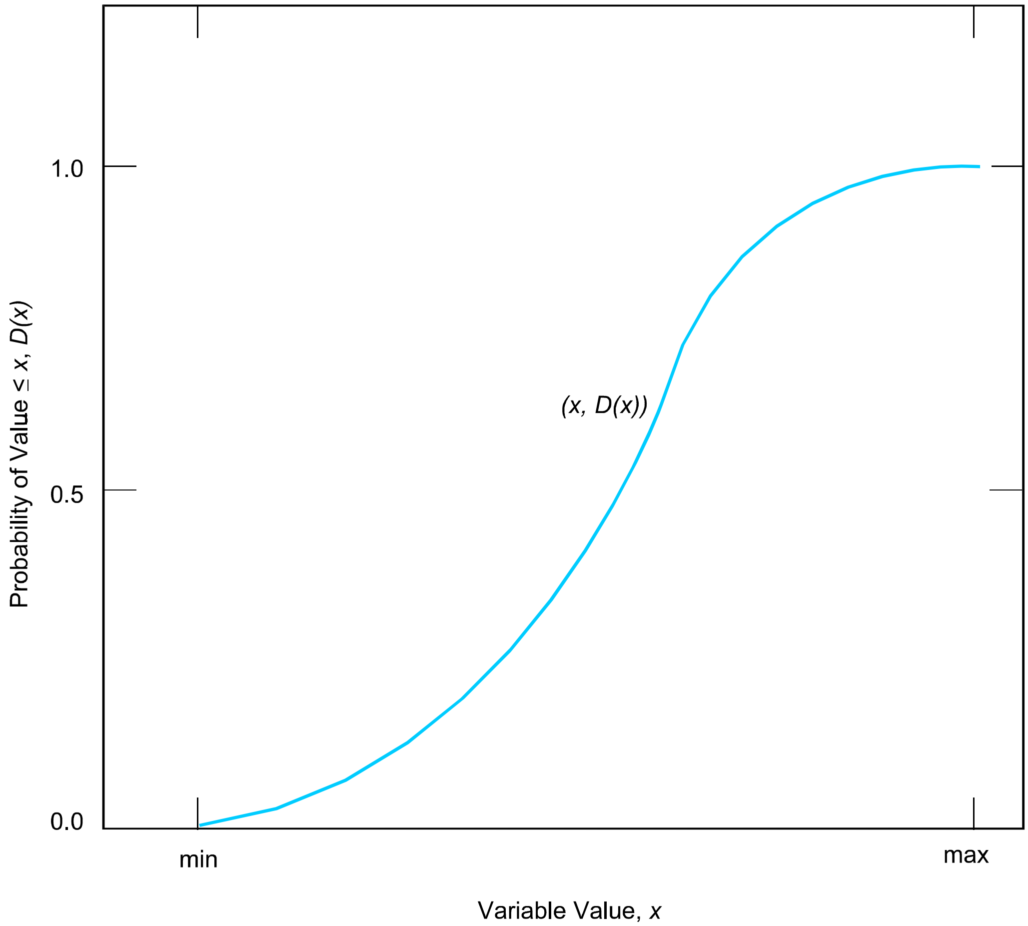

Note: For each value *x* on the abscissa, the corresponding value *D(x)* on the ordinate is the probability that the appropriate value to use in the analysis is less than or equal to *x*.

CCA-008-2

Figure ~~6-5~~*6-6*. Distribution Function for an Imprecisely Known Variable

6.1.5.3 Propagation of the Sample through the Analysis

The next step is the propagation of the sample through the analysis. Each element of the sample is supplied to the model system as input, and the corresponding model system predictions are saved for later use in uncertainty and sensitivity studies. The Software Configuration Management System (SCMS) ~~has been~~ ***was*** developed to facilitate the complex calculations performed by the model system and to store the input and output files from each program.

6.1.5.4 Uncertainty Analysis

Uncertainty analyses evaluate uncertainty in performance estimates that results from uncertainty about-imprecisely known input parameters. Once a sample has been generated and propagated through the modeling system, uncertainty in the outcome can be interpreted directly from the display of the results. For the WIPP ~~performance assessment~~***PA***, stochastic uncertainty is represented by the shape of the individual CCDFs displayed in Section 6.5. Subjective uncertainty is represented by the family of CCDFs displayed in Section 6.6.

6.1.5.5 Sensitivity Analysis

Sensitivity analyses determine the contribution of individual input variables to the uncertainty in model predictions. This is the final step in a probabilistic study. Sensitivity analyses can identify ~~those~~ parameters for which reductions in uncertainty (that is, narrowing ~~of~~ the range of values from which the sample used in the Monte Carlo analysis is drawn) have the greatest potential to increase confidence in the estimate of the disposal system's performance. However, because results of these analyses are inherently conditional on the models, data distributions, and techniques used to generate them, the analyses cannot provide insight ~~to~~ ***on*** the correctness of the conceptual models and data distributions used. Qualitative judgment about the modeling system must be used with sensitivity analyses to set priorities for ~~performance assessment~~***PA*** data acquisition and model development. Sensitivity analyses conducted as part of the WIPP ~~performance assessment~~***PA*** are described in Appendix ***PA*** ~~SA~~.

6.2 Identification and Screening of Features, Events, and Processes

The EPA has provided criteria concerning the scope of PAs in 40 CFR § 194.32. In particular, criteria relating to the identification of potential processes and events that may affect the performance ~~of the~~ disposal system are provided in ***Section***~~40 CFR §~~ 194.32(e), which states that

> Any compliance application(s) shall include information which:
>
> (1) Identifies all potential processes, events or sequences and combinations of processes and events that may occur during the regulatory time frame and may affect the disposal system;
>
> (2) Identifies the processes, events or sequences and combinations of processes and events included in performance assessments; and
>
> (3) Documents why any processes, events or sequences and combinations of processes and events identified pursuant to paragraph (e)(1) of this section were not included in performance assessment results provided in any compliance application.

This section***,*** ~~and~~ ***CCA*** Appendix SCR***, and Appendix PA, Attachment SCR*** fulfill these criteria by documenting DOE's identification, screening, and screening results of all potential processes and events consistent with the criteria specified in 40 CFR § 194.32(e).

As discussed in Section 6.1.4, the first two steps in scenario development involve the identification and screening of FEPs potentially relevant to the performance of the disposal system. This section ~~contains a discussion of~~ ***discusses*** the development of a comprehensive initial set of FEPs ***used in the CCA***, the methodology and criteria used for screening, ***the method used to reassess the CCA FEPs for the CRA-2004,*** and a summary of the FEPs retained for scenario development. Detailed discussion of the basis for eliminating or retaining particular FEPs is provided in Appendix ***PA, Attachment*** SCR. The ~~formation of~~ scenarios ***formed*** from retained FEPs ~~is~~ ***are*** discussed in Section 6.3, and the ~~specification of~~ scenarios ***specified*** for consequence analysis ~~is~~ ***are*** addressed in Section 6.4.12.

The original FEPs generation and screening were documented in the CCA and the resulting FEPs list became the FEPs compliance baseline. The baseline contained 237 FEPs and was documented in Appendix SCR of the CCA. The EPA compliance review of FEPs was

documented in EPA's Technical Support Document 194.32: Scope of PA (EPA 1998, V-B-21). The EPA numbered each FEP with a different scheme than the DOE used for the CCA. The DOE has since adopted EPA's numbering scheme.

6.2.1 *Identification of Features, Events, and Processes*

The first step of the scenario development procedure is ~~identification~~ ***identifying*** and ~~classification of~~ ***classifying*** FEPs potentially relevant to the ~~performance of the~~ disposal system ***performance***. Catalogs of FEPs have been developed in several national radioactive waste disposal programs, as well as internationally. In constructing a comprehensive list of FEPs for the WIPP, the DOE drew on ~~the work of~~ these other radioactive waste disposal programs.

As a starting point, the DOE assembled a list of potentially relevant FEPs from the compilation developed by Stenhouse et al. (1993) for the Swedish Nuclear Power Inspectorate *Statens Kärnkraftinspektion* (SKI). The SKI list was based on a series of FEP lists developed for other disposal programs and is considered ~~to be~~ the best documented and most comprehensive starting point for the WIPP. For the SKI study, an initial, raw FEP list was compiled ~~based on~~ ***from*** nine different FEP identification studies (Table ***6-3*** ~~Table 6-2~~). ***No additional lists of potentially relevant FEPs have been identified since the initial certification.***

The compilers of the SKI list eliminated a number of FEPs as irrelevant to the particular disposal concept under consideration in Sweden; these FEPs were reinstated for the WIPP effort, and several FEPs on the SKI list were subdivided to facilitate ~~for the~~ WIPP screening. Finally, to ensure comprehensiveness, other FEPs specific to the WIPP were added based on ***a*** review of key project documents and ***a*** broad examination of the preliminary WIPP list by both project participants and stakeholders. The initial, unedited list is contained in ~~Attachment 1 of the~~ ***CCA*** Appendix SCR***, Attachment 1***. The initial, unedited FEP list was restructured and revised to derive the comprehensive WIPP FEP list ~~used~~ in ~~the this application~~ ***the CCA***. The number of FEPs ~~has been~~ ***was*** reduced to ~~approximately~~ ~~240~~ ***237*** ~~for this application~~ to avoid the ambiguities caused by ~~the use of~~ ***using*** a generic list. Restructuring the list ~~for this application~~ did not remove any substantive issues from the discussion. As discussed in more detail in ~~Attachment 1 to~~ ***CCA*** Appendix SCR***, Attachment 1***, the following steps ~~have been~~ ***were*** used to ~~derive~~ ***create*** the WIPP FEP list ~~used~~ in ~~this application~~ the ***CCA*** ~~from the initial unedited list~~.

