Technical Report

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FEP report for the safety assessment SR-Site

Svensk Kärnbränslehantering AB

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Update notice

The original report, dated December 2010, was found to contain factual errors which have been corrected in this updated version. The corrected factual errors are presented below.

Updated 2013-02

Location	Original text	Corrected text
Page 40, Table 5-6, line Ge25	3.6.3	6.2

Updated 2015-05

The original report, dated December 2010, was found to contain editorial errors which have been corrected in this updated version.

Preface

This report describes the FEP processing undertaken for the SR-Site project and the resulting version of the SKB FEP database containing the SR-Site FEP catalogue. The report is authored by Kristina Skagius, Kemakta Konsult AB. She also developed the structure of the FEP database and carried out all the FEP implementations and mappings in the database.

The main part of the work was conducted within the earlier safety assessment SR-Can, which was a preparatory stage for the SR-Site assessment, and it was planned by a group consisting of Kristina Skagius, Johan Andersson, JA Streamflow AB, and the undersigned. Many of the decisions regarding FEP classification etc were made by this group as is further explained in the report.

Several other experts and generalists have been involved at specific stages of the work, including Fred Karlsson, SKB (issues related to future human actions), Jens-Ove Näslund, SKB (climate-related issues), Eva Andersson, Studsvik AB (biosphere issues). The persons involved in the implementation of the results of the audit regarding internal processes were the experts involved in developing the process descriptions, with the main contributions being from Christina Lilja, SKB (canister processes), Kastriot Spahiu, SKB (fuel processes), Patrik Sellin, SKB (buffer, tunnel backfill and closure processes), Harald Hökmark, Clay Technology AB (geosphere processes), Jan-Olof Selroos, SKB (geosphere processes), Ignasi Puigdomenech, SKB (geosphere processes) and Peter Jackson, Serco Assurance, UK (geosphere processes).

The report has been reviewed by Alan Hooper, Alan Hooper Consulting Ltd, UK, and Mike Thorne, Mike Thorne and Associates Ltd, UK.

Stockholm, December 2010

Allan Hedin

Project leader SR-Site

Summary

This report documents the analysis and processing of features, events and processes, FEPs, that has been carried out within the safety assessment SR-Site, and forms an important part of the reporting of the project. The main part of the work was conducted within the earlier safety assessment SR-Can, which was a preparatory stage for the SR-Site assessment.

The overall objective of the FEP analysis and processing in both SR-Can and SR-Site included development of a database of features, events and processes, an SKB FEP database, in a format that facilitates both a systematic analysis of FEPs and documentation of that FEP analysis, as well as facilitating revisions and updates to be made in connection with new safety assessments. The primary objective in SR-Site was to establish an SR-Site FEP catalogue within the framework of the SKB FEP database. This FEP catalogue was required to contain all FEPs that needed to be handled in SR-Site and is an update of the corresponding SR-Can FEP catalogue that was established for the SR-Can assessment.

The starting point for the handling of FEPs in SR-Site was the SR-Can version of the SKB FEP database and associated SR-Can reports. The SR-Can version of the SKB FEP database includes the SR-Can FEP catalogue, as well as the sources for the identification of FEPs in SR-Can, namely the SR 97 processes and variables, Project FEPs in the NEA International FEP database version 1.2 and matrix interactions in the Interaction matrices developed for a deep repository of the KBS-3 type. Since the completion of the FEP work within SR-Can, an updated electronic version, version 2.1, of the NEA FEP database has become available. Compared with version 1.2 of the NEA FEP database, version 2.1 contains FEPs from two more projects. As part of SR-Site, all new Project FEPs in version 2.1 of the NEA FEP database have been mapped according to the methodology adopted in SR-Can resulting in an SR-Site version of the SKB FEP database. The SKB FEP database thus encompasses the SR-97 version, the SR-Can version and the SR-Site version of the FEP database.

The SR-Site FEP catalogue is a developed version of the SR-Can FEP catalogue. It contains initial state FEPs; process FEPs for the system components fuel, canister, buffer, backfill in tunnels and geosphere; FEPs for variables in those same system components and external FEPs. These FEPs are essentially the same as those included in the SR-Can FEP catalogue. For the system components not treated in detail in SR-Can, as well as for the biosphere, SR-Site FEPs have been defined and included in the FEP catalogue. The mapping of NEA Project FEPs made to the preliminary and provisional FEPs for these system components in SR-Can has been revisited and a new mapping has been made to the FEPs now included in the SR-Site FEP catalogue. The FEP catalogue also contains Methodology FEPs and Site-specific factors. These are also the same as in the SR-Can FEP catalogue except for one of the Site-specific factors that has been excluded from the SR-Site FEP catalogue since it is not relevant for the Forsmark site.

Contents

1 Introduction

This report is one of the reports in support of the safety assessment SR-Site and the safety report SR-Site, which constitutes a part of SKB's licence application to construct and operate a final repository for spent nuclear fuel at Forsmark. The main purposes of the safety assessment project SR-Site are:

- To assess the long-term safety after repository closure, as defined in applicable Swedish regulations, of the proposed KBS-3V repository at Forsmark.
- To provide feedback to design development, to SKB's RD&D Programme, to detailed site investigations and to future safety assessment projects.

The assessment relates to the KBS-3 disposal concept in which copper canisters with a cast iron insert containing spent nuclear fuel are surrounded by bentonite clay and deposited below 450 m depth in saturated, granitic rock at Forsmark. The assessment is based on a reference design of the engineered parts of the repository, including reference methods to achieve the specified design, taking into account methods of controlling that the specifications of the reference design have been achieved.

1.1 Role of this FEP report in the SR-Site assessment

This report documents the analysis and processing of features, events and processes, i.e. FEPs, that has been carried out within the safety assessment SR-Site, and forms an important part of the reporting of the project. The detailed assessment methodology, including the role of the FEP report in the assessment, is described in the SR-Site Main report /SKB 2011/. The following excerpts describe the methodology, and clarify the role of this FEP report in the assessment.

The repository system, broadly defined as the deposited spent nuclear fuel, the engineered barriers surrounding it, the host rock and the biosphere in the proximity of the repository, will evolve over time. Future states of the system will depend on;

- the initial state of the system,
- a number of radiation-related, thermal, hydraulic, mechanical, chemical and biological processes acting within the repository system over time, and
- external influences acting on the system.

A methodology in eleven steps has been developed for SR-Site, as summarised in Figure 1-1 and described below.

1. Identification of factors to consider (FEP processing).

   This step consists of identifying all the factors that need to be included in the analysis. Experience from earlier safety assessments and KBS-3 specific and international databases of relevant features, events and processes (FEPs) influencing long-term safety are utilised. An SKB FEP database is developed where the great majority of FEPs are classified as being either initial state FEPs, internal processes or external FEPs. Remaining FEPs are either related to assessment methodology in general or deemed irrelevant for the KBS-3 concept. Based on the results of the FEP processing, an SR-Site FEP catalogue, containing FEPs to be handled in SR-Site, has been established. This step and the links to the subsequent steps are documented in this SR-Site FEP report.

2. Description of the initial state.

   The initial state of the system is described based on the design specifications of the KBS-3 repository, a descriptive model of the repository site and a site-specific layout of the repository. The initial state of the fuel and the engineered components is that immediately after deposition, as described in the respective SR-Site Production reports /SKB 2010a, b, c, d, e, f/. The initial state of the geosphere and the biosphere is that of the natural system prior to excavation, as described in the site descriptive model /SKB 2008/. The repository layout adapted to the Forsmark site is provided in an underground design report /SKB 2009/.

3. Description of external conditions.

   Factors related to external conditions are handled in the categories "climate-related issues", "large-scale geological processes and effects" and "future human actions". The handling of climate-related issues is described in the SR-Site Climate report /SKB 2010g/, whereas the few external, large-scale geosphere processes are addressed in the Geosphere process report /SKB 2010h/. The treatment of future human actions in SR-Site is described in the SR-Site FHA report /SKB 2010i/.

4. Compilation of process reports.

   The identification of relevant processes is based on earlier assessments and FEP screening. All identified processes within the system boundary relevant to the long-term evolution of the system are described in dedicated Process reports, i.e. process reports for the fuel and canister /SKB 2010j/, for the buffer, backfill and closure /SKB 2010k/ and for the geosphere /SKB 2010h/. Also short-term geosphere processes/alterations, due to repository excavation, are included. For each process, its general characteristics, the time frame in which it is important, the other processes to which it is coupled and how the process is handled in the safety assessment are documented.

5. Definition of safety functions, function indicators and function indicator criteria.

   This step consists of an account of the safety functions of the system and of how they can be evaluated by means of a set of function indicators that are, in principle, measurable or calculable properties of the system. Criteria for the safety function indicators are provided. The Process reports are important references for this step. A FEP chart is developed, showing how FEPs are related to the function indicators.

6. Compilation of input data.

   Data to be used in the quantification of repository evolution and in dose calculations are selected. The process of selection and the data adopted are reported in a dedicated Data report /SKB 2010l/. Also, a template for discussion of input data uncertainties has been developed and applied.

7. Definition and analysis of reference evolution.

   A reference evolution, providing a description of a plausible evolution of the repository system, is defined and analysed. The isolating potential of the system over time is analysed, yielding a description of the general system evolution and an evaluation of the safety function indicators. Each process is handled in accordance with the plans outlined in the process reports. Radiological consequences of potential canister failures are not analysed in this step.

8. Selection of scenarios.

   A set of scenarios for the assessment is selected. A comprehensive main scenario is defined in accordance with the Swedish Radiation Safety Authority's, SSM's, regulations SSMFS 2008:21. The main scenario is closely related to the reference evolution analysed in step 7. The selection of additional scenarios is focused on the safety functions of the repository, and the safety function indicators defined in step 5 form an important basis for the selection. For each safety function, an assessment is made as to whether any reasonable situation where it is not maintained can be identified. If this is the case, the corresponding scenario is included in the risk evaluation for the repository, with the overall risk determined by a summation over such scenarios. The set of selected scenarios also includes scenarios explicitly mentioned in applicable regulations, e.g. human intrusion scenarios, and scenarios and variants to explore design issues and the roles of various components in the repository.

9. Analysis of scenarios.

   The main scenario is analysed essentially by referring to the reference evolution in step 7, complemented by consequence calculations for potential canister failures in the reference evolution yielding a calculated risk contribution from the main scenario. The additional scenarios are analysed by focussing on the factors potentially leading to situations in which the safety function in question is not maintained. In most cases, these analyses are carried out by comparison with the evolution for the main scenario, meaning that they only encompass aspects of repository evolution for which the scenario in question differs from the main one. If the scenario leads to canister failures, consequence calculations are carried out. If the likelihood of the scenario is non-negligible, a risk contribution is also calculated.

10. Additional analyses.

In this step, a number of additional analyses, required to complete the safety assessment, are carried out. These comprise e.g. sensitivity analyses of the outcome of the scenario analyses, analyses required to demonstrate optimisation and use of best available technique, analyses of design options alternative to the reference design, analyses supporting risk discussion for the initial 1,000 years and an account of supporting arguments based on natural analogues.

11. Conclusions.

This step includes integration of the results from the various scenario analyses, development of conclusions regarding safety in relation to acceptance criteria and feedback concerning design, continued site investigations and the RD&D Programme.

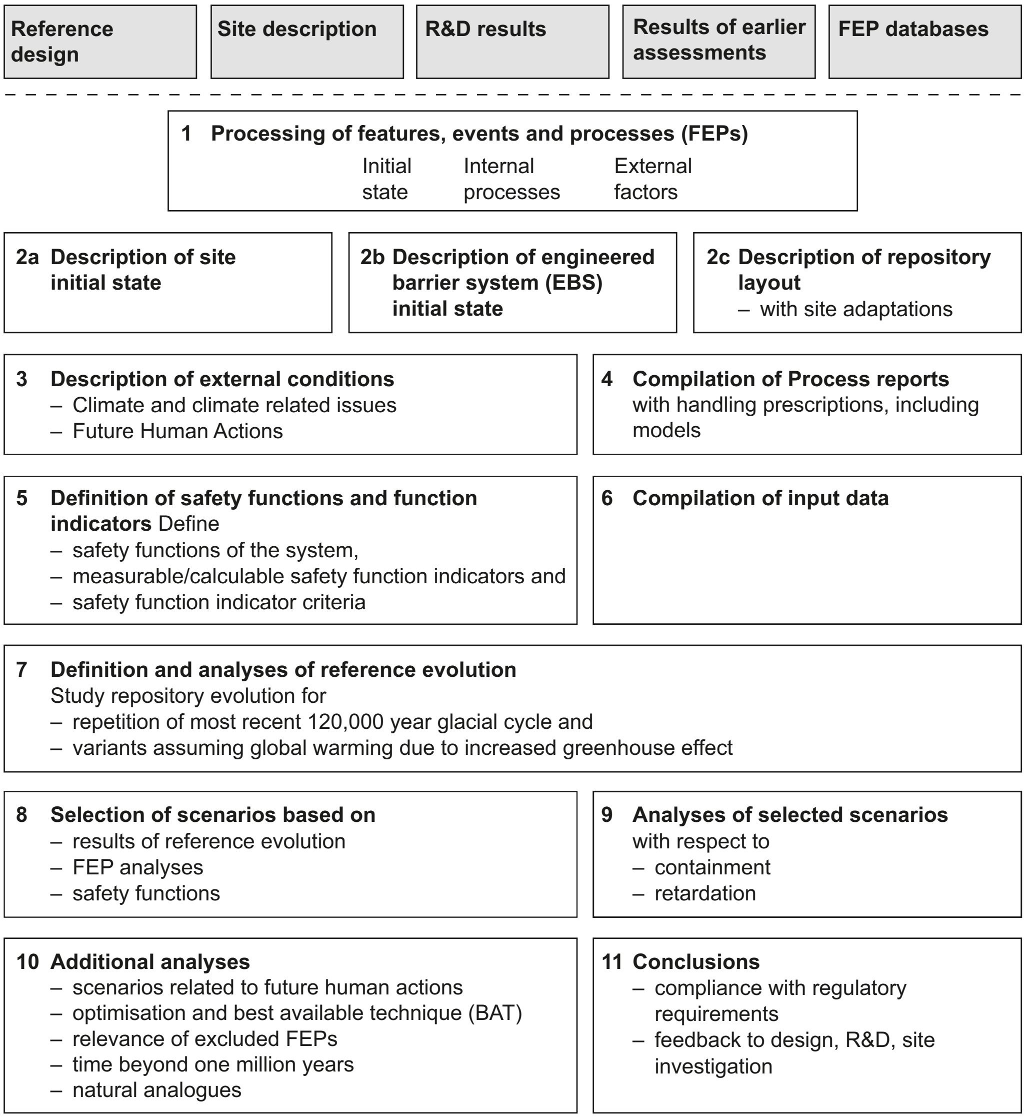

Figure 1-1. *An outline of the eleven main steps of the SR-Site safety assessment. The boxes above the dashed line are inputs to the assessment.*

1.2 Objective and scope of the FEP processing

The main part of the work with the processing of FEPs was conducted in SKB's previous safety assessment SR-Can /SKB 2006a/. The overall objective of the work in SR-Can, as well as for the complementary work in SR-Site, included development of a database of features, events and processes in a format that facilitates both a systematic analysis of FEPs and documentation of the FEP analysis, as well as facilitating revisions and updates to be made in connection with new safety assessments. The overall objective also extended to the development of procedures for such a systematic analysis and processing of FEPs, as well as to the application of those procedures in order to arrive at SR-Can and SR-Site versions of the SKB FEP database.

The primary objective in SR-Site was to establish an SR-Site FEP catalogue within the framework of the SKB FEP database. This FEP catalogue was required to contain all FEPs that need to be handled in SR-Site and is an update of the corresponding SR-Can FEP catalogue that was established for the SR-Can assessment.

The SR-Site version of the FEP database builds on the outcome of the FEP work conducted in the SR-Can interim and final assessments, as reported in the SR-Can FEP report /SKB 2006b/. The SR-Can work, in turn, utilised the SR 97 Process report /SKB 1999/ and the supporting documentation on the Interaction matrices developed for a deep repository of the KBS-3 type /Pers et al. 1999/ as the starting point.

1.3 Experts used in developing the FEP database

The procedures for developing the FEP database were established during the work with the SR-Can FEP database. As reported in the SR-Can FEP report /SKB 2006b/, the details of the FEP database development procedure were decided at meetings held at regular intervals during the course of the work. Participants in these meetings were Allan Hedin, SKB, Johan Andersson, JA Streamflow AB, and Kristina Skagius, Kemakta Konsult AB, in the forthcoming text referred to as the FEP group. This group also made decisions regarding the treatment of FEPs during the audit stage and participated in the further processing of the outcome of the auditing during the development of the SR-Can version of the FEP database. In the complementary FEP processing conducted for SR-Site, decisions regarding the treatment of FEPs during the audit stage were made by Kristina Skagius in accordance with the principles established by the FEP group during the SR-Can work.

Kristina Skagius, Kemakta Konsult AB, and Fred Karlsson and Jens-Ove Näslund, SKB, participated in the work of the processing of the list of FEPs related to initial states and external factors in SR-Site.

The persons involved in the processing of FEPs related to internal processes were the experts involved in developing the process descriptions, with the main contributions being from Kastriot Spahiu, SKB (fuel processes), Christina Lilja, SKB (canister processes), Patrik Sellin, SKB (buffer, backfill and closure processes), Harald Hökmark, Clay Technology AB (geosphere processes), Jan-Olof Selroos, SKB (geosphere processes), Ignasi Puigdomenech, SKB (geosphere processes) and Peter Jackson, Serco Assurance, UK (geosphere processes). All experts involved in development of the process descriptions are listed in the SR-Site Process reports for the fuel and canister /SKB 2010j/, buffer, backfill and closure /SKB 2010k/ and the geosphere /SKB 2010h/. Eva Andersson, Studsvik AB, has been the responsible for processing of FEPs related to the biosphere.

2 FEP processing procedures and prerequisites

As shown in the previous chapter, many of the steps in the methodology applied in SR-Site are related to the handling of FEPs. This chapter gives the prerequisites for the work and an overview of the different activities undertaken during the development of the SKB FEP database and the establishment of the SR-Site FEP catalogue. These activities are essentially the same as those established in SR-Can and reported in the SR-Can FEP report /SKB 2006b/. The development procedure is described in more detail in the following chapters together with the results from the different steps.

2.1 System definition

As with the SR-Can FEP database, the SR-Site FEP database has been devised for the KBS-3 repository system. To be able to distinguish between FEPs belonging to the repository system and FEPs acting from outside the system, a definition of the system boundary is necessary. Furthermore, in the database, this system is divided into several system components. It should be noted that these definitions primarily were set up to facilitate the auditing procedure and the development of the SKB FEP database. Therefore, all these definitions are not necessarily relevant in subsequent treatments of FEPs in the safety assessment, e.g. through modelling.

2.1.1 System boundary

To be able to distinguish between FEPs belonging to the repository system and FEPs acting from outside the system, the following definitions related to the system boundary were applied.

- Roughly the portion of the biosphere studied in site investigations, e.g. an area of the order of 100–300 km^2 above the repository, is regarded as internal, whereas the biosphere on a larger scale is regarded as external. The analysis of the biosphere extends downward to the surface of the rocks in this assessment. Depending on the analysis context this definition may be somewhat modified.
- Local effects of climate are internal, but not the climate system on a larger scale.
- Roughly the corresponding portion of the geosphere down to a depth of about 1,000 m is regarded as part of the system. Depending on the analysis context, this definition may also be somewhat modified.
- Future human behaviour on a local scale is internal to the system, but not issues related to the characteristics and behaviour of future society at large.

It was also noted that, in general, a strict boundary definition is neither necessary nor indeed possible, and that the same boundaries are not necessarily relevant to all parts of the safety assessment.

In order to distinguish between factors affecting the initial state of the repository system and factors associated with the evolution of the system, the initial time for the evolution of engineered barriers was defined as the time of deposition. The initial state of the geosphere and the biosphere was defined as that of the natural system prior to excavation and construction of the repository. This means that the evolution of the natural conditions at the site as a result of construction is included in the system description.

2.1.2 System components

The repository system encompasses the spent nuclear fuel, the canisters, the buffer, the tunnel backfill, the geosphere and the biosphere local to the repository. In the SR 97 Process report /SKB 1999/, the buffer and tunnel backfill were treated as one system component and the biosphere was not included. When starting the development of the SR-Can version of the SKB FEP database, it was decided that the buffer and the tunnel backfill should be treated as two separate system components and that the biosphere system should be added.

During the audit work in SR-Can, it was further found convenient to increase the resolution in the definition of system components outside the buffer in order to obtain system components that are reasonably homogeneous in character and to make it possible to distinguish between system components that are more important to safety and those that are less important. In SR-Site, some additional refinements of the definitions of the system components outside the buffer have been made. However, the geometrical extent and materials included in the system components "Fuel/cavity in canister" and "Cast iron insert and copper canister" remain the same as in the SR 97 version.

After these modifications, the SR-Site version of the SKB FEP database included the following system components.

- *Fuel/cavity in canister*. This system component comprises the fuel assemblies with fuel pellets, cladding tubes, channel, handle, and spacers etc, as well as cavities in the canister that could become filled with water in the case of a canister rupture.
- *Cast iron insert and copper canister*. This system component comprises the canister with its inner container of cast iron and outer shell of copper.
- *Buffer*. This system component comprises the buffer of bentonite clay that surrounds the canister in the deposition hole.
- *Bottom plate in deposition hole.* This system component comprises the concrete foundation in the bottom of each deposition hole and the copper plate on top of the concrete on which the buffer resides.
- *Backfill in tunnels.* This system component comprises the material that will be emplaced in the deposition tunnels after deposition of the canisters and buffer in the deposition holes. Since the concept for SR-Site is that the transport tunnels, the main tunnels as well as the lower parts of the ramp and shaft (see Figure 2-1), from 200 m depth and downwards, will be backfilled with the same material as the deposition tunnels, the backfill material in these parts of the repository is also included in this system component. This system component also includes engineered and residual materials, such as rock bolts, shotcrete and reinforcement nets that will be used as rock support as well as grout in the grout holes. These grout holes are used for grouting of the rock around the deposition tunnels during excavation and will be left grout-filled at repository closure.
- *Tunnel plugs.* This system component comprises all plugs in the repository that are left at closure. In the reference design, the plug is a composite of different materials including concrete, bentonite and crushed rock /SKB 2010d/. Plugs will be installed in the deposition tunnels at the intersection with the main tunnel and also to separate the transport tunnels from the central area and where an underground opening passes through highly transmissive zones (Figure 2-1).
- *Central area.* This system component comprises the remaining part below 200 m depth of the subsurface of the KBS-3 repository facility and includes rock cavities for operation, logistics and maintenance (Figure 2-1). The central area will be filled with crushed rock /SKB 2010e/. This system component also includes engineered and residual materials, such as rock bolts, shotcrete and reinforcement nets that will be used as rock support.
- *Top seal.* This system component comprises the filling in the uppermost 200 m of the ramp and shafts in the repository /SKB 2010e/. The lowest part, from 200 to 50 m depth, will be filled with crushed rock with a maximum particle size of 200 mm that has to be effectively compacted to minimise self-compaction under its own weight and overburden. The uppermost part of the ramp and shafts is planned to be backfilled with very coarse crushed rock and the shallowest part with fairly well fitted blocks of crystalline rock in order to prevent unintentional intrusion into the repository. This system component also includes engineered and residual materials.
- *Borehole seals.* This system component comprises the backfill materials in all boreholes drilled for site characterisation during the surface-based site investigations as well as during repository excavation and construction. These boreholes will be sealed with compacted bentonite in perforated copper tubes /SKB 2010e/. Borehole sections intersected by fracture zones will be filled with concrete with very low content of low-pH cement and a minimum content of super-plasticisers in order to minimise the negative impact on the contacting clay plugs. The upper part of boreholes connected to the surface will be sealed with well-fitting rock cylinders resting on a silica concrete plug and well-compacted till (Figure 2-2).

- *Geosphere.* This system component comprises the rock surrounding the repository and the investigation boreholes. It also includes grout injected into fractures in the rock during construction of the repository to prevent water inflow to tunnels and other repository cavities. In the upward direction, the geosphere is bounded by the geosphere-biosphere interface, defined as the top of the weathered host rock, which would be either at outcrop or at the interface with Quaternary deposits. For boundaries in the other directions, see definitions above regarding the system boundary.
- *Biosphere.* This system component comprises the near-surface properties and processes, both abiotic and biotic as well as humans and human behaviour, see also definitions above regarding system boundaries.

The various system components are also characterised by a number of variables, both in terms of the initial state of these variables and their states during repository evolution. For the engineered barrier system components, the variables are given in the Process reports for the fuel and canister /SKB 2010j/ and for the buffer, backfill and closure /SKB 2010k/ and the initial states of these system components are described in the Spent fuel report /SKB 2010a/ and in the Production reports for the canister /SKB 2010b/, the buffer /SKB 2010c/, the tunnel backfill and tunnel plugs /SKB 2010d/ and the closure /SKB 2010e/. The variables defined for the geosphere system component are given in the Geosphere process report /SKB 2010h/ and a description of the initial state of the geosphere is provided in the Forsmark site description /SKB 2008/.

The set of variables was established by the experts responsible for the development of the process descriptions in order to ensure that the variables are suitable for description of all conceivable alterations of the barrier properties as a result of long-term processes.

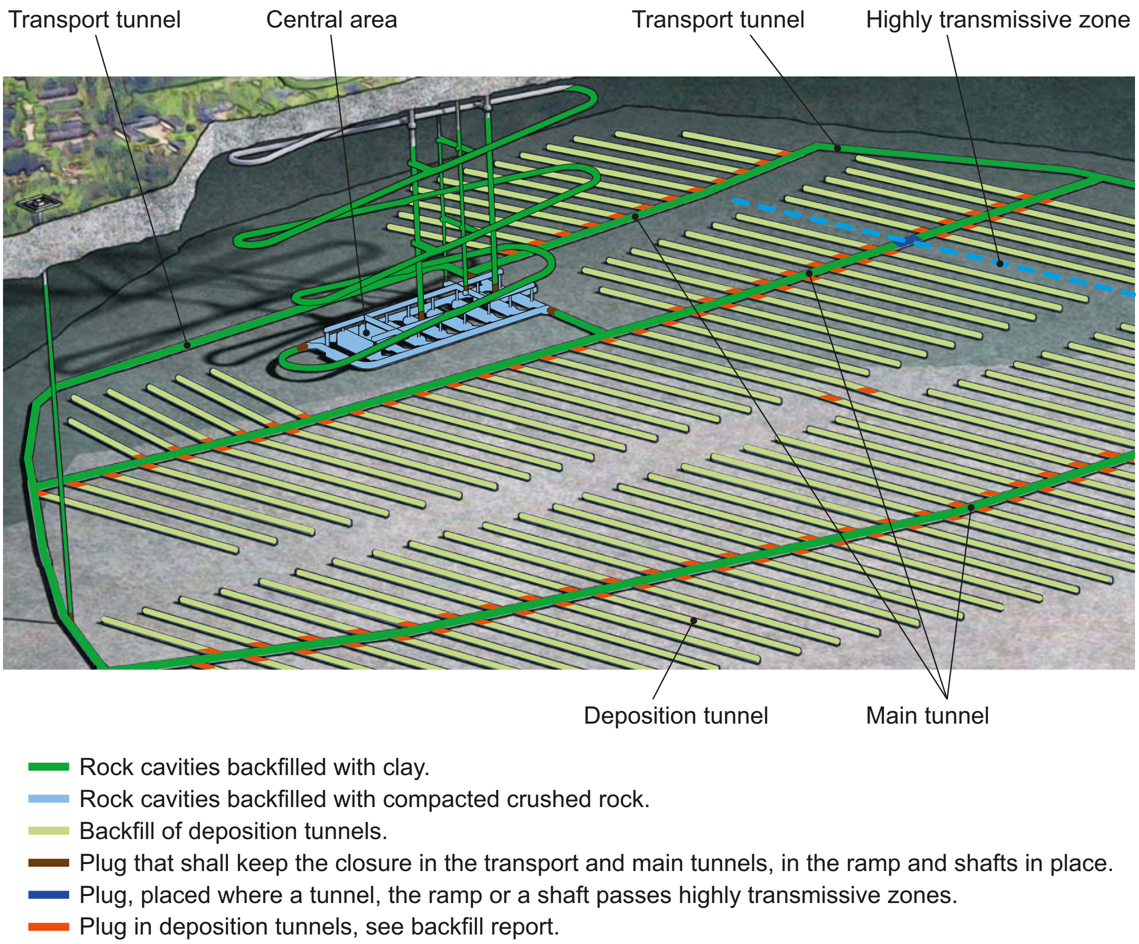

Figure 2-1. *Outline of the reference designs of closure and plugs in the different categories of underground openings (Figure 3-1 in /SKB 2010e/).*

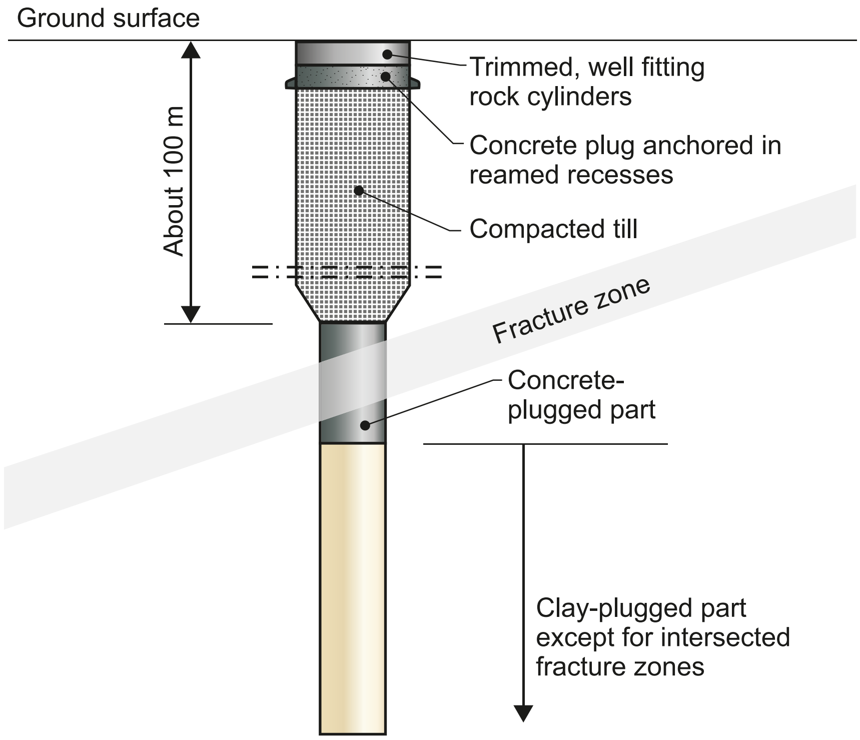

Figure 2-2. The principle for closure of the upper part of a borehole with well-compacted till below concrete and fitted rock blocks (Figure 3-7 in /SKB 2010e/).

2.2 Overview of FEP processing procedure

The handling of FEPs in SR-Site has followed the same procedure as that established for SR-Can and builds on the outcome of the FEP processing in SR-Can as reported in the SR-Can FEP report /SKB 2006b/ and documented in the SR-Can version of the SKB FEP database. The procedure is schematically illustrated in Figure 2-3 and summarised in the text below.

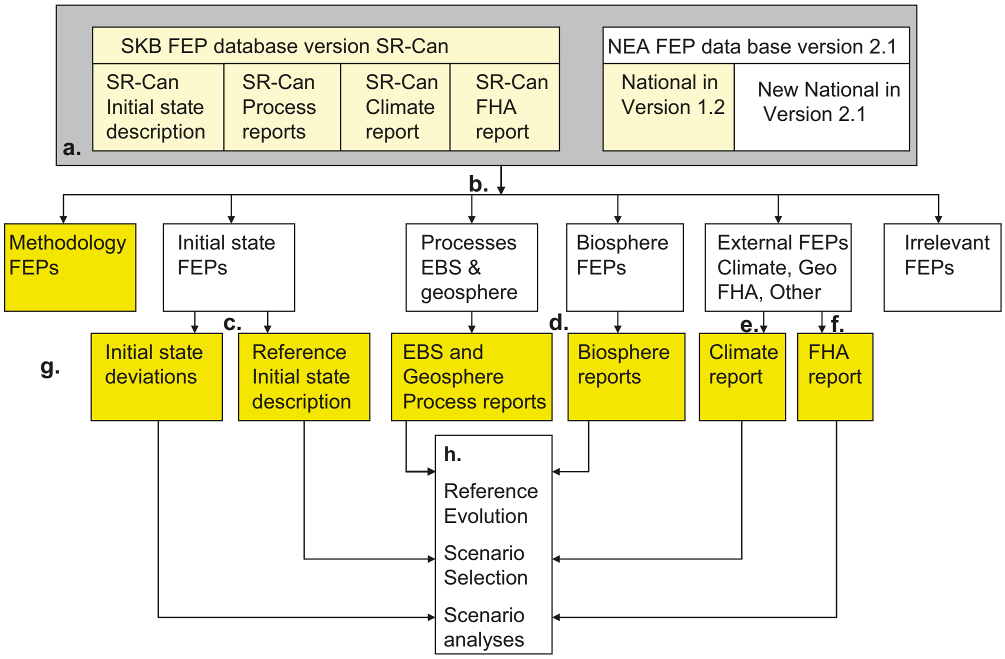

Figure 2-3. The handling of FEPs in SR-Site. The letters a to h are explained in the text.

a) FEP sources

The starting point for the handling of FEPs in SR-Site was the SR-Can version of the SKB FEP database and associated SR-Can reports. The SR-Can version of the SKB FEP database includes the SR-Can FEP catalogue, as well as the sources for the identification of FEPs in SR-Can, namely the SR 97 processes and variables /SKB 1999/, Project FEPs in the NEA International FEP database version 1.2 /NEA 1999/ and matrix interactions in the Interaction matrices developed for a deep repository of the KBS-3 type /Pers et al. 1999/. After the completion of the FEP work within SR-Can, an updated electronic version of the NEA FEP database, version 2.1, became available /NEA 2006/. This later version contains FEPs from two more national projects as compared with the older version 1.2. Therefore, FEPs in these two new national databases together with FEPs in the SR-Can version of the SKB FEP database were used as sources for the FEP handling in SR-Site.

b) FEP audit

In developing the SR-Can version of the SKB FEP database, the SR 97 processes and variables were systematically compared with all Project FEPs included in the NEA FEP database, version 1.2. In addition, an earlier audit of the SR 97 process report against the interaction matrices developed for a deep repository of the KBS-3 type /Pers et al. 1999/ was revisited and updated. The purpose of these audits was to ensure that all factors relevant to a KBS-3 repository were identified and to classify all relevant factors as being related to the *initial state of the repository system*, to *internal system processes* or to *external factors*. Most FEPs in version 1.2 of the NEA database could be mapped to one of these categories. All other FEPs were characterised as general methodology issues or determined to be irrelevant for the KBS-3 system. For SR-Site, all new Project FEPs in version 2.1 of the NEA FEP database were categorised in a similar manner and compared with FEPs in the SR-Can FEP catalogue.

The FEP audit procedure and the results are described further in Chapter 3.

c) Processing of initial state FEPs

The compiled NEA Project FEPs classified as initial state FEPs are related either to the intended initial state with tolerances, further denoted the reference initial state, or to deviations from the intended initial state. The NEA FEPs related to the reference initial state were associated with the appropriate variable and system component and included in the description of the reference initial state for the system component in question. Each variable constitutes a FEP record in the SR-Can as well as in the SR-Site FEP catalogue, see g) below.

Initial state FEPs that are related to deviations from the reference initial state and that need to be taken into account in the analyses formed the basis for the definition of Initial state FEP records in the SR-Can as well as in the SR-Site FEP catalogue, see g) below. These initial state FEPs were then propagated to the selection of scenarios.

The processing of initial state FEPs and the results obtained are described further in Section 4.2.

d) Processing of internal process FEPs and biosphere FEPs

Suggestions arising from the FEP audit in SR-Can regarding additions to, and modifications of, internal processes were addressed by the experts involved in the development of the SR-Can Process reports. The results of their work were implemented in the updated versions of the SR-Can process descriptions for the engineered barriers and the geosphere. Each process in these reports also constitutes a FEP record in the SR-Can FEP catalogue, see g) below. The complementary FEP audit conducted in SR-Site did not initiate any modifications in the list of processes relevant for SR-Site as compared with the list of processes for SR-Can. However, some modifications had to be made in order to improve the structure and logic of the descriptions. The resulting SR-Site set of processes are documented in the SR-Site Process reports /SKB 2010h, j, k/.

Biosphere processes were not included in the SR 97 Process report /SKB 1999/. Hence, the basis for updating these descriptions was not the same as for the engineered barriers and the geosphere. In SR-Can, provisional biosphere FEPs were defined and included in the SR-Can FEP catalogue.

For SR-Site, a biosphere report has been developed /SKB 2010m/. That report contains general descriptions of the processes considered to be of importance for the safety assessment, whereas the site-specific aspects of the processes and how they are handled in the safety assessment are provided in the various ecosystem reports developed for SR-Site /Andersson 2010, Aquilonius 2010, Löfgren 2010/. In the SR-Site FEP catalogue, a FEP record is included for each biosphere process in the biosphere process report.

The treatment of process FEPs and the results obtained are described further in Section 4.1.

e and f) Processing of external FEPs

FEPs in the NEA database defined as external FEPs in SR-Can were subdivided into the categories listed below. The complementary mapping of new Project FEPs in the NEA FEP database version 2.1 carried out for SR-Site did not point to any need to modify the categorisation of external FEPs. Consequently, the categorisation of external FEPs in SR-Can and in SR-Site are:

- Climate-related issues.
- Large-scale geological processes and effects.
- Future human actions.
- Other.

