMA C will be placed into an institutional control phase. During the institutional control period is to demonstrate by periodic monitoring and observation that the facility is functioning as intended to contain and isolate waste from the biosphere. The level of activity will decreases at latter stages of the institutional control period as confidence in the facility's performance increases based on the results of post-closure monitoring and observation. The eventual goal of closure is to have enough confidence that the closed WMA C will not ever represent a significant risk to human health so that the land may eventually be used for other purposes appropriate and consistent with the presence of the closed WMA C.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors relate to alternative closure condition implemented at the disposal facility than those in the approved schedule and planning. Included in this FEP is the poor closure of the disposal facility. These poorly closed conditions will influence disposal system performance.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	See cases defined in Tables B-11 through B-14 in Appendix B of RPP-RPT-48490, Rev. 1

Conceptual Site Model

How it Applies: The denominator case for the initial WMA C will evaluate a specific site closure set of conditions. Additional sensitivity cases will examine alternative performance aspects of site closure (See Table B-12 and B-13, Appendix B, RPP-RPT-48490, rev. 1) that could be consistent with either assumptions of less optimistic levels of performance or poorly closed conditions. The sensitivity cases currently proposed include:

- The effects of delaying closure by 50 yrs.
- The effects of loss of institutional control 50 yrs after closure.
- The effects of alternative barrier design lives
- The effects of other events and processes (both natural or human-induced) that could affect recharge rates after loss of institutional control and/or barrier design life and
- The effects of alternative diffusive characteristics or performance levels for emplaced grout and concrete

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Table B-11 through B-14,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to quality assurance and control procedures and tests during the design, construction and operation of the disposal facility, as well as the manufacture of the waste forms, containers and engineered features.

Comment: It can be expected that a range of quality control measures will be applied during construction and operation of the disposal facility, as well as to the manufacture of the waste forms, containers etc. In an assessment these may be invoked to avoid analysis of situations that, it is expected, can be prevented by quality control. There may be specific regulations governing quality control procedures, objectives and criteria.

Key Concepts, Examples and Related FEPs

1) **Procurement of items and services:** Factors related to quality assurance that will be applied during the procurement of items and services important to the safety of a near-surface radioactive waste disposal facility.
2) **Manufacturing:** Factors related to quality assurance that will be applied during all the manufacturing of components and subcomponents activities important to the safety of a near-surface radioactive waste disposal facility.
3) **Research and development:** Factors related to quality assurance that will be applied during research and development activities important to the safety of a near-surface radioactive waste disposal facility.
4) **Siting:** Factors related to quality assurance that will be applied during all siting activities for a near-surface radioactive waste disposal facility.
5) **Design:** Factors related to quality assurance that will be applied during the design of components and subcomponents important to the safety of a near-surface radioactive waste disposal facility.
6) **Construction:** Factors related to quality assurance that will be applied during the construction of all components and subcomponents important to the safety of a near-surface radioactive waste disposal facility.
7) **Commissioning:** Factors related to quality assurance that will be applied during the commissioning of components and subcomponents important to the safety of a near-surface radioactive waste disposal facility.
8) **Operation:** Factors related to quality assurance that will be applied during the operation of a near-surface radioactive waste disposal facility.
9) **Decommissioning (closure):** Factors related to quality assurance that will be applied during the decommissioning (closure) of components and subcomponents important to the safety of a near-surface radioactive waste disposal facility.
10) **Failure of quality assurance/control**: Factors related to the failure or poor implementation of quality assurance and quality control procedures during the life cycle of the disposal facility.

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s): See Table B-11 through B-13, Appendix B in RPP-RPT-48490, Rev. 1

Conceptual Site Model

How it Applies: The closure process for WMA C will need to meet the Quality Assurrance requirements defined in:

- Appendix H and I in HFFACO

- WAC 173-303 610 Closure Requirements
- WAC 173-303 646 RCRA Corrective Action Requirements
- WAC 173-340-700 to 760 Requirements Cleanup Levels
- DOE Order 435.1

A range of sensitivity cases will be examined to evaluate a range of expected long-term performance of important components of the Closed WMA C that could be affected by QA factors described above (see Tables B-11 and B-13 in Appendix B of RPP-RPT-48490, Rev. 1). Some of the more critical factors for the closed WMA C would include quality assurance related to the design, procurement and testing of materials, and field approaches used in the construction of the engineering surface barrier system and the emplacement of grout and concrete. These components are critical elements for controlling infitration and contamiant releases from the closed WMA C facility topoints of potential expoure within the natural environment.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
HFFACO	M-045-00	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order
DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual
WAC-173-303	610	Washington Administr	Dangerous Waste Regulations: Closure and post-closure (610)
WAC-173-303	646	Washington Administr	RCRA Corrective Action
WAC-173-340	700 to 760	Washington Administr	Model Toxics Control Act -- Cleanup
RPP-RPT-48490, Rev. 1	See Table B-11 through B-13,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to quality assurance that will be applied during the procurement of items and services important to the safety of a near-surface radioactive waste disposal facility.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s): See Table B-11 through B-13, Appendix B in RPP-RPT-48490, Rev. 1

Conceptual Site Model

How it Applies:

The closure process for WMA C will need to meet the Quality Assurrance requirements defined in:

- Appendix H and I in HFFACO
- WAC 173-303 610 Closure Requirements
- WAC 173-303 646 RCRA Corrective Action Requirements
- WAC 173-340-700 to 760 Requirements Cleanup Levels
- DOE Order 435.1

A range of sensitivity cases will be examined to evaluate a range of expected long-term performance of important components of the Closed WMA C that could be affected by QA factors described above (see Tables B-11 and B-13 in Appendix B of RPP-RPT-48490, Rev. 1). Some of the more critical factors for the closed WMA C would include quality assurance related to the design, procurement and testing of materials, and field approaches used in the construction of the engineering surface barrier system and the emplacement of grout and concrete. These components are critical elements for controlling infitration and contamiant releases from the closed WMA C facility topoints of potential expoure within the natural environment.

Another important QA element for closure would include QA related to items and services related to monitoring and surveillance of the closed facility that could potential include

- hydrologic and water quality monitoring
- borehole geophysical logging
- analytical services for soil and water sampling

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
HFFACO	M-045-00	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order

DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual
WAC-173-303	610	Washington Administr	Dangerous Waste Regulations: Closure and post-closure (610)
WAC-173-303	646	Washington Administr	RCRA Corrective Action
WAC-173-340	700 to 760	Washington Administr	Model Toxics Control Act -- Cleanup (PART VII--CLEANUP STANDARDS)
RPP-RPT-48490, Rev. 1	See Table B-11 through B-13,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to quality assurance that will be applied during all the manufacturing of components and subcomponents activities important to the safety of a near-surface radioactive waste disposal facility.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: The closure process for WMA C will need to meet the Quality Assurrance requirements defined in:

- Appendix H and I in HFFACO
- WAC 173-303 610 Closure Requirements
- WAC 173-303 646 RCRA Corrective Action Requirements
- WAC 173-340-700 to 760 Requirements Cleanup Levels
- DOE Order 435.1

QA factors speficially related to the manufacturing of some components and subcomponents activities important to the performance of the closed WMA C facility. One specific component that would be critical components of the closure configuration would include:

- the engineered materials that would incorporated in the design and construciton of the engineered surface barrier
- the grout and concrete used to stabilize and isolate waste residuals inretrieved tanks, ancillary equipment, and encasements containing pipelines.

A range of sensitivity cases will be examined to evaluate a range of expected long-term performance of important components of the Closed WMA C that could be affected by QA factors described above (see Tables B-11 and B-13 in Appendix B of RPP-RPT-48490, Rev. 1).

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
HFFACO	M-045-00	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order
DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual
WAC-173-303	610	Washington Administr	Dangerous Waste Regulations: Closure and post-closure (610)

WAC-173-303	646	Washington Administr	RCRA Corrective Action
WAC-173-340	700 to 760	Washington Administr	Model Toxics Control Act -- Cleanup (PART VII--CLEANUP STANDARDS)
RPP-RPT-48490, Rev. 1	See Table B-11 through B-13,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to quality assurance that will be applied during research and development activities important to the safety of a near-surface radioactive waste disposal facility.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s): a simplified empirical model of this work (two-stage solubility-controlled release model) is being evaluated in some sensitivity cas

Conceptual Site Model

How it Applies:

Our quality assurance requirements for tank farm supported R & D are based on a graded approach. A current program related the closure of WMA C is applied research at PNNL on contaminant leaching studies being conducted on tank waste residual samples collected following retrieval. This work has the potential to significantly increase our understanding of the fundamental geochemical characteristics, mechanisms, and processes controlled the release of risk-driving contaminants from residuals left in retireved tanks and ancillary equipment at closure.

Numerical implementation of results of this R & D into conmainant release models being used in the PA process will need to meet the QA requirements defined in:

- Appendix H and I in HFFACO
- WAC 173-303 610 Closure Requirements
- WAC 173-303 646 RCRA Corrective Action Requirements
- WAC 173-340-700 to 760 Requirements Cleanup Levels
- DOE Order 435.1

For the initital PA, a simplified empirical model of this work (two-stage solubility-controlled release model) is being evaluated in some sensitivity cases defined in Table B-13 in Appendix B RPP-RPT-48490, Rev. 1

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
HFFACO	M-045-00	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order
DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual
WAC-173-303	610	Washington Administr	Dangerous Waste Regulations: Closure and post-closure (610)

WAC-173-303	646	Washington Administr	RCRA Corrective Action
WAC-173-340	700 to 760	Washington Administr	Model Toxics Control Act -- Cleanup (PART VII--CLEANUP STANDARDS)
RPP-RPT-48490, Rev. 1	See Table B-11 through B-13,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to quality assurance that will be applied during all siting activities for a near-surface radioactive waste disposal facility.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Siting activities do not apply here since WMA C is an existing facility.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to quality assurance that will be applied during the design of components and subcomponents important to the safety of a near-surface radioactive waste disposal facility.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s): See tables B-11 through B-13 in Appendix B of RPP-RPT-48490, Rev. 1 for range of cases associated the recharge and the engine

Conceptual Site Model

How it Applies: This analysis will be based on a closed configuration and will make assumptions about performance of various engineered components such:

- recharge rates and the design life of the engineered surface barrier and their degradation over time
- effective diffusion characteristics of emplaced grout and concrete and their degradation over time

A number of cases will be conducted to evaluate a range of less than expected performance of the closed WMA C that could be related to QA applied to the conceptual design of components or subcomponents of the closed facility (See Tables B-11 through B-13 in Appendix B of RPP-RPT-48490, Rev. 1)

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Table B-11 through B-13,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to quality assurance that will be applied during the construction of all components and subcomponents important to the safety of a near-surface radioactive waste disposal facility.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	See tables B-11 through B-13 in Appendix B of RPP-RPT-48490, Rev. 1 for range of cases associated the recharge and the engine

Conceptual Site Model

How it Applies: This analysis will be based on a closed configuration and will make assumptions about performance of constructed engineered components such:

- recharge rates and the design life of the engineered surface barrier and their degradation over time
- effective diffusion characteristics of emplaced grout and concrete and their degradation over time

A number of cases will be conducted to evaluate a range of less than expected performance of the closed WMA C that could be related to QA applied to the construction of components or subcomponents of the closed facility (See Tables B-11 through B-13 in Appendix B of RPP-RPT-48490, Rev. 1)

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Table B-11 through B-13,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to quality assurance that will be applied during the commissioning of components and subcomponents important to the safety of a near-surface radioactive waste disposal facility.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s): See tables B-11 through B-13 in Appendix B of RPP-RPT-48490, Rev. 1 for range of cases associated the recharge and the engine

Conceptual Site Model

How it Applies: See responses to 1.1.05.06 (design) and 1.1.05.07 (construction)

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Table B-11 through B-13,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to quality assurance that will be applied during the operation of a near-surface radioactive waste disposal facility.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s): See tables B-11 through B-13 in Appendix B of RPP-RPT-48490, Rev. 1 for range of cases associated the recharge and the engine

Conceptual Site Model

How it Applies:

QA related factors for operation activities during the closure period to WMA C will be limited QA requirements associated with:

- Surveillance
- Monitoing and
- Maintenance

In the initial PA, a number of cases will be conducted to evaluate a range of less than expected performance of the closed WMA C that could be related to QA applied to the surveillance, monitoring, and or maintenance of the closed facility (See Tables B-11 through B-13 in Appendix B of RPP-RPT-48490, Rev. 1)

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Table B-11 through B-13,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: : Factors related to quality assurance that will be applied during the decommissioning (closure) of components and subcomponents important to the safety of a near-surface radioactive waste disposal facility.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	See Tables B-11 through B-13 in Appendix B of RPP-RPT-48490, Rev. 1

Conceptual Site Model

How it Applies: The closure process for WMA C will need to meet the Quality Assurance requirements defined in:

- Appendix H and I in HFFACO
- WAC 173-303 610 Closure Requirements
- WAC 173-303 646 RCRA Corrective Action Requirements
- WAC 173-340-700 to 760 Requirements Cleanup Levels
- DOE Order 435.1

This analysis will be based on a closed configuration and will make assumptions about performance of various engineered components at closure such:

- recharge rates and the design life of the engineered surface barrier and their degradation over time
- effective diffusion characteristics of emplaced grout and concrete and their degradation over time

A number of cases will be conducted to evaluate a range of less than expected performance of the closed WMA C that could be related to QA applied to the closure of components or subcomponents of the closed facility (See Tables B-11 through B-13 in Appendix B of RPP-RPT-48490, Rev. 1)

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
HFFACO	M-045-00	Ecology, et al, 1989	Hanford Federal Facility Agreement and Consent Order
DOE O and Man	Chapter IV	DOE	Radioactive Waste Mangement Order and Manual
WAC-173-303	610	Washington Administr	Dangerous Waste Regulations: Closure and post-closure (610)
WAC-173-303	646	Washington Administr	RCRA Corrective Action

WAC-173-340	700 to 760	Washington Administr	Model Toxics Control Act -- Cleanup (PART VII--CLEANUP STANDARDS)
RPP-RPT-48490, Rev. 1	See Table B-11 through B-13,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the failure or poor implementation of quality assurance and quality control procedures during the life cycle of the disposal facility.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: This analysis will be based on a closed configuration and will make assumptions about performance of various engineered components at closure such:

- recharge rates and the design life of the engineered surface barrier and their degradation over time
- effective diffusion characteristics of emplaced grout and concrete and their degradation over time

A number of cases will be conducted to evaluate a range of less than expected performance of the closed WMA C that could be related to failure of QA/controls applied to the closure of components or subcomponents of the closed facility (See Tables B-11 through B-13 in Appendix B of RPP-RPT-48490, Rev. 1)

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Table B-11 through B-13,	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to administrative measures to control events at or around the near-surface disposal facility, both during the operational period and after closure.