- References to subsystems ~~have been~~ ***were*** eliminated because the SKI subsystem classification ~~is~~ ***was*** not appropriate for the WIPP disposal concept. For example, in contrast to the Swedish disposal concept, canister integrity does not have a role in postoperational performance of the WIPP, and the terms near-field, far-field, and biosphere are not unequivocally defined for the WIPP site.

- Duplicate FEPs ~~have been~~ ***were*** eliminated. Duplicate FEPs arose in the SKI list because individual FEPs could act in different subsystems. FEPs have a single entry in this application list whether they are applicable to several parts of the disposal system, or to a single part only. For example, the FEP *Gas Effects: Disruption* appears in the seals, backfill, waste, canister, and near-field subsystems in the initial FEP list. These FEPs are represented by the single FEP *Disruption Due to Gas Effects* for this application.

Table *6-3*~~6-2~~. FEP Identification Studies Used in the SKI Study

Study	Country	Number of FEPS Identified
Atomic Energy of Canada Limited (AECL) study of disposal of spent fuel in crystalline rock (Goodwin et al. 1994)	Canada	275
SKI & Swedish Nuclear Fuel and Waste Management Company (SKB) study of disposal of spent fuel in crystalline rock (Andersson 1989)	Sweden	157
National Cooperative for the Storage of Radioactive Waste (NAGRA) Project Gewähr study (NAGRA 1985)	Switzerland	44
UK Department of the Environment Dry Run 3 study of deep disposal of low- and intermediate-level waste (L/ILW) (Thorne 1992)	United Kingdom	305
UK Department of Environment assessment of L/ILW disposal in volcanic rock at Sellafield (Miller and Chapman 1992)	United Kingdom	79
UK Nuclear Industry Radioactive Waste Executive (NIREX) study of the deep disposal of L/ILW (Hodgkinson and Sumerling 1989)	United Kingdom	131
Sandia National Laboratories (SNL) study of deep disposal of spent fuel (Cranwell et al. 1990)	United States	29
NEA Working Group on Systematic Approaches to Scenario Development (OECD 1992)	International	122
International Atomic Energy Agency (IAEA) Safety Series (IAEA 1981)	International	56

- FEPs that are not relevant to the WIPP design or inventory ~~have been~~ ***were*** eliminated. Examples include FEPs related to high-level waste, copper canisters, and bentonite backfill.

- FEPs relating to engineering design changes ~~have been~~ ***were*** eliminated because they are not relevant to a compliance application based on the DOE's design for the WIPP. Examples of such FEPs are *Design Modifications: Canister* and *Design Modification: Geometry*.

- FEPs relating to constructional, operational, and decommissioning errors ~~have been~~ ***were*** eliminated. The DOE has administrative and quality control procedures to ensure that the facility will be constructed, operated, and decommissioned properly.

- Detailed FEPs relating to processes in the surface environment ~~have been~~ ***were*** aggregated into a small number of generalized FEPs. For example, the SKI list includes the biosphere FEPs *Inhalation of Salt Particles, Smoking, Showers and Humidifiers*, *Inhalation and Biotic Material, Household Dust and Fumes, Deposition (wet and dry), Inhalation and Soils and Sediments, Inhalation and Gases and Vapors (indoor and outdoor)*, and *Suspension in Air*, which are represented by the FEP *Inhalation* in this application.

- FEPs relating to the containment of hazardous metals, volatile organic compounds (VOCs), and other chemicals that are not regulated by 40 CFR Part 191 ~~are~~ ***were*** not included.

- A few FEPs ~~have been~~ ***were*** renamed to be consistent with terms used to describe specific WIPP processes (for example, *Wicking*, *Brine Inflow*).

6.2.2 *Criteria* ~~for Screening of~~ ***to Screen*** *Features, Events, and Processes and Categorization of Retained Features, Events, and Processes*

~~The purpose of~~ FEP screening ~~is to identify~~ ***identifies*** those FEPs that should be accounted for in ~~performance assessment~~***PA*** calculations, and those ~~FEPs~~ that need not be considered further. The DOE's process of removing FEPs from consideration in ~~performance assessment~~***PA*** calculations involved the structured application of explicit screening criteria. The criteria used to screen out FEPs are explicit regulatory exclusions (SO-R), probability (SO-P), or consequence (SO-C). As discussed in Section 6.2.2.1, all three criteria are derived from regulatory requirements. FEPs not screened as SO-R, SO-P, or SO-C have been retained for inclusion in ~~performance assessment~~***PA*** calculations and are classified as undisturbed performance (UP) or disturbed performance (DP) FEPs. These screening criteria and FEP classifiers are discussed in this section, and FEP screening is discussed in Sections 6.2.3, 6.2.4, and 6.2.5.

6.2.2.1 ~~Elimination of~~ ***Eliminating*** Features, Events, and Processes Based on Regulation ~~(SO-R)~~, Probability ~~(SO-P)~~, or Consequence ~~(SO-C)~~

Regulation ~~(SO-R)~~. Specific FEP screening criteria are ***established by*** ~~stated in~~ 40 CFR Part 191 and 40 CFR § 194.***25, § 194.32 and § 194.54***. These ~~screening~~ criteria relating to the applicability of particular FEPs represent screening decisions made by the EPA. That is, in the process of developing and demonstrating the feasibility of the 40 CFR Part 191 standard and the 40 CFR Part 194 criteria, ~~the~~ EPA considered ~~and made conclusions on~~ the relevance, consequence, and/or probability of occurrence of particular FEPs and, in so doing, ~~allowed~~ ***eliminated*** ~~for~~ some FEPs ~~to be eliminated~~ from consideration. ***For example, 40 CFR § 194.25 outlines consideration of future states. Future human activities are assumed to be as they are today; therefore other regulations that pertain to human activities can be used to screen FEPs (i.e., State and Federal oil well plugging requirements can be used to screen borehole related FEPs).*** Section 6.2.5 describes the regulatory screening criteria that pertain to limitations on the type of human-initiated events and processes that need be analyzed.

Probability of occurrence of a FEP leading to significant release of radionuclides ~~(SO-P)~~. Low-probability events can be excluded ~~on the basis of~~ ***based on*** the criterion provided in 40 CFR § 194.32(d), which states that "PAs need not consider processes and events that have less than one chance in 10,000 of occurring over 10,000 years." In practice, for most FEPs screened out on the basis of low probability of occurrence, it has not been possible to estimate a meaningful, quantitative probability. In the absence of quantitative probability estimates, a qualitative argument has been provided.

Potential consequences associated with the occurrence of the FEPs ~~(SO-C)~~. The DOE ~~recognizes~~ ***identified*** two ***applications of*** ~~uses for~~ this criterion:

1. FEPs can be eliminated from ~~performance assessment~~***PA*** calculations on the basis of insignificant consequence. Consequence can refer to effects on the repository or site or to radiological consequence. In particular, 40 CFR § 194.34(a) states that "The results of PAs shall be assembled into "complementary, cumulative distribution functions" (CCDFs) that represent the probability of exceeding various levels of cumulative release caused by all *significant* processes and events~~.~~" (emphasis added). The DOE has omitted events and processes from ~~performance assessment~~***PA*** calculations where there is a reasonable expectation that the remaining probability distribution of cumulative releases would not be significantly changed by such omissions.

2. FEPs that are potentially beneficial to subsystem performance may be eliminated from ~~performance assessment~~***PA*** calculations, if necessary, to simplify the analysis. This argument may be used when there is uncertainty as to exactly how the FEP should be incorporated into assessment calculations or when incorporation would incur unreasonable difficulties.

In some cases, the effects of ~~the occurrence of~~ a particular event or process, although not necessarily insignificant, can be shown to lie within the range of uncertainty of another FEP already accounted for in the ~~performance assessment~~***PA*** calculations. In such cases, the event or process may be considered ~~to be~~ implicitly included in ~~performance assessment~~***PA*** calculations, within the range of uncertainty associated with the included FEP.

The distinctions between the ***screened out-regulation (***SO-R***)***, ***screened out-probability (***SO-P***)***, and ***screened out-consequence (***SO-C***)*** ~~screening~~ classifications are summarized in Figure 6-7. Although some FEPs could be eliminated from ~~performance assessment~~***PA*** calculations ~~on the basis of~~ ***based on*** more than one criterion, the most practical screening criterion was used for classification. In particular, a regulatory screening classification was used in preference to a probability or consequence screening classification, as illustrated in Figure ~~6-6~~***6-7***. FEPs that ~~have not been~~ ***were not*** screened out based on any one of the three criteria are included in the ~~performance assessment~~***PA***.

