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The Development of the Yucca Mountain Project Feature, Event, and Process (FEP) Database

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Introduction

A Total System Performance Assessment for Site Recommendation (TSPA-SR) has recently been completed (CRWMS M&O, 2000b) for the potential high-level waste repository at the Yucca Mountain site. The TSPA-SR is an integrated model of scenarios and processes relevant to the postclosure performance of the potential repository. The TSPA-SR scenarios and model components in turn include representations of all features, events, and processes (FEPs) identified as being relevant (i.e., screened in) for analysis. The process of identifying, classifying, and screening potentially relevant FEPs thus provides a critical foundation for scenario development and TSPA analyses for the Yucca Mountain site (Swift et al., 1999).

The objectives of this paper are to describe (a) the identification and classification of the comprehensive list of FEPs potentially relevant to the postclosure performance of the potential Yucca Mountain repository, and (b) the development, structure, and use of an electronic database for storing and retrieving screening information about the inclusion and/or exclusion of these Yucca Mountain FEPs in TSPA-SR.

The FEPs approach to scenario development is not unique to the Yucca Mountain Project (YMP). General systematic approaches are summarized in NEA (1992). The application of the FEPs approach in several other international radioactive waste disposal programs is summarized in NEA (1999).

Identification of YMP FEPs

The development of a YMP FEP list is an ongoing, iterative process based on site-specific information, design, and regulations. The YMP FEP list which supports TSPA-SR is catalogued in the YMP FEP Database Rev. 00 (CRWMS M&O, 2000a).

Development of the YMP FEP list began with consideration of 1261 FEPs compiled from other radioactive waste programs in Canada, Sweden, Switzerland, the United Kingdom, and the U.S. The FEPs were taken from an electronic database (Safety Assessment Management, 1997) maintained by the Nuclear Energy Agency (NEA). The NEA database is the most complete attempt internationally at compiling a comprehensive list of FEPs potentially relevant to radioactive waste disposal.

The 1261 NEA FEPs in the YMP FEP list were supplemented with 292 YMP-specific FEPs identified in a search of YMP literature (Barr 1999). Because the YMP is the only repository proposed for an unsaturated fractured tuff, many of these FEPs represent events and processes not otherwise included in the international compilation.

The resulting YMP list of 1553 FEPs identified from the NEA database and YMP literature was taken to a series of technical workshops focusing on key YMP subject areas. At these workshops, FEPs relevant to each subject area were reviewed and discussed by YMP subject matter experts. During these reviews and discussions, workshop participants identified 82 additional YMP-specific FEPs.

A set of Analysis/Model Reports (AMRs) was prepared to document the FEP screening decisions and rationale. During the preparation of these FEP AMRs, subject matter experts reviewed the existing FEPs

relevant to their subject area and identified 9 new FEPs. In addition, an NRC audit (Pickett and Leslie, 1999) of the YMP FEP list identified two new FEPs.

These FEP identification activities combined a bottom-up (i.e., non-systematic, all-inclusive) identification of an initial FEP list with a top-down series of reviews. The end product was a YMP FEP list for TSPA-SR that contained 1646 FEPs potentially relevant to postclosure Yucca Mountain repository performance.

Classification of YMP FEPs

Each of 1646 FEPs in the YMP FEP list was classified under one of 135 Headings. The Headings represent a useful level of aggregation for FEPs (typically there are tens of FEPs under each Heading). The Headings are further aggregated under 12 Categories and 4 Layers. This hierarchical classification structure, and the specific Layers, Categories, and Headings, are consistent with the NEA hierarchical structure (NEA, 1999) that groups FEPs from several different international programs into a systematic classification of generally relevant subject areas.

Each of the 1646 FEPs in the YMP FEP list is an individual entry (record) in the YMP FEP Database as are the 151 Layer, Category, and Heading entries that define the YMP FEP classifications. Therefore, the YMP FEP Database for TSPA-SR contains a total of 1797 individual entries. The mapping of FEP entries to the Heading entries resulted in a database where all related entries were grouped together under the same Heading (and under the same overarching Category and Level).

To most efficiently facilitate FEP screening, it was necessary to further classify and/or aggregate FEPs to the coarsest level at which technically sound screening decisions could be made, while still maintaining adequate detail for the purposes of the analysis. This further aggregation resulted in the creation of two additional classification levels, Primary FEPs and Secondary FEPs.