Comment: The responsibility for administrative controls during the siting, construction, operation, closure and subsequently following closure of the disposal facility may not be the same. Furthermore, the type of administrative controls may also vary depending on the stage in the disposal facility lifetime.

The post-closure period can be further divided into an institutional control period and a post-institutional control period, defined as the control of a waste site by an authority or institution designated under the laws of a country. The term institutional control is more general than regulatory control (i.e. regulatory control may be thought of as a special form of institutional control). In particular, institutional control measures:

May be imposed for reasons not related to protection or safety (although they may nevertheless have some impact on protection and safety .1

May be applied by organizations that do not meet the definition of a regulatory body .2

May apply in situations which do not fall within the scope of facilities and activities .3

May be considered more likely to endure further into the future than regulatory control .4

Key Concepts, Examples and Related FEPs

1) **Pre-operational period:** Administrative control measures and responsibilities for these measures during the pre-operational period.

2) **Operational period:** Administrative control measures and responsibilities for these measures during the operational period.

3) **Post-closure period:** Administrative control measures and responsibilities for these measures during the post-closure period. Measures applicable for the institutional control period can be divided into:

a) Active institutional control measures: These measures may include activities such as monitoring, surveillance and remedial work.

b) Passive institutional control measures: These measures may include activities such as land use control and the erection of fences around the near-surface radioactive waste disposal facility, marking of the site, kept of records.

4) ***Failure of administrative control:*** Factors related to failure of administrative control measures and responsibilities for these measures during the pre-operational, operational, and post-closure (institutional control) periods.

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: See responses to 1.1.08.01 to 1.1.08.04 that follow.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Administrative control measures and responsibilities for these measures during the pre-operational period.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: This period is not specifically being evaluated in the PA.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Administrative control measures and responsibilities for these measures during the operational period.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s): See Tables B-1 and B-5, Appendix B RPP-RPT048490, Rev. 1

Conceptual Site Model

How it Applies: The WMA C during the operational period (1943 upto the start of of post-closure period) has been and will be under administrative controls and measures with the Management & Operations contractor.

The PA will investigate impacts from the sources in WMA C during both the pre–closure and post-closure periods. The assessment context and scope of the proposed analysis of the pre-closure period, which is outlined in Section B.1 of Appendix Band described in Section 4.2 of RPP-RPT-48490, Rev. 1, will focus on an analysis of a limited set of cases focused on evaluating a range of alternative conceptual models. These modeling cases will be largely based on process-level models developed based on the Subsurface Transport Over Multiple Phases (STOMP©) code and will be conducted using a deterministic approach.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Section 4.2 and Tables B-1	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Administrative control measures and responsibilities for these measures during the post-closure period. Measures applicable for the institutional control period can be divided into:

a) Active institutional control measures: These measures may include activities such as monitoring, surveillance and remedial work.

b) Passive institutional control measures: These measures may include activities such as land use control and the erection of fences around the near-surface radioactive waste disposal facility, marking of the site, kept of records.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s): See Table B-11 through B-13, Appendix B, RPP-RPT-48490, rev. 1

Conceptual Site Model

How it Applies: The PA will investigate impacts from the sources in WMA C during both the pre–closure and post-closure periods. The assessment context and scope of the proposed analysis of the post-closure period, which is outlined in Section B.2 of Appendix B and described in Section 4.3 of the main body of RPP-RPT-48490, rev. 1, will examine a wider range of sensitivity cases This part of the analysis will also be done using a deterministic approach. However, the post-closure analysis will also use a probabilistic uncertainty analysis to more fully examine model and global parameter uncertainty of selected key model parameters identified in the deterministic sensitivity cases. The majority of modeling cases that will be examined in the post-closure period will be performed with a system-level model of WMA C developed based on the GoldSim© software.

The WMA C during the 10,000 yr post-closure period will likely be under administrative controls and measures by DOE until it is not longer deemed to be a risk. However, for purposes of analysis, the PA calculations, per guidance in DOE Order 435.1, will be based on the assumption of an institutional control period of 100 yrs. This period will be based on active IC measures that may include activities such as monitoring, surveillance and maintenance/remedial work.

A sensitivity case will evaluate a shorter (50 yr) IC period as it relates to the peorfmrance of the engineered surface barriers.

The denominator case for the initial WMA C will evaluate a specific site closure conditions with 100 yrs of IC. Additional sensitivity cases will examine alternative performance aspects of site closure (See Table B-11 and B-13, Appendix B, RPP-RPT-48490, rev. 1) that could be consistent with either assumptions of less optimistic levels of performance or poorly closed conditions. The sensitivity cases currently proposed include:

- The effects of delaying closure by 50 yrs.
- The effects of loss of institutional control 50 yrs after closure.
- The effects of alternative barrier design lives
- The effects of other events and processes (both natural or human-induced) that could affect recharge rates after loss of institutional control and/or barrier design life and
- The effects of alternative diffusive characteristics or performance levels for emplaced grout and concrete

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
RPP-RPT-48490, Rev. 1	See Section 4.3 and Tables B-11	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to failure of administrative control measures and responsibilities for these measures during the pre-operational, operational, and post-closure (institutional control) periods.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **7/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	See Table B-11 through B-13, Appendix B, RPP-RPT-48490, rev. 1

Conceptual Site Model

How it Applies: The denominator case for the initial WMA C will evaluate a specific site closure conditions with 100 yrs of IC. Additional sensitivity cases will examine alternative performance aspects of site closure (See Table B-11 and B-13, Appendix B, RPP-RPT-48490, rev. 1) that could be consistent with either assumptions of less optimistic levels of performance, poorly closed conditions, or a failure of administrative control. The sensitivity cases currently proposed include:

- The effects of delaying closure by 50 yrs.
- The effects of loss of institutional control 50 yrs after closure.
- The effects of alternative barrier design lives
- The effects of other events and processes (both natural or human-induced) that could affect recharge rates after loss of institutional control and/or barrier design life and
- The effects of alternative diffusive characteristics or performance levels for emplaced grout and concrete

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure
RPP-RPT-48490, Rev. 1	See Section 4.3 and Tables B-1	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to accidents and unplanned events during construction, operation and closure, which might have an impact on long-term performance or safety of the near-surface radioactive waste disposal facility.

Comment: Accidents are events that are outside the range of normal operations although the possibility that certain types of accident may occur should be anticipated in disposal facility operational planning. Unplanned events include accidents but could also include deliberate deviations from operational plans.
Distinction can be made between human induced accidents and unplanned events and natural occurring accidents and unplanned events.

Key Concepts, Examples and Related FEPs

1) **Human induced accidents and unplanned events:** Examples of human induced accidents and unplanned events include deviations from construction, operation, and closure plans (e.g. improper operations, faulty emplacement of waste or backfill material, pre-closure events, unsuccessful attempt to site improvement, handling accidents, oil and organic fluid spills, equipment malfunctioning, sabotage, change in site properties during construction, loss of markers or records, etc.)
2) **Natural occurring accidents and unplanned events:** Examples of natural occurring accidents and unplanned events include tornadoes and hurricanes, heavy precipitation leading to flooding of facility, excessive rise in water table, severe seismic event during the operational period, flammability and explosions, subsidence, etc.)

Applies to WMA **Yes** Entered By: **h0006384** On: **8/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: See responses to 1.1.09.01 and 1.1.09.02 that follow:

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Section 4.3 and Tables B-1	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Examples of human induced accidents and unplanned events include deviations from construction, operation, and closure plans (e.g. improper operations, faulty emplacement of waste or backfill material, pre-closure events, unsuccessful attempt to site improvement, handling accidents, oil and organic fluid spills, equipment malfunctioning, sabotage, change in site properties during construction, loss of markers or records, etc.)

Comment:

Applies to WMA **Yes** Entered By: **h0006384** On: **8/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s): Table B-11 through B-14, Appendix B in RPP-RPT-48490, Rev. 1

Conceptual Site Model

How it Applies: The impacts from human-induced accidents and events are not be specifically evaluated in WMA C but a range of sensitivity cases designed to look at a range of expected performances for the engineered components and the natural system as impacted by these accodents or unplanned events will be considered.

The range of sensitivity cases being considered in the initial PA are defined in Table B-11 through B-14, Appendix B in RPP-RPT-48490, Rev. 1

Increases in recharge through closed facility due to:
- Improper emplacement of engineered surface barrier at closure
- Barrier failure caused by significant changes in land uses or other human induced activities or unplanned events
- Changes in infiltration and vegetative cover due to human-induced land-use or development

Changes in containment of closed faciltiies (i.e. emplaced grout or concrete properties) due to:
- Improper emplacement of emplaced grout/concrete at closure

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Section 4.3 and Tables B-1	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Examples of natural occurring accidents and unplanned events include tornadoes and hurricanes, heavy precipitation leading to flooding of facility, excessive rise in water table, severe seismic event during the operational period, flammability and explosions, subsidence, etc.)

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **8/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	See Table B-11 through B-14, Appendix B in RPP-RPT-48490, Rev. 1

Conceptual Site Model

How it Applies: The impacts from naturally occuring accidents and events are not be specifically evaluated in WMA C but a range of sensitivity cases designed to look at a range of expected performances for the engineered components and the natural system as impacted by these accidents or unplanned events will be considered.

The range of sensitivity cases being considered in the initial PA are defined in Table B-11 through B-14, Appendix B in RPP-RPT-48490, Rev. 1. The accidents or unplanned events could potentially include:

Increases in recharge through closed facility due to:
- Barrier failure caused by significant changes in water- or wind-induced erosion
- Changes in precipitation and vegetative cover due climate change
- Changes in surface vegetation due to periodic wild fires
- Earthquakes or seismic events

Changes in containment of closed faciltiies (i.e. emplaced grout or concrete properties) due to:
- Chemical degradation processes
- Earthquakes or seismic events

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-48490, Rev. 1	See Section 4.3 and Tables B-1	Bergeron et al. 2011	Technical Approach and Scope for Flow and Contaminant Transport Analysis in the Initial Performance Assessment of Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to any special design, emplacement, operational or administrative measures that might be applied or considered in order to enable or ease retrieval of radioactive wastes from a near-surface radioactive waste disposal facility.

Comment: *Retrievability* is defined as the ability to reverse the action of waste emplacement. Retrievability is thus a special case of reversibility, defined as the ability to reverse one or a series of steps in disposal facility development at any stage of the programme. Designs may specifically allow for retrieval or rule it out. In some cases, an interim period might be planned, between waste emplacement and final disposal facility closure, during which time retrieval is possible.

Key Concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0006384** On: **8/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: The concept of retrievability in not being considered in the assumed landfill closure of the WMA C being evaluated in the Initial PA.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to possibility and effects of spontaneous nuclear chain reactions within the disposal facility.

Comment: A chain reaction is the self-sustaining process of nuclear fission in which each neutron released from a fission triggers, on average, at least one other nuclear fission. Nuclear criticality requires a sufficient concentration and localised mass (critical mass) of fissile isotopes (e.g. U-235, Pu-239) and also presence of neutron moderating materials in a suitable geometry; a chain reaction is liable to be damped by the presence of neutron absorbing isotopes (e.g. Pu-240).

Key Concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0006384** On: **8/2/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Factors related to spontaneous nuclear-chain reactions within the disposal facility are not expected to be important.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-41918, Rev. 0	Section 5	Connelly et al. 2010	Assessment Context for Performance Assessment for Waste in C Tank Farm Facilities after Closure

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to tectonic movement at plate boundaries, the potential for tectonic movement and its effects on the performance of the near-surface radioactive waste disposal facility.

Comment: Broadly speaking, tectonics is the study of the broad structures of the earth's lithosphere and the processes of faulting folding and warping that form them (i.e. the movement and deformation of the lithosphere). Tectonics focuses on structures on the regional scale and above (the investigation of smaller scale structural features usually being described as structural geology). Tectonics is concerned not only with the determination of the three dimensional form of geological structures but also their history, origin and relationship to each other.

Tectonic activity arises when rock masses belonging to different plates (e.g. oceanic–oceanic, oceanic–continental, continental–continental) either collide against each other or slide past each other.

Key Concepts, Examples and Related FEPs

1) **Plate boundaries**: Plates move along individual units, and interactions between plates occur along their edges. Earthquakes and volcanism most distinctively express plate interactions because a majority of the Earth's volcanoes and earthquakes occur along plate boundaries. Plates have three kinds of boundaries:

a) Divergent boundaries: Also called spreading centers because such margins are breaks in the lithosphere where new lithosphere continually forms as two plates move apart.

b) Convergent boundaries: Where two plates move towards each other. Along convergent boundaries, one plate must either sink beneath the other (subduction zone) or the two plates must collide (collision zone)

c) Transform fault boundaries: Fractures in the lithosphere where two plates slide past each other grinding and abrading their edges as they do so. Earthquakes are frequent along most transform faulty boundaries.