6.2.2.2 Undisturbed Performance Features, Events, and Processes

FEPs classified as UP are accounted for in calculations of undisturbed performance of the disposal system. Undisturbed performance is defined in 40 CFR § 191.12 as "the predicted behavior of a disposal system, including consideration of the uncertainties in predicted behavior, if the disposal system is not disrupted by human intrusion or the occurrence of unlikely natural events." The UP FEPs are accounted for in the ~~performance assessment~~***PA*** calculations to evaluate compliance with the Containment Requirements in 40 CFR § 191.13.

6.2.2.3 Disturbed Performance Features, Events, and Processes

FEPs classified as DP are accounted for only in assessment calculations for DP. ***The*** ~~As described in Appendix SCR (Sections SCR.3.1.3.2 and SCR.4), the~~ DP FEPs that remain following the screening process relate to the potential disruptive effects of future drilling and mining events in the controlled area. Consideration of both DP and UP FEPs is required to evaluate compliance with 40 CFR § 191.13.

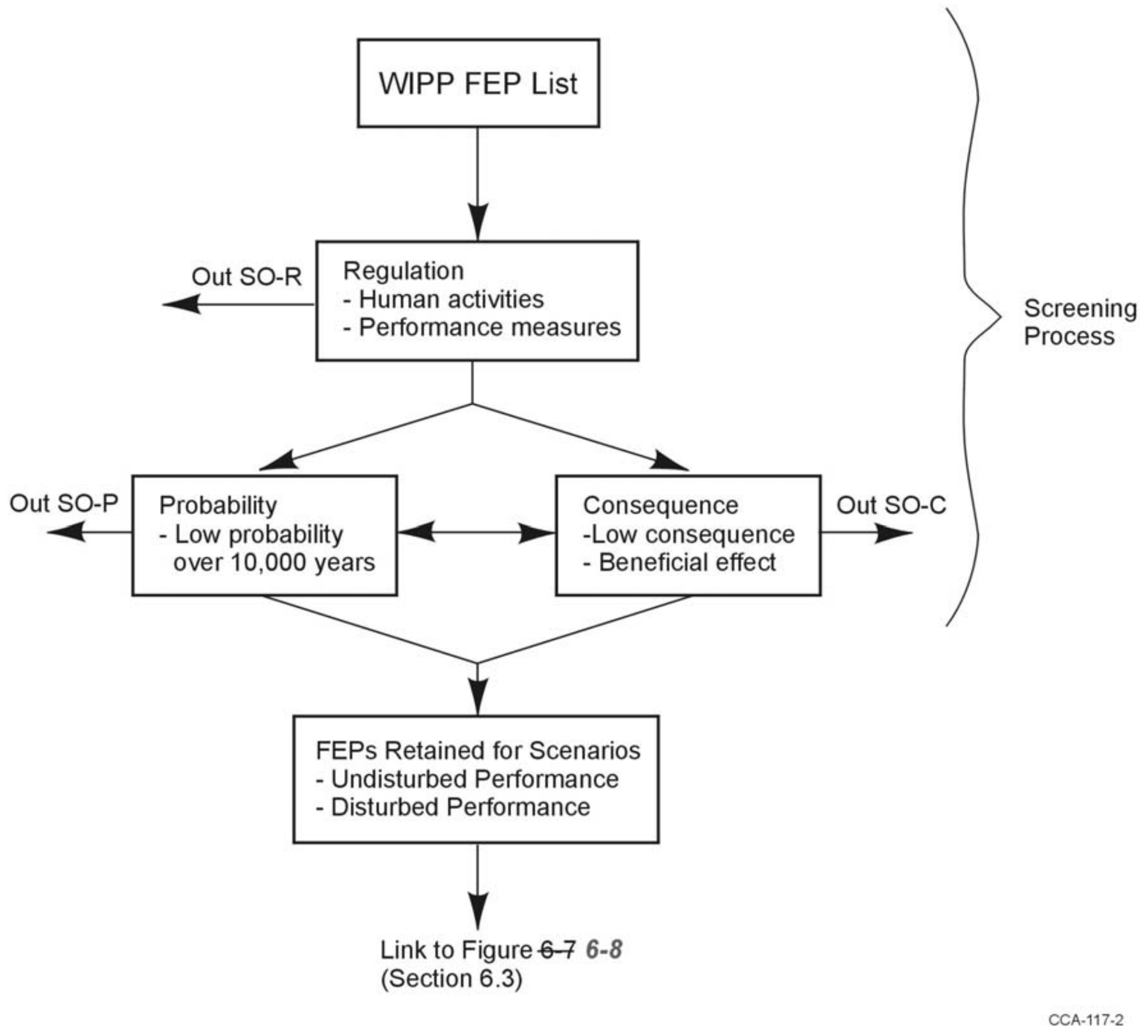

Figure ~~6-6~~*6-7*. Screening Process Based on Screening Classifications

In the following sections, FEPs are discussed under the categories Natural FEPs, Waste- and Repository-Induced FEPs, and Human-Initiated Events and Processes (EPs).

This also allows an evaluation of compliance with the individual dose criterion in 40 CFR § 191.15 and the groundwater protection requirements in 40 CFR § 191.24 (see Chapter 8.0).

6.2.3 Natural Features, Events, and Processes

This subsection briefly discusses natural FEPs ~~that have~~ ***with*** the potential to affect long-term performance of the WIPP disposal system. These FEPs and their screening classifications are listed in ***Table 6-4*** ~~Table 6-3~~; the DOE's detailed screening arguments for natural FEPs are contained in Appendix ***PA,*** ~~SCR~~ ***Attachment SCR*** ~~Section SCR.1~~. ~~This s~~***S***creening ~~of~~ natural FEPs fulfills, in conjunction with the ~~performance assessment~~***PA*** calculations, the criterion of the Future States Assumptions in 40 CFR § 194.25(b) that ~~the~~ DOE shall "document in any compliance application, to the extent practicable, effects of potential future hydrogeologic, geologic and climatic conditions on the disposal system over the regulatory time frame."

Consistent with ~~40 CFR §~~***Section*** 194.32(d), the DOE has screened out several natural FEPs from ~~performance assessment~~***PA*** calculations ~~on the basis of~~ ***based on*** a low probability of occurrence at or near the WIPP site. In particular, natural events for which there is no evidence indicating that they have occurred within the Delaware Basin ~~have been~~ ***were*** screened on this basis. In this analysis, the probabilities ~~of occurrence~~ of these events ~~occurrence~~ ***occurring*** are assumed to be zero. Quantitative, nonzero probabilities for such events, based on numbers of occurrences, cannot be ascribed without considering regions much larger than the Delaware Basin ***(see for example, FEP N 40, Impact of a Large Meteorite in Appendix PA, Attachment SCR)***, thus neglecting established geological understanding of the events and processes that occur within particular geographical provinces. No disruptive natural FEPs are likely to occur during the regulatory time frame that could ~~result in the creation of~~ ***create*** new pathways or significant***ly*** ~~alteration of~~ ***alter*** existing pathways.

In considering the overall geological setting of the Delaware Basin, the DOE ~~has~~ eliminated many FEPs from ~~performance assessment~~***PA*** calculations ~~on the basis of~~ ***based on*** low consequence. Events and processes that have had little effect on the characteristics of the region in the past are expected to be of low consequence for the regulatory time period.

6.2.4 Waste- and Repository-Induced Features, Events, and Processes

The waste- and repository-induced FEPs are those that relate specifically to the waste material, waste containers, shaft seals, MgO ~~backfill~~, panel closures, repository structures, and investigation boreholes. All FEPs related to radionuclide chemistry and radionuclide migration are included in this category. FEPs related to radionuclide transport ~~resulting~~ from future borehole intersections of the WIPP excavation are defined as waste- and repository-induced FEPs. Waste- and repository-induced FEPs and their screening classification are listed in ***Table 6-5***~~Table 6-4~~. The DOE's detailed screening discussions for these FEPs are contained in Appendix ***PA*** ~~SCR~~ (***Attachment SCR*** ~~Section SCR.2~~).

The DOE has screened out many FEPs in this category on the basis of low consequence to the performance of the disposal system. For example, the DOE has shown that the heat generated by radioactive decay of ~~the~~ emplaced RH- and CH-TRU waste will not ~~result in~~ ***increase*** temperature ~~increases~~ sufficient***ly*** to induce significant thermal convection, thermal stresses and strains, or thermally induced chemical perturbations within the disposal system (see Appendix ***PA, Attachment SCR,*** ~~SCR~~, ~~Sections SCR.2.2.2~~ ***FEP W13*** and ***FEP W72*** ~~SCR.2.5.7~~). Also, hydration of the emplaced concrete seals and chemical conditioner will be exothermic, but ~~the~~ DOE has shown that the heat generated will not ~~have a~~ significant***ly*** ~~e~~***a***ffect ~~on~~ the ~~performance of the~~ disposal system ***performance*** (see Appendix ***PA*** ~~SCR~~, ***Attachment SCR, FEP W72*** ~~Section SCR.2.5.7~~).

Other waste- and repository-induced FEPs ~~have been~~ ***were*** eliminated from ~~performance assessment~~***PA*** calculations ~~on the basis of~~ ***based on*** beneficial effect to the performance of the disposal system, if necessary to simplify the analysis.