Primary FEPs are database entries that encompass a single process or event, or a few closely related or coupled processes or events that can be addressed by a specific screening decision. Each Primary FEP is addressed by a single YMP-specific screening discussion. A Primary FEP may also include one or more related Secondary FEPs that are covered by the same screening discussion.

Secondary FEPs are database entries that are (1) redundant to another FEP (e.g., several NEA contributors often identified the same FEP), (2) specific to another program (and captured more generally in a different YMP-specific FEP), or (3) better captured or subsumed in another similar but more broadly-defined YMP-specific FEP. Each Secondary FEP is mapped to a Primary FEP and must be completely addressed by the screening discussion of that Primary FEP.

During the review and selection of Primary FEPs, 40 of the Heading entries were also selected to be Primary FEPs. After the final classifications were made, the YMP FEP Database for TSPA-SR contained 111 classification entries (151 Layers, Categories, and Headings less the 40 Heading entries that are primary FEPs), 323 Primary FEP entries (including the 40 Headings) and 1363 Secondary FEP entries. As a result of this classification scheme, it was only necessary to develop screening decisions and supporting documentation for the 323 Primary FEPs, rather than for all 1797 YMP FEP list entries. All Secondary FEPs were screened at the overlying primary FEP level. Classification entries did not require explicit screening because they were addressed in greater detail through the underlying Primary FEPs.

Screening Criteria for YMP FEPs

Each Primary FEP (and, by association, each Secondary FEP) was screened for inclusion or exclusion in the TSPA on the basis of the three following criteria, developed from the proposed federal regulation 10 CFR Part 63 (summarized in Dyer, 1999):

Regulatory – The proposed regulations provide guidance regarding certain assumptions about the TSPA. FEPs that are inconsistent with these assumptions may be excluded (screened out) from the TSPA by

regulation. The most notable examples are the regulatory specification of the human intrusion scenario and the critical group characteristics.

Probability - The proposed regulations state that TSPA analyses must consider only events that have at least one chance in 10,000 of occurring over 10,000 years. FEPs with a lower probability of occurrence may be excluded (screened out) from the TSPA on the basis of low probability.

Consequence - The proposed regulations state that specific features, events, and processes of the engineered barriers and the geologic setting must be evaluated in detail if the magnitude and time of the resulting expected annual dose would be significantly changed by their omission. FEPs whose exclusion would not significantly change the expected annual dose may be excluded (screened out) from the TSPA on the basis of low consequence.

Screening discussions for each of the 323 Primary FEPs were prepared by subject matter experts and documented in the FEP AMRs. The screening discussions were then imported from the FEP AMRs into the YMP FEP Database.

The Electronic YMP FEP Database

The organization of the FEP entries within the YMP FEP Database is controlled by a YMP FEP database number associated with each FEP entry. This number has the form x.x.xx.xx.xx and defines classification (Layer, Category, Heading), Primary, and Secondary entries as follows:

x.0.00.00.00	Layer
x.x.00.00.00	Category
x.x.xx.00.00	Heading (some of these are also Primary FEPs)
x.x.xx.xx.00	Primary FEP (where the first x.x.xx is the overlying Heading)
x.x.xx.xx.xx	Secondary FEP (where the first x.x.xx.xx is the overlying primary FEP)

With this numbering scheme, the YMP FEP database number always identifies which heading a primary FEP is mapped to and which primary FEP a secondary FEP is associated with.

For each of the 1797 entries in the database, there are 26 data/text fields. In addition to the YMP FEP Database Number field, other key fields include FEP Name, FEP Class (primary, secondary, or classification), YMP Primary FEP Description, Screening Decision (include or exclude), Screening Argument (for excluded FEPs), and TSPA Disposition (for included FEPs).

Conclusions and Discussion

The YMP FEP Database contains three types of information: a list of potentially relevant FEPs (the YMP FEP list); an organizational structure that categorizes the YMP FEP list into groups of related FEPs (the YMP FEP Classification); and screening decisions and supporting documentation (taken from FEP AMRs). The development of the YMP FEP list and database is an ongoing, iterative process. As additional information becomes available new FEPs may be added or screening decisions may change.

The Primary FEPs collectively capture all of the issues relevant to the postclosure performance of the proposed Yucca Mountain repository. Each Primary FEP requires a screening discussion identifying the technical basis for inclusion or exclusion of FEPs in the TSPA-SR analyses.

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