2) **Tectonic cycle**: The tectonic cycle deals with the movement and interaction of lithospheric plates and the internal processes of the Earth's deep interior that drives plate motion.

3) Processes driven by the Earth's geothermal energy power the tectonic cycle. Rock in the mantle melts and the magma rises to make new oceanic crust. Eventually, the oceanic crust is subducted, which causes partial melting of the mantle rocks in contact with the subducting lithosphere capped by oceanic crust. This mantle, in turn, rises to create volcanoes.

4) **Deformation of geological structures**: Associated with tectonic movement is physical deformation (elastic, plastic or brittle) of geological structures in the interior of continental or oceanic plates in response to stress fields generated either at plate margins or in regions of anomalous stress. This includes mainly faulting and fracturing of rocks and, less frequently, also their compression and folding rocks.

5) **Oceanic–continental**: The oceanic plate subducts under the lighter continental plate, resulting in the formation of a trench, volcanoes, and earthquakes. Collision causes sediment deposited on the ocean floor to be piled up at the continental plate boundary. The creation of hot magma plumes also causes the continental crust to deform producing mountains (see FEP 1.2.02).

6) **Continental–continental:** Crustal plates are subducted under another producing earthquakes. A mountain range is produced at the plate boundaries because of the deformation of rocks (see FEP 1.2.02).

Applies to WMA	**Yes**	Entered By:	**h0006384**	On:	**8/2/2011**	Reviewed By		On:	

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: See responses to 1.2.01.01 through 1.1.01.05

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Plates move along individual units, and interactions between plates occur along their edges. Earthquakes and volcanism most distinctively express plate interactions because a majority of the Earth's volcanoes and earthquakes occur along plate boundaries. Plates have three kinds of boundaries:

a) Divergent boundaries: Also called spreading centers because such margins are breaks in the lithosphere where new lithosphere continually forms as two plates move apart.

b) Convergent boundaries: Where two plates move towards each other. Along convergent boundaries, one plate must either sink beneath the other (subduction zone) or the two plates must collide (collision zone)

c) Transform fault boundaries: Fractures in the lithosphere where two plates slide past each other grinding and abrading their edges as they do so. Earthquakes are frequent along most transform faulty boundaries.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0006384** On: **8/2/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: The impacts from plate boundary interactions are not be specifically evaluated in WMA C but a range of sensitivity cases designed to look at a range of expected performances for the engineered components and the natural system are being considered that could bound the potential impacts from related earthquake or seismic events. From recent monitoring of seismic activity in the region, the occurrence of earthquake or seismic events that could change the structural stability and performance of the engineered or natural system components of the closed WMA C are expected to have low probability.

The range of sensitivity cases being considered in the initial PA are defined in Table B-11 through B-14, Appendix B in RPP-RPT-48490, Rev. 1.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: The tectonic cycle deals with the movement and interaction of lithospheric plates and the internal processes of the Earth's deep interior that drives plate motion.
3) Processes driven by the Earth's geothermal energy power the tectonic cycle. Rock in the mantle melts and the magma rises to make new oceanic crust. Eventually, the oceanic crust is subducted, which causes partial melting of the mantle rocks in contact with the subducting lithosphere capped by oceanic crust. This mantle, in turn, rises to create volcanoes.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0006384** On: **8/2/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: The impacts from tectonic cycle are not be specifically evaluated in WMA C but a range of sensitivity cases designed to look at a range of expected performances for the engineered components and the natural system are being considered that could bound the potential impacts from related potential earthquake or seismic events. From recent monitoring of seismic activity in the region, the occurrence of earthquake or seismic events that could change the structural stability and performance of the engineered or natural system components of the closed WMA C are expected to have low probability.

The range of sensitivity cases being considered in the initial PA are defined in Table B-11 through B-14, Appendix B in RPP-RPT-48490, Rev. 1.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Associated with tectonic movement is physical deformation (elastic, plastic or brittle) of geological structures in the interior of continental or oceanic plates in response to stress fields generated either at plate margins or in regions of anomalous stress. This includes mainly faulting and fracturing of rocks and, less frequently, also their compression and folding rocks.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0006384** On: **8/2/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: The impacts from deformation of geologic structures are not be specifically evaluated in WMA C but a range of sensitivity cases designed to look at a range of expected performances for the engineered components and the natural system are being considered that could bound the potential impacts from related potential earthquake or seismic events. From recent monitoring of seismic activity in the region, the occurrence of earthquake or seismic events that could change the structural stability and performance of the engineered or natural system components of the closed WMA C are expected to have low probability during period of the performance assessment.

The range of sensitivity cases being considered in the initial PA are defined in Table B-11 through B-14, Appendix B in RPP-RPT-48490, Rev. 1.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: The oceanic plate subducts under the lighter continental plate, resulting in the formation of a trench, volcanoes, and earthquakes. Collision causes sediment deposited on the ocean floor to be piled up at the continental plate boundary. The creation of hot magma plumes also causes the continental crust to deform producing mountains (see FEP 1.2.02).

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0006384** On: **8/2/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Given the location of the WMA C, this FEP is not considered to be important in the WMA C PA.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Crustal plates are subducted under another producing earthquakes. A mountain range is produced at the plate boundaries because of the deformation of rocks (see FEP 1.2.02).

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0006384** On: **8/2/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: The impacts from interaction of crustal plates are not be specifically evaluated in WMA C but a range of sensitivity cases designed to look at a range of expected performances for the engineered components and the natural system are being considered that could bound the potential impacts from related potential earthquakes or seismic events. From recent monitoring of seismic activity in the region, the occurrence of earthquake or seismic events that could change the structural stability and performance of the engineered or natural system components of the closed WMA C are expected to have low probability during period of the performance assessment.

The range of sensitivity cases being considered in the initial PA are defined in Table B-11 through B-14, Appendix B in RPP-RPT-48490, Rev. 1.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the formation of mountains (orogeny), the potential for orogeny and its effects on the performance of the near-surface radioactive waste disposal facility.

Comment: Literally speaking, orogeny is the process by which structures within mountain areas were formed through processes that include thrusting, folding and faulting in the lithosphere, often occurring over periods of a few million years, but up to several tens of millions of years. The lithosphere is the name given to the rigid, outermost layer of the earth, made up predominantly of solid rock, which are affected by processes such as metamorphism, plutonism, and, at great depth (>10 km), by plastic folding.
It is important to acknowledge that orogenic processes experience periods of quiescence alternating with periods of paroxismand that such periods are not necessarily synchronous along the whole length of an orogenic belt.
This type of movements should be considered with great care since orogenic processes can lead, in areas of active collision (e.g. Chile, Turkey, Iran, Morocco) to the propagation of fault and thrust planes up to the surface. In such events (see FEP 1.2.03 Seismicity) extreme ground fracturing, faulting could lead to breakage of containment barriers.

Key Concepts, Examples and Related FEPs

1) **Lithosphere folding**: The term folding is generally used to imply the shortening of strata that results from the formation of fold structures on a broad scale, and sometimes has the connotation of general deformation of which the actual folding is only a part.
2) **Lithosphere faulting**: A fault is a fracture in the Earth's crust accompanied by displacement of one side of the fracture relative to the other, from a few cm to several kilometres. Orogenic belts are typically characterised by compressive reverse faults as this lead to crustal shortening and duplication of geological formations. Transform faults typically occur where crustal plates slide past each other without colliding (e.g. the St. Andrea fault in California) and the relative displacement can be in the order of thousands of kilometres. Fractures and joints may be caused by compressional or tensional forces in the earth crust but do not present displacement between the rocks on each side. These forces may result in the reactivation of existing faults or, less likely, in the generation of new ones
3) **Orogeny and plate tectonics**: Orogeny is a direct consequence of the movement of plates and convergence of continental–continental and continental–oceanic plates (see FEP 1.2.01).
4) **Changes in rock properties:** Large-scale changes in the physical and chemical rock properties will accompanied orogeny processes, resulting in a change in the hydrogeological properties (see FEP 1.2.13).
5) **Metamorphism:** See FEP 1.2.05
6) **Volcanic activity:** See FEP 1.2.04
7) **Change in topography:** One of the most obvious effects of orogenic processes is a change in topography, which in turn, will have significant consequences to the geology, hydrogeology, hydrogeology, ecology, etc.
8) **Upliftment (isostasy):** After the orogenic stage, weathering and erosion begin removing material from the surface of the newly created mountains. The removal of rock mass makes the area of the continental crust where the mountains are less heavy and that end of the crust begins to float higher in the mantle. This isostatic rebound causes vertical uplift, while the tensional forces due to the movement of the crust create normal and graben faults.

Applies to WMA	**No**	Entered By:	**h0006384**	On:	**6/14/2011**	Reviewed By		On:	

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: Given the time scale of this analysis, the initial WMA C PA will not consider the effects of orogeny in its post-closure analysis.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to seismic events, the potential for seismic events and its effects on the performance of the near-surface radioactive waste disposal facility.

Comment: Rapid relative movements within the Earth's crust, usually along existing faults or geological interfaces cause a seismic event. The accompanying release of energy may result in ground movement and/or rupture, e.g. earthquakes. Most seismic activity is located along plate boundaries.

Key Concepts, Examples and Related FEPs

1) **Earthquakes:** A series of shocks and tremors resulting from the sudden release of pressure along active faults and in areas of volcanic activity. The more energy releases, the stronger the quake. The place where energy is first released to cause an earthquake is called the earthquakes focus, which is rather a region that may extend for several kilometres (e.g. along a fault) than a single point. The effects of an earthquake can be divided into two direct and four indirect effects:

a) Ground motion: Ground motion results from the movement of seismic waves through surface-rock layers.

b) Faulting: Where a fault breaks the ground surface, buildings and any feature that crosses or sits on the fault can be split.

c) Fire: Ground movement displaces stoves, break gas lines, and loosens electrical wires, thereby starting fires. Ground motion also breaks water mains, so that no water is available to put out fires.

d) Mass-wasting movements: In regions of steep slopes, earthquake vibrations may cause regolith to slip, cliffs to collapse, and other rapid mass-wasting movements to start.

e) Soil liquefaction: The sudden shaking and disturbance of water-saturated sediment and regolith can turn seemingly solid ground to a liquid like mass of quicksand.

f) Tsunami (seismic sea wave): The seismic waves that are generated by a tectonic or volcanic disturbance of the ocean floor may result in a seismic (giant) sea wave, known as a tsunami. These may be amplified by submarine soft sediment slumps along steep continental margins.

2) **Seismic waves**: When an earthquake occurs, the elastically stored energy is transmitted from the focus to other parts of the Earth. As with any other vibrating body, waves (vibrations) spread outwards from the focus. The waves, called seismic waves, spread out in all directions, just as sound waves.

3) **Volcanic activity:** Seismic events are most common in tectonically active or volcanically active regions at crustal plate margins, less commonly they also occur in the interior of continental/oceanic plates (see FEP 1.2.04).

4) **Glacial loading/unloading (isostasy):** The frequency of seismic events may be influenced by the frequency of glacial loading and unloading, which causes vertical movement of the Earth's lithosphere as a result of the releases of stresses in the rockmass.

5) **Earthquakes and plate tectonics:** There is a strong correlation between earthquake locations and the plate boundaries. Each kind of boundary is characterised by earthquakes that are distinctive as to fault motions and to the depth of the foci.

6) **Changes in rock properties:** The shaking and vibration of the Earth's associated with seismic events will result in physical and chemical changes in the rock properties (e.g. due to stress changes). The extent of the changes will vary, from changes in the geometry of the rocks to large-scale changes (e.g. activation of a faults or reactivation of an existing fault). The net result is a change in the hydrogeological properties of the rock (see FEP 1.2.13), for example changes in hydraulic head, groundwater recharge, discharge zones, open or closure of fractures.

Applies to WMA	**No**	Entered By:	**h0006384**	On:	**8/2/2011**	Reviewed By		On:	

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: performances for the engineered components and the natural system are being considered that could bound the potential impacts from related potential earthquake or seismic events. From recent monitoring of seismic activity in the region, the occurrence of earthquake or seismic events that could change the strucutural stability and performance of the engineered or natural system components of the closed WMA C are expected to have low probability during period of the performance assessment.

The range of sensitivity cases being considered in the initial PA are defined in Table B-11 through B-14, Appendix B in RPP-RPT-48490, Rev. 1.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to volcanic and magmatic activities, the potential for volcanic and magmatic activity and its effects on the near-surface radioactive waste disposal facility.

Comment: Magma is molten, mobile rock material, generated below the Earth's crust, which gives rise to igneous rocks when solidified. Magmatic activity occurs when there is intrusion of magma into the crust. A volcano is a vent or fissure in the Earth's surface through which molten or part-molten materials (lava) may flow, and ash and hot gases be expelled.
About 95 % of active volcanoes occur at the plate subduction zones and at the mid-oceanic ridges. The other 5 % occur in areas associated with lithospheric hot spots. These hot spots have no direct relationships with areas of crustal creation or subduction zones. It is believed that plumes of rising magma that have their origin within the asthenosphere causes the hot spots.