Waste- and repository-induced FEPs eliminated on the basis of low probability of occurrence over 10,000 years are generally those for which no mechanisms ~~have been~~ ***were*** identified that

Table *6-4*~~6-3~~. Natural FEPs and Their Screening Classifications

FEPs	Screening Classification	Comments	*FEP Number* ~~Appendix SCR Section~~
GEOLOGICAL FEPS			~~SCR.1.1~~
Stratigraphy			~~SCR.1.1.1~~
Stratigraphy	UP		***N1***
Brine reservoirs	DP		***N2***
Tectonics			~~SCR.1.1.2~~
Changes in regional stress	SO-C		***N3***
Regional tectonics	SO-C		***N4***
Regional uplift and subsidence	SO-C		***N5***
Structural FEPs			~~SCR.1.1.3~~
Deformation			~~SCR.1.1.3.1~~
Salt deformation	SO-P	UP near repository.	***N6***
Diapirism	SO-P		***N7***
Fracture development			~~SCR.1.1.3.2~~
Formation of fractures	SO-P	UP near repository.	***N8***
Changes in fracture properties	SO-C	UP near repository.	***N9***
Fault movement			~~SCR.1.1.3.3~~
Formation of new faults	SO-P		***N10***
Fault movement	SO-P		***N11***
Seismic activity			~~SCR.1.1.3.4~~
Seismic activity	UP		***N12***
Crustal processes			~~SCR.1.1.4~~
Igneous activity			~~SCR.1.1.4.1~~
Volcanic activity	SO-P		***N13***
Magmatic activity	SO-C		***N14***
Metamorphism			~~SCR.1.1.4.2~~
Metamorphic activity	SO-P		***N15***
Geochemical FEPs			~~SCR.1.1.5~~
Dissolution			~~SCR.1.1.5.1~~
Shallow dissolution	UP		***N16***
Deep dissolution	SO-P		***N18***
Breccia pipes	SO-P		***N20***
Collapse breccias	SO-P		***N21***
Mineralization			~~SCR.1.1.5.2~~
Fracture infills	SO-C		***N22***
SUBSURFACE HYDROLOGICAL FEPS			~~SCR.1.2~~
Groundwater characteristics			~~SCR.1.2.1~~

Table *6-4*~~6-3~~. Natural FEPs and Their Screening Classifications — Continued

FEPs	Screening Classification	Comments	*FEP Number* ~~Appendix SCR Section~~
Saturated groundwater flow	UP		*N23*
Unsaturated groundwater flow	UP	SO-C in Culebra.	*N24*
Fracture flow	UP		*N25*
Density effects on groundwater flow	SO-C		*N26*
Effects of preferential pathways	UP	UP in Salado and Culebra.	*N27*
Changes in groundwater flow			~~*SCR.1.2.2*~~
Thermal effects on groundwater flow	SO-C		*N28*
Saline intrusion	SO-P		*N29*
Freshwater intrusion	SO-P		*N30*
Hydrological response to earthquakes	SO-C		*N31*
Natural gas intrusion	SO-P		*N32*
SUBSURFACE GEOCHEMICAL FEPS			~~SCR.1.3~~
Groundwater geochemistry			~~SCR.1.3.1~~
Groundwater geochemistry	UP		*N33*
Changes in groundwater chemistry			~~SCR.1.3.2~~
Saline intrusion	SO-C		*N34*
Freshwater intrusion	SO-C		*N35*
Changes in groundwater Eh	SO-C		*N36*
Changes in groundwater pH	SO-C		*N37*
Effects of dissolution	SO-C		*N38*
GEOMORPHOLOGICAL FEPS			~~SCR.1.4~~
Physiography			~~SCR.1.4.1~~
Physiography	UP		*N39*
Meteorite impact			~~SCR.1.4.2~~
Impact of a large meteorite	SO-P		*N40*
Denudation			~~SCR.1.4.3~~
Weathering			~~SCR.1.4.3.1~~
Mechanical weathering	SO-C		*N41*
Chemical weathering	SO-C		*N42*
Erosion			~~SCR.1.4.3.2~~
Aeolian erosion	SO-C		*N43*
Fluvial erosion	SO-C		*N44*
Mass wasting	SO-C		*N45*
Sedimentation			~~SCR.1.4.3.3~~
Aeolian deposition	SO-C		*N46*
Fluvial deposition	SO-C		*N47*
Lacustrine deposition	SO-C		*N48*
Mass wasting	SO-C		*N49*

Table *6-4*~~6-3~~. Natural FEPs and Their Screening Classifications — Continued

FEPs	Screening Classification	Comments	*FEP Number* ~~Appendix SCR Section~~
Soil development			~~SCR.1.4.4~~
Soil development	SO-C		*N50*
SURFACE HYDROLOGICAL FEPS			~~SCR.1.5~~
Fluvial			~~SCR.1.5.1~~
Stream and river flow	SO-C		*N51*
Lacustrine			~~SCR.1.5.2~~
Surface water bodies	SO-C		*N52*
Groundwater recharge and discharge			~~SCR.1.5.3~~
Groundwater discharge	UP		*N53*
Groundwater recharge	UP		*N54*
Infiltration	UP	UP for climate change effects.	*N55*
Changes in surface hydrology			~~SCR.1.5.4~~
Changes in groundwater recharge and discharge	UP		*N56*
Lake formation	SO-C		*N57*
River flooding	SO-C		*N58*
CLIMATIC FEPs			~~SCR.1.6~~
Climate			~~SCR.1.6.1~~
Precipitation (for example, rainfall)	UP		*N59*
Temperature	UP		*N60*
Climate change			~~SCR.1.6.2~~
Meteorological			~~SCR.1.6.2.1~~
Climate change	UP		*N61*
Glaciation			~~SCR.1.6.2.2~~
Glaciation	SO-P		*N623*
Permafrost	SO-P		*N63*
MARINE FEPs			~~SCR.1.7~~
Seas			~~SCR.1.7.1~~
Seas and oceans	SO-C		*N64*
Estuaries	SO-C		*N65*
Marine sedimentology			~~SCR.1.7.2~~
Coastal erosion	SO-C		*N66*
Marine sediment transport and deposition	SO-C		*N67*
Sea level changes			
Sea level changes	SO-C		~~SCR.1.7.3~~*N68*
ECOLOGICAL FEPs			~~SCR.1.8~~
Flora & fauna			~~SCR.1.8.1~~

Table *6-4*~~6-3~~. Natural FEPs and Their Screening Classifications — Continued

FEPs	Screening Classification	Comments	*FEP Number* ~~Appendix SCR Section~~
Plants	SO-C		*N69*
Animals	SO-C		*N70*
Microbes	SO-C	UP for colloidal effects and gas generation	*N71*
Changes in flora & fauna			~~SCR.1.8.2~~
Natural ecological development	SO-C		*N72*

Legend:

UP FEPs accounted for in the assessment calculations for undisturbed performance for 40 CFR § 191.13 (as well as 40 CFR § 191.15 and Subpart C of 40 CFR Part 191).

DP FEPs accounted for (in addition to all UP FEPs) in the assessment calculations for disturbed performance for 40 CFR § 191.13.

SO-R FEPs eliminated from ~~performance assessment~~*PA* calculations on the basis of regulations provided in 40 CFR Part 191 and criteria provided in 40 CFR *§*~~Part~~ 194.*25, .32 and .54*

SO-C FEPs eliminated from ~~performance assessment~~*PA* (and compliance assessment) calculations ~~on the basis of~~ ***based on*** consequence.

SO-P FEPs eliminated from ~~performance assessment~~*PA* (and compliance assessment) calculations ~~on the basis of~~ ***based on*** low probability of occurrence.

1

Table *6-5*~~6-4~~. Waste- and Repository-Induced FEPs and Their Screening Classifications

FEPs	Screening Classification	Comments	*FEP Number* ~~Appendix SCR Section~~
WASTE AND REPOSITORY CHARACTERISTICS			~~SCR.2.1~~
Repository characteristics			~~SCR.2.1.1~~
Disposal geometry	UP		*W1*
Waste characteristics			~~SCR.2.1.2~~
Waste inventory	UP		*W2*
Heterogeneity of waste forms	DP		*W3*
Container characteristics			~~SCR.2.1.3~~
Container form	SO-C		*W4*
Container material inventory	UP		*W5*
Seal characteristics			~~SCR.2.1.4~~
Seal geometry	UP		*W6*
Seal physical properties	UP		*W7*
Seal chemical composition	SO-C	Beneficial SO-C	*W8*
Backfill characteristics			~~SCR.2.1.5~~
Backfill physical properties	SO-C		*W9*
Backfill chemical composition	UP		*W10*
Postclosure monitoring			~~SCR.2.1.6~~
Postclosure monitoring	SO-C		*W11*
RADIOLOGICAL FEPs			~~SCR.2.2~~
Radioactive decay			~~SCR.2.2.1~~
Radionuclide decay and ingrowth	UP		*W12*

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Table *6-5*~~6-4~~. Waste- and Repository-Induced FEPs and Their Screening Classifications — Continued