The handling of climate-related issues is documented in the SR-Site Climate report /SKB 2010g/ and corresponding climate FEPs are included in the SR-Site FEP catalogue. These climate FEPs are essentially the same as those defined for SR-Can and included in the SR-Can FEP catalogue, see g) below. In SR-Site, the handling of the NEA Project FEPs associated with these climate FEPs, as documented in the SR-Can FEP catalogue, was revisited and updated as appropriate, including new NEA Project FEPs in version 2.1 of the NEA FEP database that are associated to these climate FEPs.

Large-scale geological processes and effects were covered in SR-Can by two FEPs in the SR-Can FEP catalogue, see g) below. The same two FEPs are also included in the SR-Site FEP catalogue and described in the Geosphere process report /SKB 2010h/. As with the climate-related issues, the SR-Can documentation of the handling of each NEA Project FEP associated to these large-scale geological process FEPs has been revisited in SR-Site and updated as appropriate, considering also new Project FEPs in version 2.1 of the NEA FEP database.

Future human actions, FHA, and how these are handled in the safety assessment are described in the FHA report /SKB 2010i/. Seven FHA FEPs were defined and included in the SR-Can as well as in the SR-Site FEP catalogue, see g) below. In SR-Site, the handling of each NEA Project FEP associated with these FHA FEPs, as documented in the SR-Can FEP catalogue, was revisited and updated as appropriate, including new NEA Project FEPs in version 2.1 of the NEA FEP database.

In the category "other", only the FEP "meteorite impact" was identified in SR-Can, but excluded from further analysis. However, meteorite impact was still defined as a FEP in the SR-Can FEP catalogue and the justification for excluding this FEP from further analysis was documented in the FEP record in the SR-Can FEP catalogue. The audit of the new NEA Project FEPs in version 2.1 of the NEA FEP database did not indicate any need for modifications. Therefore, the FEP is maintained in the SR-Site catalogue, again for documentation purposes.

The processing of external FEPs and the results obtained are further described in Section 4.3.

g) Establishment of the SR-Can and SR-Site FEP catalogues

Based on the FEP processing conducted for SR-Can and briefly described above, an SR-Can FEP catalogue was established /SKB 2006b/. This FEP catalogue contains all FEPs that needed to be handled in SR-Can and is thus fundamentally a subset of FEPs in the SKB FEP database. However, the SR-Can FEP catalogue contains some preliminary FEPs for system components that were not treated in detail in SR-Can, i.e. tunnel plugs, backfill materials for cavities other than the deposition tunnels, the bottom plate in the deposition holes and borehole seals. In addition, the FEPs defined for the biosphere were provisional, since biosphere processes were not included in the SR 97 Process report /SKB 1999/ and there was, therefore, not the same basis for updating these descriptions in SR-Can as for the engineered barriers and the geosphere.

The SR-Site FEP catalogue is a developed version of the SR-Can FEP catalogue. For the system components not treated in detail in SR-Can, as well as for the biosphere, SR-Site FEPs were defined and included in the FEP catalogue. The mapping of NEA Project FEPs made to the preliminary and provisional FEPs for these system components in SR-Can was revisited and a new mapping was made to the FEPs included in the SR-Site FEP catalogue, which contains the categories of FEPs listed below.

- Initial state FEPs.
- Processes in the system components fuel, canister, buffer, bottom plate in deposition hole, tunnel backfill, tunnel plug, central area, top seal, borehole seals and geosphere.
- Variables in the system components fuel, canister, buffer, bottom plate in deposition hole, tunnel backfill, tunnel plug, central area, top seal, borehole seals and geosphere.
- Biosphere FEPs.
- External FEPs.

In addition to the categories listed above, the FEP catalogue also contains the categories Methodology FEPs and Site-specific factors. The methodology FEPs address a number of issues relevant to the basic assumptions for the assessment and to the methodology used for the assessment that were identified in the NEA FEP database. Most of these are of a very general nature, but, for the sake of comprehensiveness, they were also included in the FEP catalogue. These were defined already in SR-Can, and the audit of the new NEA Project FEPs in version 2.1 of the NEA FEP database did not result in any need for modifications. The site-specific factors represent issues that specifically were identified as relevant for the SR-Can analysis, for example the effect of a deep mine excavation near, but outside the tectonic lens at Forsmark. No additional issues that are not covered by FEPs already included in the SR-Site FEP catalogue were identified in the complementary FEP work and other analyses conducted in SR-Site.

The contents of the FEP catalogue are described in more detail in Chapter 5.

h) Repository evolution

The contents of the SR-Site FEP catalogue were propagated to the analysis of repository evolution. The reference initial state, all processes and a reference external evolution were used to define a reference evolution for the repository system. Other FEPs were considered in the selection of scenarios. This step is described in the SR-Site Main report /SKB 2011/ and is not further addressed in this FEP report, other than in respect of documentation aspects related to the FEP catalogue.

2.3 Quality assurance aspects

2.3.1 The SKB FEP database

The SKB FEP database was used as a tool for documentation of the outcome of the different steps in the FEP processing procedure as the work proceeded. This was done both in SR-Can and in SR-Site. Thus, the FEP database in itself is regarded as a quality assurance instrument. For that purpose, it contains all source information in terms of the Project FEPs included in the NEA FEP database version 1.2 /NEA 1999/ and in version 2.1 /NEA 2006/, the contents of the SR 97 Process report /SKB 1999/ in database format and the Interaction matrices developed for a deep repository of the KBS-3 type /Pers et al. 1999/, as well as the resulting SR-Can /SKB 2006b/ and SR-Site FEP catalogues. In addition, the SKB FEP database contains files created for documentation of the outcome of the FEP audits in SR-Can and in SR-Site, one for the result of the audit against the NEA Project FEPs (NEA Mapping) and one for the result of the audit against the Interaction matrices (Matrix Mapping). The overall structure of the SKB FEP database is shown in Figure 2-4.

In order to ensure a proper handling of the SKB FEP database, routines for the development and management of it were defined and applied both in SR-Can and in SR-Site. These are summarised in the following sections and further addressed, where appropriate, in the following chapters.

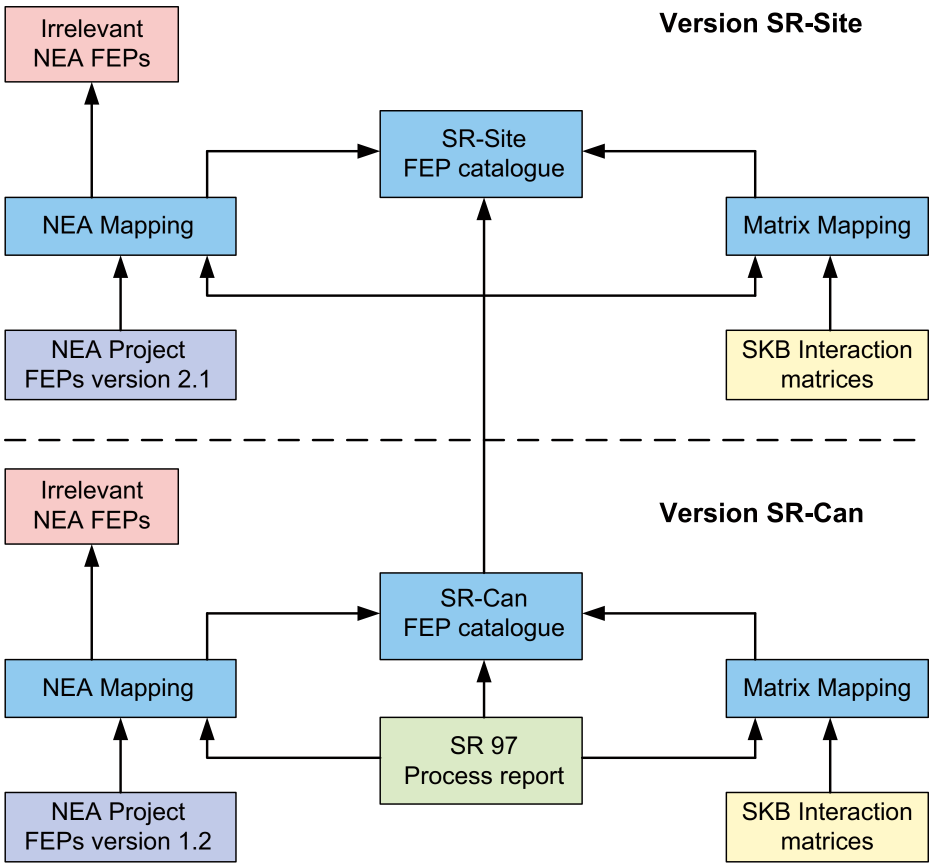

Figure 2-4. *Overall structure of the SKB FEP database.*

2.3.2 Import of NEA FEPs and Matrix interactions

The database was created with the database programme FileMaker Pro, (version 5.5), which is the same database programme as was used to set up the NEA FEP database and the SKB Interaction matrices. This made it possible to import an electronic copy of the register in the NEA FEP database containing the Project FEPs (PROFEP) and of the registers containing the documentation on the Interaction matrices. These registers, NEA Project FEPs and SKB Interaction matrices in Figure 2-4, are, however, not used for documentation. The documentation is created in the registers NEA Mapping and Matrix mapping (see Figure 2-4). These registers were created by exporting the Project FEP number, the Project FEP name and the International FEP number from the NEA FEP database (register PROFEP) to corresponding records in the NEA Mapping register in the SKB database. For creating the Matrix Mapping register, the Matrix name, the interaction number and interaction name were exported from the register SKB Interaction matrices to corresponding records in the Matrix mapping register. This means that the full copies of the NEA Project FEP register and the Interaction matrices registers are used for displaying the definition/description of the NEA Project FEPs and the Matrix interactions only and no documentation was allowed in these registers.

2.3.3 Routines for FEP processing and documentation of results

The FEP audit (b in Figure 2-3) in SR-Can and in SR-Site was carried out following a set of general procedures and rules (Section 3.1.2). In addition, a number of criteria were defined that should be fulfilled in order to determine that a FEP is not relevant for the SKB system (Section 3.1.3). These procedures, rules and criteria were applied in the work and the results of the audit as well as decisions made during the course of the work were documented in the FEP database (NEA Mapping in Figure 2-4).

The audit procedure was carried out by generalists and no attempt was made at this stage to make definite decisions on the relevance or importance of the FEPs and Matrix interactions for repository evolution. Therefore, the results of the audit, in terms of relevant FEPs and Matrix interactions and, where relevant, their links to internal processes, was propagated to experts within the project for further processing, together with instructions on how to document the result of that processing. The information in the FEP database was provided as digital word documents that were created by exporting relevant information directly from the FEP database to the digital documents.

The experts documented the results of their FEP processing using protocols addressing, for each NEA Project FEP or Matrix interaction, whether it is handled or not handled in SR-Can or SR-Site and if not handled, the reasons for this. The information developed under these protocols was then imported to the FEP database, where it is accessible for view via the FEP records in the SR-Can and SR-Site FEP catalogues (see Chapter 5). In addition, the expert responsible for the documentation of the handling is identified in the appropriate record in the database as well as the date of the final document provided for import to the database. Before entering the information into the database, its completeness and consistency was checked by the person responsible for the management of the FEP database. Minor revisions of more administrative character, such as adding cross-references and duplicating documentation of handling of similar FEPs when this information was lacking, were made by the person responsible for checking the information delivered under the protocols without consulting the expert providing the information.

Print-outs of this information from the FEP database (FEP tables) are provided as Appendices to this report.

2.3.4 Routines for management of the FEP database

Some general rules for administration of the FEP database have been followed throughout the development work. These are listed below.

- Only one person has been allowed to make modifications to the structure and content of the database. For the SR-Can project as well as the SR-Site project, this person has been Kristina Skagius, Kemakta Konsult AB.
- Suggested modifications in the structure of the database had to be checked and approved by the Project Manager Allan Hedin.
- Input of information to the database was required only to be made from documents that were dated, signed and provided by the experts assigned for the task.
- An informal log was active during the development of the FEP database to keep track of actions needed and made.
- No formal numbering of versions of the FEP database during the development was considered necessary, but dated copies were saved at regular intervals during the work. The final version for SR-Can was named the SR-Can version and the final version for SR-Site the SR-Site version of the SKB FEP database.
- The final official SR-Can and SR-Site versions of the FEP database are made available as stand alone, write-protected versions.

Before delivering the final versions of the SKB FEP database, the content was checked. This check was made in order to ensure the following.

1. All NEA Project FEPs in version 1.2 (SR-Can) and version 2.1 (SR-Site) of the NEA FEP database are included in the SKB FEP database.
2. All Matrix interactions in the SR 97 Buffer, Near-field and Far-field matrices are included in the SKB FEP database.
3. All NEA Project FEPs and Matrix interactions included in the SKB FEP database are flagged as Relevant or Not Relevant for the SKB repository system.
4. All NEA Project FEPs and Matrix interactions included in the SKB FEP database and flagged as Not Relevant for the SKB repository system are associated with documentation justifying their omission.
5. All NEA Project FEPs and Matrix Interactions included in the SKB FEP database and flagged as Relevant for the SKB repository system are associated with a documented description of their handling in SR-Can and in SR-Site.
6. All processes in process reports, defined categories of initial states, defined external factors, etc have a corresponding record in the SR-Can and SR-Site FEP catalogues.

The outcome of this check for the SR-Site version of the FEP database is provided in Appendix 1. The corresponding check for the SR-Can version of the FEP database is documented in Appendix 2 in /SKB 2006b/.

3 FEP audit

In the SR 97 Process report /SKB 1999/, processes relevant to repository safety for each of the system components, i.e. fuel, canister, buffer/backfill and geosphere, were identified. For each component, a set of variables needed to describe the evolution of the state of the component over time was also established. As a first step in the development of the SKB FEP database, these identified processes and variables were collected in an SR 97 FEP database, forming an important starting point for the SR-Can FEP handling. The SR 97 database was then systematically compared with other national databases included in the NEA international FEP database version 1.2 and with the content of the SKB interaction matrices reported in conjunction with the SR 97 safety assessment /Pers et al. 1999/. In SR-Site, a complementary FEP audit was carried out where FEPs in the SR-Can FEP catalogue were compared with Project FEPs that are added in version 2.1 as compared with version 1.2 of the NEA FEP database. This part of the work in SR-Can and SR-Site is described in the following sections of this chapter.

3.1 Comparison with the NEA FEP database

3.1.1 Introduction

The NEA international FEP database is the outcome of work by the NEA FEP Database Working Group and it consists of two parts; the international FEP List and Project Databases. The audit was carried out using the Project Databases, which is a collection of FEP lists and databases compiled during repository assessment studies in various countries. Version 1.2 of the NEA FEP database includes project-specific records from eight projects, whereas version 2.1 covers project-specific records from two more projects, i.e. in total records from ten projects. The main features of the repository concepts for each of these projects are given in Table 3-1.

To facilitate the audit against the Project FEPs in the NEA FEP database and documentation of the auditing results, “NEA mapping” files were created. The mapping file created in SR-Can link information in the NEA Project data file (PROFEP) version 1.2 with information in the SR-Can database files and the mapping file created in SR-Site links information in the corresponding Project data file (PROFEP) in version 2.1 of the NEA FEP database with the SR-Site files in the SKB FEP database.

At the start of the audit in SR-Can, the SR-Can files were identical to the corresponding SR 97 files. In a similar manner, the SR-Site files were identical to the SR-Can files when the complementary audit in SR-Site against new NEA Project FEPs in version 2.1 started. In this way, all Project FEPs in version 2.1 of the NEA FEP database were checked before the preliminary and provisional FEPs in the SR-Can catalogue were upgraded to final FEPs in the SR-Site catalogue. This ensured that all NEA FEPs associated with these preliminary and provisional FEPs were treated in a similar manner in the upgrading procedure.

3.1.2 General auditing procedure and rules

The NEA Project data file (PROFEP) in version 1.2 of the FEP database contains 1,418 FEPs. In order to make the audit work in SR-Can more efficient, the mapping of the NEA Project FEPs was carried out by a single person (Kristina Skagius), but some general procedures and rules were followed in order to keep expert judgements regarding details of process understanding to a minimum at this stage. The NEA Project data file (PROFEP) in version 2.1 of the FEP database contains 1,671 FEPs, i.e. an additional 253 FEPs compared with version 1.2 of the FEP database. These new FEPs

Table 3-1. Projects included in the NEA FEP database[1]

Project	Code	Waste type	Host rock	Engineered barrier system concept
Versions 1.2 and 2.1				
The Joint SKI/SKB Scenario Development Project, 1989	J	Spent PWR/BWR fuel	Crystalline basement	Corrosion-resistant copper containers, borehole emplacement with bentonite buffer
NEA Systematic Approaches to Scenario Development, 1992	N	Intermediate and low-level wastes	Hard rock	Steel and concrete packages, emplaced in caverns with cementitious grout and backfill
HMIP Assessment of Nirex Proposals – System Concept Group, 1993	H	Intermediate and low-level wastes	Tuff, Borrowdale Volcanic Group	Steel and concrete packages, emplaced in caverns with cementitious grout and backfill for ILW
AECL Scenario Analysis for EIS of Canadian Disposal Concept, 1994	A	Used CANDU fuel bundles	Plutonic rock of the Canadian Shield	Thin-walled titanium containers, borehole emplacement with bentonite-sand buffer
Nagra Scenario Development for Kristallin, 1994	K	Vitrified waste from reprocessing of spent PWR/BWR fuel	Crystalline basement under sedimentary cover in Northern Switzerland	Thick steel containers, in-tunnel emplacement with bentonite buffer
SKI SITE-94 Deep Repository Performance Assessment Project, 1995	S	Spent PWR/BWR fuel	Crystalline basement (based on geologic data from the Äspö site in south central Sweden)	Fuel, canister, bentonite buffer and tunnel backfill
US DOE Waste Isolation Pilot Plant, CCA, 1996	W	Contact- (CH) and remote handled (RH) Transuranic (TRU) waste	Salt (Salado Formation, New Mexico USA)	Magnesium oxide backfill as chemical conditioner, crushed salt, clay, concrete and asphalt seal components
AECL Issues for the 'Intrusion Resistant Underground Structure', 1997	I	Baled and bitumenised LLW from Chalk River Laboratories operations	Large sand ridge	Reinforced concrete vault above the water table
New in version 2.1				
SCK.CEN Catalogue relevant to disposal in Boom Clay, 1994	M	Vitrified high level waste (HLW), spent fuel (SF) and medium level waste (ILW)	Plastic clay, the Boom clay at Mol	Emplacement in concrete lined galleries
SKI Encyclopedia of FEPs for SFR and Spent Fuel Repositories, 2002	E	LLW and ILW in SFR repository; Spent BWR/PWR fuel in SFL repository	Crystalline basement: SFR ca. 60 m below seabed at Forsmark; SFL ca. 500 m below ground level	LLW and ILW in vaults and concrete silo at SFR repository; SF in copper-steel canisters in bentonite lined boreholes (KBS-3V) in SFL repository

[1] The Yucca Mountain FEP analysis is not included in version 2.1 of the NEA FEP database and has not been considered in the FEP processing in SR-Site. However, this omission is judged to be of no importance to the outcome of the FEP processing, since the disposal concept for Yucca Mountain is very different.

were in SR-Site mapped by the same person conducting the mapping in SR-Can applying the same approach set up for the mapping in SR-Can. The general procedures and rules followed in SR-Can and SR-Site were defined by the FEP group and were as listed below.

- The NEA Project FEPs regarded as irrelevant were marked as such and justification for their screening had to be provided (see Section 3.1.3 for screening criteria).
- Relevant FEPs occurring outside the system boundary were classified as External factors (see Section 3.1.4).
- A NEA Project FEP that clearly could be linked to one or several processes, variables or the initial state of one or more variables was so linked.
- Suggestions as to modifications to the descriptions of the processes and variables onto which the NEA Project FEPs were to be mapped were allowed at this stage. These modifications were required had to be documented and all objects for which modifications were required had to be marked in the database.
- All NEA Project FEPs not readily or fully fitting into one of the above categories were marked as such for further handling at a later stage.
- The mapping was required to be based on the NEA Project FEP description, rather than the FEP name.
- Any associations outside the primary meaning of the FEP that arose from consideration of the FEP description were required to be documented.

During the FEP audit in SR-Can, all NEA Project FEPs that could not readily be mapped using the general auditing rules were discussed at regular meetings in the FEP group and decisions were made on the relevance and classification of these FEPs. During the complementary mapping in SR-Site, the experience from the mapping in SR-Can was utilised and no need for separate decisions in the FEP group arose.

3.1.3 Relevance screening

The relevance of each NEA Project FEP for the SKB repository system was judged on the basis of relevance criteria defined by the FEP group. The FEP could be screened out if one or more of the following criteria were fulfilled.

- The FEP is not appropriate to the actual waste, canister design, repository design, geological or geographical setting.
- The FEP is defined by a heading without any description of what is meant by the heading, but from the interpretation of the heading it is judged that the FEP is covered by other NEA Project FEPs.
- The FEP is very general and covered by other more specific NEA Project FEPs.

It should be emphasised that certain aspects given in a FEP description could be relevant for the repository system defined for the SR-Can and SR-Site assessments, even if the FEP mainly related to a system substantially different from the SR-Can and SR-Site system. For example, NEA FEPs that are related to concrete barriers in an LLW/ILW repository concept are not necessarily screened out, since concrete is part of the SKB repository system and some aspects addressed in the NEA FEP description might, therefore, be relevant. In these cases, the FEP was judged as relevant and treated further as described in the following sub-sections.

It should also be noted that the general strategy in the screening of FEP relevance was to judge FEPs as relevant rather than to screen them out at this stage, unless it was clearly obvious that they are irrelevant. By this approach, the final decision regarding the relevance of a FEP and reasons for the decision as to whether it should be included were left to the various experts involved in the further processing of the audit results.

3.1.4 Classification of relevant FEPs

In SR-Can, NEA Project FEPs assessed to be relevant for the SKB repository system were classified into one or more of the categories listed below.

- System processes.
- Variables/initial states.
- Biosphere.
- External factors.
- Methodology issues.

In the complementary audit carried out in SR-Site, all of the new NEA Project FEPs assessed as relevant could be classified to the same categories as those defined in SR-Can.

System processes

This category was used to classify FEPs that were judged to describe a process relevant to one or several of the system components defined for the SR-Can and SR-Site assessments, excluding the biosphere, see below.

Variables/initial states

This category was used to classify FEPs that were judged to affect a variable defined to describe the state of a system component, either the initial state of the system component or the state during evolution. If the FEP was considered to address both a process relevant for the evolution of a system component and a variable affected by that process, it was always assigned to the category system process, but not always also to the category variable/initial state. However, all FEPs that were judged to be relevant to the initial state of a system component were assigned to the category variables/initial states.

Biosphere

A separate treatment of biosphere FEPs was necessary in SR-Can because the SR 97 database does not contain any biosphere processes or variables. Therefore, NEA FEPs judged as being relevant for the SR-Can biosphere were classified into a separate category "Biosphere" for later audit. The biosphere FEPs were further distinguished into the sub-categories Quaternary deposits, Surface waters, Atmosphere, Biota, Man and Others. These sub-categories correspond to the provisional Biosphere FEPs in the SR-Can FEP catalogue. In the complementary mapping carried out in SR-Site, all new NEA Project FEPs sorted to the category "Biosphere" were initially sorted to one or several of these SR-Can provisional biosphere FEPs.

External factors

The category *External factors* was used for NEA FEPs that act outside the boundary of the repository system. During the auditing work in SR-Can and SR-Site, a further division was made into the sub-categories "Large-scale geological processes and effects", "Climatic processes and effects", "Future human actions" and "Other", i.e. the same classification as is used in the NEA database.

Methodology issues

A number of relevant issues relating to the factual basis for the assessment and to the methodology of the assessment were identified in the NEA FEP database. Most of these are of a very general nature, but were for the sake of comprehensiveness also included in the SR-Can FEP catalogue as two FEPs, "Assessment basis" and "Methodology issues". The audit of the new NEA Project FEPs in version 2.1 of the NEA FEP database has not resulted in any need for modifications. Therefore, the SR-Site FEP catalogue contains the same methodology FEPs as the SR-Can FEP catalogue (see further Section 4.5).

3.1.5 Documentation of audit results

The results of the audits in SR-Can as well as in SR-Site were documented in the NEA mapping files in the database. A short description of the type of documentation made is given here.

FEP relevance

The relevance of the FEP for the SKB system was documented in the NEA mapping file (see Figure 2-4) together with justification for the judgement "not relevant", when applicable. Out of the total number of 1,418 Project FEPs in version 1.2 of the NEA database, 316 FEPs were screened out as being irrelevant for the SR-Can assessment. Examples of screened-out FEPs are those related to magmatic activity and volcanism, and FEPs addressing aspects specific to vitrified waste. In the complementary FEP work in SR-Site, 48 of the new NEA Project FEPs in version 2.1 of the database were judged as not relevant and screened out. Furthermore, an additional six of the NEA Project FEPs that are included also in version 1.2 of the FEP database and that in SR-Can were judged as relevant were in SR-Site re-assessed as not relevant. Four of these are FEPs related to the biosphere, which is one of the system components that was in focus in the complementary FEP work conducted in SR-Site. The result of the assessment of relevance of the Project FEPs in version 2.1 of the NEA FEP database is that 370 of the total of 1,671 Project FEPs are documented as not relevant for the SKB system in the SR-Site version of the SKB FEP database.

Processes and variables/initial states

All NEA Project FEPs assigned to the categories "System process" and "Variables/initial states" were marked as such in the mapping files. In SR-Can, these NEA Project FEPs in version 1.2 of the database were compared with processes and variables in the SR 97 database. For NEA FEPs that were judged to be covered by processes or variables in the SR 97 database, the links between NEA Project FEPs and SR 97 processes and variables were documented in the mapping file. In addition, NEA Project FEPs not covered by SR 97 processes or variables or aspects of NEA Project FEPs not addressed were also documented in the mapping file. As a result of this work in SR-Can, a number of processes were added to the SR-Can FEP catalogue as well as FEPs of potential relevance to the initial state of the system components /SKB 2006b/.

In SR-Site, new Project FEPs in version 2.1 of the NEA database assigned to the categories "System processes" and "Variables/initial states" were, in the NEA mapping file and in a first step, linked to appropriate FEPs in the SR-Can FEP catalogue. For system components not treated in detail in SR-Can, the SR-Can FEP catalogue contains preliminary FEPs. In SR-Site, FEPs for these system components, i.e. tunnel plugs, central area, top seal, bottom plate in deposition holes and borehole seals, were established, largely based on the list of processes and variables defined for the system components buffer and backfill. In a second step, all NEA Project FEPs linked to the preliminary FEPs in the SR-Can FEP catalogue were revisited and re-linked to the new FEPs defined for SR-Site. In addition, a few modifications in the list of processes for the system components fuel, canister, buffer, backfill and geosphere were made compared to the list of processes included in SR-Can. These modifications were not initiated by the complementary mapping of new Project FEPs in version 2.1 of the NEA FEP database, but were made to improve the structure and logic of the descriptions. For example, to improve the handling of uncertainties in the geochemical evolution of the buffer, some mechanisms included in integrated descriptions in SR-Can are in SR-Site included as separate processes, e.g. iron-bentonite interactions and cementation. Another example concerns a modification in the list of geosphere processes. In SR-Can, surface erosion and weathering was defined as a geosphere FEP and described in the Geosphere process report /SKB 2006c/, but these mechanisms are in SR-Site classified as related to climate and the biosphere and the description of these mechanisms is included in the SR-Site Climate report /SKB 2010g/ and also addressed and considered in the biosphere analyses and reporting. All modifications were implemented in the SR-Site FEP catalogue and the link between NEA Project FEPs in version 2.1 of the database and FEPs in the SR-Site FEP catalogue documented in the mapping file.

The number of NEA FEPs assigned to the category "System process" in the SR-Site version of the SKB FEP database is 678 (546 in the SR-Can version), whereas 252 NEA FEPs are assigned to the category "Variables/initial states" (194 in the SR-Can version).

Biosphere

All NEA Project FEPs classified as relevant for the biosphere in the SR-Can assessment were marked as such in the mapping file and also assigned to one or several of the provisional biosphere FEPs defined in SR-Can by markers in the SR-Can mapping file. Initially, the SR-Site FEP catalogue contained the same provisional Biosphere FEPs as the SR-Can FEP catalogue. In the complementary mapping of new Project FEPs in version 2.1 of the NEA FEP database, FEPs classified as biosphere FEPs were initially linked to one or several of these provisional biosphere FEPs.

For SR-Site, a biosphere process report /SKB 2010m/ has been developed, which contains general descriptions of the processes considered to be of importance for the safety assessment. For each process defined in the biosphere process report, a biosphere FEP has been included in the SR-Site FEP catalogue (see Section 5.5). Therefore, all NEA Project FEPs associated with the provisional SR-Can biosphere FEPs were revisited and a new linking to the defined SR-Site biosphere FEPs was carried out. The links between NEA Project FEPs and SR-Site biosphere FEPs are documented in the SR-Site mapping file. In total, 282 NEA FEPs are assigned to the Biosphere category (259 in SR-Can).

External factors

In SR-Can, all Project FEPs in version 1.2 of the NEA FEP database classified as relevant external factors for the SR-Can repository system were marked as such in the SR-Can NEA mapping file. In addition, each FEP was marked as belonging to one of the categories “Climatic processes and effects”, “Large-scale geological processes and effects”, “Future human actions” or “Other” and finally linked to the appropriate SR-Can FEP in the SR-Can FEP catalogue /SKB 2006b/. In the complementary mapping of new Project FEPs in version 2.1 of the NEA FEP database conducted in SR-Site, all these new Project FEPs could be associated with FEPs representing external factors in the SR-Can FEP catalogue. Thus, the SR-Site catalogue contains the same external FEPs as the SR-Can FEP catalogue, with one exception. This concerns the SR-Can geosphere process FEP “Surface weathering and erosion” that in SR-Site was re-classified as an external factor in the category “Climatic processes and effects” and renamed to “Denudation”. The links between Project FEPs in version 1.2 of the NEA FEP database and SR-Site external FEPs are documented in the SR-Site mapping file. In total, 209 NEA FEPs are assigned to external factors in SR-Site (175 in SR-Can).

Methodology issues

NEA Project FEPs judged to belong to the categories “Assessment basis” and “Methodology comment” were marked as such in the NEA mapping file both in SR-Can and in SR-Site. Of all Project FEPs included in version 2.1 of the NEA FEP database, 23 are associated with the SR-Site FEP “Assessment basis” and 102 with the SR-Site FEP “Assessment methodology”. The corresponding number of Project FEPs in version 1.2 of the NEA FEP database associated with the SR-Can version of the methodology issues FEPs are 9 and 102, respectively. The major reason for the larger number of NEA Project FEPs categorised as related to the assessment basis in SR-Site compared with SR-Can is that many of the NEA FEPs addressing chemical toxicity are associated with this category, whereas in SR-Can they were classified as belonging to the category “Biosphere FEPs”.

3.2 Audit against SR 97 interaction matrices

In SR-Can, the content of the SKB interaction matrices reported in conjunction with the SR 97 safety assessment was mapped to the content in the SKB FEP database in a similar way as was done for the NEA Project FEPs. The result was documented in a Matrix mapping file in the SKB FEP database /SKB 2006b/. In SR-Site, no complementary work related to matrix interactions was conducted with one exception. This concerns matrix interactions that in SR-Can were associated with the preliminary SR-Can FEPs that were defined for the system components not treated in detail in SR-Can, i.e. tunnel plugs, backfill materials for cavities other than the deposition tunnels, the bottom plates in the deposition holes and borehole seals. In SR-Site, these matrix interactions were revisited and sorted to the new SR-Site FEPs defined for these system components. In addition, the eleven matrix interactions that in SR-Can were classified as belonging to the category “Biosphere” were revisited. Two of these interactions concern issues related to environmental impact assessment and are, therefore, reclassified as belonging to Methodology issues in SR-Site. The remaining nine interactions all address issues that are covered by one or several of the SR-Site biosphere FEPs and they were, therefore, not further handled.

4 Further processing of FEPs

In SR-Can, the result of the audit against the Project FEPs in version 1.2 of the NEA FEP database and the SKB Interaction matrices was used to create check lists for updating process descriptions for the SR-Can assessment and for the preparation of descriptions of the initial states of the repository system components /SKB 2006b/. In addition, FEP lists from the audit were used as checklists for the handling of external factors as described in the SR-Can Climate report /SKB 2006d/ and the SR-Can FHA report /SKB 2006e/, as well as for the establishment of SKB FEPs for further consideration in the selection of scenarios. In SR-Site, the results of the complementary mapping of Project FEPs in version 2.1 of the NEA FEP database were used to check the updated SR-Site versions of the process reports, the climate report and the FHA report. Furthermore, all NEA Project FEPs associated to biosphere FEPs defined for SR-Site were checked in order to ensure that all important aspects are addressed in the SR-Site biosphere reports. The different procedures applied for the post-processing of the audit results are described in this chapter.

4.1 Internal processes

The results of post-processing of the process lists and the tables with documentation of the handling of Project FEPs in version 1.2 of the NEA FEP database were documented in the SR-Can version of the FEP database. In SR-Site, this information was exported from the FEP database and was, together with all new Projects FEPs in version 2.1 of the NEA FEP database associated with process FEPs in the SKB FEP database, provided to the experts responsible for updating the process reports. These experts revisited the documentation on handling of each NEA FEP in SR-Can and updated the documentation to be valid for SR-Site. In addition, the handling of all new Project FEPs in version 2.1 of the NEA FEP database was documented. This documentation was then imported into the SR-Site version of the FEP database and linked to the appropriate FEP in the SR-Site FEP catalogue (see Section 5.1). The results for the different system components are further commented upon in the following sections.

Concerning the documentation of the handling of matrix interactions associated with internal process FEPs, this was not complete in SR-Can /SKB 2006b/. Despite this, it was judged that all important aspects related to these interactions were addressed in the SR-Can process descriptions, since these interactions were input to the development of the SR 97 process descriptions, which in turn were one of the sources of the SR-Can descriptions. Since the SR-Site process descriptions are built on the SR-Can descriptions, this judgement is still valid and no systematic effort has been made in SR-Site to update and/or complement the documentation of the handling of matrix interactions linked to process FEPs in the SR-Site FEP catalogue.

4.1.1 Fuel/cavity in canister

Seventeen processes are defined for the system component *Fuel/cavity in canister* in the SR-Site Fuel and canister process report /SKB 2010j/, and these are in the FEP database represented by FEP record identities F01 to F17 (see Table 5-2 in Section 5.3).

The SR-Site processes for the system component *Fuel/cavity in canister* are essentially the same as those defined for this system component in SR-Can /SKB 2006b, f/. One new process has been added, “Chemical alteration of the fuel matrix” (F16), which refers to alteration of the spent fuel matrix under reducing conditions through the formation of coffinite.

The tables documenting the handling of NEA Project FEPs (version 2.1) associated with processes in the system component *Fuel/cavity in canister* are given in Appendix 4. The information in these FEP tables is also included in the FEP database and linked to the corresponding FEP records in the SR-Site FEP catalogue.

4.1.2 Cast iron insert and copper canister

Fifteen processes are defined for the system component *Cast iron insert and copper canister* in the SR-Site Fuel and canister process report /SKB 2010j/, and these are in the FEP database represented by FEP record identities C01 to C15 (see Table 5-3 in Section 5.3). These processes are the same as those defined for SR-Can, but somewhat reordered, which means that the FEP record identities are different for four processes as compared with SR-Can. The FEP tables with documentation of the handling of NEA Project FEPs (version 2.1) associated with canister processes are given in Appendix 5 and they are also accessible in the FEP database.

4.1.3 Buffer

Twenty-six processes are defined for the system component *Buffer* in the SR-Site Buffer, backfill and closure process report /SKB 2010k/, and these are in the FEP database represented by FEP record identities Bu01 to Bu26 (see Table 5-4 in Section 5.3).

Compared with the processes defined in SR-Can /SKB 2006g/, two mechanisms included in integrated descriptions in SR-Can are in SR-Site included as separate processes. These are "Iron-bentonite interaction" (Bu17) and "Cementation" (Bu22). This also implies that the FEP identities for many of the buffer processes are different in SR-Site compared with SR-Can. In addition, some minor changes in naming of the processes have been made, e.g. the SR-Can processes "Advection" and "Diffusion" are in SR-Site named "Advective transport of species" and "Diffusive transport of species", respectively.

The FEP tables with documentation of how NEA Project FEPs (version 2.1) associated with buffer processes are handled are provided in Appendix 6. The information in these tables is also included in the FEP database.

4.1.4 Backfill in tunnels

Twenty-two processes are defined for the system component *Backfill in deposition tunnels* in the SR-Site Buffer, backfill and closure process report /SKB 2010k/, and these are in the FEP database represented by FEP record identities BfT01 to BfT22 (see Table 5-5 in Section 5.3). These processes are the same as those defined for SR-Can /SKB 2006g/, but some changes in the naming of the processes have been made. As in SR-Can, two of these processes are not described in the SR-Site Buffer, backfill and closure report /SKB 2010k/. For BfT19, Colloid formation and transport, reference is made to the corresponding process in the Geosphere process report (Ge18 in Table 5-6) and the process BfT22, Transport of radionuclides by a gas phase, is addressed in the SR-Site Main report /SKB 2011/ (Section 13.8).

The FEP tables with documentation as to how NEA Project FEPs (version 2.1) associated with backfill processes are handled are provided in Appendix 7. The information in these tables is also included in the FEP database.

4.1.5 Geosphere

Twenty-four processes are defined for the system component *Geosphere* in the SR-Site Geosphere process report /SKB 2010h/, and these are in the FEP database represented by FEP record identities Ge01 to Ge25 (see Table 5-6 in Section 5.3), excluding Ge09, as explained in the following paragraph.

Compared with SR-Can, one modification in the list of geosphere processes has been made. In SR-Can, surface erosion and weathering was described in the Geosphere process report /SKB 2006c/. However, in SR-Site, the description of these mechanisms is included in the Climate report /SKB 2010g/ and also addressed and considered in the biosphere analyses and reporting. Therefore, a new Climate FEP is included in the FEP database (see Section 4.3.1). However, a FEP record for this process with the SR-Can identity (Ge09) is kept in the SR-Site FEP catalogue for traceability reasons, in which a cross-reference is provided to the new Climate FEP (Cli11) and to the relevant biosphere FEP (Bio38), see further Sections 4.3.1 and 4.4. Other modifications related to geosphere processes only concern small changes in the naming of the processes.