Key Concepts, Examples and Related FEPs

1) **Igneous rock formation:** The cooling and solidification of magma form all igneous rock. Distinction can be made between the following rock formation magmatic activities:
   a) Magmatic activity, Intrusive: Refers to the process of emplacement and solidification of magma within the crust (pre-existing rock).
   b) Magmatic activity, Extrusive: Refers to the process whereby magma is ejected as lava and tephra onto the surface of the Earth.
2) **Plutons**: Refer to the bodies of intrusive igneous rock laid barren by erosion. Various plutons types can be formed by intrusive magma:
   a) Dike: A tabular sheetlike body of igneous rock that cuts across the layering of the rock it intrudes.
   b) Sill: Tabular sheetlike body of igneous rock that are parallel to the layering of the rocks they intrude
   c) Laccolite: A variation of a sill, which is a variation of an igneous body intruded parallel to the layering of the rocks it intrudes and above which the layers of the intruded rocks have been bent upwards to form a dome.
   d) Volcanic pipe and neck: A volcanic pipe is the approximately cylindrical conduit that once fed magma upwards to a volcanic vent and that become filled with igneous rock or rock fragments after eruption ended. If erosion strips away surrounding rock, the body of rock that filled a pipe is called a volcanic neck.
   e) Batholiths: A batholith – the largest kind of pluton – is an intrusive igneous body of irregular shape that cuts across the layering of the rocks it intrudes.
3) **Volcanic features:** Distinction can be made between shield volcanoes, tephra cones, and stratovolcanoes. Volcanic features include:
   a) Craters: A funnel-shaped depression opening upwards from which gases tephra, and lava are ejected.
   b) Calderas: A striking and much larger depression (roughly circular and steep-walled basin) than a crater (kilometre or more in diameter) near the summit of the volcano.
   c) Fumarole: A small volcanic vent through which hot gasses are emitted.
4) **Effects of volcanic eruptions**: Hazards associated with the eruption of volcanoes include the following:
   a) Lava flow: Hot, rapidly moving pyroclastic flows and laterally directed blasts may overwhelm people and overflow structures in the vicinity of the volcano.
   b) Gas emissions: The emission of hot poisonous gasses during eruptions.
   c) Mudflow: Rain or meltwater from snow can loosen tephra piled on a steep volcano slope and start a deadly mudflow sweeping down the mountainside.
   d) Tsunami: Violent undersea eruptions can cause a tsunami.
   e) Impact on agricultural: A tephra eruption may wreak havoc on agricultural land and livestock.
   f) Topography: Volcanic eruptions may cause changes in the local topography, resulting in changes to the geology, hydrogeology, hydrogeology, ecology, etc.
5) **Magmatic mineral deposits:** The processes of partial melting and fractional crystallisation in magmas sometimes lead to the formation of large and potentially valuable mineral deposits (e.g. chromium and ilmenite). Because magma is involved in the formation process, such deposits are called magmatic mineral deposits.
6) **Metamorphism:** The high temperatures and pressures associated with volcanic and magmatic activity may result in permanent changes in the surrounding rocks. This process is referred to as metamorphism, although it is not confined to volcanic and magmatic activity alone (see FEP 1.2.05).

Applies to WMA	No	Entered By:	h0006384	On:	8/2/2011	Reviewed By		On:	

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: Volcanism and magmatic activity are a recognized part of the geologic history of the region which results in a thick sequence of flood basalts on the Columbia Plateau. However, the deposition of the Columbia River basalts are estimated to have occurred between 16.5 and 14.5 million yrs before present. Thus, the effects of these process are not considered to be important during the time-scale of this analysis (10,000 yrs post-closure) and will not be considered in the initial WMA C PA.

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-46088	Section 3.2	Bergeron et al. 2010	Flow and Transport in the Natural System at Waste Management Area C

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to metamorphism, the potential for metamorphism and its effects on the performance of the near-surface radioactive waste disposal facility.

Comment: The term metamorphism is used to describe the processes (changes) induced by the mineralogical and structural adjustment of solid rock to physical and chemical conditions, which have been imposed by the action of heat (T>200 C) and pressure at great depths (usually several kilometres) beneath the Earth's surface or near magmatic activity.

Key Concepts, Examples and Related FEPs

1) **Limits of metamorphism:** Metamorphism refers only to changes in solid rock, not to changes cause by melting. Distinction can be made between two types of metamorphism:

a) Low-grade metamorphism: Refers to metamorphic processes that occur at temperatures from 100 oC to 500 oC and at relatively low pressures.

b) High-grade metamorphism: Refers to metamorphic processes at high temperatures (above about 500 oC) and high pressure.

2) **Controlling factors in metamorphism:** factors controlling the metamorphism include the chemical composition of the rock undergoing metamorphism, as well as the chemical composition of intergranular fluid. So do changes in temperature and pressure, and the time these rocks are subject to temperature and pressure changes.

3) **Kinds of metamorphism:** The processes that result from changing temperature and stress, and that cause the metamorphic changes observed in rocks, can be grouped under the terms mechanical deformation and chemical recrystallization.

a) Cataclastic metamorphism: Mechanical deformation of a rock with only minor chemical recrystallization.

b) Contact metamorphism: Occurs adjacent to bodies of hot magma that are intruded into cool rocks of the crust. Such metamorphism involves chemical recrystallization and happens in responds to a pronounced increase in temperature.

c) Regional metamorphism: Involves pronounced differential stresses and a considerable amount of mechanical deformation in addition to chemical recrystallization.

4) **Metasomatism:** Applied to the process whereby the chemical compositions of rocks are distinctively altered by exchange with ions in solution. Metasomatism is commonly associated with contact metamorphism, espaially where the rocks being metamorphosed are limestone.

5) **Metamorphism and plate tectonics:** Regional metamorphism occurs at the subduction boundary of a plate. Continental collision is the most common setting for regional metamosphism. Metasomatism and the generation of hydrothermal solutions can be linked to plate tectonics because metasomatism is closely related to regional metamorphism and magmatic activity.

6) **Importance to near-surface disposal facilities:** Metamorphic processes are unlikely to be important at typical near-surface disposal depths, but past metamorphic history of a host lithology may be very important to understanding its present-day characteristics.

Applies to WMA	**No**	Entered By:	**h0006384**	On:	**8/3/2011**	Reviewed By		On:	

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: of this analysis (10,000 yrs post-closure) and will not be considered in the initial WMA C PA.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to hydrothermal activity, the potential for hydrothermal activity and its effects on the performance of the near-surface radioactive waste disposal facility.

Comment: Groundwater temperature is determined by the large-scale geological and petrophysical properties of the rock formations (e.g. radiogenic heat formation, thermal conductivity), as well as the hydrogeological characteristics (e.g. hydraulic conductivity) of the rock and by the tectonic environment (neotectonic, deformation, extension).

Key Concepts, Examples and Related FEPs

1) **Metasomatism:** Metasomatism and the generation of hydrothermal solutions can be linked to plate tectonics because metasomatism is closely related to regional metamorphism and magmatic activity.
2) **Hydrothermal alteration of minerals in rocks:** Alteration of rocks due to earth pressures and temperatures, which are milder than those which produce metamorphism. It may give rise to chemical changes, which are similar to weathering. Generally, weathering effects decrease from the surface downwards, while hydrothermal alteration increase downwards towards the fluids which give rise to the activity.
3) **Hydrothermal synthesis:**
4) **Scalding springs:**

Applies to WMA **No** Entered By: **h0006384** On: **6/14/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Given the geologic history and setting, the effects of these processes are not considered to be important during the time-scale of this analysis (10,000 yrs post-closure) and will not be considered in the initial WMA C PA.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the large-scale removal and accumulation of rocks and sediments, the potential for large-scale removal and accumulation of rocks and sediments, and its effects on the performance of the near-surface radioactive waste disposal facility.

Comment: Literally, denudation means the lying bare of underlying rocks or strata by the removal of overlying material. It is usually defined as a broader term than erosion, to include weathering and all processes which can wear down the surface of the earth.
Note that only the large-scale erosion processes are related to this FEP. Compare FEP 2.3.12, which is concerned with more local processes over shorter periods of time.

Key Concepts, Examples and Related FEPs

1) **Erosion**: Erosion is the process or group of processes whereby the earthy and rocky materials of the Earth's crust are loosened, dissolved, or worn away, and simultaneously removed from one place to another, by natural agencies that include weathering, solution, corrasion, and transportation. Associated with large-scale erosion and deposition is changes in topography and geological/hydrogeological conditions of the host lithology.
2) **Corrasion:** Mechanical erosion of rocks by material being transported by water, wind and ice cover and around them.
3) **Weathering**: Weathering occurs when the rocks are exposed to physical, chemical and biological conditions much different from those prevailing at the time the rocks were formed
   a) Mechanical (physical) weathering: Involves the breakdown or disintegration of rock without any substantial degree of chemical alteration taking place in the mineral which make up the rock mass
   b) Physical weathering processes: It is common in nature and takes place as a result of joints developed through tectonic forces, crystal growth, frost wedging, heat effects, and plant roots.
   c) Chemical weathering: The decomposition of rocks and minerals as chemical reactions transform into new chemical combinations that are stable at or near the Earth's surface. All the common rock-forming minerals are chemically unstable when exposed to the weather at the earth's surface.
   d) Chemical weathering processes: The effects of chemical weathering are most pronounced in regions where both precipitation and temperature are high, two conditions that enhance the rapidity of chemical reactions. Chemical weathering processes include hydrolysis, leaching, oxidation, and dissolution.
   e) Factors influencing weathering: Factors influencing weathering include the rock type and structure, the slope, climate, burrowing animals and time.
4) **Weathering rates and plate tectonics**: High rates of weathering and high mountains are related for several reasons.
   a) High mountains are areas of rapid upliftment, which goes hand in hand with rapid mechanical breakdown and erosion of rocks. This disintegration exposes large quantities of rock and mineral debris to chemical weathering.
   b) The amount of dissolved matter in streams is greatest in areas where easily eroded sedimentary rocks are exposed.
   c) High mountains forces force moisture-bearing winds upwards and generally receive large amounts of precipitation. This means high rates of stream runoff and high erosion rates.
5) **Fluvial erosion:** Erosion (downcutting) of a surface environment caused by the fluvial processes in a river, stream or channel.
6) **Aeolian erosion:** Refers to erosional processes caused by wind action, which is more dominant in dry (desert) environments.
7) **Glacier erosion**: The most significant effect of glacier erosion is the deepening of valleys, scouring of upland areas, and the modification of stream channel networks. The form of erosion is dependent on the underlying geology, the fracturing and roughness of the rock and whether the glacier is frozen right down to its base. Small-scale features caused by glacier erosion include glacial striations and grooves, while landforms created by glaciations include cirques, glacial valleys, fjords and drumlin.
8) **Glacier deposits:** Glaciers are efficient agents of erosion and transport of sediment. Examples include the following:
   a) Glacier drift: Sediment deposited directly by glaciers or indirectly by melt water in streams, in lakes and in the sea.
   b) Till: At the end of the range of ice-laid deposits is till, which is non-sorted drift deposited directly from ice. The rock particles in a body of till lie just as

they were released from the ice.

c) Erratic: A glacially deposited rock or rock fragments with a lithology different from that of the underlying bedrock is called an erratic.

d) Glacialmarine drift: Closely resembles till, glacialmarine drift is sediment deposited on the seafloor from ice shelves or bergs. As an iceberg or the base of an ice shelf slowly melts, the contained sediment is released and settles to the seafloor, where it forms a non-sorted deposit.

e) Moraine: An accumulation of till having a surface form that is unrelated to the underlying bedrock is called a moraine (e.g. ground moraine, end moraine, terminal moraine, lateral moraine).

f) Outwash: Stratified sediment (deposited by meltwater from ice, rather that the glacier directly) deposited by meltwater streams as they flow away from the glacier margin is called outwash (e.g. outwash plains, valley train, outwash terraces).

g) Ice-contact stratified drift: When rapid ablation greatly reduces a glacier's thickness in its terminal zone, ice flow may virtually cease. Sediment carried by meltwater flowing over or beside such stagnant ice is deposited as stratified drift that slumps and collapses as the supporting ice slowly melts away. Such sediment is called ice-contact stratified drift.

9) **Coastal erosion:** The world's ocean coastlines are dynamic zones of conflict where land and water meet. Erosional forces tear away at the land, and other forces move and deposit sediments, thereby adding to the land. Most erosion along the seacoast is accomplished by waves moving onshore.

10) **Mass-wasting:** The movement of regolith and masses of rock down-slope under the pull of gravity. In contrast to other erosional processes, the debris is not carried by the transporting medium, such as water, wind, or ice. Mass-wasting processes all share one characteristic: they take place on slopes. Any perceptible downslope movement of mass of bedrock, regolith, or both, is commonly referred to as a landslide. Other slope failure movements include:

a) Slump: A downward and outward rotational movement of rock or regolith occurring along a curved concave-up surface.

b) Debris fall: The free falling of detached bodies of bedrock, weather regolith and vegetation from a cliff or steep slope.

c) Debris slide: Downslope movement of detached masses of debris along an inclined surface, such as a bedding plane.

d) Sediment flow: The flow of solid particles, water and sometimes air.

e) Slurry flow: In slurry flow, the sediment mixture is often so dense that large boulders can be suspended in it. Distinction can be made between solifluction (very slow downslope movement of saturated soil and regolith), debris flow (downslope movement of unconsolidated regolith, the greater part being coarser than sand), mudflows (a debris flow that has water content sufficient to make it highly fluid and in which particles no coarser than sand predominate).

f) Granular flow: The sediment of granular flows may be largely dry, with air filling the pores, or it may be initially saturated with water but have a range of grain sizes and shapes that allow water to escape easily. Distinction can be made between creep and colluvium, earthflow, liquefaction, grain flows, debris avalanches, etc.

11) **Mass wasting in cold climates:** Mass wasting is especially active at high latitudes and high altitudes, where average temperatures are very low. These are regions where much of the landscape is underlain by perennially frozen ground and frost action is an important geologic process. Processes include:

a) Frost heaving: When water freezes, it increases in volume. Ice forming in saturated regolith therefore pushes the ground surface up. This lifting of regolith by the freezing of contained water is called frost heaving. Frost heaving during alternative freeze-thaw cycles causes a downslope movement of rocks.

a) Gelifluction: During a freeze-thaw cycle, the thawed layer becomes saturated with meltwater and is very unstable, especially on hillsides. As gravity pulls the thawed sediment slowly downslope, distinctive lobes and sheets of debris are produced. Similar to solifluction in temperate and tropical climates, this process is known as gelifluction.

b) Rock glacier: A tongue or lobe of ice-cemented rock debris that moves slowly downslope in a manner similar to glaciers. Generally they originate below steep cliffs, which provide a source of rock debris.