FEPs	Screening Classification	Comments	*FEP Number* ~~Appendix SCR Section~~
Heat from radioactive decay			~~SCR.2.2.2~~
Heat from radioactive decay	SO-C		*W13*
Nuclear criticality			~~SCR.2.2.3~~
Nuclear criticality: heat	SO-P		*W14*
Radiological effects on material properties			~~SCR.2.2.4~~
Radiological effects on waste	SO-C		*W15*
Radiological effects on containers	SO-C		*W16*
Radiological effects on seals	SO-C		*W17*
GEOLOGICAL AND MECHANICAL FEPs			~~SCR.2.3~~
Excavation-induced fracturing			~~SCR.2.3.1~~
Disturbed rock zone	UP		*W18*
Excavation-induced changes in stress	UP		*W19*
Rock creep			~~SCR.2.3.2~~
Salt creep	UP		*W20*
Changes in the stress field	UP		*W21*
Roof falls			~~SCR.2.3.3~~
Roof falls	UP		*W22*
Subsidence			~~SCR.2.3.4~~
Subsidence	SO-C		*W23*
Large scale rock fracturing	SO-P		*W24*
Effects of fluid pressure changes			~~SCR.2.3.5~~
Disruption due to gas effects	UP		*W25*
Pressurization	UP		*W26*
Effects of explosions			~~SCR.2.3.6~~
Gas explosions	UP		*W27*
Nuclear explosions	SO-P		*W28*
Thermal effects			~~SCR.2.3.7~~
Thermal effects on material properties	SO-C		*W29*
Thermally induced stress changes	SO-C		*W30*
Differing thermal expansion of repository components	SO-C		*W31*
Mechanical effects on material properties			~~SCR.2.3.8~~
Consolidation of waste	UP		*W32*
Movement of containers	SO-C		*W33*
Container integrity	SO-C	Beneficial SO-C	*W34*
Mechanical effects of backfill	SO-C		*W35*
Consolidation of seals	UP		*W36*
Mechanical degradation of seals	UP		*W37*

Table *6-5*~~6-4~~. Waste- and Repository-Induced FEPs and Their Screening Classifications — Continued

FEPs	Screening Classification	Comments	*FEP Number* ~~Appendix SCR Section~~
~~Investigation boreholes~~	~~SO-C~~		
Underground boreholes	UP		*W39*
SUBSURFACE HYDROLOGICAL AND FLUID DYNAMICAL FEPs			~~SCR.2.4~~
Repository-induced flow			~~SCR.2.4.1~~
Brine inflow	UP		*W40*
Wicking	UP		*W41*
Effects of gas generation			~~SCR.2.4.2~~
Fluid flow due to gas production	UP		*W42*
Thermal effects			~~SCR.2.4.3~~
Convection	SO-C		*W43*
GEOCHEMICAL AND CHEMICAL FEPs			~~SCR.2.5~~
Gas generation			~~SCR.2.5.1~~
Microbial gas generation			~~SCR.2.5.1.1~~
Degradation of organic material	UP		*W44*
Effects of temperature on microbial gas generation	UP		*W45*
Effects of pressure on microbial gas generation	SO-C		*W46*
Effects of radiation on microbial gas generation	SO-C		*W47*
Effects of biofilms on microbial gas generation	UP		*W48*
Corrosion			~~SCR.2.5.1.2~~
Gases from metal corrosion	UP		*W49*
Galvanic coupling	SO-~~P~~*C*		*W50*
Chemical effects of corrosion	UP		
Radiolytic gas generation			~~SCR.2.5.1.3~~
Radiolysis of brine	SO-C		*W52*
Radiolysis of cellulose	SO-C		*W53*
Helium gas production	SO-C		*W54*
Radioactive gases	SO-C		*W55*
Chemical speciation			~~SCR.2.5.2~~
Speciation	UP	UP in disposal rooms and Culebra. SO-C elsewhere, and beneficial SO-C in cementitious seals.	*W56*
Kinetics of speciation	SO-C		*W57*
Precipitation and dissolution			~~SCR.2.5.3~~
Dissolution of waste	UP		*W58*
Precipitation	SO-C	Beneficial SO-C	*W59*

Table *6-5*~~6-4~~. Waste- and Repository-Induced FEPs and Their Screening Classifications — Continued

FEPs	Screening Classification	Comments	***FEP Number*** ~~Appendix SCR Section~~
Kinetics of precipitation and dissolution	SO-C	Kinetics of waste dissolution is a beneficial SO-C	***W60***
Sorption			~~SCR.2.5.4~~
Actinide sorption	UP	UP in the Culebra and Dewey Lake. Beneficial SO-C elsewhere	***W61***
Kinetics of sorption	UP		***W62***
Changes in sorptive surfaces	UP		***W63***
~~Reduction-oxidation~~ ***Oxidation-reduction*** chemistry			~~SCR.2.5.5~~
Effect of metal corrosion	UP		***W64***
~~Reduction-oxidation~~ ***Oxidation-reduction*** fronts	SO-P		***W65***
~~Reduction-oxidation~~ ***Oxidation-reduction*** kinetics	UP		***W66***
Localized reducing zones	SO-C		***W67***
Organic complexation			~~SCR.2.5.6~~
Organic complexation	~~SO-C~~***UP***		***W67***
Organic ligands	~~SO-C~~***UP***		***W69***
Humic and fulvic acids	UP		***W70***
Kinetics of organic complexation	SO-C		***W71***
Exothermic reactions			~~SCR.2.5.7~~
Exothermic reactions	SO-C		***W72***
Concrete hydration	SO-C		***W73***
Chemical effects on material properties			~~SCR.2.5.8~~
Chemical degradation of seals	UP		***W74***
Chemical degradation of backfill	SO-C		***W75***
Microbial growth on concrete	UP		***W76***
CONTAMINANT TRANSPORT MODE FEPs			~~SCR.2.6~~
Solute transport			~~SCR.2.6.1~~
Solute transport	UP		***W77***
Colloid transport			~~SCR.2.6.2~~
Colloid transport	UP		***W78***
Colloid formation and stability	UP		***W79***
Colloid filtration	UP		***W80***
Colloid sorption	UP		***W81***
Particulate transport			~~SCR.2.6.3~~
Suspensions of particles	DP	SO-C for undisturbed conditions	***W82***
Rinse	SO-C		***W83***

Table *6-5*~~6-~~4. Waste- and Repository-Induced FEPs and Their Screening Classifications — Continued

FEPs	Screening Classification	Comments	***FEP Number*** ~~Appendix SCR Section~~
Cuttings	DP	Repository intrusion only	***W84***
Cavings	DP	Repository intrusion only	***W85***
Spallings	DP	Repository intrusion only	***W86***
Microbial transport			~~SCR.2.6.4~~
Microbial transport	UP		***W87***
Biofilms	SO-C	Beneficial SO-C	***W88***
Gas transport			~~SCR.2.6.5~~
Transport of radioactive gases	SO-C		***W89***
CONTAMINANT TRANSPORT PROCESSES			~~SCR.2.7~~
Advection			~~SCR.2.7.1~~
Advection	UP		***W90***
Diffusion			~~SCR.2.7.2~~
Diffusion	UP		***W91***
Matrix diffusion	UP		***W92***
Thermochemical transport phenomena			~~SCR.2.7.3~~
Soret effect	SO-C		***W93***
Electrochemical transport phenomena			~~SCR.2.7.4~~
Electrochemical effects	SO-C		***W94***
Galvanic coupling	SO-P		***W95***
Electrophoresis	SO-C		***W96***
Physicochemical transport phenomena			~~SCR.2.7.5~~
Chemical gradients	SO-C		***W97***
Osmotic processes	SO-C	Beneficial SO-C	***W98***
Alpha recoil	SO-C		***W99***
Enhanced diffusion	SO-C		***W100***
ECOLOGICAL FEPs			~~SCR.2.8~~
Plant, animal, and soil uptake			~~SCR.2.8.1~~
Plant uptake	SO-R	SO-C for 40 CFR § 191.15	***W101***
Animal uptake	SO-R		***W102***
Accumulation in soils	SO-C	Beneficial SO-C	***W103***
Human uptake			~~SCR.2.8.2~~
Ingestion	SO-R	SO-C for 40 CFR § 191.15	***W104***
Inhalation	SO-R	SO-C for 40 CFR § 191.15	***W105***
Irradiation	SO-R	SO-C for 40 CFR § 191.15	***W106***

Table *6-5*~~6-4~~. Waste- and Repository-Induced FEPs and Their Screening Classifications — Continued

FEPs	Screening Classification	Comments	***FEP Number*** ~~Appendix SCR Section~~
Dermal sorption	SO-R	SO-C for 40 CFR § 191.15	***W107***
Injection	SO-R	SO-C for 40 CFR § 191.15	***W108***

Legend:
UP FEPs accounted for in the assessment calculations for undisturbed performance for 40 CFR § 191.13 (as well as 40 CFR § 191.15 and Subpart C of 40 CFR Part 191).
DP FEPs accounted for (in addition to all UP FEPs) in the assessment calculations for disturbed performance for 40 CFR § 191.13.
SO-R FEPs eliminated from ~~performance assessment~~*PA* calculations on the basis of regulations provided in 40 CFR Part 191 and criteria provided in 40 CFR ***§*** ~~Part~~ 194. ***25, .32 and .54.***
SO-C FEPs eliminated from ~~performance assessment~~*PA* (and compliance assessment) calculations ~~on the basis of~~ ***based on*** consequence.
SO-P FEPs eliminated from ~~performance assessment~~*PA* (and compliance assessment) calculations ~~on the basis of~~ ***based on*** low probability of occurrence.

could result in their occurrence within the disposal system. Such FEPs include explosions resulting from nuclear criticality, and the development of large-scale reduction-oxidation fronts.