The FEP tables with documentation of how NEA Project FEPs (version 2.1) associated with geosphere processes are handled are provided in Appendix 8. The information in these tables is also included in the FEP database.

4.1.6 Additional system parts

The system components tunnel plugs, central underground area, the top seal, the bottom plate in deposition holes and borehole seals were not treated in detail in SR-Can, and only very preliminary, provisional SKB FEPs were defined and entered into the SR-Can FEP catalogue. In SR-Site, processes for these system components are described in the SR-Site Buffer, backfill and closure process report /SKB 2010k/ and corresponding process FEPs are included in the SKB FEP database. The names and record identities of these process FEPs are given in Table 5-7 in Section 5.3. The numbers of process FEPs included in the FEP database for each of these system components are listed below.

- Tunnel plug; 19 processes with record identities Pg01 to Pg19.
- Central area; 19 processes with record identities CA01 to CA19.
- Top seal; 18 processes with record identities TS01 to TS18.
- Bottom plate in deposition holes; 16 processes with record identities BP01 to BP16.
- Borehole seals; 22 processes are defined in the process report and each process is represented by a FEP record in the FEP database with record identities BhS01 to BhS22.

In general, the evolution of these system components is judged as of secondary importance for safety. Nevertheless, a check of the NEA Project FEPs (version 2.1) associated with SR-Site process FEPs for these system components has been conducted and the handling is documented in the SKB FEP database.

4.2 Initial states

In SR-Can, all Project FEPs in version 1.2 of the FEP database categorised as initial state FEPs could be further divided into two groups, FEPs that are related to the reference initial state and FEPs that are related to deviations from the reference initial state /SKB 2006b/. The former group comprised a checklist for the description of the initial states of the repository components as documented in the SR-Can Initial state report /SKB 2006h/. The handling was documented in tables created for this purpose and added to the SKB FEP database with a link to the appropriate Variable FEP record in the SR-Can FEP catalogue. The checklist with FEPs sorted to the latter group resulted in the definition of SR-Can Initial state FEPs for further consideration in the SR-Can assessment (see Section 4.2 in /SKB 2006b/). These FEPs are related to deviations from the reference initial state of the canister, the buffer and the backfill of the deposition tunnels, or to more general deviations, and are included in the SR-Can FEP catalogue with FEP record identity starting IS and followed by a letter code, e.g. Gen for general deviations in initial state and Bu for buffer.

In SR-Site, new Project FEPs in version 2.1 of the NEA FEP database classified as related to Initial state FEPs were added to the check lists. The handling in SR-Can of NEA FEPs sorted to the reference initial state was revisited and checked against the descriptions of the reference initial states for the engineered barrier system components as provided in the SR-Site Production reports /SKB 2010a, b, c, d, e, f/. As in SR-Can, the handling in SR-Site of these FEPs as well as of new Project FEPs in version 2.1 of the NEA FEP database was documented and added to the SKB FEP database with a link to the appropriate Variable FEP record in the SR-Site FEP catalogue (see Section 5.4). This check was conducted by Kristina Skagius, Kemakta.

The FEPs related to deviations from the reference initial state that are included in the SR-Can FEP catalogue are also included in the SR-Site FEP catalogue. These FEPs and all associated NEA Project FEPs are considered in the analysis of the reference evolution of the repository or in the selection of scenarios in SR-Site as reported in the SR-Site Main report /SKB 2011, Chapters 10 and 11/. As in SR-Can, these FEPs are related to deviations from the intended reference initial state of the canister, the buffer and the backfill of the deposition tunnels, or to more general deviations, and are included in the SR-Site FEP catalogue with FEP record identity starting IS and followed by a letter code, e.g. Gen for general deviations in initial state and Bu for buffer (Table 5-1 in Section 5.2). In addition, the SR-Site FEP catalogue contains corresponding FEPs for the system components that were not treated in detail in SR-Can, i.e. the tunnel plug, the central area, the top seal, the bottom plate in deposition holes and borehole seals. These system components are not of primary importance for the safety of the repository. Therefore, the consequences of deviations in their initial state are not analysed in detail, but are addressed in the analysis of the reference evolution as reported in the SR-Site Main report /SKB 2011, Chapter 10/ and, if relevant, considered in subsequent parts of the assessment.

In the FEP processing in SR-Can, it was decided to exclude two of the SR-Can Initial state FEPs of more general character from scenario selection. These FEPs are also excluded from scenario selection in SR-Site. One of them is related to severe perturbations like fire, explosions, sabotage and severe flooding (ISGen01). The reasons for excluding this FEP are i) the probabilities for such events are low and ii) if they occur, they have to be reported to the Swedish Radiation Safety Authority (SSM), their consequences assessed and correcting or mitigation actions made accordingly. The other FEP excluded is related to effects detrimental to long-term safety caused by monitoring activities (ISGen04). This FEP was excluded from further analysis because monitoring activities that could disturb the repository safety functions will not be accepted.

Another FEP in the SR-Site (and SR-Can) FEP catalogue refers the effects of phased operation (ISGen02). This affects mainly the geosphere and the subsequent development of the entire repository. The hydrological state of the bedrock is perturbed as soon as repository excavation starts (a smaller perturbation even occurs earlier during site investigations). Different parts of the repository, completed at different times, will be exposed to different hydrological conditions, affecting e.g. the saturation of the buffer and backfill. Possible upconing of saline water could also vary between different parts of the repository due to phased operation. Other factors to consider are the effects of blasting and underground traffic on completed parts of the repository. All these issues are part of the expected evolution of the repository, but are not automatically captured in the system of processes describing repository evolution over time or by the initial state descriptions. As they need to be adequately included in the discussion of repository evolution, they were propagated to the analysis of the reference evolution (see SR-Site Main report /SKB 2011/, Section 10.2.6).

The last initial state FEP of more general character in the FEP catalogue concerns the effects of an unsealed or abandoned or monitored repository (ISGen03). These issues were propagated to scenario selection (Chapter 11 in the SR-Site Main report /SKB 2011/).

The FEP tables with documentation of how NEA Project FEPs sorted to Initial state FEPs are handled in SR-Site are provided in Appendix 3. The information in these tables is also included in the FEP database together with documentation of the handling of matrix interactions associated with SR-Site Initial state FEPs.

4.3 External factors

As described in Section 3.1.4, NEA Project FEPs and Matrix interactions defined as External factors to the repository system were classified into the following four categories: “Climate processes and effects”, “Large-scale geological processes and effects”, “Future human actions”, and “Others”, both in SR-Can and in the complementary FEP audit conducted in SR-Site. Further processing and checking of these FEPs in SR-Can resulted in the inclusion of relevant FEPs in the SR-Can FEP catalogue to which a documentation of the handling of each Project FEP in version 1.2 of the NEA FEP database is linked /SKB 2006b/. In SR-Site, the documentation of the handling of each NEA Project FEP was revisited and updated as appropriate and the handling of each new Project FEP in version 2.1 of the NEA FEP database associated with external factors was added to the SKB FEP database. This check and update of the handling of NEA Project FEPs was carried out by the different experts assigned to the task.

4.3.1 Climatic processes and effects

Climate issues and their handling in SR-Site are described in the SR-Site Climate report /SKB 2010g/ and eleven Climate FEPs are included in the FEP database to represent these issues (see Table 5-10 in Section 5.6). Compared with SR-Can, one Climate FEP has been added. This additional FEP, "Denudation" corresponds to the SR-Can geosphere process "Surface weathering and erosion", which in SR-Site has been categorised as a climate-related and biosphere issue rather than a geosphere process. Another modification compared with SR-Can is that the SR-Can Climate FEP concerning earthquake activity related to the removal of large ice sheets (Cli10), in SR-Site has been classified as a large-scale geological process rather than a climate process and is, therefore, included in the SR-Site FEP related to Earthquakes (LSGe02, see Section 4.3.2). However, a FEP record for this process with the SR-Can identity (Cli09) is kept in the SR-Site FEP catalogue for traceability reasons, in which a cross-reference is provided to the large-scale geological process FEP, see further Section 4.3.2.

In SR-Site, the handling of each NEA Project FEP has been revisited and updated as appropriate, including new Project FEPs in version 2.1 of the NEA FEP database that are associated with these climate FEPs. The FEP tables with documentation of how NEA Project FEPs sorted to climate issues are handled in SR-Site are provided in Appendix 9. The information in these tables is also included in the FEP database.

4.3.2 Large-scale geological processes and effects

Large-scale geological processes occurring in the past and currently ongoing and their impact on the current mechanical state of the Baltic Shield and the repository rock are described in the Geosphere process report /SKB 2010h/. Two SR-Site FEPs are included in the FEP database to cover these, namely "Mechanical evolution of the Shield" (LSGe01) and "Earthquakes" (LSGe02) (see also Table 5-11 in Section 5.6). These FEPs are the same as those included in the SR-Can FEP catalogue /SKB 2006b/.

In SR-Site, the documentation in the SR-Can FEP catalogue has been revisited and updated as appropriate, considering also new Project FEPs in version 2.1 of the NEA FEP database that are mapped to these large-scale geological process FEPs. The FEP tables with documentation of how NEA Project FEPs sorted to large-scale geological processes are handled in SR-Site are provided in Appendix 9. The information in these tables is also included in the FEP database.

4.3.3 Future human actions (FHA)

Future human actions and how these are handled in the safety assessment are described in the SR-Site FHA report /SKB 2010i/. In SR-Can, seven FEPs were defined to represent future human actions, and the same seven FHA FEPs are included in the SR-Site FEP catalogue (see Table 5-12 in Section 5.6). In SR-Site, the documentation of the handling of each NEA Project FEP mapped to these SR-Site FEPs has been revisited and updated as appropriate, considering also new Project FEPs in version 2.1 of the NEA FEP database that are mapped to these SR-Site FHA FEPs. The result is provided in Appendix 9 and also included in the FEP database.

4.3.4 Others

In SR-Can, all NEA Project FEPs sorted to this group were related to meteorites and their impacts on repository performance. Meteorite impact was excluded from further analysis in SR-Can, but was defined as a FEP in the SR-Can FEP catalogue. The audit of the new NEA Project FEPs in version 2.1 of the NEA FEP database has not indicated any need for modifications. Therefore, meteorite impact is kept as a FEP also in the SR-Site catalogue for documentation purposes, but excluded from further analysis in SR-Site. The justification for excluding meteorite impact is that the probability is very low that a meteorite, large enough to damage the repository, will actually impact Earth, e.g. on the order of one collision every 500,000 year for objects of roughly 1 km in size /Morbidelli et al. 2002/ and about one collision every 10,000 years for objects causing craters larger than 1 km in diameter /Melosh 1989/. The probability that the hit actually occurs at the repository site is then significantly lower; e.g. an estimated frequency in the order of 10^{-13} per km^2 per year for impacts causing craters larger than 1 km in diameter has been reported by /Hartmann 1965/. Since the depth of a crater is about one third of its diameter /Melosh 1989/, the crater has to be larger than 1 km in order to expose the repository, but the rock would likely be fractured at repository depth due to somewhat smaller impacts.. Furthermore, such an impact event would cause substantial damage to the local and regional biosphere, including humans /Collins et al. 2005/, and these direct effects of a meteorite impact are deemed to be much more severe than its possible radiological consequences. The justification for excluding this FEP from further analysis is documented in the FEP record in the SR-Site FEP catalogue and the FEP tables containing the documentation of the handling of NEA Project FEPs associated with this SR-Site FEP are linked to the SR-Site FEP record in the database.

4.4 Biosphere FEPs

In SR-Can, provisional Biosphere FEPs were defined and included in the SR-Can FEP catalogue, for traceability reasons /SKB 2006b/. In SR-Site, new biosphere FEPs have been defined based on the content of the SR-Site Biosphere process report /SKB 2010m/. In total, 51 biosphere process FEPs are included in the SR-Site FEP catalogue, each represented by a FEP record in the FEP database with record identities Bio01 to Bio51 (see Table 5-8 in Section 5.5). All NEA Project FEPs associated with these SR-Site biosphere process FEPs have been checked by the experts involved in the biosphere analyses for SR-Site and the handling of each NEA Project FEP has been documented and included in the FEP database. FEP tables with the documented handling are also provided in Appendix 10.

4.5 Methodology issues

A large number of the NEA Project FEPs are related to basic assumptions for the assessment and to the methodology adopted for the assessment. Most of them are of a very general nature and it could be argued that these issues are not FEPs in the sense that they affect the future evolution of a repository. However, for the sake of comprehensiveness, these issues were, in SR-Can, also propagated to the SR-Can FEP catalogue and associated with two SR-Can FEPs, “Assessment basis” (Meth01) and “Assessment methodology” (Meth02) /SKB 2006b/.

The audit in SR-Site of the new NEA Project FEPs in version 2.1 of the NEA FEP database has not resulted in any need for modifications. Therefore, the SR-Site FEP catalogue contains the same methodology FEPs as the SR-Can FEP catalogue. NEA Project FEPs and Matrix interactions assigned to these two SR-Site FEPs have been checked against the basic assumptions in the SR-Site assessment and the assessment methodology and the result is documented in the SKB FEP database and linked to the SR-Site FEP records in the SR-Site FEP catalogue.

As in SR-Can, NEA Project FEPs categorised as belonging to the assessment basis in SR-Site relate to:

- Biological evolution that might lead to other effects of radiation in the future compared with today.
- Changes in society’s ability to treat cancer or its view on radiation hazards.
- Issues that are addressed in the environmental impact assessment rather than in the safety assessment.

In addition, NEA Project FEPs concerning technological advances in food production have been assigned to this SR-Site FEP.

NEA Project FEPs associated with the SR-Site FEP “Assessment methodology” are, as in SR-Can, related to data and modelling issues such as correlations and uncertainties, design issues and implementation of various features in the modelling.

5 The SR-Site FEP catalogue

Based on the FEP processing conducted in SR-Can, an SR-Can FEP catalogue was established. In SR-Site, the SR-Can FEP catalogue has been further developed using the outcome of the complementary FEP processing described in the previous chapters. The resulting SR-Site FEP catalogue contains all FEPs defined for the SR-Site assessment. The SR-Site FEP catalogue is included in the SKB FEP database together with registers for documentation of the FEP processing results. The SKB FEP database also encompasses the SR-97 version and the SR-Can version of the FEP database (see Figure 2-4 in Section 2.3.1). The SR 97 version contains the SR 97 processes and variables. The SR-Can and SR-Site versions contain all FEPs in the NEA database and in the national databases linked to the NEA database, versions 1.2 and 2.1, respectively, including the classification and characteristics of these FEPs. The content of the SR-Site FEP catalogue and the information it provides are described in this chapter. An electronic version of the SKB FEP database is available on a CD together with instructions on how to navigate in the FEP database.

5.1 General

The SR-Site FEP catalogue contains FEPs for the following categories.

- Initial state FEPs.
- Processes in fuel, canister, buffer, backfill, tunnel plug, central area, top seal, bottom plate in deposition holes, borehole seals and geosphere.
- Variables in fuel, canister, buffer, backfill, tunnel plug, central area, top seal, bottom plate in deposition holes, borehole seals and geosphere.
- Biosphere FEPs.
- External FEPs.
- Methodology issues.

In addition, there is a possibility to enter in the FEP catalogue any issue that is, for whatever reason, identified as relevant for the safety assessment. For SR-Can, some site-specific issues identified in the preliminary safety evaluation of the sites were included /SKB 2006b/. For Forsmark these issues concerned the potential impact of nearby nuclear power plants and the power cable to Finland and the effect of a deep mine excavation near, but outside, the tectonic lens at Forsmark. For SR-Site, no additional issues that are not covered by FEPs already included in the SR-Site FEP catalogue have been identified.

In the FEP catalogue, each SR-Site FEP is represented by a FEP record containing the SR-Site FEP ID, the FEP name, a short description/definition, a summary of the handling of the FEP in SR-Site and references to reports where more extensive documentation of the FEP and its handling are to be found. An example is given in Figure 5-1. More FEP-type specific information is also accessible through the FEP records. This is further discussed in the following sections.

In total, the SR-Site FEP catalogue contains 407 FEP records. As shown in Appendix 3 to 10, one FEP in the SR-Site catalogue can be linked to a large number of NEA Project FEPs.

5.2 Initial state FEPs

The initial state FEPs in the SR-Site FEP catalogue are related to deviations from the intended reference initial state of the engineered barrier system components or to more general deviations. These FEPs are listed in Table 5-1. Initial state FEPs in the SR-Site FEP catalogue that are related to the reference initial state are handled in the category “variables” in the SR-Site FEP catalogue (see Section 5.4).

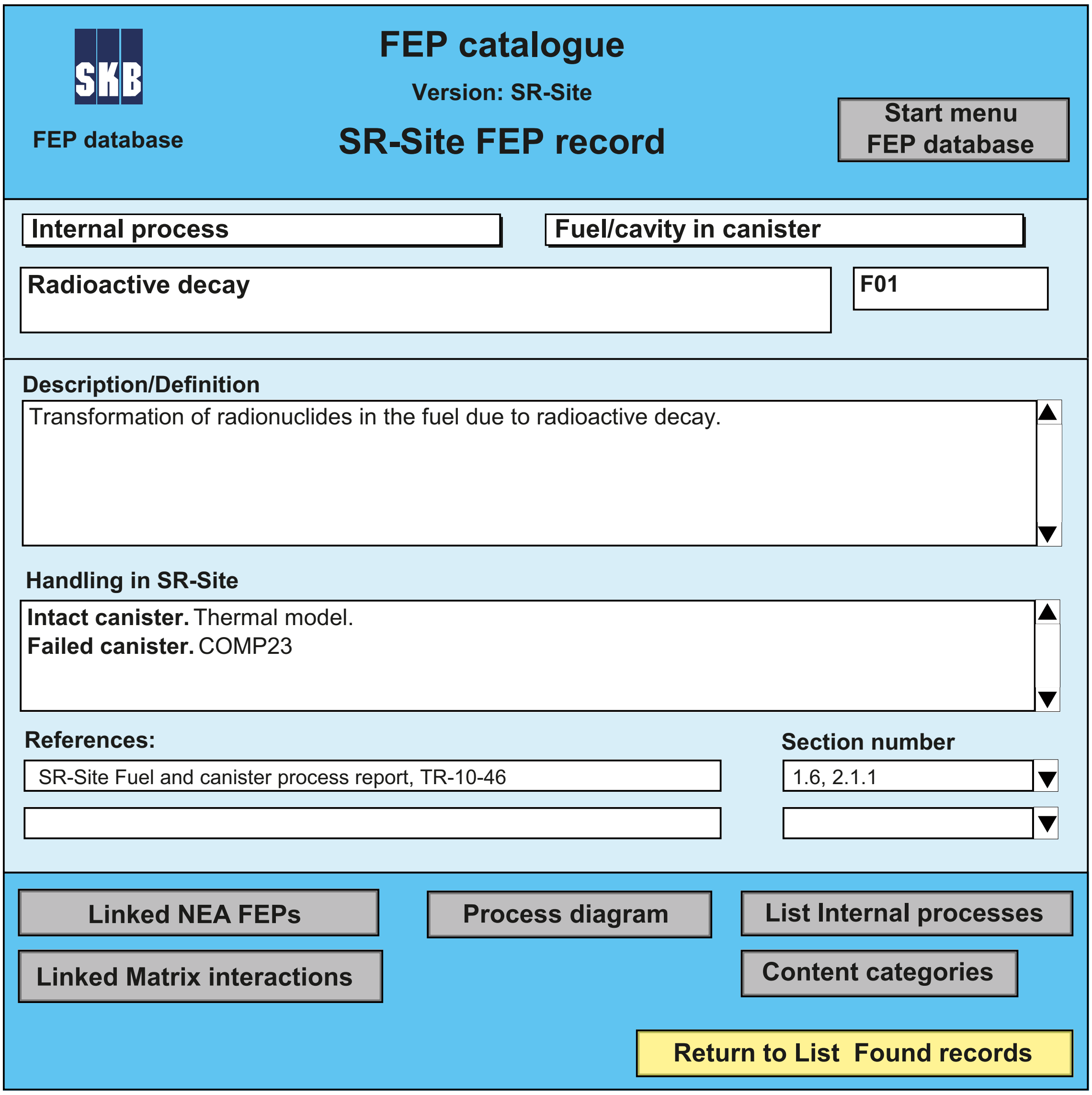

***Figure 5-1.** Print-out from the SR-Site FEP catalogue to illustrate the basic information available for each SR-Site FEP.*

As mentioned in Section 4.2, two of these FEPs (ISGen01 and ISGen04) are excluded from the assessment. This and the reasons for exclusion are documented in the FEP records. The remainder of the more general FEPs and the initial state FEPs for the engineered barrier system components were considered in the reference evolution, the scenario selection and scenario analysis in SR-Site. The handling of these FEPs in the analysis is documented in the FEP record and reference is given to the appropriate section in the SR-Site Main report /SKB 2011/ where the handling is described.

Other information accessed via the Initial state FEP records in the FEP catalogue is lists of NEA Project FEPs associated with each SR-Site FEP and if and how these are addressed by the SR-Site FEP, including the documentation related to the FEP. The FEP tables showing the handling of the NEA Project FEPs associated with SR-Site Initial state FEPs are provided in Appendix 3.

Table 5-1. Initial state FEPs in the SR-Site FEP catalogue.

FEP ID	FEP name	Description
ISGen01	Major mishaps/accidents/ sabotage	Major mishaps/accidents like fire, explosions, earthquakes and flooding in encapsulation plant, during transport and repository operation. Possible decontamination following severe mishap. Ditto sabotage (chemical, physical etc), improper management.
ISGen02	Effects of phased operation	Phased operation mainly affects the geosphere and the subsequent development of the entire repository. The hydrological state of the bedrock is perturbed as soon as repository excavation starts (a smaller perturbation even occurs earlier during site investigations). Different parts of the repository, completed at different times, will be exposed to different hydrological conditions, affecting e.g. the saturation of the buffer and backfill. Possible upconing of saline water could also vary between different parts of repository due to phased operation. Other factors to consider are the effects of blasting and underground traffic on completed parts of the repository. All these issues are part of the expected evolution of the repository, but are not automatically captured in the system of processes describing the repository evolution over time or by the initial state descriptions. As they need to be adequately included in the discussion of the repository evolution, they are propagated to the analysis of the reference evolution.
ISGen03	Incomplete closure	Concerns the effects of an unsealed, abandoned repository.
ISGen04	Monitoring activities	Implications of monitoring activities, including underground monitoring boreholes, on long-term safety.
ISC01	Mishaps – canister	Concerns mishandling and breakage of a canister during manufacturing, sealing, transport and deposition. Random defects are considered, despite quality control in manufacturing and sealing. A number of defects may be related by a common cause, despite quality control in manufacturing and sealing.
ISC02	Design deviations – canister	Welding or material defects (geometry, material composition), e.g. loss of ductility due to impurities in the copper material or bad manufacturing methods or “cold cracks” due to bad manufacturing methods. Random defects despite quality control in manufacturing and sealing. A number of defects may be related by a common cause, despite quality control in manufacturing and sealing.
ISBu01	Mishaps – buffer	Faulty or deviating buffer emplacement caused by e.g. difficulties due to inflow, problems with remote control handling, etc leading to e.g. inhomogeneous buffer and/or reduced density.
ISBu02	Design deviations – buffer	Deviations in buffer properties despite quality control.
ISBfT01	Mishaps – backfill in tunnels	Faulty or deviating backfill emplacement due to e.g. difficulties due to inflow, etc leading to e.g. inhomogeneous backfill.
ISBfT02	Design deviations – backfill in tunnels	Deviations in backfill properties despite quality control.
ISBP01	Mishaps – bottom plate in deposition holes	Faulty or deviating emplacement of bottom plate in deposition holes.
ISBP02	Design deviations – bottom plate in deposition holes	Deviations in structural material (concrete bottom plate) properties despite quality control.
ISPg01	Mishaps – plugs	Faulty or deviating emplacement of plugs.
ISPg02	Design deviations – plugs	Deviations in plug properties despite quality control.
ISCA01	Mishaps – central area	Faulty or deviating backfill emplacement in central area due to e.g. difficulties due to inflow, etc leading to e.g. inhomogeneous backfill.
ISCA02	Design deviations – central area	Deviations in central area backfill properties despite quality control.
ISTS01	Mishaps/Design deviations – top seal	Faulty or deviating top seal emplacement leading to e.g. inhomogeneity and deviations in top seal properties despite quality control.
ISBhS01	Mishaps/Design deviations – borehole seals	Faulty or deviating emplacement of borehole seals and deviations in properties despite quality control.

5.3 Process FEPs

All processes included in the SR-Site process reports are represented by a FEP record in the SR-Site FEP catalogue. The SR-Site FEP IDs and references to the corresponding process descriptions for all process FEPs are given in Table 5-2 (Fuel processes), Table 5-3 (Canister processes), Table 5-4 (Buffer processes), Table 5-5 (Backfill processes and in Table 5-6 (Geosphere processes). This information is included in the FEP records in the FEP-catalogue together with a few lines describing the process and the handling in SR-Site as provided in the summary tables in the introductory chapters in the SR-Site process reports. The SR-Site FEP catalogue also contains FEP records for processes in the tunnel plug, central area, top seal, bottom plate in deposition holes and borehole seals. The SR-Site FEP IDs and references to the corresponding process descriptions for these process FEPs are given in Table 5-7.

As for the Initial state FEPs, lists of NEA Project FEPs and Matrix interactions associated with the SR-Site Process FEPs are linked to the SR-Site FEP records as are also tables with documentation of the handling of the linked NEA Project FEPs and Matrix interactions. Examples of FEP tables showing the handling of NEA Project FEPs as documented in the FEP database are provided in Appendices 4 through 8.

Within a system component, each process is influenced by one or several of the variables describing the state of the component, and the process, in turn, influences one or several of the variables. These couplings within a system component are described by influence tables, one for each process, in the process reports. These influence tables have been included in the SKB FEP database and are accessible via the process FEP records as are also process diagrams that are generated based on the contents of the influence diagrams. This is further described in Section 5.9.

Table 5-2. SR-Site process FEPs for the system component Fuel/cavity in canister and reference to the corresponding process description in the SR-Site Fuel and canister process report /SKB 2010j/.

SR-Site FEP ID	SR-Site FEP name	Section in SR-Site process report
F01	Radioactive decay	2.1.1
F02	Radiation attenuation/heat generation	2.1.2
F03	Induced fission (criticality)	2.1.3
F04	Heat transport	2.2.1
F05	Water and gas transport in canister cavity, boiling/condensation	2.3.1
F06	Mechanical cladding failure	2.4.1
F07	Structural evolution of fuel matrix	2.4.2
F08	Advection and diffusion	2.5.1
F09	Residual gas radiolysis/ acid formation	2.5.2
F10	Water radiolysis	2.5.3
F11	Metal corrosion	2.5.4
F12	Fuel dissolution	2.5.5
F13	Dissolution of gap inventory	2.5.6
F14	Speciation of radionuclides, colloid formation	2.5.7
F15	Helium production	2.5.8
F16	Chemical alteration of the fuel matrix	2.5.9
F17	Radionuclide transport	2.6

Table 5-3. SR-Site process FEPs for the system component Cast iron insert and copper canister and reference to the corresponding process description in the SR-Site Fuel and canister process report /SKB 2010j/.

SR-Site FEP ID	SR-Site FEP name	Section in SR-Site process report
C01	Radiation attenuation/ heat generation	3.1.1
C02	Heat transport	3.2.1
C03	Deformation of cast iron insert	3.4.2
C04	Deformation of copper canister from external pressure	3.4.3
C05	Thermal expansion (both cast iron insert and copper canister)	3.4.4
C06	Copper deformation from internal corrosion products	3.4.5
C07	Radiation effects	3.4.6
C08	Corrosion of cast iron insert	3.5.1
C09	Galvanic corrosion	3.5.2
C10	Stress corrosion cracking of cast iron insert	3.5.3
C11	Corrosion of copper canister	3.5.4
C12	Stress corrosion cracking of the copper canister	3.5.5
C13	Earth currents – stray current corrosion	3.5.6
C14	Deposition of salts on canister surface	3.5.7
C15	Radionuclide transport	3.6

Table 5-4. SR-Site process FEPs for the system component Buffer and reference to the corresponding process description in the SR-Site Buffer, backfill and closure process report /SKB 2010k/.

SR-Site FEP ID	SR-Site FEP name	Section in SR-Site process report
Bu01	Radiation attenuation/ heat generation	3.1.1
Bu02	Heat transport	3.2.1
Bu03	Freezing	3.2.2
Bu04	Water uptake and transport for unsaturated conditions	3.3.1
Bu05	Water transport for saturated conditions	3.3.2
Bu06	Gas transport/dissolution	3.3.3
Bu07	Piping/erosion	3.3.4
Bu08	Swelling/mass redistribution	3.4.1
Bu09	Liquefaction	3.4.2
Bu10	Advective transport of species	3.5.2
Bu11	Diffusive transport of species	3.5.3
Bu12	Sorption (including exchange of major ions)	3.5.5
Bu13	Alterations of impurities	3.5.6
Bu14	Aqueous speciation and reactions	3.5.7
Bu15	Osmosis	3.5.8
Bu16	Montmorillonite transformation	3.5.9
Bu17	Iron-bentonite interaction	3.5.10
Bu18	Montmorillonite colloid release	3.5.11
Bu19	Radiation-induced transformations	3.5.12
Bu20	Radiolysis of porewater	3.5.13
Bu21	Microbial processes	3.5.14
Bu22	Cementation	3.5.15
Bu23	Colloid transport	3.5.4
Bu24	Speciation of radionuclides	3.6.1
Bu25	Transport of radionuclides in the water phase	3.6.2
Bu26	Transport of radionuclides in a gas phase	3.6.3

Table 5-5. SR-Site process FEPs for the system component Backfill in tunnels and reference to the corresponding process description in the SR-Site Buffer, backfill and closure process report /SKB 2010k/.

SR-Site FEP ID	SR-Site FEP name	Section in SR-Site process report
BfT01	Heat transport	4.1.1
BfT02	Freezing	4.1.2
BfT03	Water uptake and transport for unsaturated conditions	4.2.1
BfT04	Water transport for saturated conditions	4.2.2
BfT05	Gas transport/dissolution	4.2.3
BfT06	Piping/erosion	4.2.4
BfT07	Swelling/mass redistribution	4.3.1
BfT08	Liquefaction	4.3.2
BfT09	Advective transport of species	4.4.1
BfT10	Diffusive transport of species	4.4.2
BfT11	Sorption (including exchange of major ions)	4.4.3
BfT12	Alterations of backfill impurities	4.4.4
BfT13	Aqueous speciation and reactions	4.4.5
BfT14	Osmosis	4.4.6
BfT15	Montmorillonite transformation	4.4.7
BfT16	Backfill colloid release	4.4.8
BfT17	Radiation-induced transformations	4.4.9
BfT18	Microbial processes	4.4.10
BfT19	Colloid formation and transport	– [1]
BfT20	Speciation of radionuclides	4.5.1
BfT21	Transport of radionuclides in the water phase	4.5.2
BfT22	Transport of radionuclides by a gas phase	– [2]

[1] This process is not specifically addressed in the Buffer, backfill and closure process report, but the corresponding process is described in the Geosphere process report, see Ge18 in Table 5-6

[2] This process is not specifically addressed in the Buffer, backfill and closure process report, but in Section 13.8 in the SR-Site Main report /SKB 2011/.

Table 5-6. SR-Site process FEPs for the system component Geosphere and reference to the corresponding process description in the SR-Site Geosphere process report /SKB 2010h/.

SR-Site FEP ID	SR-Site FEP name	Section in SR-Site process report
Ge01	Heat transport	2.1
Ge02	Freezing	2.2
Ge03	Groundwater flow	3.1
Ge04	Gas flow/dissolution	3.2
Ge05	Displacements in intact rock	4.2
Ge06	Reactivation – Displacement along existing discontinuities	4.3
Ge07	Fracturing	4.4
Ge08	Creep	4.5
Ge09	Surface weathering and erosion	1)
Ge10	Erosion/sedimentation in fractures	4.6
Ge11	Advective transport/mixing of dissolved species	5.2
Ge12	Diffusive transport of dissolved species in fractures and rock matrix	5.3
Ge13	Speciation and sorption	5.4
Ge14	Reactions groundwater/rock matrix	5.5
Ge15	Dissolution/precipitation of fracture-filling minerals	5.6
Ge16	Microbial processes	5.7
Ge17	Degradation of grout	5.8
Ge18	Colloidal processes	5.9
Ge19	Formation/dissolution/reaction of gaseous species	5.10
Ge20	Methane hydrate formation	5.11
Ge21	Salt exclusion	5.12
Ge22	Radiation effects (rock and grout)	5.13
Ge23	Earth currents	5.14
Ge24	Transport of radionuclides in the water phase	6.1
Ge25	Transport of radionuclides in the gas phase	6.2

[1] In SR-Site classified as a Climate process and included as a Climate FEP in the SR-Site FEP catalogue (Cli11), see Table 5-10.

Table 5-7. SR-Site process FEPs for the system components Tunnel plugs (Pg), Central area (CA), Top seal (TS), Bottom plate in deposition holes (BP) and Borehole seals (BhS) and reference to the corresponding process description in the SR-Site Buffer, backfill and closure process report /SKB 2010k/.

SR-Site FEP ID	SR-Site FEP name	Section in SR-Site process report
BP01, Pg01, CA01, TS01, BhS01	Heat transport	8.1.1, 5.1.1, 6.1.1, 7.1.1, 9.1.1
BP02, Pg02, CA02, TS02, BhS02	Freezing	8.1.2, 5.1.2, 6.1.2, 7.1.2, 9.1.2
BP03, Pg03, CA03, TS03, BhS03	Water uptake and transport under unsaturated conditions	8.2.1, 5.2.1, 6.2.1, 7.2.1, 9.2.1
BP04, Pg04, CA04, TS04, BhS04	Water transport under saturated conditions	8.2.2, 5.2.2, 6.2.2, 7.2.2, 9.2.2
BP05, Pg05, CA05, TS05, BhS05	Gas transport/dissolution	8.2.3, 5.2.3, 6.2.3, 7.2.3, 9.2.3
BP06, Pg06, CA06, TS06, BhS06	Piping/erosion	8.2.4, 5.2.4, 6.2.4, 7.2.4, 9.2.4
BP07, Pg07, CA07, TS07, BhS07	Swelling/mass redistribution	8.3.1, 5.3.1, 6.3.1, 7.3.1, 9.3.1
Pg08, CA08, TS08, BhS08	Liquefaction	2.4.3, 6.3.2, 7.3.2, 9.3.2
BP08, Pg09, CA09, TS09, BhS09	Advective transport of species	8.4.1, 5.4.1, 6.4.1, 7.4.1, 9.4.1
BP09, Pg10, CA10, TS10, BhS10	Diffusive transport of species	8.4.2, 5.4.2, 6.4.2, 7.4.2, 9.4.2
BP10, Pg11, TS11, BhS11	Sorption (including exchange of major ions)	8.4.3, 5.4.3, 7.4.3, 9.4.3
CA11	Sorption	6.4.3
CA12	Alteration of central area backfill	6.4.4
BP11, Pg12, TS12, BhS12	Alteration of concrete	8.4.4, 5.4.4, 7.4.4, 9.4.4
CA15	Alteration of concrete components	6.4.5
BP12, Pg13, CA13, TS13, BhS13	Aqueous speciation and reactions	8.4.5, 5.4.5, 6.4.5, 7.4.5, 9.4.5
BP13, BhS14	Copper corrosion	8.4.6, 9.4.6,
BhS15	Alterations of impurities in bentonite	9.4.7
Pg14, CA14, BhS16	Osmosis	5.4.6, 6.4.7, 9.4.8
Pg15, BhS17	Montmorillonite transformation	5.4.7, 9.4.9
Pg16, BhS18	Montmorillonite colloid release	5.4.8, 9.4.10
TS14	Colloid release	7.4.6
TS15	Steel corrosion	7.4.7
CA16	Corrosion of steel components	6.4.8
BP14, Pg17, CA17, TS16, BhS19	Microbial processes	8.4.7, 5.4.9, 6.4.9, 7.4.8, 9.4.11
BP15, Pg18, CA18, TS17, BhS21	Speciation of radionuclides	8.5.1, 5.5.1, 6.5.1, 7.5.1, 9.5.1
BP16, Pg19, CA19, TS18, BhS22	Transport of radionuclides in the water phase	8.5.2, 5.5.2, 6.5.2, 7.5.2, 9.5.2

5.4 Variables

These FEPs are the variables needed to describe the evolution of the state of the engineered barrier system components and the geosphere over time. They are thus essentially tables with definitions. The identification of variables has been made by the experts responsible for the documentation of the processes relevant to long-term safety. The sets of variables were established in conjunction with the documentation of the processes, since it had to be ensured that the variable sets were suited to describing all conceivable alterations of the barrier properties as a result of the long-term processes.

The variable FEPs are either related to the reference initial state of the system components or to the evolution in states as a result of on-going processes. This is also reflected in the NEA Project FEPs and Matrix interactions associated with the SR-Site variables. The documentation of the handling of these aspects linked to the SR-Site variables is therefore of two kinds, where one relates to the aspects being addressed in the description of the initial state and the other to the impact of system processes on the state. In SR-Can, documentation relating to the initial state was made in cooperation with the person responsible for developing the description of the reference initial state (Karin Pers, Kemakta Konsult), whereas documentation of the impact of processes was made by the person responsible for the FEP database (Kristina Skagius) based on the documented handling of processes provided by the experts developing the process descriptions. In SR-Site, the SR-Can documentation has been revisited and updated as appropriate by Kristina Skagius. As for other FEP records in the SR-Site FEP catalogue, these tables, together with the documented handling, are accessible via the FEP records. In addition, each variable record contains a reference to the description of the reference initial state for that variable. For the engineered barrier system, this reference is to the appropriate section in the SR-Site Production reports /SKB 2010a, b, c, d, e, f/. For variables in the geosphere system, reference is given to the section in the SR-Site Data report /SKB 2010l/ where data for this variable are assessed.