12) **Events triggering mass wasting:** Mass wasting events sometimes seem to occur at random, with no apparent reason. However, most events, particularly the largest and most disastrous, are related to some extraordinary activity or occurrences. These include

a) Shock: A sudden shock, such as an earthquake may release so much energy that slope failures of many types and sizes are triggered simultaneously.

b) Slope modification: landslides often result when natural slopes are modified by human activities, e.g. where roads have been cut into the ground, creating artificially steep and unstable slopes.

c) Undercutting: slumps and other types of landslides can be triggered by the undercutting action of a stream along its banks or by surf action along the coast.

d) Exceptional precipitation: landslides are often associated with heavy or persistent rains that saturate the ground and make it unstable.

e) Volcanic eruptions: large stratovolcanoes consist of interstratified lava flows, rubble, and pyroclastic layers that form steep slopes. On high ice-glad

volcanoes, slopes may be further steepened by glacier erosion. Large volumes of water, released when summit glaciers and snowfields, melt during eruption of hot lavas or pyroclastic debris, can combine with unconsolidated deposits to form mudflows or debris flow that move rapidly downslope and often continue for many kilometres downslope.

13) **Sedimentation**: Sedimentation is the process of forming or accumulating sediment in layers, including such processes as the separation of rock particles from the material from which the sediment is derived, the transportation of these particles to the site of deposition or settling of the particles, the chemical and other (diagenetic) changes occurring in the sediment, and the ultimate consolidation of the sediment into solid rock. Sedimentary rocks, like the sediments from which they are derived, fall into three categories, clastic, chemical and biogenic.

a) Stratification: Sedimentary stratification results from the arrangement of sedimentary particles in distinct layers. Each sedimentary stratum is a distinct layer of sediment that accumulated at the Earth's surface.

b) Bedding: The layered arrangement of strata in a body of sediment or sedimentary rock is referred to as bedding. Each bed within a succession of strata can be distinguished from adjacent beds by differences in thickness or character. The top or bottom surface of a bed is a bedding plane.

14) **Depositional environments**: Depositional environments can be divided into non-marine environments and continental shelves.

a) Sediment derived from the mechanical and chemical breakdown of rocks is moved towards the sea or towards the lowest level of an inland basin. En route it is moved by water, ice, wind, or gravity. The sediment may be temporary stored and then reworked repeatedly by one or several of these agencies before reaching its final resting place, where it is slowly converted to sedimentary rock. These processes are related to stream sediments, lake sediments glacier sediments, and eolian sediments.

b) The world's rivers continuously transport detritus to the edges of the sea where it can accumulate near the mouth of streams, be moved laterally along the coast by currents, or be carried seawards to accumulate on the continental selves. These processes are related to estuarine sediments, deltaic sediments, beach sediments, offshore sediments, carbonate shelves, and marine evaporates.

15) **Sedimentation and tectonics**: sedimentation rates are high adjacent to regions of active tectonics uplift, far lower on relatively stable continental regions, and still lower in regions of the deep sea that are far from terrestrial sources of sediments.

Applies to WMA **Yes** Entered By: **h0006384** On: **8/2/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: See responses to 1.2.07.01 through 1.2.07.15

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Erosion is the process or group of processes whereby the earthy and rocky materials of the Earth's crust are loosened, dissolved, or worn away, and simultaneously removed from one place to another, by natural agencies that include weathering, solution, corrasion, and transportation. Associated with large-scale erosion and deposition is changes in topography and geological/hydrogeological conditions of the host lithology.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **8/2/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s): See Table B-11 and B-12, Appendix B in RPP-RPT-48490, Rev. 1.

Conceptual Site Model

How it Applies: The general process of erosion describved aboveis a possible set of processes that could effect long-term performance of a closded WMA C during the assumed post-institutional control period. The magnitude of the impact of this set of processes during the post IC period is difficult to predict and is not be specifically evaluated in WMA C.

However, sensitivity cases designed to look at a range of expected performances for the engineered components that could bound the impacts for erosion on recharge will be considered. The engineered surface barrier placed over the closed WMA C will contain elements designed to facilitate drainage and minimize surface erosion by wind and water during the period of institutional control and the barrier design life.

Sensitivity cases that examine a range of recharge rates for differnet assumed IC periods, barrier design lives, and barrier design recharge rates, and post-barrier life recharge rates are being considered in the initial PA. They are defined in Table B-11 and B-12, Appendix B in RPP-RPT-48490, Rev. 1.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Mechanical erosion of rocks by material being transported by water, wind and ice cover and around them.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **8/2/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	See Table B-11 and B-12, Appendix B in RPP-RPT-48490, Rev. 1.

Conceptual Site Model

How it Applies: Mechanical erosion of rocks & surficial sediments by material being transported by water, wind and ice cover and around them is a possible set of processes that could effect long-term performance of a closed WMA C during the assumed post-institutional control period. The magnitude of the impact of this set of processes during the post IC period is difficult to predict and is not be specifically evaluated in WMA C.

However, sensitivity cases designed to look at a range of expected performances for the engineered components that could bound the potential impacts for corrasion on recharge will be considered. The engineered surface barrier placed over the closed WMA C will contain elements designed to facilitate drainage and minimize surface erosion by wind and water during the period of institutional control and the barrier design life.

Sensitivity cases that examine a importance of recharge rates for differnet assumed IC periods, barrier design lives, and barrier design recharge rates, and post-barrier life recharge rates are being considered in the initial PA. They are defined in Table B-11 and B-12, Appendix B in RPP-RPT-48490, Rev. 1.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Weathering occurs when the rocks are exposed to physical, chemical and biological conditions much different from those prevailing at the time the rocks were formed

a) Mechanical (physical) weathering: Involves the breakdown or disintegration of rock without any substantial degree of chemical alteration taking place in the mineral which make up the rock mass

b) Physical weathering processes: It is common in nature and takes place as a result of joints developed through tectonic forces, crystal growth, frost wedging, heat effects, and plant roots.

c) Chemical weathering: The decomposition of rocks and minerals as chemical reactions transform into new chemical combinations that are stable at or near the Earth's surface. All the common rock-forming minerals are chemically unstable when exposed to the weather at the earth's surface.

d) Chemical weathering processes: The effects of chemical weathering are most pronounced in regions where both precipitation and temperature are high, two conditions that enhance the rapidity of chemical reactions. Chemical weathering processes include hydrolysis, leaching, oxidation, and dissolution.

e) Factors influencing weathering: Factors influencing weathering include the rock type and structure, the slope, climate, burrowing animals and time.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **8/2/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	See Table B-11 and B-12, Appendix B in RPP-RPT-48490, Rev. 1.

Conceptual Site Model

How it Applies: The processes associated with weathering of rocks and/or sediments when exposed to physical, chemical and biological conditions much different from those prevailing at the time the rocks or sediments were formed is a possible set of processes that could effect long-term performance of a closed WMA C during the assumed post-institutional control period. The magnitude of the impact of this set of processes during the post IC period is difficult to predict and is not be specifically evaluated in WMA C.

However, sensitivity cases designed to look at a range of expected performances for the engineered components that could bound the impacts for mechanical, physical, and chemical weathering of surficial sediments on recharge will be considered. The engineered surface barrier placed over the closed WMA C will contain elements designed to facilitate drainage and minimize surface erosion by wind and water during the period of institutional control and the barrier design life.

Sensitivity cases that examine a range of recharge rates for differnet assumed IC periods, barrier design lives, and barrier design recharge rates, and post-barrier life recharge rates are being considered in the initial PA. They are defined in Table B-11 and B-12, Appendix B in RPP-RPT-48490, Rev. 1.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Erosion (downcutting) of a surface environment caused by the fluvial processes in a river, stream or channel.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **8/3/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: Fluvial erosional (as well as depositional) processes has been important in shaping the general landscape in vicinity of the WMA C in the past when the cataclysmic floods associated with glacial Lake Missoula occurred (i.e. between 13,000 and 15,000 years ago) and channels of Columbia River were much differnet than they are now. However, the timing and magnitude of the impact of this set of processes during the post IC period would be difficult to predict or estimate.

Since the WMA C is not currently located in close proximity to a river, stream or channel, we propose that the direct impacts from fluvial erosion will not be specifically addressed in the initial WMA C PA.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Refers to erosional processes caused by wind action, which is more dominant in dry (desert) environments.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **8/3/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	They are defined in Table B-11 and B-12, Appendix B in RPP-RPT-48490, Rev. 1.

Conceptual Site Model

How it Applies: Erosion caused by wind action is a possible set of processes that could effect long-term performance of a closed WMA C during the assumed post-institutional control period. The magnitude of the impact of this set of processes during the post IC period is difficult to predict and will not be specifically evaluated in WMA C.

However, sensitivity cases designed to look at a range of expected performances for the engineered components that could bound the potential impacts for wind-related erosion on recharge will be considered. The engineered surface barrier placed over the closed WMA C will contain elements designed to facilitate drainage and minimize surface erosion by wind and water during the period of institutional control and the barrier design life.

Sensitivity cases that examine a importance of recharge rates for differnet assumed IC periods, barrier design lives, and barrier design recharge rates, and post-barrier life recharge rates are being considered in the initial PA. They are defined in Table B-11 and B-12, Appendix B in RPP-RPT-48490, Rev. 1.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: The most significant effect of glacier erosion is the deepening of valleys, scouring of upland areas, and the modification of stream channel networks. The form of erosion is dependent on the underlying geology, the fracturing and roughness of the rock and whether the glacier is frozen right down to its base. Small-scale features caused by glacier erosion include glacial striations and grooves, while landforms created by glaciations include cirques, glacial valleys, fjords and drumlin.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0006384** On: **8/3/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Glacial erosional processes has not been important in shaping the general landscape in vicinity of the WMA C in the past. Hence, the direct impacts from fluvial erosion will not be specifically addressed in the initial WMA C PA.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Glaciers are efficient agents of erosion and transport of sediment. Examples include the following:

a) Glacier drift: Sediment deposited directly by glaciers or indirectly by melt water in streams, in lakes and in the sea.

b) Till: At the end of the range of ice-laid deposits is till, which is non-sorted drift deposited directly from ice. The rock particles in a body of till lie just as they were released from the ice.

c) Erratic: A glacially deposited rock or rock fragments with a lithology different from that of the underlying bedrock is called an erratic.

d) Glacialmarine drift: Closely resembles till, glacialmarine drift is sediment deposited on the seafloor from ice shelves or bergs. As an iceberg or the base of an ice shelf slowly melts, the contained sediment is released and settles to the seafloor, where it forms a non-sorted deposit.

e) Moraine: An accumulation of till having a surface form that is unrelated to the underlying bedrock is called a moraine (e.g. ground moraine, end moraine, terminal moraine, lateral moraine).

f) Outwash: Stratified sediment (deposited by meltwater from ice, rather that the glacier directly) deposited by meltwater streams as they flow away from the glacier margin is called outwash (e.g. outwash plains, valley train, outwash terraces).

g) Ice-contact stratified drift: When rapid ablation greatly reduces a glacier's thickness in its terminal zone, ice flow may virtually cease. Sediment carried by meltwater flowing over or beside such stagnant ice is deposited as stratified drift that slumps and collapses as the supporting ice slowly melts away. Such sediment is called ice-contact stratified drift.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **8/3/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Some types of glacial-related deposits associated with melt waters in streams and lakes are found in the general vicinity of the Hanford Site and the WMA C. These would include the occurrence of fluvial and alluvial deposits, lacustrine sediments, and erratics. The most period of this type of depositions was between 13000 and 15000 yrs ago when the cataclysmic floods associated with glacial Lake Missoula occurred and channels of Columbia River were much differnet than they are now. However, the timing and magnitude of the impact of this set of processes during the post IC period would be difficult to predict or estimate.

The direct impacts from glacial deposition will not be specifically addressed in the initial WMA C PA.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the processes by which deposited sediment, at or near the Earth's surface are formed into rocks by e.g. compaction, cementation and crystallisation, i.e. under conditions of temperature and pressure normal to the upper few kilometres of the earth's crust.

Comment: Diagenesis includes all the chemical, physical, and biological changes, modifications, or transformations undergone by sediments after its initial deposition, and during and after its lithification, exclusive or surficial alteration (weathering) and metamorphism. It embraces those non-destructive or reconstructive processes (e.g., consolidation, compaction, cementation, reworking, authigenesis, replacement, solution, precipitation, crystallisation, oxidation, reduction, leaching, hydration, polymerisation, adsorption, bacterial action, and formation of concretions) that occur under conditions of pressure and temperature that are normal to the surficial or outer part of the Earth's crust.

Key Concepts, Examples and Related FEPs

1) **Compaction:** Compaction is the process by which the volume of a sediment is reduced as the grains are squeezed together. The weight of the overlying sediment and rock causes a reorganization of the packing of grains and the expulsion of intergranular fluid. As a result, the porosity of the sediment is reduced. The degree of compaction is controlled by such factors as grain shape, sorting, original porosity, and the amount of pore fluid present.

2) **Recrystallization:** Recrystallization is a process in which physical or chemical conditions induce a reorientation of the crystal lattices of mineral grains. These textural changes cause the sediment to become lithified. It occurs in response to such factors as pressure, temperature, and fluid phase changes. It also occurs as a result of solution and reprecipitation of mineral phases already present in the rock.

3) **Solution:** Solution refers to the process in which a mineral is dissolved. As fluids pass through the sediment, the unstable constituents will dissolve and are either transported away or are reprecipitated in nearby pores where conditions are different. Pressure solution is a process, which occurs as pressure is concentrated at the point of contact between two grains in the sediment. This causes solution and subsequent migration of ions or molecules away from the point of contact, towards an area of lower pressure where the dissolved phase can be reprecipitated.