6.2.5 Human-Initiated Events and Processes

Assessments of compliance with the Containment Requirements in 40 CFR § 191.13 require consideration of "all significant processes and events," including human-initiated EPs. These EPs and their screening classifications are listed in ***Table 6-6***~~Table 6-5~~. The DOE's detailed screening arguments for human-initiated EPs are presented in Appendix ***PA,*** ~~SCR (~~***Attachment SCR*** ~~Section SCR.3)~~.

The scope of ~~performance assessment~~***PA*** is clarified with respect to human-initiated events and processes in 40 CFR § 194.32. ~~At 40 CFR §~~***Section*** 194.32(a) ~~the EPA~~ states that

> Performance assessments shall consider natural processes and events, mining, deep drilling, and shallow drilling that may affect the disposal system during the regulatory time frame.

Thus, ~~performance assessment~~***PA*** must ~~include~~ consider~~ation of~~ human-initiated EPs relating to mining and drilling activities that might take place during the regulatory time frame. In particular, ~~performance assessments~~***PAs*** must consider the potential effects of such activities that might take place within the controlled area at a time when institutional controls cannot be assumed to completely eliminate the possibility of human intrusion.

Further criteria concerning the scope of ~~performance assessments~~***PAs*** are provided at 40 CFR § 194.32(c):

> Performance assessments shall include an analysis of the effects on the disposal system of any activities that occur in the vicinity of the disposal system prior to disposal and are expected to occur in the vicinity of the disposal system soon after disposal. Such activities shall include, but shall not be limited to, existing boreholes and the development of any existing leases that can be reasonably expected to be developed in the near future, including boreholes and leases that may be used for fluid injection activities.

Table *6-6* ~~6-5~~. Human-Initiated EPs and Their Screening Classifications

EPs	Screening Classification		Comments	*FEP Number* ~~Appendix SCR Section~~
	Historical/ Ongoing/ Near Future	Future		
GEOLOGICAL EPs				~~SCR.3.2~~
Drilling			DP for boreholes that penetrate the waste and boreholes that penetrate Castile brine underlying the waste disposal region. SO-C for other future drilling.	~~SCR.3.2.1~~
Oil and gas exploration	SO-C	DP		*H1*
Potash exploration	SO-C	DP		*H2*
Water resources exploration	SO-C	SO-C		*H3*
Oil and gas exploitation	SO-C	DP		*H4*
Groundwater exploitation	SO-C	SO-C		*H5*
Archeological investigations	SO-R	SO-R		*H6*
Geothermal	SO-R	SO-R		*H7*
Other resources	SO-C	DP		*H8*
Enhanced oil and gas recovery	SO-C	DP		*H9*
Liquid waste disposal	SO-R	SO-R		*H10*
Hydrocarbon storage	SO-R	SO-R		*H11*
Deliberate drilling intrusion	SO-R	SO-R		*H12*
Excavation activities				~~SCR.3.2.2~~
Conventional underground ~~P~~*p*otash mining	UP	DP	UP for mining outside the controlled area. DP for mining inside the controlled area.	*H13*
Solution mining for potash	*SO-R*	*SO-R*	*New to FEP Baseline*	*H58*
Solution mining for other resources	*SO-R*	*SO-R*	*New to FEP Baseline*	*H59*
Other resources	SO-C	SO-R		*H14*
Tunneling	SO-R	SO-R		*H15*
Construction of underground facilities (for example storage, disposal, accommodation)	SO-R	SO-R		*H16*
Archeological excavations	SO-C	SO-R		*H17*
Deliberate mining intrusion	SO-R	SO-R		*H18*
Subsurface explosions				~~SCR.3.2.3~~
Resource recovery				~~SCR.3.2.3.1~~

Table *6-6*~~6-5~~. Human-Initiated EPs and Their Screening Classifications — Continued

EPs	Screening Classification		Comments	*FEP Number* ~~Appendix SCR Section~~
	Historical/ Ongoing/ Near Future	Future		
Explosions for resource recovery	SO-C	SO-R		*H19*
Underground nuclear device testing				~~SCR.3.2.3.2~~
Underground nuclear device testing	SO-C	SO-R		*H20*
SUBSURFACE HYDROLOGICAL AND GEOCHEMICAL EPs				~~SCR.3.3~~
Borehole fluid flow				~~SCR.3.3.1~~
Drilling-induced flow				~~SCR.3.3.1.1~~
Drilling fluid flow	SO-C	DP	DP for boreholes that penetrate the waste. SO-C for other future drilling.	*H21*
Drilling fluid loss	SO-C	DP	DP for boreholes that penetrate the waste, SO-C for other future drilling	*H22*
Blowouts	SO-C	DP	DP for boreholes that penetrate the waste and boreholes that penetrate Castile brine underlying the waste disposal region. SO-C for other future drilling.	*H23*
Drilling-induced geochemical changes	UP	DP	SO-C for units other than the Culebra.	*H24*
Fluid extraction				~~SCR.3.3.1.2~~
Oil and gas extraction	SO-C	SO-R		*H25*
Groundwater extraction	SO-C	SO-R		*H26*
Fluid injection				~~SCR.3.3.1.3~~
Liquid waste disposal	SO-C	SO-*C*~~R~~		*H27*
Enhanced oil and gas production	SO-C	SO-*C*~~R~~		*H28*
Hydrocarbon storage	SO-C	SO-*C*~~R~~		*H29*
Fluid-injection induced geochemical changes	UP	SO-R	SO-C for units other than the Culebra	*H30*
Flow through abandoned boreholes			Classification distinguishes the time when drilling occurs.	~~SCR.3.3.1.4~~

Table *6-6*~~6-5~~. Human-Initiated EPs and Their Screening Classifications — Continued

EPs	Screening Classification: Historical/ Ongoing/ Near Future	Screening Classification: Future	Comments	*FEP Number* ~~Appendix SCR Section~~
Natural borehole fluid flow	SO-C	DP	DP for boreholes that penetrate Castile brine underlying the waste disposal region. SO-C for other future boreholes.	*H31*
Waste-induced borehole flow	SO-R	DP	DP for boreholes that penetrate the waste. SO-C for other future boreholes.	*H32*
~~Flow through undetected boreholes~~	~~SO-P~~	~~NA~~		
Borehole-induced solution and subsidence	SO-C	SO-C		*H34*
Borehole-induced mineralization	SO-C	SO-C		*H35*
Borehole-induced geochemical changes	UP	DP	SO-C for units other than the Culebra	*H36*
Excavation-induced flow			Classification distinguishes the time when excavation occurs.	~~SCR.3.3.2~~
Changes in groundwater flow due to mining	UP	DP	UP for mining outside the controlled area. DP for mining inside the controlled area.	*H37*
Changes in geochemistry due to mining	SO-C	SO-R		*H38*
Explosion-induced flow				~~SCR.3.3.3~~
Changes in groundwater flow due to explosions	SO-C	SO-R		*H39*
GEOMORPHOLOGICAL EPs				~~SCR.3.4~~
Land use and disturbances				~~SCR.3.4.1~~
Land use changes	SO-R	SO-R		*H40*
Surface disruptions	~~SO-C~~*UP*	SO-R		*H41*
SURFACE HYDROLOGICAL EPs				~~SCR.3.5~~
Water control and use				~~SCR.3.5.1~~
Damming of streams or rivers	SO-C	SO-R		*H42*
Reservoirs	SO-C	SO-R		*H43*
Irrigation	SO-C	SO-R		*H44*
Lake usage	SO-R	SO-R		*H45*

Table *6-6*~~6-5~~. Human-Initiated EPs and Their Screening Classifications — Continued

EPs	Screening Classification		Comments	*FEP Number* ~~Appendix SCR Section~~
	Historical/ Ongoing/ Near Future	Future		
Altered soil or surface water chemistry by human activities	SO-C	SO-R		***H46***
CLIMATIC EPs				~~SCR.3.6~~
Anthropogenic climate change				~~SCR.3.6.1~~
Greenhouse gas effects	SO-R	SO-R		***H47***
Acid rain	SO-R	SO-R		***H48***
Damage to the ozone layer	SO-R	SO-R		***H49***
MARINE EPs				~~SCR.3.7~~
Marine activities				~~SCR.3.7.1~~
Coastal water use	SO-R	SO-R		***H50***
Sea-water use	SO-R	SO-R		***H51***
Estuarine water use	SO-R	SO-R		***H52***
ECOLOGICAL EPs				~~SCR.3.8~~
Agricultural activities				~~SCR.3.8.1~~
Arable farming	SO-C	SO-R		***H53***
Ranching	SO-C	SO-R		***H54***
Fish farming	SO-R	SO-R		***H55***
Social and technological developments				~~SCR.3.8.2~~
Demographic change and urban development	SO-R	SO-R		***H56***
Loss of records	NA	DP		***H57***

Legend:

UP FEPs accounted for in the assessment calculations for undisturbed performance for 40 CFR § 191.13 (as well as 40 CFR § 191.15 and Subpart C of 40 CFR Part 191).