For the system components "Fuel/cavity in canister", "Cast iron insert and copper canister", "Buffer", "Backfill in tunnels" and "Geosphere", the variables are the same as those defined in SR-Can, with only some small modifications mainly in the naming of the variables. The SR-Site FEP identity, FEP name and definitions of these variables are given in tables in Appendix 2.

5.5 Biosphere FEPs

Processes and interactions between components in the biosphere that may be important in a safety assessment for radioactive waste disposal are described in a biosphere process report developed for SR-Site /SKB 2010m/. The basis for the descriptions is a biosphere interaction matrix that has been used to support the biosphere analyses in SR-Site and which is a further development of the interaction matrix set up for the safety assessment of the Swedish repository for low and intermediate level waste (SFR), the SAFE project /SKB 2001/. In the interaction matrix, components of the biosphere are included as diagonal elements and process interactions between the components as off-diagonal elements in the matrix.

In total, the biosphere interaction matrix for SR-Site contains 51 process interactions and 15 system components. For each process interaction in the matrix a corresponding process FEP record is included in the FEP database. The SR-Site FEP IDs and references to the corresponding process definitions for all process FEPs are given in Table 5-8. The NEA Project FEPs (version 2.1) that are associated with each of these SR-Site biosphere FEPs are linked to the appropriate FEP record in the SR-Site FEP catalogue. In addition, FEP tables with the documented handling of each NEA project FEP are linked to the SR-Site FEP records. These FEP tables showing the handling of NEA Project FEPs as documented in the FEP database are provided in Appendix 10.

FEP records for the components of the biosphere, as defined in the biosphere interaction matrix, are also included in the FEP catalogue. This makes it possible to reproduce the SR-Site biosphere interaction matrix in the FEP database and make all documentation accessible from an electronic version of the interaction matrix, as well as to use the electronic version in the FEP database as a tool for further developments of the interaction matrix. These SR-Site FEPs for the biosphere components are listed in Table 5-9.

Table 5-8. SR-Site process FEPs for the biosphere and reference to the corresponding process description in the Biosphere process report /SKB 2010m/.

SR-Site FEP ID	SR-Site FEP name	Section in SR-Site process report
Bio01	Bioturbation	6.1.1
Bio02	Consumption	6.1.2
Bio03	Death	6.1.4
Bio04	Decomposition	6.1.3
Bio05	Excretion	6.1.5
Bio06	Food supply	6.1.6
Bio07	Growth	6.1.7
Bio08	Habitat supply	6.1.8
Bio09	Intrusion	6.1.9
Bio10	Material supply	6.1.10
Bio11	Movement	6.1.11
Bio12	Particle release/trapping	6.1.12
Bio13	Primary production	6.1.13
Bio14	Stimulation/inhibition	6.1.14
Bio15	Uptake	6.1.15
Bio16	Anthropogenic release	6.2.1
Bio17	Material use	6.2.2
Bio18	Species introduction/extermination	6.2.3
Bio19	Water use	6.2.4
Bio20	Change of pressure	6.3.1
Bio21	Consolidation	6.3.2
Bio22	Element supply	6.3.3
Bio23	Loading	6.3.4
Bio24	Phase transitions	6.3.5
Bio25	Physical properties change	6.3.6
Bio26	Reactions	6.3.7
Bio27	Sorption/desorption	6.3.8
Bio28	Water supply	6.3.9
Bio29	Weathering	6.3.10
Bio30	Wind stress	6.3.11
Bio31	Acceleration	6.4.1
Bio32	Convection	6.4.2
Bio33	Covering	6.4.3
Bio34	Deposition	6.4.4
Bio35	Export	6.4.5
Bio36	Import	6.4.6
Bio37	Interception	6.4.7
Bio38	Relocation	6.4.8
Bio39	Resuspension	6.4.9
Bio40	Saturation	6.4.10
Bio41	Decay	6.5.1
Bio42	Exposure	6.5.2
Bio43	Heat storage	6.5.3
Bio44	Irradiation	6.5.7
Bio45	Light-related processes	6.5.4
Bio46	Radiolysis	6.5.5
Bio47	Radionuclide release	6.5.6
Bio48	Change in rock surface location	6.6.1
Bio49	Sea level change	6.6.2
Bio50	Terrestrialisation	6.6.3
Bio51	Thresholding	6.6.4

Table 5-9. SR-Site FEPs for the components of the biosphere and reference to the corresponding description in the Biosphere process report /SKB 2010m/.

SR-Site FEP ID	SR-Site FEP name	Section in SR-Site process report
CompBio01	Geosphere[1]	5.1
CompBio02	Regolith	5.2
CompBio03	Primary producers	5.3
CompBio04	Decomposers	5.4
CompBio05	Filter feeders	5.5
CompBio06	Herbivores	5.6
CompBio07	Carnivores	5.7
CompBio08	Humans	5.8
CompBio09	Water in regolith	5.9
CompBio10	Surface water	5.10
CompBio11	Water composition	5.11
CompBio12	Gas and local atmosphere	5.12
CompBio13	Temperature	5.13
CompBio14	Radionuclides	5.14
CompBio15	External conditions[1]	5.15

[1] These components are included in the biosphere interaction matrix in order to capture interactions with the geosphere and impacts from external conditions through biosphere process interactions recorded in the appropriate off-diagonal elements in the matrix.

5.6 External FEPs

External FEPs included in the SR-Site FEP catalogue are Climate FEPs (Table 5-10), Large-scale geological FEPs (Table 5-11) and FHA FEPs (Table 5-12). In addition, the FEP catalogue contains one single FEP in the category "Other" – Oth01 Meteorite impact.

As with the process FEP records, the external FEP records contain a short description, a brief note on their handling in SR-Site and references to the SR-Site reports where the SR-Site FEP and its handling are described. As described in Section 4.3, lists of NEA Project FEPs (version 2.1) associated with the SR-Site FEPs and tables with notes on how the aspects identified in the NEA Project FEPs are addressed in the SR-Site FEP are also included in the FEP database and accessible from the SR-Site FEP record. Printouts of these FEP tables are provided in Appendix 9.

Table 5-10. SR-Site Climate FEPs and references to corresponding descriptions in the SR-Site Climate report /SKB 2010g/.

SR-Site FEP ID	SR-Site FEP name	Section in SR-Site Climate report
Cli01	Climate system – Components of the climate system	2.1
Cli02	Climate system – Climate forcing	2.2
Cli03	Climate system – Climate dynamics	2.3
Cli04	Climate system – Climate in Sweden and Forsmark	2.4
Cli05	Climate related issues – Development of permafrost	3.4
Cli06	Climate related issues – Ice-sheet dynamics	3.1
Cli07	Climate related issues – Ice–sheet hydrology	3.2
Cli08	Climate related issues – Glacial isostatic adjustment	3.3
Cli09	Climate related issues – Shoreline migration	3.3
Cli10	Climate related issues – End-glacial faulting	1)
Cli11	Climate related issues – Denudation	3.5

[1)] Classified as a large-scale geological process and included in FEP LSGe02 in the SR-Site FEP catalogue.

Table 5-11. SR-Site Large-scale geological FEPs and references to corresponding descriptions in the SR-Site Geosphere process report /SKB 2010h/.

SR-Site FEP ID	SR-Site FEP name	Section in SR-Site Geosphere process report
LSGe01	Mechanical evolution of the Shield	4.1.2
LSGe02	Earthquakes	4.1.3

Table 5-12. SR-Site FHA FEPs and references to corresponding descriptions in the SR-Site FHA report /SKB 2010i/.

SR-Site FEP ID	SR-Site FEP name	Section in SR-Site FHA report
FHA01	General considerations	2
FHA02	Societal analysis, considered societal aspects	5.2
FHA03	Technical analysis, general aspects	4.2
FHA04	Technical analysis, actions with thermal impact and purpose	4.4
FHA05	Technical analysis, actions with hydraulic impact and purpose	4.5
FHA06	Technical analysis, actions with mechanical impact and purpose	4.6
FHA07	Technical analysis, actions with chemical impact and purpose	4.7

5.7 Site-specific factors

The FEP catalogue allows entry of any issue that is, for whatever reason, identified as relevant for the safety assessment. For SR-Can, some site-specific issues identified in the preliminary safety evaluation of the sites were included. One of these is specifically related to the Laxemar site (SiteFact01 Äspö HRL) and has, therefore, been removed from the SR-Site FEP catalogue. For SR-Site, no additional issues that are not covered by FEPs already included in the SR-Site FEP catalogue have been identified. This means that the SR-Site FEP catalogue contains three FEP records in this category.

The FEP SiteFact02 "Construction of nearby rock facilities" relates to the impact of future construction of rock facilities similar to the existing repository for low-level waste at Forsmark (SFR). Such potential future events have been considered in the selection and analysis of scenarios related to future human actions, which is reported in Section 6.4 in the SR-Site FHA report /SKB 2010i/.

The FEP SiteFact03 "Nearby nuclear power plant" related to the potential impact of the nearby nuclear power plant at Forsmark and specifically the power cable to Finland. Corrosion has been observed in down-hole sampling equipment in a borehole at Forsmark, and the effect has been attributed to the influence of electric power cables. Since "Earth currents" is one of the processes included in the Geosphere process report /SKB 2010h/ and "Earth currents – Stray current corrosion" is included in the Fuel and canister process report /SKB 2010j/, it is judged that this site-specific factor is covered by the descriptions and handling of the processes as reported in the process reports. Therefore, references to these two process descriptions are given in the FEP record for SiteFact03.

The FEP SiteFact04 "Mine excavation" relates to the effect of a mine excavation near the repository, but outside the tectonic lens at Forsmark. Such a potential future event has been considered in the selection and analysis of scenarios related to future human actions, which is reported in Section 6.5 in the SR-Site FHA report /SKB 2010i/.

5.8 Methodology issues

Although not regarded as FEPs in a strict sense, two FEP records to cover methodological issues are included in the FEP catalogue. These are Meth01 "Assessment basis" and Meth02 "Assessment methodology". The basis for including these FEPs and their meaning are already discussed in Section 4.5 and this material is not repeated here.

5.9 Couplings included in the FEP database

FEPs are coupled in several ways and on several levels, and the FEP database is used as a tool for documentation and visualisation of some of them. This is further described in the following sections.

5.9.1 Influence tables and process diagrams

Within a system component, each process is influenced by one or several of the variables describing the state of the component, and the process, in turn, influences one or several of the variables. These couplings within a system component are described by influence tables, one for each process, in the SR-Site process reports. These influence tables have been included in the SKB FEP database. Based on these influence tables, process diagrams are automatically generated for each process and for each system component in the FEP database. The process diagram for a system component essentially takes the form of a table with the processes as rows and the variables as columns. The table matrix consists of arrows describing the influences between processes and variables.

Both the process diagrams and the underlying influence tables are accessible via the process FEP records in the FEP catalogue. An example is given in Figure 5-2, which shows the process diagram for the fuel process Radiation attenuation/heat generation (F02). The presence of an arrow or not and its colour are automatically generated based on the contents of the influence tables. A green arrow means that the influence is neglected and a red arrow represents an influence that is handled in SR-Site. For the system components that are most important for repository safety, i.e. the fuel, the canister, the buffer, the tunnel backfill and the geosphere, the adjacent system components and the interactions over the boundaries are also indicated in the process diagram.

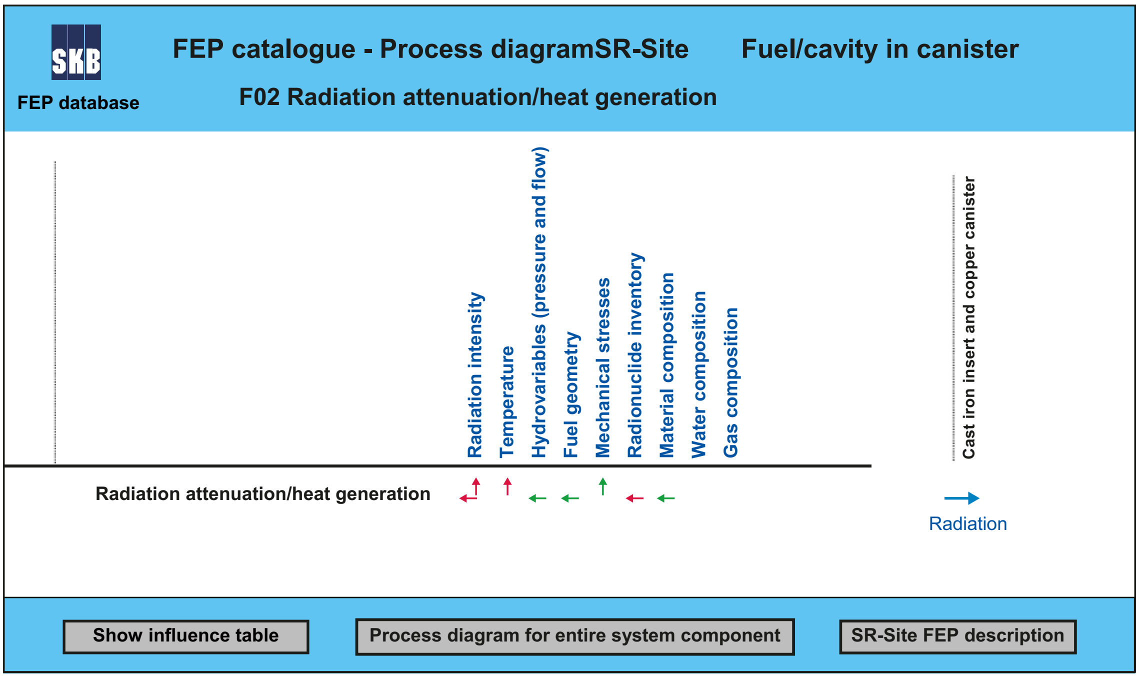

Figure 5-2. Example of a process diagram generated in the FEP database and accessible from the FEP records in the SR-Site FEP catalogue. Interactions between the variables defined for the system component and the process are shown by arrows that are coloured red if they are handled in the assessment or green if they are neglected. Interactions over the boundary to adjacent system components are also indicated. In this example radiation is transferred to the cast iron insert and copper canister.

5.9.2 FEP chart and link to process tables

In order to provide an overview of the relationship between initial state factors, variables, processes and the safety functions of the repository, a FEP chart has been developed. It aids an expert in analysing the system qualitatively, and is used, in combination with other sources, for scenario selection and analysis in SR-Site. This is further described in the SR-Site Main report /SKB 2011, Section 8.5/. This FEP chart is reproduced in the FEP database and the items in the FEP chart are linked to process FEPs in the SR-Site FEP catalogue and the links are displayed in process tables. These process tables summarise the handling of each process in the assessment, as described in Chapter 7 in the SR-Site Main report /SKB 2011/. The process tables are accessed through the process FEP records in the FEP catalogue.

5.9.3 Assessment model flow chart, AMF, and link to process tables

To give an overview of the models used in the evaluation of repository evolution, the dependencies/interactions between them, and data used in the modelling, two assessment model flow charts, AMFs, have been developed. One AMF concerns the excavation/operation and initial temperate period, Figure 7-3 in the SR-Site Main report /SKB 2011/ and one represents permafrost and glacial conditions, Figure 7-4 in the SR-Site Main report /SKB 2011/. These AMFs and a table that provides links between the process FEPs in the process tables and the modelling activities described by the AMF (corresponding to Table 7-7 in the SR-Site Main report /SKB 2011/) are reproduced in the FEP database.

6 Concluding remarks

The development of the SKB FEP database for SR-Can and SR-Site has involved a comprehensive and time-consuming audit against the NEA FEP databases versions 1.2 and 2.1 with only a few additions of new FEPs to the list of SR-Can FEPs and none to the list of SR-Site FEPs as a result. Therefore, the SR-Site FEP catalogue and experience from the SR-Site assessment would be the appropriate starting point for any updates of the FEP catalogue judged as necessary for future safety assessments.

The FEP processing work has been conducted in a systematic way according to defined procedures and instructions involving requirements for documentation of the various steps. In broader terms, both the overall objective to develop a database of features, events and processes in a format that would facilitate both a systematic analysis of FEPs and documentation of the FEP analysis and the primary objective to establish an SR-Site FEP catalogue within the framework of the SKB FEP database have been fulfilled. The lack of final sets of biosphere FEPs as well as process FEPs for the system components not addressed in detail in SR-Can has been handled in SR-Site and the SR-Site FEP catalogue is upgraded with FEPs supported by definitions and descriptions in SR-Site process reports. Concerning the incomplete documentation of the results of the processing of matrix interactions associated with internal processes and variables after the FEP processing in SR-Can, this still remains after the completion of the FEP work in SR-Site. However, these interactions were already used as input to the SR 97 Process report /SKB 1999/ and essential aspects should, therefore, have been propagated to the SR-Can and SR-Site process descriptions through the update of the SR 97 and SR-Can process descriptions, respectively. In addition, the systematic treatment of potential interactions in the process descriptions and the peer review of the process reports where these descriptions are documented strongly support that all relevant FEPs have been considered in the SR-Site assessment.

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Appendix 1

Result of checking the final content of the SKB FEP database – version SR-Site

The corresponding check of the SR-Can version of the FEP database is documented in Appendix 1 of the FEP report for SR-Can /SKB 2006b/.

1. All NEA Project FEPs in version 2.1 of the NEA FEP database are included in the SKB FEP database.

   Yes.

   Number of records in NEA Project FEP register PROFEP = 1,671.

   Number of records in SKB FEP database register NEA Mapping = 1,671.

   No records in the NEA Mapping register with duplicate NEA Project FEP numbers or without NEA Project FEP number found when scrolling through the NEA Project FEP listing in the NEA Mapping register.

2. All NEA Project FEPs included in the SKB FEP database are flagged as Relevant or Not relevant for the SKB repository system.

   Yes.

   Number of records in NEA Mapping register flagged as Not relevant = 370.

   Number of records in NEA Mapping register flagged as Relevant = 1,301.

   Sum of records in NEA mapping register flagged as Not relevant or Relevant = 1,671.

3. All NEA Project FEPs included in the SKB FEP database and flagged as Not relevant for the SKB repository system have a justification documented for their omission.

   Yes.

   Search in NEA mapping register for text in field for documenting reason for not being relevant reveals 370 records, i.e. the number of records flagged as Not relevant.

4. All NEA Project FEPs and Matrix interactions included in the SKB FEP database and flagged as Relevant for the SKB repository system have a documented description of the handling in SR-Site.

   NEA Project FEPs: Yes.

   Checked by comparing records in the NEA mapping register flagged as relevant with records in the register used for documenting the handling in SR-Site.

   Matrix interaction: No. The documentation of handling of Matrix interactions is not complete, see Section 3.2.

5. All processes in process reports, defined categories of initial states, defined external factors, etc have a corresponding record in the SR-Site FEP catalogue register.

   Yes. Except for two processes in the system component “Central area”. These processes are “Colloid release” and “Radiation-induced transformations” (Sections 6.4.10 and 6.4.11 in the Buffer, backfill and closure process report /SKB 2010k/). These processes are related to a system component of small importance for the safety and they are neglected in the SR-Site assessment. Furthermore, they are not included in the process table in the Buffer, backfill and closure process report /SKB 2010k, Table 2-14/. Therefore, this deviation is assessed as acceptable for the SR-Site version and can be corrected in future updates of the FEP catalogue, if required.

   List of SR-Site FEPs in the SR-Site catalogue compared with list of contents of the associated reports. All SR-Site FEP records have a reference to the corresponding section in the associated SR-Site reports.

Appendix 2

SR-Site variable FEPs

Variable FEPs for the system component “Fuel/cavity in canister” and their definitions in the SR-Site FEP catalogue, as provided in the Fuel and canister process report /SKB 2010j, Section 1.5/.

SR-Site FEP ID	SR-Site FEP name	SR-Site definition
VarF01	Radiation intensity	Intensity of alpha, beta, gamma and neutron radiation as a function of time and space in the fuel assembly.
VarF02	Temperature	Temperature as a function of time and space in the fuel assembly.
VarF03	Hydrovariables (pressure and flow)	Flows, volumes and pressures of water and gas as a function of time and space in the cavities in the fuel and the canister.
VarF04	Fuel geometry	Geometric dimensions of all components of the fuel assembly, such as fuel pellets and Zircaloy cladding. Also includes the detailed geometry, including cracking, of the fuel pellets.
VarF05	Mechanical stresses	Mechanical stresses as a function of time and space in the fuel assembly.
VarF06	Radionuclide inventory	Occurrence of radionuclides as a function of time and space in the different parts of the fuel assembly. The distribution of the radionuclides in the pellets between matrix and surface is also described here.
VarF07	Material composition	The materials of which the different components in the fuel assembly are composed, excluding radionuclides.
VarF08	Water composition	Composition of water (including any radionuclides and dissolved gases) in the fuel and canister cavities.
VarF09	Gas composition	Composition of gas (including any radionuclides) in the fuel and canister cavities.

Variable FEPs for the system component “Cast iron insert and copper canister” and their definitions in the SR-Site FEP catalogue, as provided in the Fuel and canister process report /SKB 2010j, Section 1.9/.

SR-Site FEP ID	SR-Site FEP name	SR-Site definition
VarC01	Radiation intensity	Intensity of gamma and neutron radiation as a function of time and space in the cast iron insert and copper canister.
VarC02	Temperature	Temperature as a function of time and space in the cast iron insert and copper canister.
VarC03	Canister geometry	Geometric dimensions of all components of the cast iron insert and copper canister.
VarC04	Material composition	The detailed chemical composition of the materials used for the cast iron insert and copper canister. This also includes cast iron and copper corrosion products.
VarC05	Mechanical stresses	Mechanical stresses as a function of time and space in the cast iron insert and copper canister.

Variable FEPs for the system component “Buffer” and their definitions in the SR-Site FEP catalogue, as provided in the Buffer, backfill and closure process report /SKB 2010k, Section 2.2.2/.

SR-Site FEP ID	SR-Site FEP name	SR-Site definition
VarBu01	Radiation intensity	Intensity of (α-, β-), γ- and neutron radiation as a function of time and space in buffer.
VarBu02	Temperature	Temperature as a function of time and space in buffer.
VarBu03	Water content	Water content as a function of time and space in buffer.
VarBu04	Gas content	Gas contents (including any radionuclides) as a function of time and space in buffer.
VarBu05	Hydrovariables (pressure and flow)	Flows and pressures of water and gas as a function of time and space in buffer.
VarBu06	Buffer geometry	Geometric dimensions for buffer. An example is description of interfaces (on the inside towards the canister and on the outside towards the geosphere).
VarBu07	Pore geometry	Pore geometry as a function of time and space in buffer. The porosity, i.e. the fraction of the volume that is not occupied by solid material, is often given.
VarBu08	Stress state	Stress conditions as a function of time and space in buffer.
VarBu09	Bentonite composition	Chemical composition of the bentonite (including any radionuclides) in time and space in buffer, levels of impurities in time and space in buffer.
VarBu10	Montmorillonite composition	The mean molecular structure of montmorillonite including the type of charge compensating cations.
VarBu11	Porewater composition	Composition of the porewater (including any radionuclides and dissolved gases) in time and space in the buffer.
VarBu12	Structural and stray materials	Chemical composition and quantity of any stray materials accidently left in the buffer. At this stage, no structural materials are defined for this component.

Variable FEPs for the system component “Backfill in tunnels” and their definitions in the SR-Site FEP catalogue, as provided in the Buffer, backfill and closure process report /SKB 2010k, Section 2.3.2/.

SR-Site FEP ID	SR-Site FEP name	SR-Site definition
VarBfT01	Temperature	Temperature as a function of time and space in deposition tunnels.
VarBfT02	Water content	Water content as a function of time and space in deposition tunnels.
VarBfT03	Gas content	Gas content (including any radionuclides) as a function of time and space in deposition tunnels.
VarBfT04	Hydrovariables (pressure and flow)	Flows and pressures of water and gas as a function of time and space in deposition tunnels.
VarBfT05	Backfill geometry	Geometric dimensions for backfill. A description of e.g. interfaces towards buffer and towards the geosphere.
VarBfT06	Backfill pore geometry	Pore geometry as a function of time and space in backfill. The porosity, i.e. the fraction of the volume that is not occupied by solid material, is often given.
VarBfT07	Stress state	Stress state as a function of time and space in backfill.
VarBfT08	Backfill materials – composition and content	Total chemical composition and content of the backfill material (including any radionuclides) in time and space.
VarBfT09	Backfill porewater composition	Composition of the porewater (including any radionuclides and dissolved gases) in time and space in backfill.
VarBfT10	Structural and stray materials	Chemical composition and quantity of structural materials (rock bolts, filling material in boreholes for grouting, nets etc) and stray materials in deposition tunnels.

Variable FEPs for the system component "Geosphere" and their definitions in the SR-Site FEP catalogue, as provided in the Geosphere process report /SKB 2010h, Section 1.4/.

SR-Site FEP ID	SR-Site FEP name	SR-Site definition
VarGe01	Temperature	Temperature in the bedrock as a function of time and space.
VarGe02	Groundwater flow	Groundwater flow as a function of time and space in the geosphere's fracture system.
VarGe03	Groundwater pressure	Groundwater pressure as a function of time and space in the geosphere's fracture system.
VarGe04	Gas phase flow	Gas phase flow as a function of time and space in the geosphere's fracture system.
VarGe05	Repository geometry	Geometric description of deposition holes, tunnels, ramps, boreholes etc; i.e. of all excavated volumes.
VarGe06	Fracture geometry	All cavities, from fracture zones to micropores in the matrix. Also included here is the excavation-disturbed zone (EDZ) and any other geometric changes in the fracture structure induced by construction.
VarGe07	Rock stresses	Rock stresses as a function of time and space.
VarGe08	Matrix minerals	Chemical composition of the rock matrix as a function of (time and) space, i.e. a description of the various minerals that occur and their extent.
VarGe09	Fracture minerals	Chemical composition of the fracture minerals as a function of time and space, i.e. a description of the various fracture-filling minerals that occur. Also the amount and composition of these fracture-filling minerals.
VarGe10	Groundwater composition	Chemical composition of the groundwater as a function of time and space, i.e. concentrations of relevant components in the groundwater. This variable also includes quantities such as Eh and pH, as well as any radionuclides and dissolved gases.
VarGe11	Gas composition	Chemical composition of gases, including any radionuclides and naturally occurring gases, in geosphere cavities.
VarGe12	Structural and stray materials	Chemical composition and quantities of grouts and other structural and stray materials injected/located in fractures in the rock and left there at repository closure.
VarGe13	Saturation	Degree of water saturation of the geosphere

Variable FEPs for the system component "Bottom plate in deposition holes" and their definitions in the SR-Site FEP catalogue, as provided in the Buffer, backfill and closure process report /SKB 2010k, Section 2.7.2/.

SR-Site FEP ID	SR-Site FEP name	SR-Site definition
VarBP01	Temperature	Temperature as a function of time and space in the bottom plate.
VarBP02	Bottom plate water content	Water content as a function of time and space in the bottom plate.
VarBP03	Bottom plate gas content	Gas content as a function of time and space in the bottom plate.
VarBP04	Hydrovariables (pressure and flow)	Flows and pressures of water and gas as a function of time and space in the bottom plate.
VarBP05	Bottom plate geometry	Geometric dimensions of the bottom plate.
VarBP06	Bottom plate pore geometry	Pore geometry as a function of time and space in the plate components. The porosity, i.e. the fraction of the volume that is not occupied by solid material, is often given.
VarBP07	Stress state	Stress conditions as a function of time and space in the bottom plate.
VarBP08	Bottom plate materials – composition and content	Composition of the concrete plate and the copper plate.
VarBP09	Bottom plate porewater composition	Composition of the porewater in time and space in the bottom plate.
VarBP10	Structural and stray materials	(undefined) The structural materials in the bottom plate are already included in the "Bottom plate materials – composition and content" variable – stray materials are assumed to be of no concern since no long-term performance is expected from the bottom plate.

Variable FEPs for the system component "Plugs" and their definitions in the SR-Site FEP catalogue, as provided in the Buffer, backfill and closure process report /SKB 2010k, Section 2.4.2/.

SR-Site FEP ID	SR-Site FEP name	SR-Site definition
VarPg01	Temperature	Temperature as a function of time and space in the plug.
VarPg02	Water content	Water content as a function of time and space in the plug.
VarPg03	Gas content	Gas content as a function of time and space in the components.
VarPg04	Hydrovariables (pressure and flow)	Flows and pressures of water and gas as a function of time and space in the plug.
VarPg05	Plug geometry	Geometric dimensions of the plug.
VarPg06	Plug pore geometry	Pore geometry as a function of time and space in the components. The porosity, i.e. the fraction of the volume that is not occupied by solid material, is often given.
VarPg07	Stress state	Stress conditions as a function of time and space in the plug.
VarPg08	Plug materials – composition and content	Composition of the concrete plug, the concrete beams, the bentonite, the drainage and the filter material in space and time.
VarPg09	Plug porewater composition	Composition of the porewater in time and space in the plug.
VarPg10	Structural and stray materials	(undefined) The structural materials in the plug are already included in the "Plug materials – composition and content" variable – stray materials are assumed to be of no concern since no long-term performance is expected from the plug.

Variable FEPs for the system component "Central area" and their definitions in the SR-Site FEP catalogue, as provided in the Buffer, backfill and closure process report /SKB 2010k, Section 2.5.2/.

SR-Site FEP ID	SR-Site FEP name	SR-Site definition
VarCA01	Temperature	Temperature as a function of time and space in the component.
VarCA02	Water content	Water content as a function of time and space in the component.
VarCA03	Gas content	Gas content as a function of time and space in the component.
VarCA04	Hydrovariables (pressure and flow)	Flows and pressures of water and gas as a function of time and space in the component.
VarCA05	Central area geometry	Geometric dimensions of the component.
VarCA06	Central area pore geometry	Pore geometry as a function of time and space in the component. The porosity, i.e. the fraction of the volume that is not occupied by solid material, is often given.
VarCA07	Stress state	Stress conditions as a function of time and space in the component.
VarCA08	Central area materials – composition and content	Composition of the crushed rock in time and space in the component.
VarCA09	Central area porewater composition	Composition of the porewater in time and space in the component.
VarCA10	Structural and stray materials	Composition and quantity of construction, reinforcements and stray materials in the component as a function of time and space.

Variable FEPs for the system component "Top seal" and their definitions in the SR-Site FEP catalogue, as provided in the Buffer, backfill and closure process report /SKB 2010k, Section 2.6.2/.

SR-Site FEP ID	SR-Site FEP name	SR-Site definition
VarTS01	Temperature	Temperature as a function of time and space in the component.
VarTS02	Water content	Water content as a function of time and space in the component.
VarTS03	Gas content	Gas content as a function of time and space in the component.
VarTS04	Hydrovariables (pressure and flow)	Flows and pressures of water and gas as a function of time and space in the component.
VarTS05	Top seal geometry	Geometric dimensions of the component.
VarTS06	Top seal pore geometry	Pore geometry as a function of time and space in the components. The porosity, i.e. the fraction of the volume that is not occupied by solid material, is often given.
VarTS07	Stress state	Stress conditions as a function of time and space in the component.
VarTS08	Top seal materials – composition and content	Composition of the crushed rock in time and space in the component.
VarTS09	Top seal porewater composition	Composition of the porewater in time and space in the component.
VarTS10	Structural and stray materials	Composition and quantity of construction, reinforcements and stray materials in the component as a function of time and space.

Variable FEPs for the system component "Borehole seals" and their definitions in the SR-Site FEP catalogue, as provided in the Buffer, backfill and closure process report /SKB 2010k, Section 2.8.2/.

SR-Site FEP ID	SR-Site FEP name	SR-Site definition
VarBhS01	Temperature	Temperature as a function of time and space in the components.
VarBhS02	Water content	Water content as a function of time and space in the components.
VarBhS03	Gas content	Gas content as a function of time and space in the components.
VarBhS04	Hydrovariables (pressure and flow)	Flows and pressures of water and gas as a function of time and space in the component.
VarBhS05	Borehole geometry	Geometric dimensions of the components.
VarBhS06	Pore geometry	Pore geometry as a function of time and space in the component. The porosity, i.e. the fraction of the volume that is not occupied by solid material, is often given.
VarBhS07	Stress state	Stress conditions as a function of time and space in the component.
VarBhS08	Sealing materials – composition and content	Composition of the bentonite and the concrete in time and space in the component.
VarBhS09	Porewater composition	Composition of the porewater in time and space in the component.
VarBhS10	Structural and stray materials	Composition and quantity of construction, reinforcements and stray materials in the components as a function of time and space. This includes the copper tube, the till, rock cylinders and the anchor materials.