4) **Cementation:** Cementation is the process in which chemical precipitates (in the form of new crystals) form in the pores of a sediment or rock, binding the grains together. Some common cements are quartz, calcite and hematite, but a wide variety of cements are known, such as aragonite, gypsum, and dolomite. Pressure solution produces locally derived cement, but many cements consist of new minerals previously in solution in the fluid phase. Cementation reduces porosity by filling in the pore spaces between the grains.

5) **Authigenesis:** Authigenesis (neocrystallization) is the process in which new mineral phases are crystallized in the sediment or rock during diagenesis. These new minerals may be produced

a) by reactions involving phases already present in the sediment (or rock)
b) through precipitation of materials introduced in the fluid phase, or
c) from a combination of primary sedimentary and introduced components.

This process overlaps with weathering and cementation, usually involves recrystallization, and may result in replacement. Authigenic phases include silicates such as quartz, alkali feldspar, clays and zeolites; carbonates such as calcite and dolomite; evaporite minerals such as halite, sylvite and gypsum, as well as many others.

6) **Replacement:** Replacement occurs when a newly formed mineral replaces a pre-existing one in situ. Replacement may be:

a) Neomorphic: where the new grain is the same phase as the old grain, or is a polymorph of it (i.e. albitization; replacing a grain with a more Na-rich plagioclase grain).
b) Pseudomorphic: where the old grain is replaced with a new mineral but the relict crystal form is retained,
c) Allomorphic: an old phase is replaced with a new phase with a new crystal form

Although there are many replacement phases, dolomite, opal, quartz, and illite are some of the most important phases.

7) **Bioturbation:** Bioturbation refers to the physical and biological activities that occur at or near the sediment surface which cause the sediment to become mixed. Burrowing and boring by organisms in this way, can increase the compaction of the sediment and usually destroys any laminations or bedding. During bioturbation, some organisms precipitate minerals that act as cement.

Applies to WMA	**No**	Entered By:	**h0006384**	On:	**6/14/2011**	Reviewed By		On:	

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: Given the geologic time-scale of processes related to diagenesis, these processes are deemed not to apply. Thus, the effects of these processes are not considered to be important during the time-scale of this analysis (10,000 yrs post-closure) and will not be considered in the initial WMA C PA.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the development and origin of soils, with reference to the factors responsible for the formation of "solum", or true soil, from unconsolidated parent material.

Comment: Pedogenesis may have an effect on the behaviour of near surface disposal systems as it involves geohydrologic, atmospheric and biological processes (burrowing animals, plant roots activity/invasion) operation at or near surface on time scales of few hundred to thousands of years.

Key Concepts, Examples and Related FEPs

1) **Climate**: Climate plays a very important role in the genesis of a soil. On the global scale, there is an obvious correlation between major soil types and the Köppen climatic classification systems major climatic types. At regional and local scales, climate becomes less important in soil formation. Instead, pedogenesis is more influenced by factors like parent material, topography, vegetation, and time. The two most important climatic variables influencing soil formation are temperature and moisture.

a) Temperature has a direct influence on the weathering of bedrock to produce mineral particles. Rates of bedrock weathering generally increase with higher temperatures. Temperature also influences the activity of soil microorganisms, the frequency and magnitude of soil chemical reactions, and the rate of plant growth.

a) Moisture levels in most soils are primarily controlled by the addition of water via precipitation minus the losses due to evapotranspiration. If additions of water from precipitation surpass losses from evapotranspiration, moisture levels in a soil tend to be high. If the water loss due to evapotranspiration exceeds inputs from precipitation, moisture levels in a soil tend to be low. High moisture availability in a soil promotes the weathering of bedrock and sediments, chemical reactions, and plant growth. The availability of moisture also has an influence on soil pH and the decomposition of organic matter.

2) **Living organisms**: Living organisms have a role in a number of processes involved in pedogenesis including organic matter accumulation, profile mixing, and biogeochemical nutrient cycling. Under equilibrium conditions, vegetation and soil are closely linked with each other through nutrient cycling. The cycling of nitrogen and carbon in soils is almost completely controlled by the presence of animals and plants. Through litterfall and the process of decomposition, organisms add humus and nutrients to the soil which influences soil structure and fertility. Surface vegetation also protects the upper layers of a soil from erosion by way of binding the soils surface and reducing the speed of moving wind and water across the ground surface.

3) **Parent material**: Parent Material refers to the rock and mineral materials from which the soils develop. These materials can be derived from residual sediment due to the weathering of bedrock or from sediment transported into an area by way of the erosive forces of wind, water, or ice. Pedogenesis is often faster on transported sediments because the weathering of parent material usually takes a long period of time. The influence of parent material on pedogenesis is usually related to soil texture, soil chemistry, and nutrient cycling.

4) **Topography**: Topography generally modifies the development of soil on a local or regional scale. Pedogenesis is primarily influenced by topography's effect on microclimate and drainage. Soils developing on moderate to gentle slopes are often better drained than soils found at the bottom of valleys. Good drainage enhances a number of pedogenic processes of illuviation and eluviation that are responsible for the development of soil horizons. Under conditions of poor drainage, soils tend to be immature. Steep topographic gradients inhibit the development of soils because of erosion. Erosion can retard the development through the continued removal of surface sediments. Soil microclimate is also influenced by topography. In the Northern Hemisphere, south facing slopes tend to be warmer and drier than north facing slopes. This difference results in the soils of the two areas being different in terms of depth, texture, biological activity, and soil profile development.

5) **Time**: Time influences the temporal consequences of all of the factors described above. Many soil processes become steady state overtime when a soil reaches maturity. Pedogenic processes in young soils are usually under active modification through negative and positive feedback mechanisms in attempt to achieve equilibrium.

6) **Laterization**: Laterization is a pedogenic process common to soils found in tropical and subtropical environments. High temperatures and heavy precipitation result in the rapid weathering of rocks and minerals. Movements of large amounts of water through the soil cause eluviation and leaching to occur. Almost all of the by products of weathering, very simple small compounds or nutrient ions, are translocated out of the soil profile by leaching if not taken up by plants for nutrition. The two exceptions to this process are iron and aluminum compounds. Iron oxides give tropical soils their unique reddish coloring. Heavy leaching also causes these soils to have an acidic pH because of the net loss of base cations.

7) **Podzolization**: Podzolization is associated with humid cold mid-latitude climates and coniferous vegetation. Decomposition of coniferous litter and heavy summer precipitation create a soil solution that is strongly acidic. This acidic soil solution enhances the processes of eluviation and leaching causing the removal of soluble base cations and aluminum and iron compounds from the A horizon. This process creates a sub-layer in the A horizon that is white to gray in color and composed of silica sand.
8) **Calcification**: Calcification occurs when evapotranspiration exceeds precipitation causing the upward movement of dissolved alkaline salts from the groundwater. At the same time, the movement of rainwater causes a downward movement of the salts. The net result is the deposition of the translocated cations in the B horizon. In some cases, these deposits can form a hard layer called caliche. The most common substance involved in this process is calcium carbonate. Calcification is common in the prairie grasslands.
9) **Salinization**: Salinization is a process that functions in the similar way to calcification. It differs from calcification in that the salt deposits occur at or very near the soil surface. Salinization also takes place in much drier climates.
10) **Gleization**: Gleization is a pedogenic process associated with poor drainage. This process involves the accumulations of organic matter in the upper layers of the soil. In lower horizons, mineral layers are stained blue-gray because of the chemical reduction of iron.

Applies to WMA **Yes** Entered By: **h0006384** On: **6/28/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Given the time-scale of processes related to pedagenesis, these processes can potentially apply. The effects of these processes may need to be considered in the WMA C PA. Soil-development processes could potentially affect the hydraulic properties of the upper components of the surface engineered barrier system.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the presence of salt diapirism and the associated dissolution of the salt, the long-term evolution of salt formations, as well as its effects on the performance of the near-surface radioactive waste disposal facility.

Comment: Diapirism is the lateral or vertical intrusion or upwelling of either buoyant or non-buoyant rock into overlying strata (the overburden) from a source layer. It is most commonly associated with salt formations where a salt diapir comprises a mass of salt that has flowed in a ductile manner from a source layer and pierces or intrudes into the over-lying rocks. The term can also be applied to magmatic or migmatic intrusion.
Dissolution of the salt may occur where the evolving salt formation is in contact with groundwater with salt content below saturation.

Key Concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0006384** On: **6/14/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: Given the geologic history and setting of the hanford Site, the processes of salt diapirism and dissolution are deemed not to apply.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to changes in sea level, which may occur as a result of global (eustatic) change or regional geological change, e.g. isostatic movements.

Comment: Sea levels fluctuate daily as a result of tidal forces. However, it also fluctuates over much longer time scales as a result of (i) changes in the volume of water in the oceans as continental glaciers wax and wane, and (ii) the motions of lithspheric plates that cause the volume of the ocean basins to change.

Key Concepts, Examples and Related FEPs

1) **Eustatic changes:** The component of sea-level change involving the interchange of water between land ice and the sea is referred to as eustatic change. As ice sheets melt so the ocean volume increases and sea levels rise. Timescales for eustatic changes is in the order of 104 to 108 years. Using estimates of eustatic sea level rise as an indicator of climate change faces the difficulty that sea level rise is an output combining many individual effects. Some of these effects can offset others, so that the exact response of global sea level to climate change remains somewhat uncertain. It is necessary to work out a hydrological (e.g. water storage in artificial reservoirs that would otherwise have flowed into the oceans) and geophysical budget for the various contributors to local and global sea level changes.
2) **Epeirogenic changes**: Vertical movements of the crust occur over timescales in the order of 104 to 108 years.
3) **Isostatic change:** Sea level at a given location will also be affected by vertical movement of the land mass, e.g. depression and rebound due to glacial loading and unloading, referred to as isostatic change (c.f. FEP 1.3.01). Occurs over timescales of 102 to 108 years.
4) **Flooding:** A rise in sea level will inevitable result in the flooding of coastal regions. A direct consequence will be sea water intrusion. Alternatively, a fall in sea level will cause sea land to be exposed above the water.
5) **Change in the hydrological cycle:** Changes in the sea level will likely lead to some significant local and regional changes in the hydrological cycle.

Applies to WMA **No** Entered By: **h0006384** On: **8/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Given the location of WMA C, the effects of seal level changes is not deemed relevant to the WMA C PA.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the physical processes and associated landforms in cold but ice-sheet-free environments. This may be at the immediate margins of former and existing glaciers and ice sheets or an environment in which frost actions is dominant.

Comment: Land areas beyond the limit of glaciers where low temperature and frost action are important factors in determining landscape characteristics are called periglacial zones. An important characteristic of periglacial environments is the seasonal change from winter freezing to summer thaw with large water movements and potential for erosion.

Key Concepts, Examples and Related FEPs

1) **Permafrost:** The term permafrost was first introduced to describe the condition of earth materials that remain below 0 oC continuously for at least two years. It is defined exclusively on the basis of temperature, irrespective of the type of earth material, water content, degree of induration, or lithologic character. The distribution and thickness of the permafrost is governed by the energy balance between the earth and the atmosphere. Above the permafrost is a seasonally frozen active layer, frozen in the winter and thawed in the summer. The seasonal frost must penetrate the entire active layer to contact the permafrost in most years or the permafrost will degrade. The distribution and thickness of the permafrost and the thickness of the active layer are determined by factors that control soil temperature fluctuations such as vegetation cover, thermal conductivity of the earth materials, and aspect. Vegetation cover may be the single most important controlling influence.

a) Solifluction: Meltwater of the seasonal thaw is unable to percolate downwards due to permafrost and saturates the surface materials; this can result in a mass movement called solifluction (literally soil-flow).

b) Gelifluction: A type of solifluction occurring in pariglacial environments underlain by permafrost. Suitable conditions for gelifluction occur in areas where downward percolation of water through the soil is limited by the permafrost table and where the melt of segregated ice lenses provides excess water, which reduces internal friction and cohesion in the soil. Particularly favourable sites include areas beneath or below late-lying snowbanks.

c) Taliks: Permafrost layers may isolate the deep hydrological regime from surface hydrology, or flow may be focused at "taliks" (localised unfrozen zones, e.g. under lakes, large rivers or at regions of groundwater discharge).

d) Permafrost depth: Depth of up to 1,500 m (in Siberia) has been recorded. The depth of permafrost penetration is affected by the topography, the thickness of snow cover, and the geothermal gradient.

2) **Freeze-thaw cycle**: A cycle in which temperature fluctuates both above and below 0 0C. The amplitude of the temperature change and the period of time over which the fluctuation occur are important considerations since freezing does not occur instantaneously, nor does it always occur at 0 0C.

3) **Freezing front:** The boundary between frozen or partially frozen ground and non-frozen ground. During freezing in permafrost regions, freezing fronts move downwards from the ground surface and upwards from the permafrost table.

4) **Frost creep:** The downslope movement of the particles as a result of the frost heaving of the ground and subsequent settling upon thawing.

5) **Frost heaving:** The predominantly upward movement of mineral soil during freezing caused by the migration of water to the freezing plane and its subsequent expansion upon freezing.

6) **Frost weathering:** A general term used to describe the complex of weathering processes, both physical and chemical, which operates either independently of in combination, in cold non-glacial environments.

a) Frost action: The mechanical weathering process caused by alternative or repeated cycles of freezing and thawing of water in pores, cracks and other openings, usually at the ground surface. The expansion of water upon freezing forces rock apart. Termed frost wedging, its efficacy depends upon the frequency of freeze-thaw cycles, the availability of moisture, and the lithological/strength of the material.