DP FEPs accounted for (in addition to all UP FEPs) in the assessment calculations for disturbed performance for 40 CFR § 191.13.

SO-R FEPs eliminated from performance assessment calculations on the basis of regulations provided in 40 CFR Part 191 and criteria provided in 40 CFR ***§***~~Part~~ 194. ***25, .32 and .54.***

SO-C FEPs eliminated from ~~performance assessment~~***PA*** (and compliance assessment) calculations ~~on the basis of~~ ***based on*** consequence.

SO-P FEPs eliminated from ~~performance assessment~~***PA*** (and compliance assessment) calculations ~~on the basis of~~ ***based on*** low probability of occurrence.

NA FEPs not applicable to the particular category.

~~Performance assessments~~***PAs*** must ~~include~~ consider~~ation of~~ all human-initiated EPs relating to activities that have taken place or are reasonably expected to take place outside the controlled area in the near future.

In order to implement the criteria in ~~40 CFR §~~***Section*** 194.32 relating to the scope of ~~performance assessment~~***PA***, the DOE has divided human activities into three categories~~.~~***:*** ~~Distinctions are made between~~ (1) human activities that are currently taking place and those that took place prior to the time of the compliance application, (2) human activities that might be initiated in the near future after submission of the compliance application, and (3) human activities that might be initiated after repository closure. The first two categories of EPs are considered under undisturbed performance; ~~and~~ EPs in the third category lead to disturbed performance conditions.

(1) Historical and current human activities include resource extraction activities that have ~~historically~~ taken place and are currently taking place outside the controlled area. These activities are of potential significance insofar as they could affect the geological, hydrological, or geochemical characteristics of the disposal system or groundwater flow pathways outside the disposal system. Current human activities taking place within the controlled area are essentially those associated with development of the WIPP repository. Historical activities include existing boreholes.

(2) Near-future human activities include resource extraction activities that may ~~be expected to~~ occur outside the controlled area based on existing plans and leases. Thus, the near future includes the expected lives of existing mines and oil and gas fields, and the expected lives of new mines and oil and gas fields that the DOE expects will be developed based on existing plans and leases. These activities are of potential significance insofar as they could affect the geological, hydrological, or geochemical characteristics of the disposal system or groundwater flow pathways outside the disposal system. The only human activities ~~that are~~ expected to occur within the controlled area in the near future are those associated with ~~development of the~~ WIPP repository ***development***. The DOE assumes that any activity ~~that is expected to be initiated~~ in the near future, based on existing plans and leases, will be initiated prior to repository closure. Activities initiated prior to repository closure are assumed to continue until their completion.

(3) Future human activities include activities that might be initiated within or outside the controlled area after repository closure. This includes drilling and mining for resources within the disposal system ~~at a time~~ when institutional controls cannot be assumed to completely eliminate the possibility of such activities. Future human activities could influence the transport of contaminants within and outside the disposal system by directly removing waste from the disposal system or altering the geological, hydrological, or geochemical characteristics of the disposal system.

~~In order t~~***T***o satisfy the criteria in 40 CFR § 194.32, ~~performance assessments~~***PAs*** must consider the potential effects of historical, current, near-future, and future human activities on the ~~performance of the~~ disposal system ***performance***. The criterion in 40 CFR § 194.25(a) concerned with ~~predictions of~~ ***predicting*** the future states of society requires that ~~performance assessments~~***PAs*** and compliance assessments "shall assume that the characteristics of the future remain what they are at the time the compliance application is prepared." This criterion has been applied to eliminate the following human-initiated EPs from ~~performance assessment~~***PA*** calculations:

- drilling associated with geothermal energy production ***(H7)***, liquid waste disposal ***(H10)***, hydrocarbon storage ***(H11)***, and archeological investigations ***(H6)*** ~~(Appendix SCR, Sections SCR.3.2.1.1 and SCR.3.2.1.2)~~;

- excavation activities associated with tunneling ***(H15)*** and construction of underground facilities ***(H16)*** (for example, storage, disposal, and accommodation) ~~(Appendix SCR, Sections SCR.3.2.2.1 and SCR.3.2.2.2)~~;

- changes in land use ***(H40)*** ~~(Appendix SCR, Section SCR.3.4.1.2)~~;

- anthropogenic climate change ***(H47, H48 and H49)*** ~~(Appendix SCR, Section SCR.3.6.1)~~;

- changes in agricultural practices ***(H53, H54 and H55)*** ~~(Appendix SCR, Section SCR.3.8.1.2)~~;

- demographic change, urban developments, and technological developments ***(H56)*** ~~(Appendix SCR, Section SCR.3.8.2)~~; and

- ***solution mining (H58 and H59).***

As discussed in Chapter 8.0, compliance assessments (to determine compliance with 40 CFR § 191.15 and Subpart C of 40 CFR Part 191) need ***to*** consider the UP of the disposal system.

6.2.5.1 Historical, Current, and Near-Future Human Activities

~~The observational data obtained as part of WIPP site characterization reflect any effects of historical and current human activities in the vicinity of the WIPP, such as groundwater extraction and oil and gas production. As discussed in Appendix SCR (Section SCR.3), historic and current human activities are modeled or found to be of low consequence to long-term performance.~~

Historical, current, and near-future human activities could affect WIPP site characteristics ~~subsequent to~~ ***after*** the submission of this application, and could influence the ~~performance of the~~ disposal system ***performance***. The hydrogeological impacts of historical, current, and near-future potash mining outside the controlled area are accounted for in calculations of the undisturbed performance of the disposal system. Near-future potash mining is assumed to continue for the expected economic life of each mine. The potential consequences to the ~~performance of the~~ disposal system ***performance*** ~~of~~ ***from*** other human-initiated EPs expected to occur in the Delaware Basin in the near future are discussed in Appendix ***PA,*** ~~SCR~~ ~~(~~***Attachment SCR*** ~~Section SCR.3)~~, which describes how these EPs are eliminated ***based*** on ~~the basis of~~ low consequence.

6.2.5.2 Future Human Activities

~~Performance assessment~~***PA*** (but not compliance assessments, as discussed in Chapter 8.0) must consider the effects of future human activities on the ~~performance of the~~ disposal system ***performance***. The EPA has provided criteria relating to future human activities in 40 CFR

§ 194.32(a), which limits the scope of consideration of future human actions in ~~performance assessments~~***PAs*** to mining and drilling.

6.2.5.2.1 Criteria Concerning Future Mining

The EPA provides additional criteria concerning the type of future mining that should be considered by the DOE in 40 CFR § 194.32(b):

> Assessments of mining effects may be limited to changes in the hydraulic conductivity of the hydrogeologic units of the disposal system from excavation mining for natural resources. Mining shall be assumed to occur with a one in 100 probability in each century of the regulatory time frame. Performance assessments shall assume that mineral deposits of those resources, similar in quality and type to those resources currently extracted from the Delaware Basin, will be completely removed from the controlled area during the century in which such mining is randomly calculated to occur. Complete removal of such mineral resources shall be assumed to occur only once during the regulatory time frame.

Thus, ~~consideration of~~ ***considering*** future mining may be limited to mining within the controlled area at ~~the~~ locations of resources that are similar in quality and type to those currently extracted from the Delaware Basin. Potash is the only resource ~~that has been~~ identified within the controlled area in quality similar to that currently mined from underground deposits elsewhere in the Delaware Basin. Within the controlled area, the McNutt of the Salado provides the only potash of appropriate quality. The hydrogeological impacts of future potash mining within the controlled area are accounted for in ~~calculations of the~~ DP ***calculations*** of the disposal system. Consistent with 40 CFR § 194.32(b), all economically recoverable resources in the vicinity of the disposal system (outside the controlled area) are assumed to be extracted in the near future.

6.2.5.2.2 Criteria Concerning Future Drilling

With respect to ~~consideration of~~ future drilling, in the preamble to 40 CFR Part 194, the EPA "reasoned that while the resources drilled for today may not be the same as those drilled for in the future, the present rates at which these boreholes are drilled can nonetheless provide an estimate of the future rate at which boreholes will be drilled." Criteria concerning the consideration of future deep and shallow drilling[2] in ~~performance assessments~~***PAs*** are provided in 40 CFR § 194.33. These criteria require that, to calculate future drilling rates, the DOE should examine the historical rate of drilling for resources in the Delaware Basin. Historical drilling for purposes other than resource exploration and recovery (such as WIPP site investigation) need not be considered in determining future drilling rates.

In particular, ~~in~~ ***when*** calculating the frequency of future deep drilling, 40 CFR § 194.33(b)(3)(i) states that the DOE should

> Identify deep drilling that has occurred for each resource in the Delaware Basin over the past 100 years prior to the time at which a compliance application is prepared.