Appendix 3

Handling of NEA Project FEPs sorted to SR-Site Initial states

SR-Site FEP ISGen01 Major mishaps/accidents/sabotage

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.32 Explosions	Explosions are included in the FEP definition.		
A 1.44 Improper operation	See NEA FEP A 1.70.		
A 1.61 Preclosure events	Flooding is included in the FEP definition.		
A 1.70 Sabotage and improper operation	Sabotage, explosions, flooding, fires, terrorist activities are included in the FEP definition.		
A 2.23 Explosion	Explosions are included in the FEP definition.		
A 2.56 Sabotage	Sabotage is included in the FEP definition		
H 1.2.7 Flammability	Explosions and fires are included in the FEP definition.		
I 022 Explosions/bombs/ blasting/collision/ impacts/vibration	Explosions in the repository before closure are covered by the FEP definition.		Impact of construction activities are discussed, see e.g. SKB FEPs Ge07 and Ge03.
J 1.4 Sudden energy release	Sabotage is included in the FEP definition.		
J 5.04 Decontamination materials left	Possible decontamination following severe mishap is included in the FEP description.		
J 5.05 Chemical sabotage	Sabotage is included in the FEP definition.		
M 2.2.06 Accidents during operation	Accidents are included in the FEP definition.		
M 2.2.07 Sabotage	Sabotage is included in the FEP definition.		
M 2.2.08 Repository flooding during operation	Flooding is included in the FEP definition.		
M 3.3.06 Gas effects	Explosions and fires are included in the FEP definition.		
W 2.027 Gas explosions	Explosions are included in the FEP definition.		
Recorded by: Kristina Skagius			**Date:** Dec 2010
Checked and revised by:			**Date:**

SR-Site FEP ISGen02 Effects of phased operation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.61 Preclosure events	Effects of underground traffic is mentioned in SR-Site.		
A 2.01 Blasting and vibration	Effects of blasting on completed parts of the repository.		
I 022 Explosions/bombs/ blasting/collision/ impacts/vibration	Effects of blasting and vibration on completed parts of the repository are mentioned.		
N 2.2.12 Effects of phased operation	Effects of phased operation.		
Recorded by: Kristina Skagius			**Date:** Dec 2010
Checked and revised by:			**Date:**

SR-Site FEP ISGen03 Incomplete closure

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.45 Incomplete closure	Incomplete construction and/or premature abandonment.		
A 1.70 Sabotage and improper operation	Incompletely backfilled/sealed drifts and boreholes.		
A 2.47 Open boreholes	Non-sealed shafts are part of the FEP definition.		
A 2.70 Vault closure (incomplete)	Incomplete or improper closure of vaults.		
I 203 Monitoring shaft (failure to close)	Unsealed shafts are part of the FEP definition.		
J 5.02 Non-sealed repository	A non-closed repository is part of the FEP definition.		
J 5.09 Unsealed boreholes and/or shafts	Unsealed shafts are part of the FEP definition.		
M 2.1.03 Shaft or access tunnel seal failure and degradation	Unsealed shafts are part of the FEP definition.		
M 2.2.09 Abandonment of unsealed repository	A non-closed repository is part of the FEP definition.		
M 2.2.10 Poor closure	A non-closed repository is part of the FEP definition.		
M 2.2.12 Effects of phased operation	A non-closed repository is part of the FEP definition.		
Recorded by: Kristina Skagius			**Date:** Dec 2010
Checked and revised by:			**Date:**

SR-Site FEP ISGen04 Monitoring activities

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.56 Monitoring and remedial activities	Monitoring activities are part of FEP definition.		
J 5.39 Postclosure monitoring	Monitoring activities are part of FEP definition.		
K 5.25 Exploratory boreholes (sealing)	Monitoring activities are part of FEP definition.		
M 2.2.11 Post-closure monitoring	Monitoring activities are part of FEP definition.		
W 2.011 Postclosure monitoring	Monitoring activities are part of FEP definition.		
Recorded by: Kristina Skagius			**Date:** Dec 2010
Checked and revised by:			**Date:**

SR-Site FEP ISC01 Mishaps - canister

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.17 Container failure (early)	Mishandling and breakage during transport.		
A 1.70 Sabotage and improper operation	Failure of quality assurance of engineering and construction		
J 2.5.01 Random canister defects - quality control	Random defects despite quality control.		
J 2.5.02 Common cause canister defects - quality control	Defects related by a common cause		
J 5.10 Accidents during operation	Accidents during operation.		
K 1.26 Handling accidents	Handling accidents.		
M 2.2.04 Inadvertent inclusion of undesirable materials	Handling accidents.		
M 2.2.06 Accidents during operation	Handling accidents.		
Recorded by: Kristina Skagius			**Date:** Dec 2010
Checked and revised by:			**Date:**

SR-Site FEP ISBu01 Mishaps - buffer

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.33 Faulty buffer emplacement	Faulty emplacement of buffer.		
A 1.70 Sabotage and improper operation	Failure of quality assurance of engineering and construction.		
E SFL-16 Dilution of the buffer and backfill	Faulty emplacement.		
I 011b Backfill (faulty emplacement)	Faulty emplacement.		
I 029 Buffer (faulty emplacement)	Faulty emplacement.		
J 5.10 Accidents during operation	Accidents during operation.		
K 3.23 Poor emplacement of buffer	Faulty emplacement of buffer.		
M 2.2.06 Accidents during operation	Accidents during emplacement.		
Recorded by: Kristina Skagius			**Date:** Dec 2010
Checked and revised by:			**Date:**

SR-Site FEP ISBu02 Design deviations - buffer

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 3.1.01 Degradation of the bentonite by chemical reactions	Material deficiencies.		
J 3.2.01.2 Uneven swelling of bentonite	Material deficiencies.		
J 3.2.11 Backfill material deficiencies	Material deficiencies.		
M 2.1.08 Poor quality construction	Material deficiencies.		
M 2.2.04 Inadvertent inclusion of undesirable materials	Material deficiencies.		
Recorded by: Kristina Skagius			**Date:** Dec 2010
Checked and revised by:			**Date:**

SR-Site FEP ISBfT01 Mishaps - backfill of deposition tunnels

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.70 Sabotage and improper operation	Failure of quality assurance of engineering and construction.		
I 011b Backfill (faulty emplacement)	Faulty emplacement.		
J 4.2.01 Mechanical failure of repository	Lack of QA during excavation of the vault (improper rock inforcement).		
J 5.10 Accidents during operation	Accidents during operation.		
M 2.2.02 Inadequate backfill or compaction voidage	Faulty emplacement.		
M 2.2.06 Accidents during operation	Accidents during emplacement.		
Recorded by: Kristina Skagius			**Date:** Dec 2010
Checked and revised by:			**Date:**

SR-Site FEP ISBfT02 Design deviations - backfill of deposition tunnels

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 3.2.11 Backfill material deficiencies	Backfill material deficiencies.		
M 2.1.08 Poor quality construction	Backfill material deficiencies.		
M 2.2.02 Inadequate backfill or compaction voidage	Backfill material deficiencies.		
M 2.2.04 Inadvertent inclusion of undesirable materials	Backfill material deficiencies.		
M 3.3.04 Subsidence/collapse	Backfill material deficiencies.		
Recorded by: Kristina Skagius			**Date:** Dec 2010
Checked and revised by:			**Date:**

SR-Site FEP ISBP01 Mishaps - bottom plate in deposition holes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.70 Sabotage and improper operation	Failure of quality assurance of engineering and construction.		
J 5.10 Accidents during operation	Accidents during operation.		
M 2.2.06 Accidents during operation	Accidents during emplacement.		
Recorded by: Kristina Skagius			**Date:** Dec 2010
Checked and revised by:			**Date:**

SR-Site FEP ISBP02 Design deviations - bottom plate in deposition holes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 062a1 Concrete (incorrect structural design)	Deviation in properties.		
I 062a2 Concrete (incorrect mix design)	Deviation in properties.		
I 062b Concrete (incorrect preparation/emplacement)	Deviation in properties.		
I 062f Concrete (poor quality - procurement)	Deviation in properties.		
M 2.1.08 Poor quality construction	Material deficiencies.		
M 2.2.04 Inadvertent inclusion of undesirable materials	Material deficiencies.		
Recorded by: Kristina Skagius			**Date:** Dec 2010
Checked and revised by:			**Date:**

SR-Site FEP ISPg01 Mishaps - plugs

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.70 Sabotage and improper operation	Failure of quality assurance of engineering and construction.		
E GEN-35 Fast transport pathways	Failure of quality assurance of engineering and construction – poorly sealed shafts.		
M 2.2.06 Accidents during operation	Material deficiencies.		
Recorded by: Kristina Skagius			**Date:** Dec 2010
Checked and revised by:			**Date:**

SR-Site FEP ISPg02 Design deviations - plugs

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 062a1 Concrete (incorrect structural design)	Deviation in properties.		
I 062a2 Concrete (incorrect mix design)	Deviation in properties.		
I 062b Concrete (incorrect preparation/emplacement)	Deviation in properties.		
I 062f Concrete (poor quality - procurement)	Deviation in properties.		
M 2.1.08 Poor quality construction	Material deficiencies.		
M 2.2.04 Inadvertent inclusion of undesirable materials	Material deficiencies.		
Recorded by: Kristina Skagius			**Date:** Dec 2010
Checked and revised by:			**Date:**

SR-Site FEP ISCA01 Mishaps – central area

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.70 Sabotage and improper operation	Failure of quality assurance of engineering and construction.		
Recorded by: Kristina Skagius			**Date:** Dec 2010
Checked and revised by:			**Date:**

SR-Site FEP ISCA02 Design deviations – central area

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
M 2.1.08 Poor quality construction	Material deficiencies.		
M 2.2.04 Inadvertent inclusion of undesirable materials	Material deficiencies.		
M 3.3.04 Subsidence/ collapse	Backfill material deficiencies.		
Recorded by: Kristina Skagius			**Date:** Dec 2010
Checked and revised by:			**Date:**

SR-Site FEP ISTS01 Mishaps/Design deviations – top seal

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.70 Sabotage and improper operation	Failure of quality assurance of engineering and construction.		
M 2.1.08 Poor quality construction	Material deficiencies.		
M 2.2.04 Inadvertent inclusion of undesirable materials	Material deficiencies.		
M 3.3.04 Subsidence/ collapse	Material deficiencies.		
Recorded by: Kristina Skagius			**Date:** Dec 2010
Checked and revised by:			**Date:**

SR-Site FEP ISBhS01 Mishaps/Design deviations - borehole seals

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.47 Open boreholes	Open or improperly sealed boreholes.		
E GEN-35 Fast transport pathways	Failure of quality assurance of engineering and construction - poorly sealed boreholes.		
J 5.09 Unsealed boreholes and/or shafts	Unsealed boreholes and shafts.		
K 5.25 Exploratory boreholes (sealing)	Open boreholes.		
M 2.1.08 Poor quality construction	Material deficiencies.		
W 3.031 Natural borehole fluid flow	Unsealed/poorly sealed boreholes.		
Recorded by: Kristina Skagius			**Date:** Dec 2010
Checked and revised by:			**Date:**

Appendix 4

Handling of NEA Project FEPs sorted to SR-Site Fuel processes

SR-Site FEP F01 Radioactive decay

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.65 Radioactive decay	Radioactive decay is covered.		
E GEN-28 Radioactive decay	Radioactive decay is covered.		This FEP also deals with heat generation as a consequence of radioactive decay, see FEP F02.
E SFL-02 Changes in the spent fuel radionuclide inventory	Radioactive decay and ingrowth of new radionuclides are covered.	Potential inventory changes in case of a criticality event not covered because the risk for criticality can be neglected (see FEP F03).	This FEP also deals with potential inventory changes in case of criticality, see FEP F03.
H 1.3.1 Radioactive decay and ingrowth	Radioactive decay and ingrowth of new radionuclides are covered.		
I 045 Progency nuclides (critical radionuclides)	The ingrowth of new radionuclides in the fuel has been covered.		The FEP also deals with decay and daughter nuclides after release from the fuel, see e.g. FEP Bu23.
K 0.1 Radioactive decay	Radioactive decay is covered.		
M 3.4.04 Radioactive decay ingrowth	Radioactive decay and ingrowth of new radionuclides are covered.		
S 005 Changes in radionuclide inventory	Radioactive decay and ingrowth of new radionuclides are covered.		
S 069 Radioactive Decay, fuel	Radioactive decay and ingrowth of new radionuclides are covered.		This FEP also deals with heat generation as a consequence of radioactive decay, see FEP F02.
Recorded by: Kastriot Spahiu			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP F02 Radiation attenuation/heat generation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.52 Long-term transients	Heat generation in the fuel is covered.		Deals with the whole repository
E GEN-28 Radioactive decay	Radioactive decay and heat generation are covered.		
E SFL-14 Different thermal expansion and contraction of the near-field barriers	Heat generation in the fuel is covered.		Deals with iron, copper and bentonite thermal expansion.
E SFL-46 Temperature of the near-field	Temperature evolution in the near field is covered.		
I 146 Heat generation in IRUS vault(B)	Heat generation in the fuel is covered.		Also deals with decomposition of organic material.

SR-Site FEP F02 Radiation attenuation/heat generation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 1.1.02 Radioactive decay; heat	Heat generation in the fuel is covered.		Also deals with heat effects on groundwater flow (FEP Ge03)
K 1.08 Heat output (RN decay heat)	Heat generation in the fuel is covered.		
S 069 Radioactive Decay, fuel	Heat generation in the fuel is covered.	This FEP deals with the consequences of heat generation in the fuel on the canister temperature.	
W 2.013 Heat from radioactive decay	Heat generation in the fuel is covered.		
Recorded by: Kastriot Spahiu			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP F03 Induced fission (criticality)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.26 Criticality	Criticality is covered. Criticality outside the canister can be excluded in a KBS 3 repository.		
E SFL-02 Changes in the spent fuel radionuclide inventory	Addressed/covered.	Potential inventory changes in case of a criticality event not covered because the risk for criticality can be neglected.	
E SFL-12 Criticality	Criticality in a canister is covered. Criticality outside the canister can be excluded in a KBS-3 repository.		
E SFL-13 Degradation of the spent fuel elements	Addressed/covered.		
H 1.3.2 Nuclear criticality	Criticality is covered. Criticality outside the canister can be excluded in a KBS 3 repository.		
I 081 Criticality event	Criticality is covered. Criticality outside the canister can be excluded in a KBS 3 repository.		
J 1.1.01 Criticality	Criticality in a canister is covered. Criticality outside the canister can be excluded in a KBS 3 repository.		
K 0.4 Nuclear criticality	Criticality in a canister is covered. Criticality outside the canister can be excluded in a KBS 3 repository.		
M 3.4.03 Nuclear criticality	Criticality in a canister is covered.		
S 005 Changes in radionuclide inventory	Criticality and the changes in criticality with time are covered.		
S 017 Criticality	Criticality in a canister is covered. Criticality outside the canister can be excluded in a KBS 3 repository.		

SR-Site FEP F03 Induced fission (criticality)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 090 Temperature, canister		The risk for criticality can be neglected. Therefore, any heat generation caused by criticality can also be neglected.	
W 2.014 Nuclear criticality: heat	Criticality in a canister is covered. Criticality outside the canister can be excluded in a KBS 3 repository.	The risk for criticality can be neglected. Therefore, any heat generation caused by criticality can also be neglected.	
W 2.028 Nuclear explosions		Criticality outside the canister can be excluded in a KBS 3 repository. Therefore, there will be no risk for a nuclear explosion.	
Recorded by: Kastriot Spahiu			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP F04 Heat transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.52 Long-term transients		This FEP deal with contaminant transport during the thermal pulse. It is not applicable to the fuel/cavity and the time scale for possible water intrusion.	
E SFL-46 Temperature of the near-field	Temperature evolution in the near field is covered.		
S 090 Temperature, canister	The heat transport in the fuel and in the cavity is covered.	This FEP deals with the consequences of heat generation in the fuel on the canister temperature.	Also deals with criticality, see FEP F03
Recorded by: Kastriot Spahiu			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP F05 Water and gas transport in canister cavity, boiling/condensation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.35 Formation of gases	Gas generation and impact on water and gas transport in failed canister is discussed.		Residual gas radiolysis is covered in F09. Any gas generation caused by radiolysis after water intrusion will be negligible compared to gas generated by corrosion of the insert.
E SFL-23 Gas escape from the canister	Gas generation and impact on water and gas transport in failed canister is discussed.		
E SFL-29 Internal gas pressure	Gas generation and impact on water and gas transport in a failed canister is discussed.		
E SFL-52 Evolving water chemistry in the canister	Influence of water chemistry in fuel dissolution and metal corrosion is discussed.		

SR-Site FEP F05 Water and gas transport in canister cavity, boiling/condensation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E SFL-56 Water turnover in the copper shell		Concerns the cavity between copper and cast iron insert.	Addressed in C09.
E SFL-57 Water turnover in the cast iron insert	Addressed: several scenarios for the development of a failed canister are discussed.		
H 1.2.1 Hydrogen by metal corrosion	Gas generation and impact on water and gas transport in failed canister is discussed.		
J 1.2.04 Gas generation	Gas generation and impact on water and gas transport in failed canister is discussed.		Residual gas radiolysis is covered in F09. Any gas generation caused by radiolysis after water intrusion will be negligible compared to gas generated by corrosion of the insert.
K 2.17 Effect of hydrogen on corrosion		The build-up of hydrogen pressure will not have a major impact on the corrosion rate.	This NEA FEP is based on an incorrect assumption.
S 034 Failure of copper canister	Gas generation and impact on water and gas transport in failed canister is discussed.		This FEP also deals with failure due to mechanical impact, see FEPs C04, C06.
S 040 Gas escape from canister	Gas generation and impact on water and gas transport in failed canister is discussed.		This FEP deals mainly with gas transport through the buffer, see FEP Bu06.
S 041 Gas flow and transport, buffer/backfill	Gas generation and impact on water and gas transport in failed canister is discussed.		This FEP deals mainly with gas transport through the buffer, see FEP Bu06.
S 105 Water turnover, copper canister	Gas generation and impact on water and gas transport in failed canister is discussed.		This FEP deals mainly with water transport in and out of the gap between copper shell and the cast iron insert.
S 106 Water turnover, steel vessel	Gas generation and impact on water and gas transport in failed canister is discussed.		This FEP deals mainly with water transport in and out of the cavity in the canister.
Recorded by: Kastriot Spahiu			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP F06 Cladding failure

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.42 Hydride cracking	Hydride induced cracking is covered.		
E SFL-13 Degradation of the spent fuel elements	Failure of the cladding is covered.		Degradation of fuel is covered in F07 and F15.
M 3.3.03 Embrittlement and cracking		Concerns embrittlement of steel waste canisters.	Embrittlement of cast iron insert is covered in C07 and C08.

SR-Site FEP F06 Cladding failure

S 019 Degradation of fuel elements	Failure of the cladding is covered.		Degradation of fuel is covered in F07 & F15.
S 053 Internal pressure	Failure of the cladding due to helium build-up is covered		Gas generation due to corrosion is covered in F05

Recorded by: Kastriot Spahiu — **Date:** Dec 2010

Checked and revised by: Kristina Skagius — **Date:** Dec 2010

SR-Site FEP F07 Structural evolution of fuel matrix

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.64 Radiation damage	Alpha damage to the fuel matrix has been covered.		
E SFL-13 Degradation of the spent fuel elements	Alpha damage to fuel matrix is covered.		Effect of He build-up is covered in F15.
E SFL-22 Gap and grain boundary release	Alpha radiation assisted migration of fission products is covered.		
J 1.1.03 Recoil of alpha-decay	Alpha damage to the fuel matrix has been covered.		
S 019 Degradation of fuel elements	Alpha damage to the fuel matrix has been covered.		
W 2.015 Radiological effects on waste	Alpha damage to the fuel matrix has been covered.		
W 2.099 Alpha recoil	Alpha damage to the fuel matrix has been covered.		This FEP also concerns possible release from the fuel of the recoil nucleus. This contribution to the radionuclide release is of negligible importance.

Recorded by: Kastriot Spahiu — **Date:** Dec 2010

Checked and revised by: Kristina Skagius — **Date:** Dec 2010

SR-Site FEP F08 Advection and diffusion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.09 Chemical gradients		This FEP deals with chemical gradients due to temperature changes, radiolysis and ingress of salt water in the near field. The canister is expected to be intact during the period when radiolysis and high temperatures prevail. Salinity has a very limited effect of fuel dissolution.	
A 2.16 Diffusion	Diffusion and advection are covered.		
E SFL-15 Diffusion in and through the canister	Transport through canister is discussed.		See F17 Radionuclide transport.

SR-Site FEP F08 Advection and diffusion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E SFL-40 Radionuclide release from the spent fuel matrix	Radionuclide release from fuel matrix is covered.		Fuel dissolution and corrosion is discussed in F12.
E SFL-49 Radionuclides release and transport from the canister	Radionuclide releases from fuel and metallic parts and their transport form canister are covered.		Discussed/covered in F11, F12, F13, F14 and F17.
E SFL-52 Evolving water chemistry in the canister	Water chemistry evolution is covered in radionuclide transport F17.		The water chemistry and its effects on corrosion and solubilities are discussed in F11, F12 and F14.
S 102 Water chemistry, canister	Diffusion and advection are covered.		The water chemistry and its effects on corrosion are discussed in F11, F14, C08 & C11. Fuel corrosion is discussed in F12
Recorded by: Kastriot Spahiu			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP F09 Residual gas radiolysis/ acid formation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.66 Radiolysis	The effects of radiolysis on the residual gases in the cavity are covered.		
E SFL-10 Canister corrosion prior to wetting	Canister corrosion prior to breaching is covered.		
E SFL-25 Gas generation in the canister	Radiolysis of residual gases in the cavity is covered.		Other aspects of gas generation are covered in C08 and F15.
E SFL-37 Radiolysis inside the canister prior to wetting	Radiolysis of residual gases inside the canister prior to wetting is covered.		
S 014 Corrosion prior to wetting	The effects of radiolysis on the residual gases in the cavity are covered.		Other corrosion aspects of residual water in the cavity are covered in F11 & F14.
S 045 Gas generation, canister	The effects of radiolysis on the residual gases in the cavity are covered.		Other aspects of gas generation are covered in C08, F11 & F15.
S 069 Radioactive Decay, fuel	The effects of radiolysis on the residual gases in the cavity are covered.		
S 072 Radiolysis prior to wetting	The effects of radiolysis on the residual gases in the cavity are covered.		
Recorded by: Kastriot Spahiu			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP F10 Water radiolysis

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.09 Chemical gradients		Not relevant for this process.	Radiolytic change of local redox conditions covered in F12. Pessimistically neglected pore plugging in F12 and F17.
A 1.35 Formation of gases	Relevant parts as hydrogen production addressed/ covered.	Methane and H_2S production by organic matter decomposition not relevant for a KBS 3 repository.	FEP concerns a low level waste repository with no carbon steel
A 1.66 Radiolysis	Addressed/covered.		Also discussed in F09 and F12.
E GEN-30 Radiolysis	Radiolytic decomposition of water is covered.		
E SFL-21 Spent fuel dissolution and conversion		Impact of radiolysis in fuel dissolution addressed in F12.	
E SFL-23 Gas escape from the canister	Gas production by gamma radiolysis addressed/covered.		
E SFL-25 Gas generation in the canister	Gas production by gamma radiolysis addressed.	Other aspects of gas production are not covered here, but in other processes.	Also addressed in F09, F12, F15, F17, C08, C15.
E SFL-38 Redox fronts		Third aspect (close to fuel) addressed/covered in F12. Post closure transient covered only inside canister.	
E SFL-52 Evolving water chemistry in the canister	Addressed/covered.		
I 238 Radiation effects		FEP relevant to low level waste as bituminized waste.	
J 1.2.01 Radiolysis	Addressed/covered.		Also discussed in F09, F12 and F14.
J 1.2.04 Gas generation	Gas generation by radiolysis addressed/ covered.	Carbon dioxide and organic matter decomposition not covered because irrelevant for a KBS 3 repository.	Helium production addressed mainly in F15.
J 1.2.08 Redox potential	Parameter, addressed/covered in the radiolysis effects in the near field.		Also discussed in F12, F14 and C07.
J 3.1.09 Radiolysis	Addressed/covered.		Same as J 1.2.01, screened out for administrative reasons.
K 3.19 Radiolysis	Gamma radiolysis addressed/covered.	Radiolysis prior to failure covered in F09 and radiolysis in fuel dissolution addressed in F12.	Discusses also redox conditions in canister and redox front in buffer.
M 3.4.01 Radiolysis	Gamma radiolysis inside canister addressed/covered.		Radiolysis outside canister discussed/covered in C07.
S 045 Gas generation, canister	Radiolytic decomposition of water by gamma radiation addressed/covered.	Other aspects of gas production are not covered here, but in other processes.	Also addressed in F09, F12, F15, F17, C08, C15.
S 069 Radioactive Decay, fuel	Radiolysis of water by gamma radiation and gas production addressed/covered.	Other consequences of decay as heat generation, radiolysis outside canister etc. discussed elsewhere.	Discussed mainly in F01, F02, F12 and C07.
S 071 Radiolysis	Gamma radiolysis addressed/covered.	Radiolysis in fuel dissolution addressed in F12.	

SR-Site FEP F10 Water radiolysis

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 102 Water chemistry, canister	The impact of water chemistry is discussed.		
W 2.049 Gases from metal corrosion	Gas from water radiolysis is discussed.		Gas generation from iron corrosion covered in C08.
Recorded by: Kastriot Spahiu			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP F11 Metal corrosion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.11 Chemical kinetics		The FEP deals with the effects on Eh of chemical kinetics. The fast reaction between water and cast iron will control the Eh. The effects of corrosion of other metal parts will be negligible.	The corrosion of the cast iron insert is covered in C08.
A 1.75 Source terms (expected)	The release of radionuclides from the metal parts of the fuel is covered.		
E SFL-08 Corrosion of the metal non-fuel waste parts	The corrosion of the metal parts of the fuel elements is covered.		
E SFL-10 Canister corrosion prior to wetting	Canister corrosion prior to wetting is covered.		
E SFL-25 Gas generation in the canister		Hydrogen production from corrosion of metal parts negligible as compared to that from iron corrosion.	Also addressed in F09, F12, F15, F17, C08, C15.
E SFL-41 Radionuclide release from the metal non-fuel parts	The release of radionuclides from the metal parts of the fuel element is covered.		
E SFL-48 Total release from the fuel elements		Addressed/covered in F11, F12, F13.	
E SFL-52 Evolving water chemistry in the canister	Influence of water chemistry on corrosion of metallic parts of a fuel element is covered.		
H 1.2.1 Hydrogen by metal corrosion	The corrosion of the metal parts of the fuel is covered.		Hydrogen produced through corrosion of the iron insert is covered in C08.
I 065 Waste container (metal corrosion products)	The corrosion of the metal parts of the fuel is covered.		
S 012 Corrosion of metal parts	The corrosion of the metal parts of the fuel is covered.		The build-up of hydrogen will not reach a pressure where the corrosion is suppressed.

SR-Site FEP F11 Metal corrosion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 045 Gas generation, canister	The corrosion of the metal parts of the fuel is covered.		The corrosion of the cast iron insert is covered in C08. Helium formation is covered in F15.
S 077 Release from metal parts	The release of radionuclides from the metal parts of the fuel is covered.		
S 095 Total release from fuel elements	The release of radionuclides from the metal parts of the fuel is covered.		Release from the fuel is covered in F12 & F13.
W 2.049 Gases from metal corrosion	The corrosion of the metal parts of the fuel is covered.		
Recorded by: Kastriot Spahiu			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP F12 Fuel dissolution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.09 Chemical gradients		Not covered due to negligible relevance inside canister	FEP concerns mainly buffer
A 1.11 Chemical kinetics	Addressed/covered	Poorly poised Eh not relevant. Concentrations below solubility limits pessimistically neglected in F14.	Other aspects of chemical kinetics covered
A 1.30 Electrochemical gradients		Not covered because the effect on fuel dissolution inside the massive Fe/Cu canister is expected to be negligible.	
A 1.62 Precipitation and dissolution	Dissolution of UO_2 addressed/covered	Solubility constraints, dissolution of zircaloy not covered; discussed elsewhere.	Also discussed in F11, F13, F14.
A 1.66 Radiolysis	Addressed/covered		Also discussed in F09, F10.
A 1.75 Source terms (expected)	Addressed/covered		Also discussed in F11, F13.
A 1.76 Source terms (other)		Not covered because irrelevant. Mechanical breakdown discussed in F07, other aspects highly improbable.	FEP considered irrelevant in NEA database.
A 1.79 Stability of UO2	Addressed/covered		
E GEN-27 Radionuclide precipitation and dissolution		Radionuclide precipitation and dissolution discussed/covered in F14.	
E SFL-13 Degradation of the spent fuel elements	Addressed/covered		Degradation of fuel is covered in F07 and F15.
E SFL-21 Spent fuel dissolution and conversion	Addressed/covered		

SR-Site FEP F12 Fuel dissolution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E SFL-38 Redox fronts	Third aspect (close to fuel) addressed/covered. Post closure transient covered only inside canister.		
E SFL-40 Radionuclide release from the spent fuel matrix	Addressed/covered		
E SFL-48 Total release from the fuel elements	Radionuclide release from fuel matrix addressed/covered.	Release from metallic parts covered in F11, instant release in F13.	
E SFL-52 Evolving water chemistry in the canister	Addressed/covered		See also F11.
J 1.2.06 Solubility within fuel matrix	Addressed/covered		Also discussed in F14.
J 1.2.07 Recrystallization		Pessimistically neglected in F14. Recrystallization in cement not relevant.	Ill-formulated FEP concerning recrystallization coupled to radiolysis.
J 1.2.08 Redox potential	Addressed/covered in relevant parts.		Also discussed in F14, C08.
J 1.2.09 Dissolution chemistry	Addressed/covered.		Also discussed in F14.
J 2.1.02 Coupled effects (electrophoresis)		Not covered because affects migration of radionuclides. Effect on fuel dissolution negligible.	See F17.
J 3.1.11 Redox front	Third aspect (close to fuel) addressed/covered. Post closure transient covered only inside canister.	Effect of oxidizing waters in far field discussed elsewhere.	See e.g. Ge14.
J 5.44 Solubility and precipitation	Potential effects of precipitates on fuel dissolution and solubility of UO_2(s) addressed/covered	Factors that affect solubility mainly discussed elsewhere.	Also discussed in F14.
M 1.6.06 Solubility limit		Solubility limits discussed/covered in F14.	
M 1.6.08 Dissolution, precipitation and cristallization		Dissolution, precipitation and crystallization covered in F14.	The same phenomena are discussed also for the clay layer in a clay repository.
S 038 Fuel dissolution and conversion	Addressed/covered		
S 060 Precipitation/dissolution	Addressed/covered redox front at fuel surface.	Precipitation/dissolution of elements released from fuel and their transport not covered; discussed elsewhere.	Discussed mainly in F14 and F17.
S 074 Redox front	Third aspect (close to fuel) addressed/covered. Post closure transient covered only inside canister	Effect of oxidizing waters in far field discussed elsewhere.	See e.g. Ge14. FEP identical to J. 3.1.11.
S 076 Release from fuel matrix	Addressed/covered		

SR-Site FEP F12 Fuel dissolution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 095 Total release from fuel elements	Two components of total release (instant release and matrix dissolution) addressed/covered.	Release from metallic parts covered in F11, instant release in F13.	Also discussed in F11, F13 and F17.
W 2.060 Kinetics of precipitation and dissolution		Not covered because discusses kinetics of precipitation/dissolution of radionuclides released from WIPP waste. Certain aspects addressed/covered in F14.	
W 2.066 Reduction-oxidation kinetics	Addressed/covered		Other aspects of redox kinetics also covered.
W 2.099 Alpha recoil		Not addressed because irrelevant consequences for fuel.	FEP relevant to actinide waste, judged irrelevant in WIPP.
Recorded by: Kastriot Spahiu			**Date:** Dec 2010
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SR-Site FEP F13 Dissolution of gap inventory

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.75 Source terms (expected)	Addressed/covered.		Modelled as part of IRF. Also discussed in F07.
E SFL-13 Degradation of the spent fuel elements	Gap and grain boundary component addressed/covered.		Degradation of fuel is covered in F07 and F15.
E SFL-21 Spent fuel dissolution and conversion	Gap inventory component addressed/covered.	Release from fuel matrix and release from metallic parts not covered. They are discussed respectively in F12 and F11.	
E SFL-22 Gap and grain boundary release	Addressed/covered.		
E SFL-27 Radionuclide accumulation at the spent fuel surface	Addressed/covered.	Release from rim part of fuel matrix discussed in F12.	
E SFL-48 Total release from the fuel elements	Gap and grain boundary inventory component addressed/covered.	Release from fuel matrix and release from metallic parts not covered. They are discussed respectively in F12 and F11.	
E SFL-52 Evolving water chemistry in the canister		Not relevant due to pessimistic assumptions (instant dissolution).	
J 1.2.05 I, Cs-migration to fuel surface	Addressed/covered.		Modelled as part of IRF.
M 1.6.06 Solubility limit		Solubility limits addressed/covered in F14.	
M 1.6.08 Dissolution, precipitation and cristallization		Dissolution, precipitation and crystallization covered in F14.	The same phenomena are discussed also for the clay layer in a clay repository.
S 039 Gap and	Addressed/covered.		Modelled as part of

SR-Site FEP F13 Dissolution of gap inventory

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
grain boundary release			IRF.
S 050 I, Cs-migration to fuel surface	Addressed/covered.		Modelled as part of IRF.
S 095 Total release from fuel elements	Gap inventory component addressed/covered.	Release from fuel matrix and release from metallic parts not covered. They are discussed respectively in F12 and F11.	
Recorded by: Kastriot Spahiu			**Date:** Dec 2010
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SR-Site FEP F14 Speciation of radionuclides, colloid formation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.13 Colloids	Addressed/covered		Also discussed in F12 and C08.
A 1.14 Complexation by organics		Not relevant in canister.	
A 1.37 Geochemical pump	Addressed/covered.		
A 1.77 Speciation	Addressed/covered	Pressure effect on speciation considered negligible.	Also discussed in F11, F12 and C08.
E SFL-06 Colloids and particles in the canister	Addressed/covered		Colloid transport in geosphere is discussed elsewhere.
E SFL-28 Radionuclide interaction with corrosion products		Radionuclide immobilization on anoxic Fe corrosion products pessimistically neglected.	
E SFL-49 Radionuclides release and transport from the canister	Solubility limits are addressed/covered.	Releases addressed/covered in F11, F12, F13 and transport in F17.	
I 065 Waste container (metal corrosion products)	Influence in canister environment addressed/covered.	Sorption on container corrosion products pessimistically neglected.	Fe corrosion products discussed mainly in C08.
I 233 Source term & solubility limits		Not considered because discusses solubility limits in far field.	
J 1.2.06 Solubility within fuel matrix	Solubility limits addressed/covered	Dissolution of fuel matrix discussed in F12.	
J 1.2.08 Redox potential	Parameter addressed/covered in relevant parts		Also discussed in F12 and C08.
J 1.2.09 Dissolution chemistry	Chemical equilibria addressed/covered.	Dissolution chemistry and radionuclide transport discussed in F12 and F17.	
J 5.44 Solubility and precipitation	Addressed/covered		Also discussed in F11, F12 and F13.

SR-Site FEP F14 Speciation of radionuclides, colloid formation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 2.14 Chemical buffering (canister corrosion products)	Addressed/covered		Discussed mainly in C08.
K 3.18 Elemental solubility/precipitation	Addressed/covered		
M 1.6.06 Solubility limit	Solubility limits are addressed/covered.		
S 010 Colloids/particles in canister		Addressed/covered in F12. If necessary the discussion may be repeated also in this process.	Colloid transport in geosphere discussed elsewhere.
S 051 Interaction with corrosion products		Neglected as irrelevant because discusses effect of oxidized iron corrosion products on radionuclide sorption/ coprecipitation.	RN immobilization on anoxic Fe corrosion products pessimistically neglected.
S 060 Precipitation/dissolution	Addressed/covered	Radiolysis effect covered mainly in F12.	
S 076 Release from fuel matrix	The solubility of elements addressed/covered	Release from fuel matrix discussed mainly in F12.	
W 2.056 Speciation	Addressed/covered	Sorption pessimistically neglected, effect of cementitious water not covered because irrelevant.	
W 2.057 Kinetics of speciation	Addressed/covered		
W 2.064 Effect of metal corrosion	Hydrogen production and influence of metal corrosion on redox conditions addressed/covered.	Oxic corrosion of metals and aerobic degradation of organic material not covered because irrelevant for a KBS 3 repository.	Also discussed in C08.
W 2.066 Reduction-oxidation kinetics	Addressed/covered		
Recorded by: Kastriot Spahiu			**Date:** Dec 2010
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SR-Site FEP F15 Helium production

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.35 Formation of gases		The FEP refers to formation of other gases than He.	
E SFL-23 Gas escape from the canister	Helium production by alpha decay in fuel is covered.	Hydrogen production by anoxic iron corrosion is covered in C08.	The escape of He from the canister is not considered to be of any consequence for the safety assessment.
E SFL-25 Gas generation in the canister	He production is considered.		Hydrogen gas production through iron corrosion discussed in C08.

J 1.1.04 Gas generation: He production	The helium production by the fuel is covered.		
J 1.2.04 Gas generation	The helium production by the fuel is covered.		
K 1.24 He gas production	The helium production by the fuel is covered.		The escape of He from the canister is not considered to be of any consequence for that safety assessment.
S 045 Gas generation, canister	The helium production by the fuel is covered.		The hydrogen production through iron corrosion is covered in F14 and C08.
W 2.049 Gases from metal corrosion	The helium production by the fuel is covered.		The hydrogen production through iron corrosion is covered in C08.
W 2.054 Helium gas production	The helium production by the fuel is covered.		
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SR-Site FEP F16 Chemical alteration of the fuel matrix

No NEA Project FEP associated with this SR-Site FEP

SR-Site FEP F17 Radionuclide transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.21 Containers - partial corrosion	Partially damaged canisters are considered.		
A 1.36 Galvanic coupling		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
A 1.73 Sorption	Sorption is considered.		
A 1.74 Sorption - nonlinear	Saturation of sorption sites is discussed.		Considered to be irrelevant.
A 2.16 Diffusion	Diffusion is considered.		
A 2.58 Saturation	Saturation of sorption sites is discussed.		
E GEN-28 Radioactive decay	Radioactive decay is considered.		
E SFL-02 Changes in the spent fuel radionuclide inventory	Inventory changes due to radioactive decay are covered.	Inventory changes due to a criticality event not covered because the risk for criticality can be neglected.	
E SFL-15 Diffusion in and through the canister	Diffusion in and through the canister is covered.		See also F08.
E SFL-21 Spent fuel dissolution and conversion	Spent fuel dissolution and conversion is considered.		
E SFL-28 Radionuclide interaction with corrosion products		Sorption and co-precipitation of radionuclides with iron corrosion products is pessimistically neglected.	

SR-Site FEP F17 Radionuclide transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E SFL-34 Preferential transport pathways in the canister		No transport resistances within canister are considered.	
E SFL-40 Radionuclide release from the spent fuel matrix	Addressed/covered.		Release from fuel matrix covered in F12.
E SFL-49 Radionuclides release and transport from the canister	Addressed/covered.		
E SFL-52 Evolving water chemistry in the canister	Water chemistry evolution is covered.		See also F11, F12, F14.
H 1.1.4 Electrochemical effects of metal corrosion		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
H 1.2.4 Radioactive gases	Radionuclide transport in gas phase is considered.		
H 1.6.4 Thermal effects: Transport (diffusion) effects	The effect of temperature on diffusion is discussed.		
I 065 Waste container (metal corrosion products)		The effect of corrosion products on transport is neglected - considered small compared to other barriers.	
J 1.5 Release of radionuclides from the failured canister	Radionuclide transport is considered.		
J 2.1.02 Coupled effects (electrophoresis)		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
J 2.1.04 Role of the eventual channeling within the canister		No transport resistances within canister are considered.	
J 2.1.06.2 Natural telluric electrochemical reactions		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
K 0.3 Gaseous and volatile isotopes	Radionuclide transport in gas phase is considered.		
K 1.15 Elemental solubility limits	Solubility limits are discussed.		
K 2.15 Radionuclide sorption and co-precipitation		Sorption and co-precipitation of radionuclides with canister corrosion products is pessimistically neglected.	
K 2.18 Corrosion products (physical effects)	The corrosion products are discussed in canister evolution.		
K 2.20 Radio-nuclide transport	Radionuclide transport is considered.		

SR-Site FEP F17 Radionuclide transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 024 Diffusion in and through failed canister	Transport through canister is discussed.		
S 029 Electrochemical effects/gradients		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
S 035 Failure of steel vessel	The canister evolution is discussed.		
S 038 Fuel dissolution and conversion	Fuel dissolution is considered.		
S 051 Interaction with corrosion products	The chemical effects of corrosion products on fuel stability are discussed.		
S 061 Preferential pathways in canister		No transport resistances within canister are considered.	
S 063 Properties of failed canister	Partially damaged canisters are considered.		
S 095 Total release from fuel elements	Release from different parts of the fuel is discussed.		
S 097 Transport and release of nuclides, failed canister	Radionuclide transport is considered.		
W 2.050 Galvanic coupling		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
W 2.055 Radioactive gases	Radionuclide transport in gas phase is considered.		
W 2.061 Actinide sorption	Sorption is considered.		
W 2.067 Localized reducing zones	The chemical effects of corrosion products on fuel stability are discussed.		
W 2.089 Transport of radioactive gases	Radionuclide transport in gas phase is considered.		
W 2.095 Galvanic coupling		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
W 2.096 Electrophoresis		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	

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Appendix 5

Handling of NEA Project FEPs sorted to SR-Site Canister processes

SR-Site FEP C01 Radiation attenuation/ heat generation

No NEA Project FEP associated with this SR-Site FEP

SR-Site FEP C02 Heat transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E SFL-46 Temperature of the near-field	The heat transport in the canister materials is covered.		The heat transfer in the canister is an integrated part of the thermal evolution in the repository.
K 1.08 Heat output (RN decay heat)		This FEP deals with the heat generated by the decay of radionuclides. This is covered in F02.	The decay heat and its evolution with time is the source for the heat transfer in the canister and are covered in F02.
K 2.19 Canister temperature	The heat transport in the canister is covered.		The heat transfer in the canister is an integrated part of the thermal evolution in the repository.
S 090 Temperature, canister	The heat transport in the canister is covered.	Heat generated by criticality is not covered since criticality has been excluded as a possible scenario. Other aspects of increased temperatures such as copper creep, corrosion, microbial activities will be covered elsewhere.	The decay heat and its evolution with time is the source for the heat transfer in the canister.
Recorded by: Christina Lilja			**Date:** Dec 2010
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SR-Site FEP C03 Deformation of cast iron insert

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.19 Container failure (mechanical processes)	Addressed: the canister is designed to withstand the pressures in the repository.		The FEP seems to address the stability of a titanium container.
A 1.80 Swelling pressure	Addressed: the canister is designed to withstand the pressures in the repository.	Not addressed: Any effect of pressure on solubilities at these low pressures.	
E SFL-11 Creeping of the metal in the canister	Creep in copper as well as in iron is addressed.		
E SFL-19 Failure of the cast iron insert	Addressed: the canister is designed to withstand the mechanical loads in the repository.		
E SFL-30 Mechanical impact on the canister	Addressed: the canister is designed to withstand the mechanical loads in the repository.	Not addressed: Pressure build-up due to radiolysis and corrosion prior to canister failure is totally insignificant if resulting at all in a pressure build-up.	Pressure build-up after canister failure is dealt with in C06.