Applies to WMA	**Yes**	Entered By:	**h0006384**	On:	**6/14/2011**	Reviewed By		On:	

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: Within the time frame of this analysis, climatic change that would results in the encroachment of the study by glaciation is a possibility. However, the initial WMA C PA will only consider the indirect effects of climate change on precipitation patterns and not the effect of glaciation or periglacial processes are dominant.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the effects of glaciers and ice sheets within the region of a near-surface radioactive waste disposal facility, e.g. changes in the geomorphology, erosion, meltwater and hydraulic effects.

Comment: **Comment:** The scope of this FEP is distinct from the effect of large ice masses on global and regional climate, c.f. FEP 1.3.01 and FEP 1.3.02. To be called a glacier, a mass of ice must be capable of motion. Glacial movement occurs when the growing ice mass becomes too heavy to maintain its rigid shape and begins to flow by plastic deformation. In most mountain glaciers, flow of ice begins with accumulations of snow and ice greater than 20 meters. The velocity of flow of glacier ice is influenced by a variety of factors. Some of the more important factors are the gradient of the valley floor, the temperature and thickness of the ice, and the constriction caused by the valley walls.

The main inputs to the glacial system are water, in the form of snow, and eroded sediments that are picked up by the moving ice. Water leaves the glacial system when ice is converted into water or vapor. Sediment is deposited at the base of the glacier as till and at its terminal end as moraines or materials reworked by glaciofluvial processes.

The mass balance of a glacier involves two main components: accumulation of snow in the glacier's zone of accumulation and the ablation of ice in the zone of ablation. The zone of accumulation occurs in the upper reaches of the glacier where yearly additions of snow exceed losses due to melting, evaporation, and sublimation. The surface of this zone is covered by snow throughout the year. Below the zone of accumulation is the zone of ablation. In this zone, the losses of snow and ice from melting, evaporation, and sublimation are greater than the additions.

Eventually, all glacier ice is lost in the zone of ablation by the processes of melting, evaporation, and sublimation. Another process that can remove mass from a glacier is calving. This process occurs in glaciers whose terminus reaches large bodies of water.

Key Concepts, Examples and Related FEPs

1) **Types of glaciers**: Because glaciers vary considerably in their physical characteristics, distinction can be made between several kinds of glaciers based on their shape and size, as well as their internal temperature:

a) Cirque glacier: Occupies a cirque on a mountainside.
b) Valley glacier: Flows from cirque(s) onto and along the floor of a valley.
c) Fjord glacier: Valley glacier that occupies a fjord. Base lies below sea level. May have a steep front that recedes rapidly as icebergs break off and floats away.
d) Piedmont glacier: Broad lobe of ice that terminates on open slopes beyond a mountain front. Fed by one or more large valley glaciers.
e) Ice cap: Dome-shaped body of ice and snow that covers mountain highlands and display generally radial outward flow.
f) Ice sheet: Continent size mass of ice that overwhelms nearly all land within its margins.
g) Ice shelf: Thick slablike glacier that floats on the sea and is fed by one or more glaciers on land. Commonly located in large bays.

2) **Erosion**: Erosional processes (abrasion, over-deepening) associated with glacial action, especially advancing glaciers and ice sheets, and with glacial meltwaters beneath the ice mass and at the margins, can lead to morphological changes in the environment e.g. U-shaped valleys, hanging valleys, fjords and drumlins.

3) **Basal sliding**: A process known as basal sliding enhances the movement of ice over the ground in most temperate glaciers. The immense pressure caused by the weight of the overlying glacial mass causes the ice making contact with the ground to melt because of pressure, despite subzero temperatures (pressure melting). The melting ice then forms a layer of water that reduces the friction between the glacial ice and the ground surface. This water then facilitates the movement of the ice over the ground surface by producing a layer with very little friction. Because of basal sliding, some glaciers can move up to 50 meters in one day. However, average rates of movement are usually less than 1 meter per day. Cold glaciers tend to move very slowly because there is no basal sliding. Movement in these glaciers

takes place mainly due to internal slippage of the ice over the ground.
4) **Deposition**: Depositional features associated with glaciers and ice sheets include moraines and eskers. The pressure of the ice mass on the landscape may result in significant and even depression of the regional crustal plate.
5) **Glacial ages**: The study of the glacial ages provides us with dramatic evidence of rapid global climatic changes on the Earth and with clues about how natural physical and biological systems responded to these changes.

a) Ice-age glaciers: The development of large continental ice sheets during the glacial-interglacial cycles.
b) Drainage diversions and glacial lakes: The growth of ice sheets over the continents caused disruption of major stream systems when glaciers blocked preglacial drainage paths, water ponded to form ice-dammed lakes.
c) Lowering of sea level: Whenever large glaciers formed on the land, the moisture needed to produce and sustain them was derived primarily from the ocean. As a result, sea level was lowered in proportion to the volume of ice on land. During the most recent glacial age, world sea levels fell at least 100 m, thereby causing large expanses of the shallow continental shelves to emerge as dry land.
d) Deformation of the crust: The weight of the massive ice sheet caused the crust of the Earth to subside beneath them. Because ice is one-third as dense as average crusted rock, an ice sheet 3 km thick could cause the crust to subside by as much as 1 km.
e) Earlier glaciations: Paleomagnetic dating of marines sediments shows tat during the last 800,000 years the lengths of the glacial-interglacial cycles average about 100,000 years. For the Pleistocene Epoch as a whole, more than 20 glacial ages are recorded.
f) Little ice ages: During the recent interval of generally cool climate, which started in the mid-thirteenth century and lasted until the mid-nineteenth century, mountain glaciers expanded worldwide. This Little Ice Age, as it is commonly known, was similar to other brief episodes of glacier expansion that were superimposed on the much longer glacial-interglacial cycles.

Applies to WMA **Yes** Entered By: **h0006384** On: **6/14/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Within the time frame of this analysis, climatic change that would results in the encroachment of the study by glaciation is a possibility. However, the initial WMA C PA will only consider the indirect effects of climate change on precipitation patterns and not the effect of glaciation or periglacial processes are dominant.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to warm tropical and desert climates and their effect on the performance of the near-surface radioactive waste disposal facility.

Comment: The tropics can be defined as the area of the Earth found between the Tropic of Cancer and the Tropic Capricorn. In this region, the sun will be directly overhead during some part of the year.
Desert is generally used as a synonym for land where annual rainfall is less than 250 mm or in which the potential evaporation rate exceeds the precipitation rate, regardless of whether the land is "deserted". Aridity is thus the chief characteristic of a desert.

Key Concepts, Examples and Related FEPs

1) **Intertropical convergence zone**: One of the most important weather features found in the tropics is the intertropical convergence zone, which is distinguished by a wide band of cumulus and cumulonimbus clouds that are created by dynamic atmospheric lifting due to convergence and convection. Normally, the intertropical convergence zone delineates the location where the noonday sun is directly overhead on the globe. Because of the high sun, this zone receives the greatest quantity of daily solar insolation in the tropics. This energy is used to evaporate large amounts of water and is converted into sensible heat at the ground surface and within the atmosphere. Often, these processes lead to an almost daily development of convective thunderstorms by providing moisture and heat for the development of cumulonimbus clouds.The intertropical convergence zone also represents the location of convergence of the northeast and southeast trade winds. The convergence of these wind systems enhances the development of convective rain clouds at the tropics.

2) **Tropical moist climates (A)**: Tropical moist climates extend northward and southward from the equator to about 15 to 25 degrees of latitude. In these climates all months have average temperatures greater than 18 degrees Celsius. Annual precipitation is greater than 1500 mm. Three minor Köppen climate types exist in the A group, and their designation is based on seasonal distribution of rainfall.

a) Af or tropical wet is a tropical climate where precipitation occurs all year long. Monthly temperature variations in this climate are less than 3 degrees Celsius. Because of intense surface heating and high humidity, cumulus and cumulonimbus clouds form early in the afternoons almost every day. Daily highs are about 32 degrees Celsius, while night time temperatures average 22 degrees Celsius.

b) Am is a tropical monsoon climate. Annual rainfall is equal to or greater than Af, but most of the precipitation falls in the 7 to 9 hottest months. During the dry season very little rainfall occurs.

c) The tropical wet and dry or savanna (Aw) has an extended dry season during winter. Precipitation during the wet season is usually less than 1000 millimeters, and only during the summer season.

3) **Dry climates (B):** The most obvious climatic feature of this climate is that potential evaporation and transpiration exceed precipitation. These climates extend from 20 - 35 degrees North and South of the equator and in large continental regions of the mid-latitudes often surrounded by mountains. Minor types of this climate include:

a) Bw or dry arid (desert) is a true desert climate. It covers 12 % of the Earth's land surface and is dominated by xerophytic vegetation.

b) Bs or dry semiarid (steppe) is a grassland climate that covers 14% of the Earth's land surface. It receives more precipitation than the Bw either from the intertropical convergence zone or from mid-latitude cyclones.

4) **Extreme weather conditions:** Regions with a tropical climate may experience extreme weather patterns (monsoons, hurricanes), which that could result in flooding, storm surges, high winds etc. with implications for erosion and hydrology.

5) **Hurricanes**: Hurricanes are intense cyclonic storms that develop over the warm oceans of the tropics. By international agreement, the term tropical cyclone is used by most nations to describe hurricane-like storms that originated over tropical oceans.

6) **Desert types**: Desert lands of various kinds total 25% of the land area of the world outside the polar regions. In addition, a smaller though still large percentage of semi-arid land exists in which the annual rainfall varies between 250 and 500 mm. The desert regions are not randomly scattered across the globe, but instead are related to the Earth's geography and the atmospheric circulation. In all five types of deserts are recognised:

a) Subtropical: Centered in belts of descending, dry air about 20−300 north and south latitudes.
b) Continental: In continental interiors, far from moisture sources.
c) Rainshadow: To lee of mountain barriers that trap moist air flowing from the ocean.
d) Coastal Continental margins where cold, upwelling marine water cools maritime air flowing onshore.
e) Polar: In regions where cold, dry air descends, creating very low precipitation.

7) **Weathering (deserts)**: The regolith in a desert in thinner, less continuous, and coarser in texture than in moist areas. Much of this is the result of mechanical weathering. Although chemical weathering does take place in deserts, its intensity is greatly diminished because of reduced soil moisture. Mechanically weathered fragments of rock tend to break off along joints, leaving steep rugged cliffs.

8) **Desert stream and fluvial landforms**: Much of the nonsandy areas of deserts is either crossed by system of stream valleys or covered by alluvial fans and alluvial plains. Thus, in many deserts apparently streams did more geologic work than winds. Most streams that flow into deserts from adjacent mountains never reach the sea, for they soon disappear as the water evaporates and some soaks into the ground.

a) Flash flood: The sparse vegetation cover in deserts presents no great impediment to surface run-off, which can readily erode loose regolith. A major rainstorm is likely to be accompanied by a flash flood, a sudden, swift flood that can transport large quantities of sediment. The debris from such floods forms fans at the bases of mountain slopes and on the floors of wide valleys and basins.
b) Alluvial fans: Alluvial fans develop under a wide range of climatic conditions, but they are especially common in arid and semi arid areas, where they typically are composed of both alluviam and debris-flow deposits. They are a characteristic landform of deserts and can be a major source of groundwater for irrigation. In some arid regions, entire cities have been built on alluvial fans.
c) Desert lakes and playas: Runoff in arid regions is rarely abundant enough to sustain permanent lakes. Instead the floor of a desert basin may contain a dry lakebed, called a playa. Following a rainstorm, runoff may be sufficient to form a temporary playa lake that will last up to several weeks. Salts at the dry surface of a playa, left by the repeated formation and evaporation of temporary lakes, can accumulate to thicknesses of tens of meters and constitute an important source of industrial chemicals.
d) Pediment: One of the most characteristic landforms of dry regions is the pediment, a broad, relatively flat surface, eroded across bedrock and thinly or discontinuously veneered with alluvium, which slopes away from the base of a highland.
e) Inselbergs: Steep-sided mountains, ridges or isolated hills that rise abruptly from adjoining plains like rocky islands standing above the surface of a broad flat sea.

9) **Desertification**: The invasion of desert in nondesert areas, which can be result of natural environmental changes, as well as from human activities. The major symptoms are declining groundwater tables, increasing saltiness of water and topsoil, reduction of supplies of surface water, unnaturally high rates of soil erosion, and destruction of natural vegetation. In arid climates, total rainfall, erosion and recharge may be dominated by infrequent storm events.

Applies to WMA	**Yes**	Entered By:	**h0006384**	On:	**6/14/2011**	Reviewed By		On:	

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies:	Within the time frame of this analysis, climatic change that would result in the encroachment of the study area by a warmer climate is a possibility. However, the initial WMA C PA will only consider the indirect effects of climate change on precipitation patterns and not the direct effect of a warmer (tropical or desert) climate.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Performance of underground nuclear testing that will influence both the integrity of the disposal facility and the characteristics of the contaminant migration pathways.

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **Yes** Entered By: **h0006384** On: **8/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Bacuse, it has nover occurred on the Hanford Site in the past, the possibility of underground nuclear testing at hanford is remote. Thus the PA will not be considering this FEP.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Underground excavation activities performed with or without complete knowledge of the existence, location and/or nature of the disposal facility with the purpose to retrieve or extract components of the disposed waste for malicious purposes (e.g., sabotage or war).

Comment:

Key concepts, Examples and Related FEPs

Applies to WMA **No** Entered By: **h0006384** On: **8/1/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):	See Table 3-1 Summary of Exposure Parameters for the Various Receptors to Be Used in the Risk Assessments at Waste Manag

Conceptual Site Model

How it Applies: The Initial PA will not be considering underground excavation activities performed with or without complete knowledge of the existence, location and/or nature of the closed WMA C facility with the purpose to retrieve or extract components of the residual wastes waste for malicious purposes (e.g., sabotage or war).