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[2] The EPA has defined two types of drilling in 40 CFR § 194.2: deep drilling, ~~is~~ defined as "drilling events in the Delaware Basin that reach or exceed a depth of 2,150 ft below the surface relative to where such drilling occurred"; ***and*** shallow drilling, ~~is~~ defined as "drilling events in the Delaware Basin that do not reach a depth of 2,150 ft below the surface relative to where such drilling occurred."

Oil and gas are the only known resources below 655 m (2,150 ft) that have been exploited over the past 100 years in the Delaware Basin. However, some potash and sulfur exploration boreholes have been drilled in the Delaware Basin to depths in excess of 2,150 feet (655 meters) below the surface relative to where the drilling occurred. Thus, consistent with 40 CFR § 194.33(b)(3)(i), the DOE ~~has~~ used the historical record of deep drilling associated with oil, gas, potash and sulfur exploration, and oil and gas exploitation in the Delaware Basin ~~in calculations~~ to determine the rate of deep drilling within the controlled area and throughout the basin in the future, as discussed in Appendix ***DATA, Section 2 and Attachment A*** ~~DEL, Section DEL.7.4 (see also Table DEL-6)~~. Deep drilling may occur within the controlled area after the end of ~~the period of~~ active institutional control (100 years after disposal).

In calculating the frequency of future shallow drilling, 40 CFR § 194.33(b)(4)(i) states that the DOE should

> Identify shallow drilling that has occurred for each resource in the Delaware Basin over the past 100 years prior to the time at which a compliance application is prepared.

An additional criterion with respect to ~~the calculation of~~ ***calculating*** future shallow drilling rates is provided in 40 CFR § 194.33(b)(4)(iii):

> In considering the historical rate of all shallow drilling, the Department may, if justified, consider only the historical rate of shallow drilling for resources of similar type and quality to those in the controlled area.

As an example, ~~of the use of the criterion in 40 CFR § 194.33(b)(4)(iii) the~~ EPA states in the preamble to 40 CFR Part 194 that "if only non-potable water can be found within the controlled area, then the rate of drilling for water may be set equal to the historical rate of drilling for non-potable water in the Delaware Basin over the past 100 years." Thus, the DOE may limit the rate of future shallow drilling based on a determination of the potential resources in the controlled area. Shallow drilling associated with water, potash, sulfur, oil, and gas extraction has taken place in the Delaware Basin over the past 100 years. However, of these resources, only water and potash are present at shallow depths (less than 655 m [2,150 ft] below the surface) within the controlled area. Thus, consistent with 40 CFR § 194.33(b)(4), the DOE ~~has~~ used the historical record of shallow drilling associated with water and potash extraction in the Delaware Basin in calculations to determine the rate of shallow drilling within the controlled area, as discussed in Appendix ***DATA, Section 2 and Attachment A*** ~~DEL (Sections DEL.7.2 and DEL.7.4)~~.

The EPA also provides a criterion in 40 CFR § 194.33(d) concerning the use of future boreholes subsequent to drilling:

> With respect to future drilling events, performance assessments need not analyze the effects of techniques used for resource recovery subsequent to the drilling of the borehole.

Thus, ~~performance assessments~~***PAs*** need not consider the effects of techniques used for resource extraction and recovery that would occur ~~subsequent to~~ ***after*** the drilling of a ***future*** borehole ~~in the future~~.

The EPA provides an additional criterion ~~that~~ ***to*** limit~~s~~ the severity of human intrusion scenarios that must be considered in ~~performance assessments~~***PAs***. In 40 CFR § 194.33(b)(1), ~~the~~ EPA states that

> Inadvertent and intermittent intrusion by drilling for resources (other than those resources provided by the waste in the disposal system or engineered barriers designed to isolate such waste) is the most severe human intrusion scenario.

Thus, human intrusion scenarios involving deliberate intrusion need not be considered in ~~performance assessments~~***PAs***.

6.2.5.2.3 Screening of Future Human-Initiated EPs

Future human-initiated EPs accounted for in ~~performance assessment~~***PA*** calculations for the WIPP are those associated with mining and deep drilling within the controlled area at a time when institutional controls cannot be assumed to completely eliminate the possibility of such activities. All other future human-initiated EPs, if not eliminated from ~~performance assessment~~***PA*** calculations based on regulation, have been eliminated based on low consequence or low probability. For example, the effects of future shallow drilling within the controlled area ~~have been~~ ***were*** eliminated from ~~performance assessment~~***PA*** calculations on the basis of low consequence to the performance of the disposal system. These screening decisions are listed in ***Table 6-6*** ~~Table 6-5~~ and are discussed in Appendix ***PA*** ~~SCR~~***, Attachment SCR*** ~~(Section SCR.3)~~.

6.2.6 Reassessment of Features, Events, and Processes for the Compliance Recertification

As part of the recertification effort, the DOE assessed the impacts of new information on the original FEPs baseline to determine if changes to the original decisions are necessary. The FEPs baseline could be affected by new information from literature, experiments, observations from monitoring programs, or changes implemented by the DOE (moving the WIPP horizon to Clay G, for example). The processes and results of the FEPs baseline reassessment are documented in Appendix PA, Attachment SCR.

The FEP assessment resulted in the addition of two new FEPs to better represent solution mining (H57 and H58) and the deletion of four FEPs (by combining the deleted FEPs into other related FEPs). Seven screening decisions were also changed as a result of new information. However, only three FEPs previously screened out were screened into the CRA-2004 PA. The impact of organic ligands (W68 and W69) was screened into the CRA-2004 PA as a result of new information. This FEP screening decision change is the only impact to the PA system. The inclusion of ligands is discussed in Section 6.4.3.4. The FEP Surface Disruptions (H41) was also screened in. This FEP was already implicitly included in PA through past site characterization and current monitoring data (Appendix PA, Attachment SCR). The changes to the FEPs baseline are summarized in Table 6-7.

6.3 Scenario Development and Selection

This section addresses ~~the formation of~~ scenarios ***formed*** from FEPs that ~~have been~~ ***were*** retained for ~~performance assessment~~***PA*** calculations, and introduces the specification of scenarios for consequence analysis. ~~Specification of p~~***P***robabilities associated with scenarios ~~is~~ ***are*** discussed in Section 6.4.12.

Logic diagrams are used to illustrate the formation of scenarios for consequence analysis from combinations of FEPs that remain after FEP screening (Cranwell et al. 1990) (Figure ~~6-7~~***6-8***). Each scenario shown in Figure ~~6-7~~***6-8*** is defined by a combination of occurrence and

Table 6-7. FEPs Reassessment Summary Results

EPA FEP I.D.	FEP Name	Summary of Change
FEPs Combined with other FEPs		
N17	Lateral Dissolution	Combined with N16, "Shallow Dissolution." N17 removed from baseline.
N19	Solution Chimneys	Combined with N20, "Breccia Pipes." N19 removed from Baseline.
H33	Flow Through Undetected Boreholes	Combined with H31, "Natural Borehole Fluid Flow." H33 removed from baseline.
W38	Investigation Boreholes	Addressed in H31, "Natural Borehole Fluid Flow," and H33, "Flow Through Undetected Boreholes." W38 removed from baseline.
FEPs With Changed Screening Decisions		
W50	Galvanic Coupling	SO-P to SO-C
W68	Organic Complexation	SO-C to UP
W69	Organic Ligands	SO-C to UP
H27	Liquid Waste Disposal	SO-R to SO-C
H28	Enhanced Oil and Gas Production	SO-R to SO-C
H29	Hydrocarbon Storage	SO-R to SO-C
H41	Surface Disruptions	SO-C to UP (HCN)
New FEPs for CRA-2004		
H58	Solution Mining for Potash	Separated from H13, "Potash Mining."
H59	Solution Mining for Other Resources	Separated from H13, "Potash Mining."

nonoccurrence of all potentially disruptive EPs. Disruptive EPs are defined as those ~~EPs~~ that ~~result in the creation of~~ ***create*** new pathways, or significant***ly*** ~~alteration of~~ ***alter*** existing pathways for fluid flow and, potentially, radionuclide transport within the disposal system. Each of these scenarios also contains a set of features and nondisruptive EPs that remain after FEP screening. As shown in Figure ~~6-7~~***6-8***, undisturbed performance ***(UP)*** and disturbed performance ***(DP)*** scenarios are considered in consequence modeling for the WIPP ~~performance assessment~~***PA***. The ~~undisturbed performance~~***(UP)***scenario, as discussed in Chapter 8.0, is used for compliance assessments. Important aspects of ~~undisturbed performance~~***(UP)*** and ~~disturbed performance~~***(DP)*** are summarized in this section.

6.3.1 Undisturbed Performance

Undisturbed performance is defined in 40 CFR § 191.12 to mean "the predicted behavior of a disposal system, including consideration of the uncertainties in predicted behavior, if the disposal system is not disrupted by human intrusion or the occurrence of unlikely natural events." ~~Consideration of~~ ***Considering*** only ~~undisturbed performance~~***(UP)*** is required for compliance assessments with respect to the Individual and Groundwater Protection Requirements (40 CFR § 191.15 ~~and 40 CFR § 191.24) (~~see Chapter 8.0). Undisturbed performance is also considered ~~together~~ with ~~disturbed performance~~***(DP)*** for ~~performance assessments~~***PAs*** with respect to the Containment Requirements (40 CFR § 191.13).