SR-Site FEP C03 Deformation of cast iron insert

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E SFL-39 Reduced mechanical strength of the canister	Addressed: corrosion of a failed canister will eventually lead to collapse and enlargement of the initial penetration.		Weakening of the strength of the insert due to radiation is dealt with in C07.
J 2.2 Creeping of copper	Copper creep is addressed.		
J 2.3.07.1 External stress	External stress caused by rock displacement is addressed.		
J 2.3.07.2 Hydrostatic pressure on canister	Addressed: The hydrostatic load (5MPa) is a negligible stress.		
J 2.3.08 Internal pressure	Addressed: internal pressure build-up caused by alpha decay is negligible with the present canister design.		
K 3.04 Bentonite swelling pressure	Addressed: the effect of the swelling pressure on the canister	Not addressed: the effect of the swelling pressure on the host rock.	
S 003 Bentonite swelling, buffer	Addressed: consequences of the swelling for the canister are considered.		Most of the FEP refers to processes inside the buffer as a result of swelling. These are not considered here. See FEP Bu08.
S 016 Creeping of steel/copper	Creep in copper as well as in iron is addressed.		
S 035 Failure of steel vessel	Addressed: the canister is designed to withstand the pressures in the repository.	Not addressed: collapse of the insert due to weakening from corrosion. Weakening from corrosion will only occur in an already failed canister.	
S 053 Internal pressure	Addressed: Pressure increase due to helium build-up.	Not addressed: Pressure build-up due to radiolysis and corrosion prior to canister failure is totally insignificant if resulting at all in a pressure build-up.	Pressure build-up after canister failure is dealt with in C06.
S 055 Mechanical impact on canister	Addressed: the canister is designed to withstand the pressures in the repository.		
S 075 Reduced mechanical strength	Addressed: corrosion of a failed canister will eventually lead to collapse and enlargement of the initial penetration.		Weakening of the strength of the insert due to radiation is dealt with in C07.
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SR-Site FEP C04 Deformation of copper canister from external pressure

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.19 Container failure (mechanical processes)	Addressed: the canister is designed to withstand all hydrostatic loads in the repository.		
A 1.80 Swelling pressure	Addressed: the canister is designed to withstand all hydrostatic loads in the repository.		
E SFL-11 Creeping of the metal in the canister	Addressed: the design of the canister will limit any creep deformation to well below the creep ductility of copper.		
E SFL-18 Failure of the copper shell	Addressed: the canister is designed to withstand all hydrostatic loads in the repository.		Failure by corrosion is addressed in C10 to C14.
E SFL-30 Mechanical impact on the canister	Addressed: the canister is designed to withstand the mechanical loads in the repository.	Not addressed: Pressure build-up due to radiolysis and corrosion prior to canister failure is totally insignificant if resulting at all in a pressure build-up.	Pressure build-up after canister failure is dealt with in C06.
J 2.2 Creeping of copper	Addressed: the design of the canister will limit any creep deformation to well below the creep ductility of copper.		
J 2.3.07.1 External stress	Addressed: the canister is designed to withstand shear movements of up to 5 cm.		
J 2.3.07.2 Hydrostatic pressure on canister	Addressed: the canister is designed to withstand all hydrostatic loads in the repository.		
K 3.04 Bentonite swelling pressure	Addressed: the effect of the swelling pressure on the canister	Not addressed: the effect of the swelling pressure on the host rock.	
S 003 Bentonite swelling, buffer	Addressed: consequences of the swelling for the canister are considered.		Most of the FEP refers to processes inside the buffer as a result of swelling. These are not considered here. See FEP Bu08.
S 016 Creeping of steel/copper	Addressed: the design of the canister will limit any creep deformation to well below the creep ductility of copper.		
S 034 Failure of copper canister		Addressed in e.g. C11	
S 035 Failure of steel vessel		Addressed in e.g. C08	
S 055 Mechanical impact on canister	Addressed: the canister is designed to withstand the pressures in the repository.		
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SR-Site FEP C05 Thermal expansion (both cast iron insert and copper canister)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E SFL-11 Creeping of the metal in the canister	Addressed: the design of the canister will limit any creep deformation to well below the creep ductility of copper.		
E SFL-14 Different thermal expansion and contraction of the near-field barriers	The different thermal expansion coefficients of iron and copper are evaluated for the cooling of the canister.		
J 2.2 Creeping of copper	Addressed: the design of the canister will limit any creep deformation to well below the creep ductility of copper.		
J 2.3.01 Thermal cracking		Not addressed: copper will not behave like a brittle material for the temperatures that will exist in the repository.	
K 2.10 Other canister degradation processes		Not addressed: high temperature creep and hydrogen embrittlement are not expected to lower the strength of an intact canister.	Radiation damage is addressed in C07.
S 022 Differential thermal expansion of near-field barriers	Addressed: the canister is designed to withstand these loads, which are small compared to the maximum design load.		
S 055 Mechanical impact on canister	Addressed: the canister is designed to withstand the pressures in the repository.		
W 2.031 Differing thermal expansion of repository components	Addressed: the canister is designed to withstand any loads caused by the heat generation in the fuel.		The FEP refers to a salt repository and most of the effects discussed are irrelevant for a repository in hard rock.
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SR-Site FEP C06 Copper deformation from internal corrosion products

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.19 Container failure (mechanical processes)	Addressed: the canister is designed to withstand all hydrostatic loads and the load from the swelling of the bentonite.		This FEP does not address the deformation from internal corrosion products.
E SFL-11 Creeping of the metal in the canister	Addressed: the design of the canister will limit any creep deformation to well below the creep ductility of copper.		
E SFL-30 Mechanical impact on the canister	Addressed: the canister is designed to withstand the mechanical loads in the repository.	Not addressed: Pressure build-up due to radiolysis and corrosion prior to canister failure is totally insignificant if resulting at all in a pressure build-up.	Pressure build-up after canister failure is dealt with in C06.
E SFL-51 Expansion of solid corrosion products	Addressed: Several scenarios for the development of a failed canister are discussed but they all eventually lead to collapse of the cast iron insert. Copper corrosion is too slow to have any significant effect.		

SR-Site FEP C06 Copper deformation from internal corrosion products

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 2.2 Creeping of copper	Addressed: the design of the canister will limit any creep deformation to well below the creep ductility of copper.		This FEP does not address the deformation from internal corrosion products.
J 3.2.07 Swelling of corrosion products	Addressed: Several scenarios for the development of a failed canister are discussed but they all eventually lead to collapse of the cast iron insert.		
K 2.18 Corrosion products (physical effects)	Addressed: copper corrosion is too slow to have any significant effect.		This FEP is related to a steel canister.
S 016 Creeping of steel/copper	Addressed: the design of the canister will limit any creep deformation to well below the creep ductility of copper.		
S 034 Failure of copper canister		Addressed in C11.	
S 055 Mechanical impact on canister	Addressed: the canister is designed to withstand the pressures in the repository.		
S 063 Properties of failed canister		Addressed in F05.	
S 075 Reduced mechanical strength			Weakening of the strength of the insert due to radiation is dealt with in C07.
S 100 Volume increase of corrosion products	Addressed: copper corrosion is too slow to have any significant effect.		
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SR-Site FEP C07 Radiation effects

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.24 Corrosion		Addressed in C10 and C12.	
A 1.64 Radiation damage	Addressed: the effect of neutron and gamma radiation is negligible.		
E SFL-36 Radiation effects on the canister	Addressed: the effect of neutron and gamma radiation is negligible.		
E SFL-39 Reduced mechanical strength of the canister	Addressed: the effect of radiation on mechanical strength.		
I 238 Radiation effects	Addressed: the effect of neutron and gamma radiation is negligible.		
J 2.3.05 Radiation effects on canister	Addressed: the effect of neutron and gamma radiation is negligible.		

SR-Site FEP C07 Radiation effects

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 2.10 Other canister degradation processes	Addressed: the effect of radiation on mechanical strength.	Not addressed: high temperature creep and hydrogen embrittlement are not expected to lower the strength of an intact canister.	See C05.
M 3.4.02 Material propertiy changes	Addressed: the effect of radiation on mechanical strength of the canister materials.		
S 068 Radiation effects on canister	Addressed: the effect of neutron and gamma radiation is negligible.		
W 2.016 Radiological effects on containers	Addressed: the effect of neutron and gamma radiation is negligible.		
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SR-Site FEP C08 Corrosion of cast iron insert

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.03 Biological activity		No bacterial activity is expected inside the bentonite barrier.	
A 1.11 Chemical kinetics	Chemical kinetics is unimportant in comparison to transport kinetics.		
A 1.13 Colloids		Any colloids produced by corrosion are not expected to be able to pass through the buffer barrier.	
A 1.18 Container failure (long-term)		The corrosion of the insert is controlled mainly by the availability of water. Other factors of marginal importance.	
A 1.21 Containers - partial corrosion	The consequences of limited access to water are discussed.		The possible transport resistance to release is a migration issue.
A 1.24 Corrosion	The consequences of corrosion are discussed.		
A 1.35 Formation of gases	The formation of hydrogen gas is discussed.		
A 1.42 Hydride cracking		Possible hydride cracking is not discussed as high temperatures are needed for hydrogen gas charging of the metals.	
A 1.60 Pitting		Pitting corrosion is of no consequence for the cast iron insert.	

SR-Site FEP C08 Corrosion of cast iron insert

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.77 Speciation		The chemical speciation of the corrosion products will not be temperature dependent or pressure dependent in the temperature and pressure ranges that are expected in the canister.	
A 1.86 Uniform corrosion	The consequences of corrosion are discussed.		
E SFL-09 Corrosion of the cast iron insert	The consequences of corrosion are discussed.		
E SFL-10 Canister corrosion prior to wetting			The interior of the canister is treated as a fuel process.
E SFL-19 Failure of the cast iron insert			Addressed in C03.
E SFL-23 Gas escape from the canister	The formation of hydrogen gas is discussed.		Addressed in C03. The formation of helium is treated as a fuel process.
E SFL-25 Gas generation in the canister			Addressed in C03.
E SFL-29 Internal gas pressure	The formation of hydrogen gas is discussed.		The formation of helium is treated as a fuel process.
E SFL-39 Reduced mechanical strength of the canister	Addressed: the canister is designed to withstand the mechanical loads in the repository.		
E SFL-51 Expansion of solid corrosion products			Addressed in C06.
E SFL-52 Evolving water chemistry in the canister	The anaerobic corrosion of the cast iron insert is discussed.		Addressed in C06.
E SFL-56 Water turnover in the copper shell		The gap between the copper and iron is closed quickly by creep of the copper.	
E SFL-57 Water turnover in the cast iron insert	Addressed: Several scenarios for the development of a failed canister are discussed.		Addressed in C06.
H 1.1.1 Container metal corrosion	Only anaerobic corrosion is discussed.		Water access to the insert is assumed to occur only after the repository has gone anaerobic.
H 1.2.1 Hydrogen by metal corrosion	The formation of hydrogen gas is discussed.		Any consequences for microbes in concrete are not discussed.
I 012 Biological activity (bacteria & microbes)		No bacterial activity is expected inside the bentonite barrier.	
I 015 Gas generation (CH4, CO2, H2)	The formation of hydrogen gas is discussed.	No bacterial degradation of organic material is expected inside the canister.	

SR-Site FEP C08 Corrosion of cast iron insert

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 065 Waste container (metal corrosion products)		The release of Fe(II) from the insert to the buffer will be negligible as long as the copper shell remains largely intact.	
I 300 Termperature effects (on transport)		The influence of the changes in temperature during the time the insert corrodes on the corrosion rate is negligible.	The possible consequences for transport in the near field is a migration issue
J 1.2.04 Gas generation	Gas generated through corrosion is covered.	Helium production has no consequences for the corrosion of the insert.	Gas generated through radiolysis is covered in F09 and F15. There will, most likely, be no organic material to decompose inside the canister.
J 1.2.08 Redox potential	Gas generated through corrosion is covered.		The redox potential in the canister will be controlled by the corroding iron.
J 2.1.07 Pitting		Pitting corrosion is of no consequence for the cast iron insert.	
J 3.1.11 Redox front		The redox potential in the canister will be controlled by the corroding iron. There will be no redox front originating from the canister.	
J 4.1.08 Change of groundwater chemistry in nearby rock		The presence of water is the most important factor that controls the corrosion of the insert.	
K 2.03 Corrosion on wetting	Corrosion in water and water vapour has been considered.		In fact, the corrosion in water vapour is not very much lower than that in liquid water.
K 2.04 Oxic corrosion		Corrosion of the cast iron insert is expected to occur only after the repository has become anaerobic.	
K 2.05 Microbially-mediated corrosion		No bacterial activity is expected inside the bentonite barrier.	
K 2.06 Anoxic corrosion	Anoxic corrosion of the cast iron insert is the only form of corrosion that we consider after failure of the copper shell.		
K 2.07 Localised corrosion		Pitting corrosion is of no consequence for the cast iron insert.	
K 2.10 Other canister degrada-tion processes		Possible hydride cracking and high temperature creep are not discussed due to that such high temperatures are not conceivable in the repository.	

SR-Site FEP C08 Corrosion of cast iron insert

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 2.14 Chemical buffering (canister corrosion products)	Gas generated through corrosion is covered.		The redox potential in the canister will be controlled by the corroding iron.
K 2.16 Hydrogen production	Hydrogen gas generation has been considered.		
K 2.18 Corrosion products (physical effects)	Transport through the corrosion products is the rate limiting step in the corrosion process.		
K 2.19 Canister temperature		The influence of the changes in temperature during the time the insert corrodes on the corrosion rate is negligible.	
K 3.15 Gas permeability	The build-up of hydrogen gas does not affect the corrosion rate.		
M 3.2.01 Metallic corrosion	Different corrosion processes are discussed.		
M 3.3.03 Embrittlement and cracking	Embrittlement of cast iron by radiation is addressed in C07.	Possible hydride cracking is not discussed due to that such high temperatures are not conceivable in the repository.	
S 013 Corrosion of steel vessel	The anaerobic corrosion of the cast iron insert has been discussed.	Possible effects of components from the fuel on the corrosion rate are of no consequence.	Galvanic corrosion is discussed in C09.
S 014 Corrosion prior to wetting	Corrosion prior to failure of the copper shell has been discussed and is considered to have negligible consequences.		
S 034 Failure of copper canister	The size and shape of the hole in the copper canister will control the availability of water to the cast iron insert.		
S 035 Failure of steel vessel	The size and shape of the hole in the cast iron insert will control the availability of water to the void in the insert.		
S 045 Gas generation, canister	Hydrogen production through corrosion has been considered.	Other sources of gas will give negligible contributions to the gas pressure inside the canister.	There will, most likely, be no organic material inside the canister.
S 051 Interaction with corrosion products	Sorption and precipitation on solid corrosion products are covered.		
S 063 Properties of failed canister	The size and shape of the hole in the cast iron insert will control the availability of water to the void in the insert.		
S 074 Redox front		The redox potential in the canister will be controlled by the corroding iron. There will be no redox front originating from the canister.	Also addressed in F12.

SR-Site FEP C08 Corrosion of cast iron insert

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 075 Reduced mechanical strength		Obviously the corrosion will eventually lead to mechanical failure of the canister.	When and how the canister fails depend on the external circumstances.
S 102 Water chemistry, canister	The water chemistry has an effect on the corrosion rate, but the most important factor for the corrosion is the availability of water.		
S 103 Water chemistry in near-field rock	The water chemistry has an effect on the corrosion rate, but the most important factor for the corrosion is the availability of water.		
W 2.049 Gases from metal corrosion	Hydrogen production through corrosion has been considered.	Other sources of gas will give negligible contributions to the gas pressure inside the canister.	There will, most likely, be no organic material inside the canister.
W 2.051 Chemical effects of corrosion	Gas generated through corrosion is covered.		The FEP concerns the effects of corrosion products on brines.
W 2.057 Kinetics of speciation		The effects of reaction kinetics are irrelevant for iron corrosion	
W 2.064 Effect of metal corrosion	Generation soluble and solid iron corrosion products and their effects on the chemical environment inside the canister are covered.		
Recorded by: Christina Lilja			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP C09 Galvanic corrosion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.30 Electrochemical gradients			See Stray current corrosion C13.
A 1.86 Uniform corrosion			See Corrosion of cast iron insert C08.
E GEN-13 Electrochemical effects			See Stray current corrosion C13.
E SFL-07 Corrosion of the copper shell	The galvanic coupling between iron and copper does not lead to noticeable increase in the corrosion rate.		
E SFL-09 Corrosion of the cast iron insert	The galvanic coupling between iron and copper does not lead to noticeable increase in the corrosion rate.		
H 1.1.4 Electrochemical effects of metal corrosion		This FEP discusses a situation where all the canisters in the repository are in contact with each other.	

SR-Site FEP C09 Galvanic corrosion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 126 Corrosion (galvanic coupling)	The galvanic coupling between iron and copper does not lead to noticeable increase in the corrosion rate.		
J 2.1.02 Coupled effects (electrophoresis)		The electrophoresis in connection with galvanic corrosion is not discussed. The galvanic does not lead to noticeable increase in the corrosion rate.	
J 2.1.06.2 Natural telluric electrochemical reactions			See Stray current corrosion C13.
S 011 Corrosion of copper canister		The galvanic coupling between iron and copper does not lead to copper corrosion.	
S 013 Corrosion of steel vessel	The galvanic coupling between iron and copper does not lead to noticeable increase in the corrosion rate.		
S 029 Electrochemical effects/gradients	The galvanic coupling between iron and copper does not lead to noticeable increase in the corrosion rate.		See Stray current corrosion C13.
W 2.050 Galvanic coupling	The galvanic coupling between iron and copper does not lead to noticeable increase in the corrosion rate.		
W 2.095 Galvanic coupling	The galvanic coupling between iron and copper does not lead to noticeable increase in the corrosion rate.		
Recorded by: Christina Lilja			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP C10 Stress corrosion cracking of cast iron insert

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.24 Corrosion	The risk for SCC caused by radiolytically produced nitrate is discussed.		
E SFL-09 Corrosion of the cast iron insert	The risk for SCC caused by radiolytically produced nitrate is discussed.		Other aspects of cast iron corrosion are discussed in C08.
J 2.3.06 Cracking along welds		There are no welds in the cast iron insert.	
K 2.09 Stress corrosion cracking	The risk for SCC caused by radiolytically produced nitrate is discussed.		
S 013 Corrosion of steel vessel	The risk for SCC caused by radiolytically produced nitrate is discussed.		Other aspects of cast iron corrosion are discussed in C08.
S 014 Corrosion prior to wetting	The risk for SCC caused by radiolytically produced nitrate is discussed.		Other aspects of cast iron corrosion are discussed in C08.

SR-Site FEP C10 Stress corrosion cracking of cast iron insert

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 035 Failure of steel vessel	The risk for SCC caused by radiolytically produced nitrate is discussed.		Other aspects of cast iron corrosion are discussed in C08.
S 055 Mechanical impact on canister	The risk for SCC caused by radiolytically produced nitrate is discussed.		Other aspects of cast iron corrosion are discussed in C08.
Recorded by: Christina Lilja			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP C11 Corrosion of copper canister

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.03 Biological activity	Bacterial activity in the bentonite barrier is considered.		
A 1.18 Container failure (long-term)	Uniform corrosion controlled by the supply of sulphides is considered in the long term. During the aerobic period, pitting and SCC could be possible.		Hydrogen cracking is not considered a failure mode for oxygen-free copper.
A 1.20 Container healing		Possible healing of a hole in the copper shell due to clogging by iron corrosion products is not discussed because the probability for such an event cannot be assessed.	
A 1.21 Containers - partial corrosion		This has no consequence for copper corrosion.	
A 1.24 Corrosion	All conceivable forms of corrosion have been considered.		
A 1.60 Pitting	During the aerobic period, pitting could be possible.		
A 1.66 Radiolysis	The consequences of radiolytically generated corrosive gases are discussed.		
A 1.86 Uniform corrosion	Uniform corrosion controlled by the supply of sulphides is considered in the long term.		
E GEN-06 Groundwater salinity changes	Changes in groundwater salinity are considered.		
E SFL-07 Corrosion of the copper shell	All conceivable forms of corrosion have been considered.		
E SFL-18 Failure of the copper shell	Different failure modes of the copper shell are considered.		Mechanical failure modes are addressed in C04.
E SFL-51 Expansion of solid corrosion products			Addressed in C06.
E SFL-52 Evolving water chemistry in the canister	The anaerobic corrosion of the cast iron insert is discussed.		Addressed in C08.

SR-Site FEP C11 Corrosion of copper canister

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E SFL-56 Water turnover in the copper shell		The gap between the copper and iron is closed quickly by creep of the copper.	
E SFL-57 Water turnover in the cast iron insert	Addressed: Several scenarios for the development of a failed canister are discussed.		Addressed in C06.
I 012 Biological activity (bacteria & microbes)	Bacterial activity in the bentonite barrier is considered and dismissed.		
I 300 Termperature effects (on transport)	The effect of temperature on transport of corrodants is considered and found to be of limited importance.		
J 2.1.01 Chemical reactions (copper corrosion)	Corrosion is considered.		
J 2.1.03 Internal corrosion due to waste		Any corrosion caused by fission products is totally negligible. All the iodine in a canister can corrode less 100 g of Cu.	
J 2.1.05 Role of chlorides in copper corrosion	The role of chloride has been considered.		
J 2.1.07 Pitting	During the aerobic period, pitting could be possible.		
J 2.1.08 Corrosive agents, Sulphides, oxygen etc	Uniform corrosion controlled by the supply of sulphides is considered in the long term.		
J 2.1.09 Backfill effects on Cu corrosion	Initially trapped oxygen is considered. Uniform corrosion controlled by the supply of sulphides is considered in the long term.		
J 4.1.08 Change of groundwater chemistry in nearby rock		The changes in groundwater chemistry caused by the construction are considered to be of negligible importance for the long-term corrosion.	
J 5.01 Saline (or fresh) groundwater intrusion		Chemical equilibrium will not be reached for the corrosion reaction.	
K 2.05 Microbially-mediated corrosion	Bacterial activity in the bentonite barrier is considered.		
K 2.07 Localised corrosion	During the aerobic period, pitting and SCC could be possible.		
K 2.19 Canister temperature	The effect of temperature on copper corrosion can be neglected. The effect of temperature on transport of corrodants is considered and found to be of limited importance.		

SR-Site FEP C11 Corrosion of copper canister

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
M 3.2.07 Microbiological effects	Bacterial activity in the bentonite barrier is considered.		
S 011 Corrosion of copper canister	Uniform corrosion controlled by the supply of sulphides is considered in the long term. During the aerobic period, pitting and SCC could be possible.		
S 034 Failure of copper canister	Uniform corrosion controlled by the supply of sulphides is considered in the long term. During the aerobic period, pitting and SCC could be possible.		
S 063 Properties of failed canister		A hole in the copper shell has consequences for the corrosion of the insert but not for copper corrosion.	
S 075 Reduced mechanical strength		Reduced strength of the cast iron insert has no consequence for the copper corrosion.	
S 103 Water chemistry in near-field rock	Initially trapped oxygen is considered. Uniform corrosion controlled by the supply of sulphides is considered in the long term.		The changes in groundwater chemistry caused by the construction are considered to be of negligible importance for the long-term corrosion.
Recorded by: Christina Lilja			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP C12 Stress corrosion cracking, copper canister

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.24 Corrosion	SCC is discussed.		
E SFL-07 Corrosion of the copper shell	SCC is discussed.		
E SFL-18 Failure of the copper shell	SCC is discussed but not identified as a potential failure mode.		
J 2.3.03 Stress corrosion cracking	SCC is discussed.		
J 2.3.06 Cracking along welds	SCC is discussed with no particular emphasis on the welds. Any part of the canister with tensile stresses can in principle be susceptible to SCC.		
K 2.09 Stress corrosion cracking	SCC is discussed.		
S 011 Corrosion of copper canister	SCC is discussed.		

SR-Site FEP C12 Stress corrosion cracking, copper canister

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 034 Failure of copper canister	SCC is discussed but not identified as a potential failure mode.		
S 055 Mechanical impact on canister	Considered: external pressure can give rise to tensile stresses.		
Recorded by: Christina Lilja			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP C13 Earth currents - stray current corrosion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E GEN-13 Electrochemical effects	Natural and man-made electrical gradients are found not to increase copper corrosion.		
H 1.1.4 Electrochemical effects of metal corrosion	The corrosion aspects for the canister of electrical fields underground are discussed.		
J 2.1.06.2 Natural telluric electrochemical reactions	The corrosion aspects for the canister of telluric currents are discussed.		
S 029 Electrochemical effects/gradients	The corrosion aspects for the canister of telluric currents are discussed.		
W 2.050 Galvanic coupling	The corrosion aspects for the canister of telluric currents are discussed.		This FEP relates to a repository for long lived low level waste in salt.
W 2.094 Electrochemical effects	The corrosion aspects for the canister of telluric currents are discussed.		
W 2.095 Galvanic coupling	The corrosion aspects for the canister of telluric currents are discussed.		This FEP relates to a repository for long lived low level waste in salt.
W 2.096 Electrophoresis	The corrosion aspects for the canister of telluric currents are discussed.		
Recorded by: Christina Lilja			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP C14 Deposition of salts on canister surface

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
M 1.6.08 Dissolution, precipitation and cristallization	The influence of deposition of salts on corrosion is considered.		
Recorded by: Christina Lilja			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP C15 Radionuclide transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 024 Diffusion in and through failed canister	Transport through canister is discussed.		See FEP F17 Radionuclide transport.
Recorded by: Christina Lilja			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

Appendix 6

Handling of NEA Project FEPs sorted to SR-Site Buffer processes

SR-Site FEP Bu01 Radiation attenuation/ heat generation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.52 Long-term transients	Decay heat is discussed		
E SFL-14 Different thermal expansion and contraction of the near-field barriers			Discussed in Bu08.
E SFL-46 Temperature of the near-field	The temperature in the near field in considered in the assessment.		
J 1.1.02 Radioactive decay; heat	Decay heat is discussed.		
S 069 Radioactive Decay, fuel	Decay heat is discussed.		
W 2.013 Heat from radioactive decay	Decay heat is discussed.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu02 Heat transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.52 Long-term transients	Decreasing decay heat is considered.		
E SFL-46 Temperature of the near-field	The temperature in the near field in considered in the assessment.		
H 1.2.8 Thermo-chemical effects	The effect of gas filled gaps around the canister is discussed.		The effect of gas generation on the thermal evolution is not considered since the processes occur in different time frames.
K 3.02 Thermal evolution	The effect of buffer properties on the thermal evolution is considered.		
S 089 Temperature, bentonite buffer	The thermal evolution in the near field is discussed.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu03 Freezing

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E GEN-26 Permafrost	The potential freezing is discussed.		
J 5.17 Permafrost	The potential freezing is discussed.		
K 10.13 Permafrost	The potential freezing is discussed.		
S 059 Permafrost	The potential freezing is discussed.		Identical to J.5.17.
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu04 Water uptake and transport for unsaturated conditions

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.52 Long-term transients	Resaturation is discussed.		
A 1.68 Reflooding	"Reflooding" is discussed.		SKB does not use the term reflooding.
A 1.84 Transport in gases or of gases	The effect of a gas phase is discussed.		
E SFL-20 Groundwater flow through the buffer and backfill	Advection in buffer and backfill is discussed.		
E SFL-42 Hydraulic resaturation of the buffer and backfill	Resaturation of buffer/backfill is discussed.		
E SFL-53 Evolving water chemistry in the buffer	Resaturation of buffer/backfill is discussed.	The chemical evolution is covered by Bu13.	
K 1.08 Heat output (RN decay heat)	Resaturation is discussed.		
K 3.03 Bentonite saturation	The effect of heat on resaturation is discussed.		
M 2.1.05 Dewatering of host rock			This is a Geosphere FEP (Ge03 and Ge04).
S 079 Resaturation of bentonite buffer	Resaturation is discussed.		
W 2.013 Heat from radioactive decay	The effect of heat on resaturation is discussed.		This FEP may not be relevant for this process.
W 2.098 Osmotic processes	The effect of salinity is discussed.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
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SR-Site FEP Bu05 Water transport for saturated conditions

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.40 Hydraulic conductivity	The effect of varying hydraulic conductivity is discussed.		
E SFL-20 Groundwater flow through the buffer and backfill	Advection in buffer and backfill is discussed.		
K 3.08 Buffer impermeability	Low permeability is discussed.		
S 037 Flow through buffer/backfill	The effect of an increased conductivity is discussed.		
W 2.013 Heat from radioactive decay	The effect of temperature on conductivity is discussed.		Thermally driven flow under saturated conditions is neglected.
W 2.098 Osmotic processes	The effect of salinity is discussed.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
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SR-Site FEP Bu06 Gas transport/dissolution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.35 Formation of gases	Gas generation is discussed.		
A 1.84 Transport in gases or of gases	The effect of gas on buffer transport properties is discussed.		
E SFL-23 Gas escape from the canister	Gas transport in bentonite is discussed.		
E SFL-24 Gas flow through the buffer and backfill	Gas transport in bentonite is discussed.		
H 1.2.6 Gas transport	Gas transport in the near field is discussed.		
J 3.2.12 Gas transport in bentonite	Gas transport in bentonite is discussed.		
K 3.15 Gas permeability	Gas transport in bentonite is discussed.		
M 1.6.04 Gas mediated transport		Covered by FEP Bu26.	
M 3.3.06 Gas effects	The aspects of gas formation are discussed.		
S 040 Gas escape from canister	Gas transport in bentonite is discussed.		
S 041 Gas flow and transport, buffer/backfill	Gas transport in bentonite is discussed.		
S 044 Gas generation, buffer/backfill	Gas generation is discussed.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
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SR-Site FEP Bu07 Piping/erosion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.40 Hydraulic conductivity	Increased conductivity caused by piping is discussed.		
E SFL-04 Coagulation of bentonite			Covered by Bu18.
E SFL-05 Colloid behaviour in the buffer and backfill			Basically a Geosphere FEP. Filtration effect covered by Bu23.
E SFL-16 Dilution of the buffer and backfill	The erosion aspect is discussed.		
E SFL-17 Erosion of the buffer and backfill			Covered by Bu18.
I 027 Buffer (channelling)	The effect of pathways in the buffer is discussed		
J 3.2.04 Erosion of buffer/backfill	Erosion is discussed.		
J 3.2.08 Preferential pathways in the buffer/backfill			Do not understand this FEP.
J 3.2.09 Flow through buffer/backfill	The effect of pathways in the buffer is discussed.		
K 3.06 Bentonite erosion	Erosion is discussed.		
S 025 Dilution of buffer/backfill	Erosion is discussed.		
S 031 Erosion of buffer/backfill	Erosion is discussed.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu08 Swelling/mass redistribution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.08 Cave ins	Rock buffer interactions are considered.		
A 1.31 Excessive hydrostatic pressures	Thermal expansion is considered.		
A 1.47 Interfaces (boundary conditions)	Mechanical interactions are considered.		
A 1.80 Swelling pressure	Mechanical interactions are considered.		
E GEN-03 Cave-in	Rock buffer interactions are considered.		
E GEN-06 Groundwater salinity changes	Salinity effects on swelling pressure are considered.		
E GEN-36 Stress field			Basically a Geosphere FEP.
E SFL-01 Swelling of the bentonite buffer	Swelling pressure and expansion are considered.		

SR-Site FEP Bu08 Swelling/mass redistribution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E SFL-14 Different thermal expansion and contraction of the near-field barriers	Thermal expansion is discussed.		
E SFL-16 Dilution of the buffer and backfill	Loss of mass is considered.		
E SFL-17 Erosion of the buffer and backfill	Loss of mass is considered.		
E SFL-31 Mechanical impact on the buffer and backfill	Mechanical interactions are considered.		
E SFL-33 Movement of the canister in the buffer	Canister movement is considered.		
E SFL-51 Expansion of solid corrosion products	Mechanical interactions are considered.		
I 298 Swelling pressure (clay)	Swelling pressure is considered.		
J 3.2.01.1 Swelling of bentonite into tunnels and cracks	Mechanical interactions are considered.		
J 3.2.01.2 Uneven swelling of bentonite	Uneven swelling is considered.		
J 3.2.02 Movement of canister in buffer/backfill	Canister movement is considered.		
J 3.2.03 Mechanical failure of buffer/backfill	Interaction with rock is considered.		
J 3.2.07 Swelling of corrosion products	Mechanical interactions are considered.		
J 4.2.09 Creeping of rock mass	Mechanical interactions are considered.		Basically a geosphere FEP, see Ge08.
K 2.18 Corrosion products (physical effects)	Mechanical interactions are considered.		
K 3.03 Bentonite saturation	Build up of pressure is considered.		
K 3.04 Bentonite swelling pressure	Swelling pressure is considered.		
K 3.05 Bentonite plasticity	Mechanical properties are considered.		
K 3.07 Canister sinking	Mechanical interactions are considered.		
K 4.04 Effect of bentonite swelling on EDZ	Mechanical interactions are considered.		Basically a geosphere FEP.
M 3.1.01 Differential elastic response		The meaning of this FEP for the buffer is unclear.	
M 3.1.02 Non-elastic reponse	Mechanical interactions are considered.		

SR-Site FEP Bu08 Swelling/mass redistribution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
M 3.3.01 Canister or container movement	Canister movement is considered.		
S 003 Bentonite swelling, buffer	Swelling pressure is considered.		
S 004 Cave in	Rock buffer interactions are considered.		
S 015 Creeping of rock mass, near-field	Rock buffer interactions are considered.		Basically a geosphere FEP, see Ge08.
S 022 Differential thermal expansion of near-field barriers	Thermal expansion is considered.		
S 025 Dilution of buffer/backfill	Loss of mass is considered.		Also covered in colloid formation Bu17.
S 030 Enhanced rock fracturing	Rock buffer interactions are considered.		Basically a geosphere FEP, see Ge07.
S 034 Failure of copper canister	Mechanical interactions are considered.		
S 056 Mechanical impact/failure, buffer/backfill	Mechanical interactions are considered.		
S 058 Movement of canister in buffer/backfill	Mechanical interactions are considered.		
S 062 Properties of bentonite buffer	Very general FEP - most aspects are considered.		
S 065 Properties of near-field rock	Mechanical interactions are considered.		Basically a geosphere FEP, see e.g. Ge07.
S 066 Properties of tunnel backfill	Mechanical interactions are considered.		
S 100 Volume increase of corrosion products	Mechanical interactions are considered.		
W 2.031 Differing thermal expansion of repository components	Thermal expansion is considered.		
W 2.035 Mechanical effects of backfill	Mechanical interactions are considered.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu09 Liquefaction

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 277 Soil liquefaction (seismic)	Liquefaction is considered.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu10 Advective transport of species

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.22 Convection	Convection(advection) is discussed.		
A 1.28 Dispersion		Not considered within the buffer - pure diffusion will dominate under normal circumstances.	
E SFL-50 Radionuclides release and transport from the buffer and backfill			Covered by Bu25.
E SFL-53 Evolving water chemistry in the buffer			Covered by Bu13.
J 3.2.08 Preferential pathways in the buffer/backfill	Advection in the buffer is discussed.		
W 2.090 Advection	Advection in the buffer is discussed.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu11 Diffusive transport of species

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.09 Chemical gradients	Concentration gradients are discussed.		
A 1.27 Diffusion	Diffusion is discussed.		
A 1.36 Galvanic coupling		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradients.	
A 2.16 Diffusion	Diffusion is discussed.		
E GEN-02 Anion exclusion	Anion-exclusion is discussed.		
E GEN-09 Diffusion	Diffusion is discussed.		
E SFL-44 Soret effect in the buffer and backfill		The process is neglected due to the small thermal gradients over the buffer.	
E SFL-50 Radionuclides release and transport from the buffer and backfill			Covered by Bu25.
E SFL-53 Evolving water chemistry in the buffer			Covered by Bu13.
H 1.1.4 Electrochemical effects of metal corrosion		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradients.	
H 1.6.4 Thermal effects: Transport (diffusion) effects	Increased diffusivity of species is discussed in the modelling of the chemical evolution.		It is assumed that the radionuclide transport will take place after the thermal pulse.