The PA analysis will be considering the possibility of the effects of a range ofdirect contact and water-bourne exposures from inadvertant intrusion into soils contaminated with past releases and residual waste left behind in tanks and ancillary equipment and pipelines.

See Sections 3.1, 3.2 and 3.3 in RPP-RPT-47479, Rev. 1 for exposure scenarios that will be considered in the WMA C PA

FEP References

Document Num.	Page or Section	Document Author(s)	Document Title
RPP-RPT-47479, Rev. 1	Section 3.1, 3.2, and 3.3	Connelly et al. 2011	Exposure Scenarios for the Waste Management Area C Performance Assessment Waste Management Area C Exposure Scenarios for the Waste Management Area C Performance Assessment

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the chemical and geochemical processes that affect the geosphere, and the overall evolution of conditions with time. This includes the effects of changes in condition (e.g. Eh, pH) due to the excavation, construction and long-term presence of the disposal facility.

Comment: The hydrochemical regime refers to the groundwater chemistry in the geological formations in the disposal facility region, and the factors that control this. Changes of the hydrochemical regime due to the construction and/or presence of the disposal facility are included.
Note that the scope of this FEP is limited to the chemical/geochemical process and conditions in the geosphere and how these processes and conditions will evolve with time, but it does not include the influence of these process and condition on the migration of contaminants through the geosphere, which is covered in Category 3.2.

Key Concepts, Examples and Related FEPs

1) **Chemical composition, groundwater**: The chemical composition of groundwater refers to the mass per volume of dissolved constituents in a groundwater sample. Under natural conditions, dissolved constituents in the groundwater provide clues on its geological history, its influence on the soil or rock masses through which it passes, the presence of hidden ore deposits, and its mode of origin within the hydrological cycle.
2) **Chemical composition, evolution**: Factors that might change the time dependent chemical/geochemical processes and conditions in the geosphere can be divided into natural, human induced factors, and changes induced by the presence of the disposal facility.
   a) Natural Factors: Change in recharge conditions
   b) Human induced factors: pollution, construction of dams, mining related changes, borehole-induced changes (drilling, injection of fluid into a borehole)
   c) Facility induced factors:
3) **Geosphere related chemical/geochemistry factors:** Groundwater chemistry parameters that should be considered include speciation, solubility, complexants, redox (reduction/oxidation) conditions, rock mineral composition and weathering processes, salinity and chemical gradients.
4) **Geochemical interactions**: Chemical interactions in the geosphere affecting the chemical/geochemical composition and conditions include:
   a) Dissolution and precipitation of minerals along the groundwater flow path, affecting groundwater flow, rock properties, and sorption of contaminants.
   b) Chemical gradients: Induced the formation or destabilisation of colloids by chemical precipitation.
5) **Groundwater recharge**: Different sources of recharge water, or intrusion of saline water, could affect the chemistry of the groundwater in the vicinity of the disposal facility.
6) **Geothermal effects:** Changes in groundwater temperature in the geosphere may change the solubility and speciation of some contaminants, and thus the contaminant migration processes.
7) **Solubility constraints, geosphere:** The significant factors that control solubility in the geosphere, are
   a) changes in the pH, Eh and in the ionic strength
   b) natural occurring complexing agents (and complexing agents formed in the near-field)
   c) natural occurring colloids (and colloids formed in the near-field)
   d) microbes and major ions migrating from the near-field and the common ion effect
8) Oxidizing conditions:
9) Complexing agents in groundwater:

Applies to WMA	**Yes**	Entered By:	**h0006384**	On:	**6/14/2011**	Reviewed By		On:	

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: Include to a little extent. The initial WMA C PA will only be able to address the effect of chemical and geochemical processes on contaminant mobility using either solubility-controlled release, linear sorption isotherm approach, or diffusion-controlled wastes release and transport models. Detailed data and information to support the incorporation of broad range of reactive transport processes is very limited for the initial PA and may not be available in a form that is readily usable in anticipated numerical models for some time to come.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the biological and biochemical processes that affect the geosphere and the overall evolution of conditions with time. This includes the effects of changes in condition (e.g. microbe populations) due to the construction and long-term presence of the disposal facility.

Comment: Note that the scope of this FEP is limited to the biological/biochemical process and conditions in the geosphere and how these processes and conditions will evolve with time, but it does not include the influence of these process and condition on the migration of contaminants through the geosphere, which is covered in Category 3.2.

Key Concepts, Examples and Related FEPs

1) **Biogeochemical changes:** The biological (microbial) load of recharge water to the geosphere may change with time as the surface environment changes (e.g. through climate changes).
2) **Microbial species, in groundwater:** Microorganisms in the geological environment (e.g. anaerobic bacteria such as methanogenic bacteria or sulphate reducers).
3) **Generating of chelating agents:**
4) **Influences on pH:**
5) **Influences on redox potential:**
6) **Change in microbe population:**

Applies to WMA **Yes** Entered By: **h0006384** On: **6/14/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Not sure, very limited data and information available at this time to incorporate in initial WMA C PA post-closure analysis.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the thermal processes that affect the geosphere and the overall evolution of conditions with time. This includes the effects of changes in condition, e.g. temperature, due to the construction and long-term presence of the disposal facility.

Comment: Geothermal regime refers to sources of geological heat, the distribution of heat by conduction and transport (convection) in fluids, and the resulting thermal field or gradient. Changes of the geothermal regime due to the construction and/or presence of the disposal facility are included.

Key Concepts, Examples and Related FEPs

1) **Sources of geothermal heat**:
   a) Metamorphic activity
   a) Heat generated by the waste in disposal facility
2) **Temperature, geosphere**: The temperature in the geosphere will be affected by the geothermal gradient in the rock, changes in the temperature in the near-field, climate changes (e.g. permafrost) and the thermal properties of the rock including the water. In addition, the groundwater flow in the geosphere may affect the temperature.
3) **Distribution of geothermal heat:** Through the process of conduction or convection of fluid
4) **Geothermal gradient:** Groundwater flow will be influenced by existing geothermal gradients – groundwater may tend to form convention cells.
5) **Geothermal induced changes**:
   a) Thermally induced stresses superimposed on existing shear stresses might induce fracturing and fracture displacement.
   b) Change in the hydrogeochemistry (e.g. change in solubility and speciation of some contaminants)
   c) Change direction of groundwater flow paths due to the existence of buoyancy forces

Applies to WMA **Yes** Entered By: **h0006384** On: **6/14/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: No, not considered to be relevant for the post-closure analysis. Estimates of the inventory beyond the time-scale of administrative and institutional controls would preclude these processes being a significant factor in facility.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the characteristics of the coastal zone and the evolution of this zone.

Comment: he coastal zone is the warm nutrient rich, shallow water that extends from the high-tide mark on land to the gentle sloping, shallow edge of the continental shelf (the submerged part of the continents). This zone, which are characterised by a number of features, has numerous interactions with the land and thus easily affected by human activities.

Coastal features include headlands, bays, beaches, spits, cliffs, coastal wetlands and estuaries, while the processes operating on these features include active erosion, deposition and longshore transport. These processes determine the development of the coastal system and may represent a significant mechanism for dilution or accumulation of materials (including contaminants) entering the system.

Water flow associated with coastal features to facilitate contaminant migration includes groundwater flow (discharge), surface run-off (rivers), sea spray and tidal currents along the coast.

Key Concepts, Examples and Related FEPs

1) **Shore profiles:** The shore profile is a vertical section along a line drawn perpendicular to the shore. Such a profile combined with the forces that act parallel to the shore, defines a three dimensional picture of coastal activities.

a) Beach: A beach is more than just the sandy surface above the water along a shore; it is wave-washed sediment accumulated along a coast, including the dynamic sediment in the surf zone, which is continually in motion. Beach profiles are determined by the steepness of the waves and the size of the sediment. These profiles may be highly changeable and display either swell or storm profiles at different times of the year.

b) Rocky (cliffed) coasts: Elements of a cliffed coast are a wave–cut cliff and wave–cut bench, both the work of erosion, and a beach, which is the result of deposition

c) Factors affecting the shore profile: Through erosion and the creation, transport and deposition of sediments, the form of the coast changes, often very slowly but at some times very rapidly. Factors influencing the shore profile include wave action, permeability of the underlying beach sediments, and storms.

2) **Estuary:** The section of the river that flows into the sea and is influenced by tidal currents. Estuaries form transition zones between fresh water rivers and salt-water oceans, with fluctuations in water level, salinity, temperature and velocity. They are constantly modified by erosion and deposition, resulting in tidal flats and salt marshes, deltas, spits and lagoons.

3) **Marine deltas:** Marine deltas are formed when constructional processes prograde (build out) the coastline more rapidly than it can be destroyed by surf. The extent to which a marine delta projects seawards from the land is a compromise between the rate at which the river delivers sediment at its mouth and the ability of the currents and waves to erode sediments along the delta front and move it somewhere else along the coast.

4) **Spit:** A spit is an elongated ridge of sand or gravel that projects from land and ends in open water. A spit is built of sediments moved by longshore drift and dropped at the mouth of a bay where the longshore current encounters deeper waters and its velocity decreases.

5) **Bay barrier:** Along an embayed coast with abundant sediment supply, a ridge of sand or gravel may be built across the mouth of a bay to form a bay barrier. A bay barrier develops as beach drift lengthens a split across a bay, in which tidal or river currents are too weak to scour away the split as it is built.

6) **Barrier island:** A barrier island is a long, narrow sandy island lying offshore and parallel to a coast. An elongate bay lying inshore from the barrier island or other low, enclosing strip of land (such as a coral reef), is called a lagoon.

7) **Coastal hazards:** Like the floodplains of large rivers, the coastal zone is often exposed to natural hazardous events that can be devastating. During these, sometimes infrequent, events, the dynamic nature of the coastal environment becomes especially obvious.

a) Storm: The approximately equilibrium among the forces that operates along costs is occasionally interrupted by exceptional storms (storm surges e.g. hurricanes, cyclones, typhoons) that erode cliffs and beaches at rates far greater than the long term average. Such infrequent bursts of rapid erosion not only can be quantitatively important in the natural evolution of a coastal zone, but also can have a significant impact on coastal inhabitants, and other human activities in the area, especially in low-lying coastal areas.

b) Tsunami: A strong earthquake or other brief, large scale disturbance of the ocean floor, such as a coastal landslide or volcanic eruption, can generate a potentially dangerous seismic sea wave called a tsunami (sometimes referred to as a tidal wave, but it has nothing to do with tides).
c) Landslide: Cliffed shorelines are susceptible to frequent land sliding as erosion eats away at the base of the sea cliff. Roads buildings and other structures built too close to the cliffs can become casualties when sliding occurs.

8) **Tidal currents**: The periodic (twice-daily) horizontal (rise and fall) of the sea, generated by the gravitational attraction between the moon (and to a lesser degree, the sun) and the earth.

9) **Sea water intrusion**: See FEP 2.3.03

Applies to WMA **No** Entered By: **h0006384** On: **6/14/2011** Reviewed By _____ On: _____

Denominator/Sensitivity Case(s):

Conceptual Site Model

How it Applies: Given the location of WMA C, this FEP do not apply.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments

Definition: Factors related to the characteristics of open seas and oceans – including the seabed – and their evolution.

Comment: Seawater covers 70.8 % of the Earth's surface, and most of it is contained in three huge interconnected basins – the Pacific, Atlantic, and Indian Oceans. All three are connected with the Southern Ocean that completely encircles Antarctica. Collectively, these four vast interconnected bodies of water, together with a number of smaller ones, are often referred to as the world ocean. Smaller seas and gulfs vary considerable in shape and size; some are almost completely surrounded by land, whereas others are only partly enclosed.

Each one of these seas and oceans has its own distinctive characteristics, with influences on the coastal features and local climatic conditions. Processes operating on these features such as erosion, deposition, thermal stratification and salinity gradients, determine the development of the system and may represent a significant mechanism for dilution or accumulation of contaminant materials entering the system.

Key Concepts, Examples and Related FEPs

1) **Salinity**: Salinity is a measure of the sea's saltiness, the principle contributing elements being sodium and chloride. Factors affecting salinity are:
   a) Evaporation – which removes water and leaves the remaining water saltier
   b) Precipitation – which add water, thereby diluting the seawater and making it less salty
   c) Inflow of fresh water (river) water – which makes the sea water less salty
   d) Freezing and melting of sea ice – when seawater freezes, salts are excluded from the ice, leaving the unfrozen seawater saltier.

2) **Marine currents:** Drift currents in the oceans are driven by the major global wind systems, and therefore contribute to the net pole ward energy transfer necessitated by latitudinal imbalance in solar radiation receipt. Near the equator dominantly eat-west currents are driven by the trade winds, and an easterly directed counter current at the equator completes a circulation known as "gyre". Within the ocean basins currents follow the continental margins. Marine currents provides a mean of water flow and consequently for the migration, mixing and dilution of contaminants, as well as associated erosion, sedimentation and deposition processes.

3) **Seas:** Examples of smaller seas include the Norwegian Sea, North Sea, Caribbean Sea, Gulf of Mexico, Hudson Bay, Bering Sea, Sea of Okhotsk, Sea of Japan, East China Sea, Coral Sea, Tasman Sea, Arabian Sea, Persian Gulf, Baltic Sea, Red Sea, Black Sea, Iris Sea and the Mediterranean Sea

4) **Mid-ocean ridge:** Large linear arches on the sea floor, which mark the lines of volcanic activity along which basaltic rocks are added to the sea floor as it separates. Volcanic activity long the ridges may produce sea mounts, guyots and islands.

Applies to WMA	**No**	Entered By:	**h0006384**	On:	**6/14/2011**	Reviewed By		On:	

Denominator/Sensitivity Case(s):	

Conceptual Site Model

How it Applies: Given the location of WMA C, this FEP do not apply.

FEP References

Related Features, Events, and Processes

Alternative Point of View

Regulator Comments