SR-Site FEP Bu11 Diffusive transport of species

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 300 Termperature effects (on transport)	Increased diffusivity of species is discussed in the modelling of the chemical evolution.		
J 2.1.06.2 Natural telluric electrochemical reactions		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
J 3.2.06 Diffusion - surface diffusion	"Surface diffusion" is discussed.		
J 3.2.10 Soret effect		The process is neglected due to the small thermal gradients over the buffer.	
K 3.10 Radionuclide retardation	Sorption and diffusion of radionuclides are discussed.		
K 3.16 Radionuclide transport through buffer	Sorption and diffusion of radionuclides are discussed.		
K 4.02 Natural radionuclides/elements		Naturally occurring radioelements are not included in SR-Site (pessimistically).	
M 1.6.02 Diffusion	Diffusion is discussed.		
M 1.6.14 Chemical gradients (electrochemical effects, osmosis)	Concentration gradients are discussed.	Osmosis is covered by Bu15.	
S 002 Anion-exclusion	Anion-exclusion is discussed.		
S 023 Diffusion	Included by definition.		
S 029 Electrochemical effects/gradients		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
S 083 Soret effect		The process is neglected due to the small thermal gradients over the buffer.	
S 096 Transport and release of nuclides, bentonite buffer	Discussed in the "radionuclide transport" process Bu25.		
W 2.093 Soret effect		The process is neglected due to the small thermal gradients over the buffer.	
W 2.096 Electrophoresis		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu12 Sorption (including exchange of major ions)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.06 Buffer characteristics			The FEP is included in "water transport under saturated conditions" (Bu05) and "advection" (BU10).
A 1.14 Complexa-tion by organics		Not a buffer process.	
A 1.73 Sorption	Sorption is discussed.		
A 1.74 Sorption - nonlinear		Non-linear sorption is not included - the Kd approach is however justified.	
A 2.58 Saturation		Not considered - amount of sorbing species is low.	
E GEN-34 Radionuclide sorption	Sorption is discussed.		
E SFL-50 Radionuclides release and transport from the buffer and backfill			Covered by Bu25.
E SFL-53 Evolving water chemistry in the buffer			Covered by Bu13.
I 028b Buffer (quality)			The FEP is discussed in the description of the initial state.
I 182 Buffer (chemical saturation)	The effect of ground water ionic strength is discussed.		
J 3.1.02 Saturation of sorption sites		Non-linear sorption is not included - the Kd approach is however justified.	
J 4.1.04 Sorption	Sorption is discussed.		
J 4.1.09 Complexing agents		Not a buffer process.	
K 3.10 Radio-nuclide retardation	Sorption and diffusion of radionuclides are discussed.		
K 3.16 Radionuclide transport through buffer	Sorption and diffusion of radionuclides are discussed.		
M 1.6.07 Sorption	Sorption is discussed.		
M 1.6.10 Complexing agents		Not a buffer process.	
M 1.6.13 Mass, isotopic and species dilution		Unclear what this means.	
M 1.6.14 Chemical gradients (electrochemical effects, osmosis)			Covered by Bu11 and Bu15.
S 018 Deep saline water intrusion	Impact of water composition on sorption discussed.		Also discussed in Osmosis Bu15 and alterations of impurities Bu13.
S 062 Properties of bentonite buffer	Very general FEP - most aspects discussed.		
S 084 Sorption	Sorption is discussed.		
W 2.061 Actinide sorption	Sorption is discussed.		

SR-Site FEP Bu12 Sorption (including exchange of major ions)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 2.062 Kinetics of sorption		Not discussed - sorption coefficient are based on laboratory experiments where on fast kinetics is detected.	
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu13 Alterations of impurities

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.16 Container corrosion products	Effects of corrosion products are discussed.		
A 1.43 Hydrothermal alteration	Transport of species in thermal gradient is discussed.		The FEP is also discussed in Montmorillonite transformation Bu16.
A 1.51 Long-term physical stability	Transport of species in thermal gradient and the precipitation of minerals is discussed.		The FEP is also discussed in Montmorillonite transformation Bu16.
A 1.62 Precipitation and dissolution	Dissolution/precipitation is discussed.		
E SFL-03 Chemical alteration of the buffer and backfill	Alteration of accessory minerals is discussed.		The FEP is also discussed in Montmorillonite transformation Bu16.
E SFL-47 Thermal degradation of the buffer and backfill	Alteration of accessory minerals is discussed.		The FEP is also discussed in Montmorillonite transformation Bu16.
E SFL-53 Evolving water chemistry in the buffer	Changes in groundwater/porewater composition is discussed.		
J 3.1.01 Degradation of the bentonite by chemical reactions	Dissolution/precipitation of impurities is discussed.		The FEP is also discussed in Montmorillonite transformation Bu16.
J 3.1.03 Effects of bentonite on groundwater chemistry	Changes in groundwater/porewater composition is discussed.		
J 3.1.10 Interactions with corrosion products and waste	Effects of corrosion products are discussed.		
J 4.1.08 Change of groundwater chemistry in nearby rock	Changes in groundwater/porewater composition is discussed.		
J 5.11 Degradation of hole- and shaft seals	The FEP describes a mix of several processes - all of them are discussed.		
K 3.09 Bentonite porewater chemistry	Changes in groundwater/porewater composition are discussed.		
K 3.14 Canister/bentonite interaction	Effect of iron is discussed.		

SR-Site FEP Bu13 Alterations of impurities

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
M 1.6.08 Dissolution, precipitation and cristallization	Alteration of accessory minerals is discussed.		
M 2.1.11 Chemical effects: oxidation of the host rock (1)			Basically a Geosphere FEP.
S 006 Chemical alteration of buffer/backfill	All aspects mentioned are discussed.		
S 062 Properties of bentonite buffer	Very general FEP - most aspects discussed.		
S 079 Resaturation of bentonite buffer	The potential effect is identified.		
S 094 Thermal degradation of buffer/backfill	Dissolution/precipitation of impurities is discussed.		The FEP is also discussed in Montmorillonite transformation Bu16.
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu14 Aqueous speciation and reactions

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E SFL-53 Evolving water chemistry in the buffer	Changes in groundwater/porewater composition is discussed.		
M 1.6.08 Dissolution, precipitation and cristallization			Covered by Bu13.
W 2.057 Kinetics of speciation		Homogeneous aqueous geochemical speciation reactions involving relatively small inorganic species occur rapidly.	
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu15 Osmosis

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.51 Long-term physical stability	Effects of salinity are discussed.		
M 1.6.14 Chemical gradients (electrochemical effects, osmosis)	Osmosis is discussed.		
W 2.098 Osmotic processes	Osmosis is discussed.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu16 Montmorillonite transformation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.07 Buffer evolution	The effect of elevated temperatures is discussed.		
A 1.15 Concrete	Effect of increased pH is discussed.		
A 1.43 Hydro-thermal alteration	The effect of elevated temperatures is discussed.		
A 1.51 Long-term physical stability	The long-term stability is discussed.		
E SFL-03 Chemical alteration of the buffer and backfill	Degradation is discussed.		
E SFL-47 Thermal degradation of the buffer and backfill	Degradation is discussed.		
E SFL-53 Evolving water chemistry in the buffer	Effects of water chemistry on alteration are discussed.		
I 028a Buffer (degradation)	Different mechanisms for montmorillonite transformation are discussed.		Unclear description.
I 048 Buffer (degradation by concrete)	The effect of high pH is discussed.		
J 3.1.01 Degradation of the bentonite by chemical reactions	Degradation is discussed.		
J 3.2.05 Thermal effects on the buffer material	The effect of elevated temperatures is discussed.		
J 5.11 Degradation of hole- and shaft seals	Degradation is discussed.		
K 3.12a Minera-logical alteration - short term	The effect of elevated temperatures is discussed.		
K 3.12b Minera-logical alteration - long term	Degradation is discussed.		
K 3.13 Bentonite cementation	Some aspects of “cementation” are discussed.		The FEP is also discussed in Alteration of impurities Bu13.
K 3.14 Canister/bentonite interaction	The effect of iron is discussed.		
K 3.25 Interaction with cement components	The effect of high pH is discussed.		
M 1.6.08 Dissolution, precipitation and cristallization			This FEB refers to radionuclide transport Bu25.
M 2.1.11 Chemical effects: oxidation of the host rock (1)			Basically a Geosphere FEP.
M 3.1.05 Induced chemical changes	Degradation is discussed.		

SR-Site FEP Bu16 Montmorillonite transformation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 006 Chemical alteration of buffer/backfill	Degradation is discussed.		
S 062 Properties of bentonite buffer	Very general FEP - most aspects discussed.		
S 094 Thermal degradation of buffer/backfill	The effect of elevated temperatures is discussed.		The FEP is also discussed in Alteration of impurities Bu13.
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu17 Iron-bentonite interaction

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E SFL-03 Chemical alteration of the buffer and backfill	Degradation is discussed.		
E SFL-53 Evolving water chemistry in the buffer	Effects of water chemistry on alteration are discussed.		
J 3.1.10 Interactions with corrosion products and waste	Iron-bentonite interactions are discussed.		Mapped to Bu16 in SR-Can, which contained iron-bentonite interaction. Remapped to this FEP extracted from Bu16 in SR-Site.
K 3.09 Bentonite porewater chemistry	Effects on and from chemistry are discussed.		Mapped to Bu16 in SR-Can, which contained iron-bentonite interaction. Remapped to this FEP extracted from Bu16 in SR-Site.
K 3.14 Canister/bentonite interaction	Iron-bentonite interactions are discussed.		Mapped to Bu16 in SR-Can, which contained iron-bentonite interaction. Remapped to this FEP extracted from Bu16 in SR-Site.
S 006 Chemical alteration of buffer/backfill	Alteration is discussed.		Mapped to Bu16 in SR-Can, which contained iron-bentonite interaction. Remapped to this FEP extracted from Bu16 in SR-Site.
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu18 Montmorillonite colloid release

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.13 Colloids	Colloid generation from the buffer is discussed.		
A 2.50 Pseudo-colloids	Colloid generation from the buffer is discussed.		

SR-Site FEP Bu18 Montmorillonite colloid release

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E SFL-04 Coagulation of bentonite	Colloid generation from the buffer is discussed - this is the reverse process - included by definition.		This FEP does not make sense.
E SFL-05 Colloid behaviour in the buffer and backfill	Colloid generation from the buffer is discussed.		
E SFL-16 Dilution of the buffer and backfill	Loss of buffer mass is a consequence of colloid generation – yes.		
E SFL-17 Erosion of the buffer and backfill	Erosion as a consequence of colloid release is discussed.		
E SFL-43 Sedimentation of the buffer and backfill	Erosion as a consequence of colloid release is discussed.		The description of the FEP is unclear.
I 058 Colloid formation (natural and vault generated)	Colloid generation from the buffer is discussed.		Does not really fit the FEP description.
J 3.1.04 Colloid generation - source	Colloid generation from the buffer is discussed.		
J 3.1.05 Coagulation of bentonite	Colloid generation from the buffer is discussed - this is the reverse process - included by definition.		
J 3.1.06 Sedimentation of bentonite			Sedimentation of bentonite occurs in the geosphere - it is however considered in the integrated description of colloid release.
J 3.2.04 Erosion of buffer/backfill	Colloid generation from the buffer is discussed.		
J 5.11 Degradation of hole- and shaft seals			Unclear meaning of FEP.
K 3.06 Bentonite erosion	Colloid generation from the buffer is discussed.		
K 4.12 Colloids	Colloid generation from the buffer is discussed.		
S 007 Coagulation of bentonite	Colloid generation from the buffer is discussed - this is the reverse process - included by definition.		
S 009 Colloid generation-source	Colloid generation from the buffer is discussed.		
S 025 Dilution of buffer/backfill	Loss of buffer mass is a consequence of colloid generation – yes.		
S 031 Erosion of buffer/backfill	Erosion as a consequence of colloid release is discussed.		
S 065 Properties of near-field rock	Very general FEP - the colloid aspects are discussed.		
S 082 Sedimentation of bentonite			Sedimentation of bentonite occurs in the geosphere - it is however considered in the integrated description of colloid release.

SR-Site FEP Bu18 Montmorillonite colloid release

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 2.082 Suspen-sions of particles		Not relevant.	
W 2.083 Rinse		Not relevant.	
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu19 Radiation-induced transformations

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.51 Long-term physical stability	Radiation effects are discussed.		
A 1.64 Radiation damage	Radiation effects are discussed.		
E SFL-35 Radiation effects on the buffer and backfill	Radiation effects are discussed.		
I 238 Radiation effects	Radiation effects are discussed.		
J 3.1.13 Radiation effects on bentonite	Radiation effects are discussed.		
K 2.11 Radiation shielding	Credit is taken for shielding.		
M 3.4.02 Material propertiy changes	Radiation effects are discussed.		
S 067 Radiation effects on buffer/backfill	Exactly what is covered in this process.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu20 Radiolysis of porewater

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.66 Radiolysis	Radiolysis is discussed.		
E GEN-30 Radiolysis	Radiolysis is discussed.		
E SFL-26 Gas generation in the buffer and backfill		Not discussed - gamma-radiolysis is expected to give very little gas - corrosion gas will dominate in the case of a breached canister.	
E SFL-53 Evolving water chemistry in the buffer	Effects of radiolysis are discussed.		
I 238 Radiation effects	Radiolysis is discussed.		
J 1.2.01 Radiolysis	Radiolysis is discussed.		
J 1.2.02 Hydrogen/oxygen explosions		Not addressed - sounds speculative.	
J 3.1.09 Radiolysis	Radiolysis is discussed.		
K 2.11 Radiation shielding	Credit is taken for shielding.		

M 3.4.01 Radiolysis	Radiolysis is discussed.		
S 044 Gas generation, buffer/backfill		Not discussed - gamma-radiolysis is expected to give very little gas - corrosion gas will dominate in the case of a breached canister.	
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu21 Microbial processes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.03 Biological activity	Microbes are considered.		
A 1.35 Formation of gases	Gas generation is discussed.		
A 1.51 Long-term physical stability		The buffer is not expected to be affected by microbes.	Reduction of iron may be an exception.
A 1.53 Methylation		Organic compounds are not expected to have any significant effect on the buffer - since the levels are very low.	
A 1.54 Microbes		The buffer is not expected to be affected by microbes.	Reduction of iron may be an exception.
A 1.55 Microorganisms	Microbes are considered.		
E SFL-26 Gas generation in the buffer and backfill	Gas generation is mentioned in the process description.		Gas generation from microbial activity is not relevant in a spent fuel repository.
E SFL-32 Microbial activity	Microbes are considered.		
E SFL-53 Evolving water chemistry in the buffer	Effects of microbes discussed.		
I 012 Biological activity (bacteria & microbes)	Microbes are considered.		
J 2.1.10 Microbes	Microbes are considered.		
K 3.17 Microbial activity	Microbes are considered.		
M 3.2.07 Microbiological effects	Microbes are considered.		
S 044 Gas generation, buffer/backfill	Gas generation is discussed.		Gas generation from microbial activity is not relevant in a spent fuel repository.
S 057 Microbial activity	Microbes are considered.		
W 2.044 Degradation of organic material	Gas generation is discussed.	.	Gas generation from microbial activity is not relevant in a spent fuel repository.
W 2.045 Effect of temperature on microbial gas generation	Gas generation is discussed.		Gas generation from microbial activity is not relevant in a spent fuel repository.

SR-Site FEP Bu21 Microbial processes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 2.046 Effect of pressure on microbial gas generation	Pressure is discussed.		Gas generation from microbial activity is not relevant in a spent fuel repository.
W 2.047 Effect of radiation on microbial gas generation	Radiation is discussed.		Gas generation from microbial activity is not relevant in a spent fuel repository.
W 2.048 Effect of biofilms on microbial gas generation	Biofilms are discussed.		Gas generation from microbial activity is not relevant in a spent fuel repository.
W 2.088 Biofilms	Biofilms are discussed.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu22 Cementation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.07 Buffer evolution	Cementation is discussed.		Mapped to Bu16 in SR-Can, which addressed cementation effects. Remapped to this FEP extracted from Bu16 in SR-Site.
A 1.51 Long-term physical stability			Covered by Bu16.
E SFL-03 Chemical alteration of the buffer and backfill			Covered by Bu16.
I 028a Buffer(degradation)			Covered by Bu16.
J 3.1.01 Degradation of the bentonite by chemical reactions			Covered by Bu16.
K 3.13 Bentonite cementation	Cementation is discussed.		Mapped to Bu16 in SR-Can, which addressed cementation effects. Remapped to this FEP extracted from Bu16 in SR-Site.
M 1.6.08 Dissolution, precipitation and cristallization			Covered by Bu13 and Bu25.
S 006 Chemical alteration of buffer/backfill			Covered by Bu16.
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu23 Colloid transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.13 Colloids			Covered by Bu18.
A 1.63 Psuedo-colloids	Transport of radionuclides sorbed onto colloids is discussed.		
E SFL-50 Radionuclides release and transport from the buffer and backfill			Covered by Bu25.
K 3.11 Colloid filtration	Criteria for colloid filtration is discussed.		
S 009 Colloid generation-source			Covered by Bu18.
S 096 Transport and release of nuclides, bentonite buffer	Criteria for colloid filtration is discussed.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu24 Speciation of radionuclides

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.14 Complexation by organics			Most aspects of speciation of radionuclides is discussed in the fuel/canister process report.
A 1.37 Geochemical pump		The process as such is not discussed in the report - however, the concept is included in the transport model.	
A 1.77 Speciation	Speciation is discussed.		Most aspects of speciation of radionuclides is discussed in the fuel/canister process report, see F14.
E GEN-27 Radionuclide precipitation and dissolution			Basically a fuel process.
J 4.1.04 Sorption	Sorption is discussed.		
J 4.1.09 Complexing agents	Speciation is discussed.		
K 0.2 Speciation	Speciation is discussed.		
K 2.14 Chemical buffering (canister corrosion products)			Most aspects of speciation of radionuclides is discussed in the fuel/canister process report.
K 5.21 Organics		Not relevant for a spent fuel repository.	
K 6.21 Organics		Not relevant for a spent fuel repository.	
M 1.6.06 Solubility limit			Basically a fuel process.
M 1.6.10 Complexing agents	Speciation is discussed.		

SR-Site FEP Bu24 Speciation of radionuclides

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
M 1.6.13 Mass, isotopic and species dilution	Speciation is discussed.		
S 060 Precipitation/dissolution			Most aspects of speciation of radionuclides is discussed in the fuel/canister process report.
S 084 Sorption	Sorption is discussed.		
W 2.056 Speciation	Speciation is discussed.		
W 2.057 Kinetics of speciation		Assumed to be fast.	
W 2.060 Kinetics of precipitation and dissolution			Most aspects of speciation of radionuclides is discussed in the fuel/canister process report.
W 2.071 Kinetics of organic complexation		Not relevant for a spent fuel repository.	
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu25 Transport of radionuclides in the water phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.28 Dispersion		Only diffusion is considered in the buffer.	
A 1.65 Radioactive decay	Radioactive decay is considered.		
A 2.51 Radioactive decay	Chain decay is considered.		
E GEN-28 Radioactive decay	Radioactive decay is considered.		
E SFL-40 Radionuclide release from the spent fuel matrix			Basically a Fuel process.
E SFL-50 Radionuclides release and transport from the buffer and backfill	Radionuclide transport is discussed.		
E SFL-53 Evolving water chemistry in the buffer		Effects of nuclides on chemistry are ignored.	
H 1.3.1 Radioactive decay and ingrowth	Chain decay is considered.		
I 027 Buffer (channelling)	Preferential pathways is discussed.		
I 045 Progency nuclides (critical radionuclides)	Chain decay is considered.		
J 3.2.08 Preferential pathways in the buffer/backfill	Preferential pathways is discussed.		
K 0.1 Radioactive decay	Radioactive decay is considered.		

SR-Site FEP Bu25 Transport of radionuclides in the water phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 3.16 Radionuclide transport through buffer	Yes.		
M 3.4.04 Radioactive decay ingrowth	Radioactive decay is considered.		
S 070 Radioactive decay of mobile nuclides	Radioactive decay is considered.		
S 096 Transport and release of nuclides, bentonite buffer	All relevant aspects are covered.		
W 2.090 Advection	Advection is considered.		Not a relevant FEP.
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bu26 Transport of radionuclides in a gas phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E GEN-28 Radioactive decay	Radioactive decay is considered.		
E SFL-23 Gas escape from the canister	Gas transport is considered.		
E SFL-50 Radionuclides release and transport from the buffer and backfill	Gas transport is considered.		
H 1.2.4 Radioactive gases	Radioactive gases are considered.		
K 0.3 Gaseous and volatile isotopes	Radioactive gases are considered.		
K 3.16 Radionuclide transport through buffer			This FEP neglects gas transport.
S 096 Transport and release of nuclides, bentonite buffer	Gas transport is considered.		
W 2.055 Radioactive gases	Radioactive gases are considered.		
W 2.089 Transport of radioactive gases	Gas transport is considered.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

Appendix 7

Handling of NEA Project FEPs sorted to SR-Site Backfill processes

SR-Site FEP BfT01 Heat transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.52 Long-term transients	Decreasing decay heat is considered.		
E SFL-46 Temperature of the near-field	Temperature evolution of the backfill is considered.		
H 1.2.8 Thermo-chemical effects		The effect of gas generation on the thermal evolution is not considered since the processes occur in different time frames.	
S 093 Temperature, tunnel backfill	Temperature evolution of the backfill is considered.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP BfT02 Freezing

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E GEN-26 Permafrost	Freezing of backfill is discussed.		
J 5.17 Permafrost	The properties of a frozen backfill are discussed.		
K 10.13 Permafrost		This FEP does not discuss freezing at repository level.	
S 059 Permafrost	The properties of a frozen backfill are discussed.		Identical to J.5.17.
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP BfT03 Water uptake and transport for unsaturated conditions

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.68 Reflooding	"Reflooding" is discussed.		SKB does not use the term reflooding.
A 1.84 Transport in gases or of gases	The effect of a gas phase is discussed.		
E SFL-20 Groundwater flow through the buffer and backfill	Flow **into** the backfill is discussed.		
E SFL-42 Hydraulic resaturation of the buffer and backfill	Saturation is discussed.		
E SFL-54 Evolving water chemistry in the backfill			Covered by BfT12.

SR-Site FEP BfT03 Water uptake and transport for unsaturated conditions

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
M 2.1.05 Dewatering of host rock	Rock characteristics are discussed.		
S 080 Resaturation of tunnel backfill	Resaturation is discussed.		
W 2.013 Heat from radioactive decay	The effect of heat on resaturation is discussed.		This FEP may not be relevant for this process.
W 2.098 Osmotic processes	The effect of salinity is discussed.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP BfT04 Water transport for saturated conditions

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.01 Backfill characteristics	Backfill properties are discussed.		
A 1.40 Hydraulic conductivity	The effect of varying hydraulic conductivity is discussed.		
A 1.52 Long-term transients		None of the processes are expected to occur in the backfill.	
A 1.59 Percolation in shafts	Convection is mentioned, but not considered.		Basically a geosphere process.
A 2.60 Shaft seal failure	Impact of degradation of plugs on flow in deposition tunnels is mentioned.		See also SKB FEP Pg04.
E SFL-20 Groundwater flow through the buffer and backfill	Advection is discussed.		
S 037 Flow through buffer/backfill	The effect of an increased conductivity is discussed.		
W 2.013 Heat from radioactive decay	The effect of temperature on conductivity is discussed.		Thermally driven flow under saturated conditions is neglected.
W 2.098 Osmotic processes	The effect of salinity is discussed.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP BfT05 Gas transport/dissolution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.84 Transport in gases or of gases		Gas mediated transport in the backfill is neglected. Gas effects on backfill are neglected.	
E SFL-24 Gas flow through the buffer and backfill	Gas transport is discussed.		
H 1.2.6 Gas transport	Gas transport in the near field is discussed.		
M 1.6.04 Gas mediated transport		Gas mediated transport in the backfill is neglected.	
M 3.3.06 Gas effects		Gas effects on backfill are neglected.	
S 041 Gas flow and transport, buffer/backfill	Gas transport in the near field is discussed.		
S 044 Gas generation, buffer/backfill		Not expected to be an issue in a spent fuel repository.	
S 066 Properties of tunnel backfill	The effect of gas in the backfill is considered.		
S 104 Water chemistry, tunnel backfill		Gas is not expected to be of concern for the chemistry of the water in the backfill.	
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP BfT06 Piping/erosion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.40 Hydraulic conductivity	Increased conductivity caused by piping is discussed.		
E SFL-04 Coagulation of bentonite	Colloid generation from the buffer is discussed - this is the reverse process - included by definition.		
E SFL-05 Colloid behaviour in the buffer and backfill			Basically a Geosphere FEP.
E SFL-16 Dilution of the buffer and backfill	The erosion aspect is discussed.		
E SFL-17 Erosion of the buffer and backfill			Covered by BfT16.
I 027 Buffer (channelling)	The effect of pathways in the backfill is discussed.		
J 3.2.04 Erosion of buffer/backfill	Erosion is discussed.		
J 3.2.08 Preferential pathways in the buffer/backfill			Do not understand this FEP.
J 3.2.09 Flow through buffer/backfill	The effect of pathways in the buffer is discussed.		
K 3.06 Bentonite erosion	Erosion is discussed.		
S 025 Dilution of buffer/backfill	Erosion is discussed.		
S 031 Erosion of buffer/backfill	Erosion is discussed.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP BfT07 Swelling/mass redistribution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.08 Cave ins	Rock backfill interactions are considered.		
A 1.31 Excessive hydrostatic pressures	Thermal expansion is considered.		
A 1.47 Interfaces (boundary conditions)	Mechanical interactions are considered.		
E GEN-03 Cave-in	Rock backfill interactions are considered.		
E GEN-06 Groundwater salinity changes	Swelling pressure is considered.		
E GEN-36 Stress field	Mechanical interactions are considered.		
E SFL-16 Dilution of the buffer and backfill	Loss of mass is considered.		
E SFL-17 Erosion of the buffer and backfill	Loss of mass is considered.		
E SFL-31 Mechanical impact on the buffer and backfill	Mechanical interactions are considered.		
E SFL-45 Swelling of the tunnel backfill	Swelling pressure is considered.		
H 1.4.2 Vault collapse	Rock backfill interactions are considered.		
I 298 Swelling pressure (clay)	Swelling pressure is considered.		
J 3.2.01.2 Uneven swelling of bentonite	Uneven swelling is considered.		
J 3.2.03 Mechanical failure of buffer/backfill	Interaction with rock is considered.		
J 4.2.09 Creeping of rock mass	Backfill rock interactions are discussed.		Basically a geosphere FEP, see process "Creep" Ge08.
M 3.1.01 Differential elastic response	Thermal expansion is discussed.		
M 3.1.02 Non-elastic reponse	Mechanical interactions are considered.		
M 3.3.04 Subsidence/collapse	Backfill rock interactions are discussed.		
S 004 Cave in	Rock backfill interactions are considered.		
S 015 Creeping of rock mass, near-field	Backfill rock interactions are discussed.		Basically a geosphere FEP, see process "Creep" Ge08.
S 025 Dilution of buffer/backfill	Loss of mass is considered.		Also covered in process "Colloid release" BfT16.
S 056 Mechanical impact/failure, buffer/backfill	Mechanical interactions are considered.		
S 066 Properties of tunnel backfill	Very general FEP - most aspects are covered.		
S 088 Swelling of tunnel backfill	Swelling pressure is considered.		
W 2.022 Roof falls	Mechanical interactions are considered.		
W 2.035 Mechanical effects of backfill	Mechanical interactions are considered.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP BfT08 Liquefaction

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 277 Soil liquefaction (seismic)	Liquefaction is considered.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP BfT09 Advective transport of species

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.01 Backfill characteristics	Backfill properties are discussed.		
A 1.22 Convection	Convection (advection) is discussed.		
A 1.28 Dispersion		Only advection and diffusion are considered.	
A 2.18 Dispersion		Only advection and diffusion are considered.	
E SFL-50 Radionuclides release and transport from the buffer and backfill	Conditions for RN transport are considered.		RN transport is discussed in processes "Diffusion" (BfT10) and "Transport of radionuclides in the water phase" (BfT21) as well as in the Fuel process report.
E SFL-54 Evolving water chemistry in the backfill	Advection in the backfill is discussed.		Chemical evolution is discussed in BfT12.
J 3.2.08 Preferential pathways in the buffer/backfill	Piping is considered.		
M 1.6.01 Advection and dispersion	Advection in the backfill is discussed.		
S 037 Flow through buffer/backfill	Advection in the backfill is discussed.		
S 099 Transport and release of nuclides, tunnel backfill	Conditions for RN transport are considered.		RN transport is discussed in processes "Diffusion" (BfT10) and "Transport of radionuclides in the water phase (BfT21) as well as in the Fuel process report.
W 2.090 Advection	Advection in the backfill is discussed.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP BfT10 Diffusive transport of species

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.09 Chemical gradients	Concentration gradients are discussed.		
A 1.27 Diffusion	Diffusion is discussed.		

SR-Site FEP BfT10 Diffusive transport of species

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.36 Galvanic coupling		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradients.	
A 2.16 Diffusion	Diffusion is discussed.		
E GEN-02 Anion exclusion	Anion-exclusion is discussed.		
E GEN-09 Diffusion	Included by definition.		
E SFL-44 Soret effect in the buffer and backfill		The process is neglected due to the small thermal gradients over the backfill.	
E SFL-50 Radionuclides release and transport from the buffer and backfill	The transport mechanisms are discussed.		See also BfT 21.
E SFL-54 Evolving water chemistry in the backfill	Diffusion in the backfill is discussed.		Chemical evolution is discussed in BfT12.
H 1.1.4 Electrochemical effects of metal corrosion		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradients.	
H 1.6.4 Thermal effects: Transport (diffusion) effects	Increased diffusivity of species is discussed in the modelling of the chemical evolution.		It is assumed that the radionuclide transport will take place after the thermal pulse.
I 300 Termperature effects (on transport)	Mentioned, but not considered.		
J 2.1.06.2 Natural telluric electrochemical reactions		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
J 3.2.06 Diffusion - surface diffusion	Surface diffusion is discussed.		
J 3.2.08 Preferential pathways in the buffer/backfill	Loss of the diffusion barrier is discussed in the "advection" process.		
J 3.2.10 Soret effect		The process is neglected due to the small thermal gradients over the backfill.	
K 4.02 Natural radionuclides/elements		Naturally occurring radioelements are not included in SR-Site (pessimistically).	
M 1.6.02 Diffusion	Included by definition.		
M 1.6.14 Chemical gradients (electrochemical effects, osmosis)	Concentration gradients are discussed.		Osmosis is covered by BfT14.
S 002 Anion-exclusion	Anion-exclusion is discussed.		
S 023 Diffusion	Included by definition.		
S 029 Electrochemical effects/gradients		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
S 083 Soret effect		The process is neglected due to the small thermal gradients over the backfill.	

SR-Site FEP BfT10 Diffusive transport of species

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 099 Transport and release of nuclides, tunnel backfill	Discussed in the "radionuclide transport" process, BfT21.		
W 2.050 Galvanic coupling		Not relevant here - canister process.	See FEP C09.
W 2.093 Soret effect		The process is neglected due to the small thermal gradients over the backfill.	
W 2.095 Galvanic coupling		Not relevant here - canister process.	See FEP C09.
W 2.096 Electrophoresis		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP BfT11 Sorption (including exchange of major ions)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.14 Complexation by organics		Not a backfill process.	
A 1.73 Sorption	Sorption is discussed.		
A 1.74 Sorption - nonlinear		Non-linear sorption is not included - the Kd approach is however justified.	
A 2.58 Saturation		Not considered - amount of sorbing species is low.	
E GEN-34 Radionuclide sorption	Sorption is discussed.		
E SFL-50 Radionuclides release and transport from the buffer and backfill	The sorption mechanisms are discussed.		
E SFL-54 Evolving water chemistry in the backfill	Sorption is discussed.		Chemical evolution is discussed in BfT12.
J 4.1.04 Sorption	Sorption is discussed.		
J 4.1.09 Complexing agents		Not a backfill process.	
M 1.6.07 Sorption	Sorption is discussed.		
M 1.6.10 Complexing agents	The sorption mechanisms are discussed.		Speciation is discussed in BfT13 and BfT20.
M 1.6.13 Mass, isotopic and species dilution		Unclear what this means.	
M 1.6.14 Chemical gradients (electrochemical effects, osmosis)			Covered by BfT10 and BfT14.
S 018 Deep saline water intrusion	Impact of water composition on sorption discussed.		Also discussed in Osmosis (BfT14) and alteration of impurities (BfT12).
S 066 Properties of tunnel backfill	Very general FEP - most aspects discussed.		
S 084 Sorption	Sorption is discussed.		

SR-Site FEP BfT11 Sorption (including exchange of major ions)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 099 Transport and release of nuclides, tunnel backfill	Sorption is discussed.		Also discussed in "radionuclide transport" (BfT21).
W 2.061 Actinide sorption	Sorption is discussed.		
W 2.062 Kinetics of sorption		Not discussed - sorption coefficient are based on laboratory experiments where on fast kinetics is detected.	
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP BfT12 Alterations of backfill impurities

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.43 Hydrothermal alteration	Transport of species in thermal gradient is discussed.		The FEP is also discussed in Montmorillonite transformations (BfT15).
A 1.51 Long-term physical stability	Transport of species in thermal gradient and the precipitation of minerals is discussed.		The FEP is also discussed in Montmorillonite transformations (BfT15).
A 1.62 Precipitation and dissolution	Dissolution/precipitation is discussed.		
E SFL-03 Chemical alteration of the buffer and backfill	Dissolution/precipitation of impurities is discussed.		The FEP is also discussed in Montmorillonite transformations (BfT15).
E SFL-47 Thermal degradation of the buffer and backfill	Dissolution/precipitation of impurities is discussed.		The FEP is also discussed in Montmorillonite transformations (BfT15).
E SFL-54 Evolving water chemistry in the backfill	Changes in groundwater/porewater composition are discussed.		
J 3.1.01 Degradation of the bentonite by chemical reactions	Dissolution/precipitation of impurities is discussed.		The FEP is also discussed in Montmorillonite transformations (BfT15).
J 3.1.03 Effects of bentonite on groundwater chemistry	Changes in groundwater/porewater composition are discussed.		
K 3.09 Bentonite porewater chemistry	Changes in groundwater/porewater composition are discussed.		
M 1.6.08 Dissolution, precipitation and cristallization	Dissolution/precipitation of impurities is discussed.		
M 2.1.11 Chemical effects: oxidation of the host rock (1)			Basically a Geosphere FEP
S 006 Chemical alteration of buffer/backfill	All aspects mentioned are discussed.		
S 066 Properties of tunnel backfill	Very general FEP - most aspects discussed.		
S 080 Resaturation of tunnel backfill	The potential effect is identified.		

SR-Site FEP BfT12 Alterations of backfill impurities

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 094 Thermal degradation of buffer/backfill	Dissolution/precipitation of impurities is discussed.		The FEP is also discussed in Montmorillonite transformations (BfT15).
S 104 Water chemistry, tunnel backfill	Many aspects are discussed.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP BfT13 Aqueous speciation and reactions

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E SFL-54 Evolving water chemistry in the backfill	Changes in groundwater/porewater composition are discussed.		
M 1.6.08 Dissolution, precipitation and cristallization			Covered by BfT12.
S 104 Water chemistry, tunnel backfill	Relevant aspects are discussed.		
W 2.057 Kinetics of speciation		Homogeneous aqueous geochemical speciation reactions involving relatively small inorganic species occur rapidly.	
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP BfT14 Osmosis

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.51 Long-term physical stability	Effects on swelling pressure are discussed.		
M 1.6.14 Chemical gradients (electrochemical effects, osmosis)	Osmotic effects discussed.		
W 2.098 Osmotic processes	Osmosis is discussed.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
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SR-Site FEP BfT15 Montmorillonite transformation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.02 Backfill evolution	The effect of elevated temperatures is discussed.		
A 1.15 Concrete	pH effects are discussed.		
A 1.43 Hydrothermal alteration	The effect of elevated temperatures is discussed.		
A 1.51 Long-term physical stability	Degradation is discussed.		
E SFL-03 Chemical alteration of the buffer and backfill	Degradation is discussed.		
E SFL-45 Swelling of the tunnel backfill	The documentation of this FEP is confusing, it is however possible that some aspects are covered by the process.		
E SFL-47 Thermal degradation of the buffer and backfill	Degradation is discussed.		
E SFL-54 Evolving water chemistry in the backfill	Effects of GW chemistry are discussed.		
I 048 Buffer (degradation by concrete)	The effect of high pH is discussed.		
I 061 Concrete (influence on vault chemistry)	The effect of high pH is discussed.		
J 3.1.01 Degradation of the bentonite by chemical reactions	Degradation is discussed.		
J 4.2.10 Chemical effects of rock reinforcement	The effect of high pH is discussed.		
K 3.12b Mineralogical alteration - long term	Degradation is discussed.		
K 3.25 Interaction with cement components	The effect of high pH is discussed.		
M 1.6.08 Dissolution, precipitation and cristallization	Dissolution of clay is discussed.		
M 2.1.11 Chemical effects: oxidation of the host rock (1)			Basically a Geosphere FEP.
M 3.1.05 Induced chemical changes	Degradation is discussed.		
S 006 Chemical alteration of buffer/backfill	Degradation is discussed.		
S 021 Degradation of rock reinforcement and grout	The effect of high pH is discussed.		
S 066 Properties of tunnel backfill	Very general FEP - most aspects discussed.		
S 094 Thermal degradation of buffer/backfill	The effect of elevated temperatures is discussed.		The FEP is also discussed in Alteration of impurities (BfT12).
S 104 Water chemistry, tunnel backfill	Relevant aspects are discussed.		
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP BfT16 Backfill colloid release

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.13 Colloids	Colloid generation is discussed.		
A 1.51 Long-term physical stability	Loss of backfill is discussed.		
A 2.50 Pseudo-colloids	Colloid generation from the backfill is discussed.		
E SFL-04 Coagulation of bentonite	Colloid generation is discussed - this is the reverse process - included by definition.		This FEP does not make sense.
E SFL-05 Colloid behaviour in the buffer and backfill	Colloid generation is discussed.		
E SFL-16 Dilution of the buffer and backfill	Erosion is discussed.		
E SFL-17 Erosion of the buffer and backfill	Erosion is discussed.		
E SFL-43 Sedimentation of the buffer and backfill			Sedimentation of bentonite occurs in the geosphere - it is however considered in the integrated description of colloid release.
I 058 Colloid formation (natural and vault generated)	Colloid generation from the backfill is discussed.		Does not really fit the FEP description.
J 3.1.05 Coagulation of bentonite	Colloid generation is discussed - this is the reverse process - included by definition.		
J 3.2.04 Erosion of buffer/backfill	Colloid generation is discussed.		
K 3.06 Bentonite erosion	Colloid generation is discussed.		
K 4.12 Colloids	Colloid generation is discussed.		
S 007 Coagulation of bentonite	Colloid generation is discussed - this is the reverse process - included by definition.		
S 009 Colloid generation-source	Colloid generation is discussed.		
S 025 Dilution of buffer/backfill	Loss of mass is a consequence of colloid generation - yes.		
S 031 Erosion of buffer/backfill	Erosion as a consequence of colloid release is discussed.		
S 066 Properties of tunnel backfill	Colloid aspects are discussed.		
S 082 Sedimentation of bentonite			Sedimentation of bentonite occurs in the geosphere - it is however considered in the integrated description of colloid release.
W 2.082 Suspensions of particles		Not relevant.	
W 2.083 Rinse		Not relevant.	
Recorded by: Patrik Sellin			**Date:** Dec 2010
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SR-Site FEP BfT17 Radiation-induced transformations

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.64 Radiation damage	Radiation effects are discussed.		
E SFL-35 Radiation effects on the buffer and backfill	Radiation effects are discussed.		
I 238 Radiation effects	Radiation effects are discussed.		
S 066 Properties of tunnel backfill		Radiation effects on properties are neglected.	
S 067 Radiation effects on buffer/backfill	Radiation effects are discussed.		
W 2.017 Radiological effects on seals		Radiation effects on properties are neglected.	
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP BfT18 Microbial processes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.03 Biological activity	Microbes are considered.		
A 1.51 Long-term physical stability		The backfill is not expected to be affected by microbes.	Reduction of iron may be an exception.
A 1.53 Methylation		Organic compounds are not expected to have any significant effect on the backfill - since the levels are very low.	
A 1.54 Microbes		The buffer is not expected to be affected by microbes.	Reduction of iron may be an exception.
A 1.55 Microorganisms	Microbes are considered.		
E SFL-26 Gas generation in the buffer and backfill		Gas generation from microbial activity is not relevant in a spent fuel repository	
E SFL-32 Microbial activity	Microbes are considered.		
E SFL-54 Evolving water chemistry in the backfill	Microbial effects are discussed.		
H 1.2.3 Gas generation from concrete		Microbial effects on concrete are not considered.	
I 012 Biological activity (bacteria & microbes)	Microbes are considered.		
I 270 Seeds in vault/wate		Plants and fungi are not considered.	
J 2.1.10 Microbes	Microbes are considered.		
K 3.17 Microbial activity	Microbes are considered.		
M 3.2.07 Microbiological effects	Microbial effects are discussed.		

SR-Site FEP BfT18 Microbial processes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 044 Gas generation, buffer/backfill		Gas generation from microbial activity is not relevant in a spent fuel repository.	
S 057 Microbial activity	Microbes are considered.		
W 2.044 Degradation of organic material	Organic stray materials are discussed.		
W 2.045 Effect of temperature on microbial gas generation		Gas generation from microbial activity is not relevant in a spent fuel repository.	
W 2.046 Effect of pressure on microbial gas generation		Gas generation from microbial activity is not relevant in a spent fuel repository.	
W 2.048 Effect of biofilms on microbial gas generation		Gas generation from microbial activity is not relevant in a spent fuel repository.	
W 2.076 Microbial growth on concrete		Concrete structures are not assigned any long-term properties.	
W 2.088 Biofilms		Not a backfill process.	
Recorded by: Patrik Sellin			**Date:** Dec 2010
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SR-Site FEP BfT19 Colloid formation and transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.13 Colloids			Included in "Backfill colloid release" (BfT16).
A 1.63 Psuedo-colloids	Transport of radionuclides sorbed onto colloids is discussed.		Considered to be mainly a geosphere process. See FEP Ge24.
S 009 Colloid generation-source			Included in "Backfill colloid release" (BfT16).
S 099 Transport and release of nuclides, tunnel backfill	Transport of radionuclides sorbed onto colloids is discussed.		Considered to be mainly a geosphere process. See FEP Ge24.
W 2.097 Chemical gradients		Not relevant for KBS-3.	
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP BfT20 Speciation of radionuclides

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.14 Complexation by organics			Most aspects of speciation of radionuclides are discussed in the fuel/canister process report, see SKB FEP F14.
A 1.37 Geochemical pump		The process as such is not discussed in the report - however, the concept is included in the transport model.	
A 1.77 Speciation	Speciation is discussed.		Most aspects of speciation of radionuclides are discussed in the fuel/canister process report, see SKB FEP F14
A 2.09 Complexation by organics			Most aspects of speciation of radionuclides are discussed in the fuel/canister process report (see e.g. SKB FEP F14).
E GEN-27 Radionuclide precipitation and dissolution		Not considered for the backfill.	
J 4.1.04 Sorption	Sorption is discussed.		
J 4.1.09 Complexing agents	Speciation is discussed.		
K 5.21 Organics		Not relevant for a spent fuel repository.	
K 6.21 Organics		Not relevant for a spent fuel repository.	
M 1.6.06 Solubility limit		Not considered for the backfill.	
M 1.6.10 Complexing agents	Speciation is discussed.		
M 1.6.13 Mass, isotopic and species dilution	Speciation is discussed.		
S 060 Precipitation/dissolution			Most aspects of speciation of radionuclides are discussed in the fuel/canister process report, see SKB FEP F14.
S 084 Sorption	Sorption is discussed.		
S 099 Transport and release of nuclides, tunnel backfill			Discussed in radionuclide transport (BfT21).
W 2.057 Kinetics of speciation		Assumed to be fast.	
W 2.060 Kinetics of precipitation and dissolution			Most aspects of speciation of radionuclides is discussed in the fuel/canister process report, see SKB FEP F14.
W 2.071 Kinetics of organic complexation		Not relevant for a spent fuel repository.	
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP BfT21 Transport of radionuclides in the water phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.28 Dispersion	Advection/dispersion is discussed.		
A 1.65 Radioactive decay	Radioactive decay is considered.		
A 2.18 Dispersion	Advection/dispersion is discussed.		
A 2.51 Radioactive decay	Chain decay is considered.		
E GEN-28 Radioactive decay	Radioactive decay is considered.		
E SFL-05 Colloid behaviour in the buffer and backfill		Ignored for the backfill.	
E SFL-50 Radionuclides release and transport from the buffer and backfill	Radionuclide transport is discussed.		
E SFL-54 Evolving water chemistry in the backfill		Effects of nuclides on chemistry are ignored.	
H 1.3.1 Radioactive decay and ingrowth	Chain decay is considered.		
I 027 Buffer (channelling)	Preferential pathways are discussed.		Preferential pathways are covered in the description of the Geosphere. See also BfT07.
I 045 Progency nuclides (critical radionuclides)	Chain decay is considered.		
J 3.2.08 Preferential pathways in the buffer/backfill	Preferential pathways are discussed.		Preferential pathways are covered in the description of the Geosphere. See also BfT07.
K 0.1 Radioactive decay	Radioactive decay is considered.		
M 3.4.04 Radioactive decay ingrowth	Radioactive decay is considered.		
S 070 Radioactive decay of mobile nuclides	Radioactive decay is considered.		
S 099 Transport and release of nuclides, tunnel backfill	All relevant aspects are covered.		
W 2.090 Advection	Advection is considered.		Not a relevant FEP.
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP BfT22 Transport of radionuclides by a gas phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E GEN-28 Radioactive decay	Radioactive decay is considered.		
H 1.2.4 Radioactive gases	Radioactive gases are considered.		
K 0.3 Gaseous and volatile isotopes	Radioactive gases are considered.		
S 099 Transport and release of nuclides, tunnel backfill		The gas pathway is assumed to be a short cut.	
W 2.055 Radioactive gases	Radioactive gases are considered.		
W 2.089 Transport of radioactive gases		The gas pathway is assumed to be a short cut.	
Recorded by: Patrik Sellin			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

Appendix 8

Handling of NEA Project FEPs sorted to SR-Site Geosphere processes

SR-Site FEP Ge01 Heat transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.52 Long-term transients	Thermal pulse of decaying fuel.		
A 2.69 Unsaturated rock		For heat transport, the degree of rock saturation is not important.	
E GEN-36 Stress field	Temperature effects on stress field.		
E GEN-38 Temperature of the far-field	Influence of natural geothermal temperature on the near-field temperature. Effects on far field of heat generation in the near field. Permafrost depth.		
E SFL-46 Temperature of the near-field	Effects of decaying fuel, near field rock thermal properties.		
K 5.13 Geothermal regime	Geothermal temperature at repository depth.		
K 6.13 Geothermal regime	Geothermal temperature at repository depth.		The FEP definition is covered by the previous FEP (K 5.13)
S 091 Temperature, far-field	Influence of natural geothermal temperature on the near-field temperature. Effects on far field of heat generation in the near field. Permafrost depth.		
S 092 Temperature, near-field rock	Effects of decaying fuel, near field rock thermal properties.		
Recorded by: Harald Hökmark			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Ge02 Freezing

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E GEN-26 Permafrost	Permafrost development and freezing depths under various climate assumptions. Freezing of parts of the repository.		
H 1.5.5 Transport of chemically-active substances into the near-field	Freeze-out of salt during permafrost growth.		
H 3.1.2 Climate change: Natural	Permafrost growth. Changes in groundwater flow during glacial cycle.		
J 5.17 Permafrost	Permafrost growth. Freezing of parts of the repository. Freezing in buffer erosion cavities.		
K 10.13 Permafrost	Permafrost growth. Presence of taliks. Permafrost - biosphere interaction.		

SR-Site FEP Ge02 Freezing

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 10.16 Ice sheet effects (loading, melt water recharge)	Groundwater recharge in relation to permafrost distribution.		
S 059 Permafrost	Permafrost growth and groundwater recharge. Freezing in buffer erosion cavities.		
S 091 Temperature, far-field	Dependence of far-field ground-water recharge, from ice sheet basal melting, on ground temperature /freezing during glacial coverage.		
Recorded by: Jens-Ove Näslund			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.12 Climate change	Impact on groundwater flow due to climate change is discussed.		
A 1.41 Hydraulic head	Hydraulic head and resulting gradients as driving forces.		
A 1.52 Long-term transients	The following processes listed under this FEP are taken into account: effect of the thermal pulse on flow, resaturation, effects of grouting. Other processes such as land uplift and climate change leading to shore-line displacement and changes to recharge, possible development of permafrost and ice sheet cover are also taken into account.		Calculations of the effect of the thermal pulse were carried out for SR-Can.
A 1.67 Recharge groundwater	Variations in the chemistry of recharging groundwater over time are addressed. Saline intrusion and also saline upcoming beneath the repository are considered.		
A 1.68 Reflooding	Resaturation.		The term resaturation is used in the Process Report for the process in question.
A 2.01 Blasting and vibration	The effects of blasting and vibration during the construction of the repository are incorporated in the EDZ.		The EDZ is explicitly incorporated in some flow models.
A 2.04 Borehole seal failure	Boreholes and failed boreholes are addressed.		
A 2.06 Cavitation		Is considered not to be an issue for crystalline rock.	
A 2.13 Damaged zone	The EDZ is addressed.		The EDZ is explicitly incorporated in some flow models.
A 2.15 Dewatering	Dewatering during construction and operation phases is addressed.		The process is represented in some models, which address drawdown and saline intrusion.

SR-Site FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.17 Discharge zones	Discharge zones for groundwater flow.		These are determined by the flow calculation. Note that the locations where radionuclides migrating from the repository would discharge are determined by particle tracking calculations. This is done for flow fields corresponding to specific times.
A 2.22 Erosion	Erosion of the bedrock and redistribution of Quaternary deposits as a result of glaciation is discussed.		Rates of erosion of bedrock are expected to be low so this process is not considered quantitatively (see also SKB Climate FEP Cli11)
A 2.27 Gases and gas transport	Impact of gas on GW flow is discussed in the sections addressing gas (see also Ge04)		Scoping calculations were carried out for SR-Can. Possible two-phase flow effects handled in RD&D programme (although this is mainly for open repository applications).
A 2.28 Geothermal gradient effects	Impact of thermal gradients on flow.		Geothermal gradient taken into account in the flow calculations.
A 2.30 Glaciation	Changes to topography, sea-level, the possible development of permafrost and the upper boundary condition for the flow, leading to changes in recharge and discharge zones, are considered.		Special simulation of groundwater flow during glacial conditions performed. Input from ice-sheet model on e.g. glacier thickness, surface and basal melt rate of glacier.
A 2.35 Hydraulic properties - evolution	Factors causing change in fracture transmissivity over time are discussed.		See also "Dissolution/ precipitation of fracture-filling minerals" (Ge15).
A 2.38 Isostatic rebound	Effect on topography and sea-level.		Included in the shore-line displacement function used as BC for groundwater flow simulations.
A 2.48 Ozone layer	Changes in groundwater flow as a result of climate changes are discussed.		See also SKB FEP Cli01.
A 2.57 Salinity effects on flow	Variable-density flow.		Density driven flow included in groundwater flow models.
A 2.59 Sea level change	Sea level change as a result of climate change is considered.		Shore-line displacement considered as BC for groundwater flow simulations.
A 2.60 Shaft seal failure	The FEP is discussed.		
A 2.69 Unsaturated rock	The (relatively very thin) un-saturated region near the ground surface and the unsaturated region that will develop as a result of groundwater drawdown because of repository construction are addressed.		Unsaturated flow is not explicitly modelled.
A 2.71 Vault heating effects	The impact of the heat generated by the waste on the flow is discussed.		Effects of the heat from the waste on the flow not included in main calculations but were addressed in separate scoping calculations for SR-Can.

SR-Site FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.73 Wells	Impact of wells on flow. Wells included in biosphere and in assessment calculations. Well yield or consumption used for assessing dilution.		Wells not included in groundwater flow models; assumption that typical wells will not change groundwater flow field much. Wells included in biosphere and in dose calculations. Well yield or consumption used for assessing dilution.
A 2.74 Wells (high-demand)		This FEP is not relevant for the site considered.	
E GEN-06 Groundwater salinity changes	Variable density flow addressed.		See NEA FEP A 2.57.
E GEN-12 Earth tides		This process may be utilized in interpreting experimental measurements, but occurs on a much shorter time scale about 12.5 hours) than the time scales relevant to repository performance. In principle, earth tides may lead to transfer of water back and forth between fractures and rock matrix leading to enhanced retardation as a result of rock matrix-diffusion.	See NEA FEP S 028.
E GEN-15 Excavation effects on the near field rock	Effects of EDZ on flow are addressed.		See NEA FEP A 2.01.
E GEN-16 External flow boundary conditions	This is addressed.		Topography and changes to sea-level included in gw model. see also NEA FEPs A 1.52 and A 2.57.
E GEN-21 Glaciation	Changes to topography, sea-level, the possible development of permafrost and the upper boundary condition for the flow, leading to changes in recharge and discharge zones, are considered.		See NEA FEP A 2.30.
E GEN-23 Groundwater flow	This is considered.		See NEA FEP H 1.5.4.
E GEN-29 Erosion and weathering	This is discussed.		See NEA FEP A 2.22.
E GEN-32 Hydraulic resaturation of the near-field rock	This is considered.		See NEA FEP A 1.68.
E GEN-33 Sea level changes	Sea level change as a result of climate change is considered.		See NEA FEP A 2.59.
E GEN-35 Fast transport pathways	Fast transport pathways that correspond to Hydraulic Conductor Domains or arise as a result of the variation in fracture properties are addressed.	Fast transport paths arising from highly channelled flow or wormholes are not addressed.	
E GEN-37 Surface water chemistry	The effects of variations in the chemistry of recharging water over time are addressed.		See NEA FEP A 1.67.

SR-Site FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E SFL-55 Evolving water chemistry in the near-field rock	The near-field processes leading to variations in the chemistry of the near-field water are discussed.		
H 1.5.1 Desaturation (pumping) effects	Desaturation addressed. Pumping considered in the open repository simulations, where specifically up-coning and changes on groundwater table are addressed.		See NEA FEP A 1.68
H 1.5.2 Disturbed zone (hydromechanical) effects	Effects of EDZ on flow are addressed.		See NEA FEP A 2.01
H 1.5.3 Unsaturated flow due to gas production	Impacts of gas on flow are addressed.		Not included in hydrogeology modelling because the volumes of gas produced are expected to be small.
H 1.5.4 Saturated groundwater flow	This is the primary flow process, and is considered.		
H 1.6.2 Thermal effects: Hydrogeological changes	Impact of thermal gradients on flow.		See NEA FEP A 2.71.
H 2.1.6 Seismicity		Effects of earthquakes on groundwater flow not explicitly considered, but the potential impact on radionuclide transport is illustrated by simple calculations.	
H 2.2.1 Changes in geometry and driving forces of the flow system	This FEP really deals with changes over time to the flow in the vicinity of the repository as a result of process such as land uplift and climate change. These processes are considered.		
H 2.2.2 Rock property changes	The main processes affecting the relevant rock properties (fracture transmissivity, fracture porosity and matrix porosity) are stress changes (due to ice loading during glaciation) formation of permafrost, and precipitation and dissolution are discussed.	Changes due to the alkaline plume are not considered.	
H 2.3.7 Far-field transport: Changes in groundwater chemistry and flow direction	Changes in groundwater flow direction are addressed. In-so-far as changes in groundwater chemistry are the result of mixing of groundwaters with different compositions, this is addressed.		
H 2.3.11 Far-field transport: Gas induced groundwater transport	Impact of gas on flow addressed.		Scoping calculations carried out for SR-Can.
H 2.4.1 Generalised denudation	The main erosion process will be glacial erosion, and the main effect of this will be redistribution of the Quaternary deposits, which may affect recharge. This is discussed.		
H 2.4.2 Localised denudation			See NEA FEP H 2.4.1.

SR-Site FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 3.1.2 Climate change: Natural	Influence of climate related conditions on groundwater flow is discussed.		See also SKB Climate FEPs.
H 4.1.1 Groundwater discharge to soils and surface waters	Groundwater discharge addressed.		See NEA FEP A 2.17.
H 5.1.1 Loss of integrity of borehole seals	This is discussed.		
H 5.1.2 Loss of integrity of shaft or access tunnel seals	This is discussed.		See NEA FEP A 1.72
I 022 Explosions/bombs /blasting/collision/ impacts/vibration	Blasting/vibration during repository construction leads to the formation of the EDZ, whose effects are discussed.		See NEA FEP A 2.01.
I 049 Climate change	Impact of climate change on groundwater flow is discussed.		See also SKB Climate FEPs Cli03 and Cli04.
I 143 Groundwater (redirection of)	The processes leading to changes in groundwater flow direction such as groundwater abstraction from wells, or the effects of climate change are considered.		
I 266 Sea level (rising)	Impact on groundwater flow of changes in sea level is considered.		
J 1.1.02 Radioactive decay; heat	The impact of the heat generated by the waste is discussed.		Not included in far-field models in general. Only included in scoping calculations for SR-Can.
J 4.2.02.1 Excavation/backfilling effects on nearby rock	The effect of the EDZ is taken into account.		See NEA FEP A 2.01.
J 4.2.03 Extreme channel flow of oxidants and nuclides	Channeling of flow is discussed. This can affect the flow itself primarily through its effect on the specific fracture surface available for matrix diffusion, which may affect the salinity and hence the flow.		Moderate channelling can be taken into account through variation of the transmissivity over fractures. Extreme channelling cannot be dealt with as readily. See also Ge11.
J 4.2.04 Thermal buoyancy	The impact of thermal buoyancy on flow is taken into account.		The effect of the natural geothermal gradient is taken into account in the main flow calculations. The effect of heat generated by the waste was taken into account in scoping calculations for SR-Can.
J 4.2.06 Faulting	The effects of changes to the rock properties are discussed.		
J 4.2.07 Thermo-hydro-mechanical effects	The FEP is discussed.		
J 5.01 Saline (or fresh) groundwater intrusion	The effects of variations in salinity on the flow are addressed.		

SR-Site FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 5.14 Resaturation	Resaturation discussed.		Resaturation addressed and handled in open repository calculation. Assumption made that two-phase flow not needed for such calculations. This is argued with help of supporting analyses.
J 5.16 Uplift and subsidence	Uplift and subsidence are discussed.		The effects of uplift and subsidence on the shoreline are taken into account in the flow calculations. Possible effects on the rock properties are not currently modelled.
J 5.17 Permafrost	The possible development of permafrost and the upper boundary condition for the flow, leading to changes in recharge and discharge zones, are considered.		
J 5.27 Human induced actions on groundwater recharge	Wells, dams, tunnels, vaults etc, human effects on climate discussed.		See also SKB FHA FEPs.
J 5.31 Change in sealevel	Changes in groundwater flow and salinity due to shore-line migration are considered.		See also SKB Climate FEPs.
J 5.42 Glaciation	Impact of glacial conditions on flow is discussed.		Special simulation of groundwater flow during glacial conditions performed. Input from ice-sheet model on e.g. glacier thickness, surface and basal melt rate of glacier. See also SKB Climate FEPs and NEA FEP A 2.30.
J 6.13 Geothermally induced flow .	Impact of thermal gradients on flow addressed.		The effects of natural geothermal gradients taken into account in the flow calculations.
J 7.07 Human induced changes in surface hydrology	Discussed.		Handled through variants in Main Scenario, but will likely not result in special cases for groundwater flow model. See also SKB FHA FEPs.
K 4.01 Excavation-disturbed zone (EDZ)	Impact of EDZ addressed.		See NEA FEP A 2.01.
K 4.03 Desaturation/resaturation of EDZ	Desaturation and resaturation addressed.		
K 4.07 Water flow at the bentonite-host rock interface	Impact of EDZ addressed.		Water flow through the EDZ is handled in the gw flow model for saturated conditions.
K 4.08 Radionuclide migration	Impact of EDZ on water flow discussed.		Other aspects addressed in "Advection/mixing" (Ge11) and "Radionuclide transport in water phase" (Ge24).
K 5.11 Intrusion of saline groundwater	Variable-density flow.		See NEA FEP A 2.57.

SR-Site FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 5.12 Density-driven groundwater flow (thermal)	The impact of thermal buoyancy on flow is taken into account.		See NEA FEP J 4.2.04.
K 5.17 Gas pressure effects	Effects of gas pressure are discussed.		See NEA FEP A 1.35.
K 5.18 Hydraulic gradient changes (magnitude, direction)	Changes over time as a result of process such as land uplift and climate change.		
K 6.11 Intrusion of saline groundwater	Variable-density flow.		See NEA FEP A 2.57.
K 6.12 Density-driven groundwater flows (thermal)	The impact of thermal buoyancy on flow is taken into account.		See NEA FEP J 4.2.04.
K 6.17 Gas pressure effects	Effects of gas pressure are discussed.		See NEA FEP A 1.35.
K 6.18 Hydraulic gradient changes (magnitude, direction)	Changes over time to the flow in the vicinity of the repository as a result of process such as land uplift and climate change are discussed.		See NEA FEP H 2.2.1
K 7.11 Erosion	Erosion of the bedrock and redistribution of Quaternary deposits as a result of glaciation are discussed.		See NEA FEP A 2.22
K 7.13 Density-driven groundwater flows (temperature/salinity differences)	Discussed.		See NEA FEPs J 4.2.04 and J 5.01
K 9.06 Stress changes - hydrogeological effects	Effects of stress changes on the transmissivity are discussed.		
K 9.07 Erosion/ denudation	Erosion of the bedrock and redistribution of Quaternary deposits as a result of glaciation are discussed.		See NEA FEP A 2.22
K 10.13 Permafrost	Impact of permafrost on flow addressed.		See also "Freezing" Ge02 and SKB Climate FEPs.
K 10.14 Glacial erosion/ sedimentation	Impact or erosion discussed.		See NEA FEP A 2.22.
K 10.16 Ice sheet effects (loading, melt water recharge)	Impact of glacial conditions addressed.		Special simulation of groundwater flow during glacial conditions performed. Input from ice-sheet model on e.g. glacier thickness, surface and basal melt rate of glacier. See also SKB Climate FEPs.

SR-Site FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
M 1.2.11 Rock heterogeneity	The heterogeneity of the basement rocks and the Quaternary deposits are addressed.		In groundwater flow calculations, differences between Hydraulic Conductor Domains, Hydraulic Fracture Domains and Hydraulic Soil Domains are taken into account. The Fracture Domains are further subdivided into vertical zones and fractures within the zones represented. Variations in the Quaternary deposits are also taken into account.
M 1.3.01 Precipitation, temperature and soil water balance	The effects of changes in precipitation as a result of climate change are discussed.	The effects of changes to water usage as a result of climate change are not addressed.	
M 1.4.03 River, stream, channel erosion		The main erosion process will be glacial erosion, which is discussed. River stream and channel erosion are not addressed.	
M 1.5.03 Recharge to ground water	This is addressed.		See NEA FEP H 1.5.4.
M 1.5.04 Ground water discharge	This is addressed.		See NEA FEP A 2.17.
M 1.5.05 Ground water flow	This is addressed.		See NEA FEP H 1.5.4.
M 1.5.07 Saline or freshwater intrusion	This is addressed.		See NEA FEP A 2.57.
M 2.1.05 Dewatering of host rock	Dewatering during construction and operation phases is addressed.		See NEA FEP A 2.15.
M 3.1.04 Induced hydrological changes	This FEP relates to the effects of temperature variation. These effects are taken into account in the groundwater flow calculations.		See NEA FEP H 1.5.4.
S 001 Alteration/weathering of flow paths	Discussed.		See NEA FEP H 2.2.1
S 018 Deep saline water intrusion	Density driven flow addressed.		Density driven flow included in groundwater flow model. Geochemical implications, see Chemical processes, e.g. "Advection/mixing" (Ge11), "Speciation/ sorption" (Ge13).

SR-Site FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 028 Earth tides		This process may be utilized in interpreting experimental measurements, but occurs on a much shorter time scale about 12.5 hours) than the time scales relevant to repository performance. In principle, earth tides may lead to transfer of water back and forth between fractures and rock matrix leading to enhanced retardation as a result of rock matrix-diffusion.	
S 032 Excavation effects on nearby rock	Excavation effects on flow are discussed.		See NEA FEP A 2.01.
S 033 External flow boundary conditions	Addressed.		Topography and changes in sea-level included in gw model.
S 036 Faulting	The effects of changes to the rock properties are discussed.		
S 047 Glaciation	Impact of glacial condition on flow discussed.		Special simulation of groundwater flow during glacial conditions performed. Input from ice-sheet model on e.g. glacier thickness, surface and basal melt rate of glacier. See also SKB Climate FEPs.
S 049 Groundwater flow	All aspects addressed.		See NEA FEP H 1.5.4.
S 059 Permafrost	Impact of permafrost on flow discussed.		See also processes "Freezing" (Ge02), "Gas flow/ dissolution" (Ge04), "Salt exclusion" (Ge21) and SKB Climate FEPs.
S 064 Properties of far-field rock	Discussed.		
S 065 Properties of near-field rock	Discussed.		
S 078 Resaturation, near-field rock	Resaturation addressed.		Resaturation addressed in open repository calculation. Assumption made that two-phase flow not needed for such calculations. This is argued with help of supporting analyses.
S 081 Sea level changes	Changes in groundwater flow and salinity due to shore-line migration are considered.		See also SKB Climate FEPs.
S 086 Stress field	The effects of the stress field on the rock properties (porosity and fracture transmissivity) are discussed.		The effects of changing stress fields are not taken into account in the flow calculations.
S 091 Temperature, far-field	The effects of the temperature on groundwater properties (density and viscosity) and the driving force for groundwater flow are discussed.		The geothermal gradient is taken into account in the flow calculations

SR-Site FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 092 Temperature, near-field rock	The effects of the temperature on groundwater properties (density and viscosity) and the driving force for groundwater flow are discussed.		The effects of the heat generated by the waste are not addressed in the main flow calculations, but are taken into account in scoping calculations for SR-Can.
W 1.009 Changes in fracture properties	Factors causing change in fracture transmissivity over time discussed.		See NEA FEP A 2.35.
W 1.022 Fracture infills	Factors causing change in fracture transmissivity over time discussed.		See NEA FEP A 2.35.
W 1.024 Unsaturated groundwater flow	The (relatively very thin) unsaturated region near the ground surface and the unsaturated region that will develop as a result of groundwater drawdown because of repository construction are addressed.		See NEA FEP A 2.69.
W 1.025 Fracture flow	Considered.		
W 1.026 Density effects on groundwater flow	Variable-density flow.		See NEA FEP A 2.57.
W 1.028 Thermal effects on groundwater flow	Addressed.		See NEA FEPs J 4.2.04, H 1.6.1, H 2.3.12.
W 1.029 Saline intrusion	Salinity effects discussed.		See NEA FEP A 2.57.
W 1.030 Freshwater intrusion	Variable-density flow.		See NEA FEP A 2.57.
W 1.031 Hydrological response to earthquakes		Effects of earthquakes on groundwater flow not explicitly considered, but the potential impact on radionuclide transport is illustrated by simple calculations.	
W 1.034 Saline intrusion	Salinity effects discussed.		Density driven flow included in groundwater flow models.
W 1.035 Freshwater intrusion	Freshwater intrusion mainly addressed and handled as a consequence of a melting glacier.		See chemical processes e.g. "Advection/mixing" Ge11 for geochemical aspects. See also SKB Climate FEPs.
W 1.053 Groundwater discharge	Groundwater discharge addressed.		See NEA FEP A 2.17.
W 1.056 Changes in groundwater recharge and discharge	Cause for changes addressed.		See NEA FEP A 2.17.
W 2.013 Heat from radioactive decay	The effects of the temperature on groundwater properties (density and viscosity) and the driving force for groundwater flow are discussed.		The effects of the heat generated by the waste are not addressed in the main flow calculations, but are taken into account in scoping calculations for SR-Can.
W 2.018 Disturbed rock zone	Impact on flow addressed.		See NEA FEP A 2.01.

SR-Site FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 2.042 Fluid flow due to gas production	Impact of gas generation and flow are discussed.		See NEA FEP A 2.27.
W 2.043 Convection	Impacts of thermal gradients on flow are discussed.		See NEA FEP J 1.1.02.
W 3.031 Natural borehole fluid flow	Impact of existing boreholes addressed.		For impact of drilling of future boreholes, see SKB FHA FEPs.
W 3.033 Flow through undetected boreholes		Undetected boreholes can be ruled out for the present application.	
W 3.035 Borehole-induced mineralization		The effect is considered to be small and localized.	
W 3.036 Borehole-induced geochemical changes		The effect is considered to be small and localized.	
Recorded by: Peter Jackson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Ge04 Gas flow/dissolution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.35 Formation of gases	Sources for gas in the geosphere addressed and the effect of the pressure due to gas formation is discussed.		See also e.g. processes "Water radiolysis" (F10) and "Corrosion of cast iron insert" (C08).
A 1.68 Reflooding	Resaturation.		The term resaturation is used in the Process Report for the process in question.
A 2.15 Dewatering	Dewatering during construction and operation phases is discussed.		
A 2.27 Gases and gas transport	This FEP is discussed.		Scoping calculations carried out for SR-Can. Possible two-phase flow effects handled in RD&D programme (although this is mainly for open repository applications).
A 2.69 Unsaturated rock	The unsaturated region that will develop as a result of groundwater drawdown because of repository construction is addressed.		See process "Groundwater flow" Ge03.
E GEN-15 Excavation effects on the near field rock	Effects of EDZ on flow are addressed.		See NEA FEP A 2.01.
E GEN-18 Gas flow in the far-field	This FEP is discussed.		Scoping calculations carried out for SR-Can. Possible two-phase flow effects handled in RD&D programme (although this is mainly for open repository applications). See NEA FEP A 2.27.
E GEN-23 Groundwater flow	This is considered.		See NEA FEP H 1.5.4.

SR-Site FEP Ge04 Gas flow/dissolution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E GEN-32 Hydraulic resaturation of the near-field rock	Resaturation is discussed.		Resaturation addressed and handled in open repository calculation. Assumption made that two-phase flow not needed for such calculations. This is argued with help of supporting analyses. Effects of gas generation not taken into account because the volumes of gas generated are expected to be small.
H 1.2.6 Gas transport	This FEP is discussed.		See NEA FEP A 2.27.
H 1.5.1 Desaturation (pumping) effects	Desaturation and resaturation are discussed.		
H 1.5.3 Unsaturated flow due to gas production	This FEP is discussed.		
H 2.1.9 Effects of natural gases.	The effects of dissolved natural gases are discussed.		
H 2.3.11 Far-field transport: Gas induced groundwater transport	Gas phase and two-phase flow discussed.		
H 4.1.3 Gas discharge	The possible consequences of this FEP are discussed.		
J 5.14 Resaturation	Resaturation is discussed.		
J 5.17 Permafrost	Accumulation of gas under permafrost is discussed.		See also SKB Climate FEPs.
J 5.22 Accumula-tion of gases under permafrost	The FEP is discussed.		
J 5.43 Methane intrusion	This FEP is discussed.		See also Ge19 and Ge20.
J 6.02 Gas transport	This FEP is discussed.		
K 4.03 Desaturation/resaturation of EDZ	Discussed.		
K 5.17 Gas pressure effects	Discussed.		See NEA FEP A 1.35.
K 5.24 Geogas	Natural gas content and the gas flow characteristics addressed.		See also SKB FEP Ge25
K 6.17 Gas pressure effects	Discussed.		See NEA FEP A 1.35.
K 6.24 Geogas	Natural gas content and the gas flow characteristics addressed.		See also SKB FEP Ge25
M 1.2.13 Natural gas intrusion		This is not addressed because it is not considered to be relevant.	
M 1.6.04 Gas mediated transport		This is not addressed because it is considered that the volumes of gas generated are expected to be small.	

SR-Site FEP Ge04 Gas flow/dissolution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
M 2.1.05 Dewatering of host rock	Dewatering during construction and operation phases is addressed.		The process is represented in some models, which address drawdown and saline intrusion. See NEA FEP A 2.15.
M 3.3.06 Gas effects		This FEP covers the generation of gas pressures and the probability of explosions and fires. These are not addressed because they are considered not relevant because the volume of gas generated is expected to be small.	
S 042 Gas flow and transport, near-field rock/far-field	Gas and two-phase flow discussed.		
S 043 Gas generation and gas sources, far-field	Sources for gas in the geosphere addressed.		See also "Microbial processes" (Ge16) and "Formation/ dissolution/reaction of gaseous species" (Ge19).
S 046 Gas generation, near-field rock	Sources for gas in the geosphere addressed.		See also "Microbial processes" (Ge16) and "Formation/ dissolution/reaction of gaseous species" (Ge19).
S 059 Permafrost	Accumulation of gas under permafrost is discussed.		See also processes "Freezing" (Ge02), "Groundwater flow" (Ge03), "Salt exclusion" (Ge21) and SKB Climate FEPs.
S 064 Properties of far-field rock	Discussed.		
S 065 Properties of near-field rock	Discussed.		
S 078 Resaturation, near-field rock	Resaturation addressed.		See also "Groundwater flow" Ge03.
W 1.024 Unsaturated groundwater flow	Unsaturated water flow as a special case (simplification) of two-phase flow is discussed.		See NEA FEP A 2.24.
W 1.032 Natural gas intrusion	The effects of dissolved natural gases are noted in the Process Report.		
W 2.042 Fluid flow due to gas production	Gas phase flow discussed.		
Recorded by: Peter Jackson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Ge05 Displacements in intact rock

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.71 Vault heating effects	Thermally induced stresses.		
E GEN-15 Excavation effects on the near field rock	Excavation induced stress redistribution.		
H 1.6.1 Thermal effects: Rock-mass changes	Thermally induced stresses.		This FEP regards intermediate level waste with "modest envisaged heating", not HLW.
J 4.2.02.1 Excavation/backfilling effects on nearby rock	The role of excavation peripheries as near-field rock stress boundaries.		FEP seems to regard mainly effects on permeability.
J 4.2.07 Thermo-hydro-mechanical effects	Thermally induced stresses.		FEP definition looks similar to NEA FEP J.4.2.02.1
M 3.1.01 Differential elastic response		No aspects addressed. (no data on any systematic variability in heat expansion coefficient)	
M 3.1.02 Non-elastic reponse		No aspects relevant to intact crystalline rock.	
M 3.3.02 Changes in in-situ stress field	Stress changes caused by excavation, thermal pulse and glacial loads.		
S 065 Properties of near-field rock	Near-field rock properties considered are the volumetric heat expansion and the bulk modulus.		
S 086 Stress field	Thermally induced stresses		
W 2.013 Heat from radioactive decay	Thermally induced stresses.		FEP regards repository in salt.
W 2.029 Thermal effects on material properties		Intact rock properties are not sensitive to temperatures in expected temperature interval.	FEP regards repository in salt.
W 2.030 Thermally-induced stress changes	Thermally induced stresses.		FEP regards repository in salt.
Recorded by: Harald Hökmark			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Ge06 Reactivation - Displacement along existing discontinuities

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.29 Earthquakes	Induced shear movements on fractures that may potentially intersect canister positions.		
A 2.21 Earthquakes	Induced shear movements on fractures that may potentially intersect canister positions.		
A 2.24 Faulting	Induced shear movements on fractures that may potentially intersect canister positions.		
A 2.30 Glaciation	Change of load on fractures and following fracture movements.		
A 2.71 Vault heating effects	Change of load on fractures and following fracture movements.		

SR-Site FEP Ge06 Reactivation - Displacement along existing discontinuities

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.045 Earthquakes	Induced shear movements on fractures that may potentially intersect canister positions.		
E GEN-15 Excavation effects on the near field rock	Fracture movement following stress redistribution.		
E GEN-17 Faulting	Possibility of post-glacial earthquakes on existing deformation zones.		
H 1.6.1 Thermal effects: Rock-mass changes	Changes in fracture apertures.		
H 2.1.7 Faulting/fracturing	Reactivation and causes.		
H 2.2.2 Rock property changes	Changes in fracture apertures.		
J 4.2.01 Mechanical failure of repository	Induced shear movements on fractures that may potentially intersect canister		
J 4.2.02.1 Excavation/backfilling effects on nearby rock	Change of load on fractures and following fracture movements.		
J 4.2.06 Faulting	Seismically induced (secondary) slip across deposition holes.		
J 4.2.07 Thermo-hydro-mechanical effects	Permeability changes caused by shear and fracture displacement due to thermal load.		
J 5.15 Earthquakes	Seismically induced (secondary) slip across deposition holes.		
J 5.42 Glaciation	Change of load on fractures and following fracture movements.		
K 9.06 Stress changes - hydrogeological effects		No systematic changes in hydrological conditions expected in response to seismicity in reverse faulting stress regimes.	
M 1.2.09 Fault activation	Possibility of post-glacial earthquakes on existing deformation zones.		
M 3.1.03 Host rock fracture aperture changes	Estimates of transmissivity effects induced by excavation, thermal pulse and glacial loads.		
M 3.3.02 Changes in in-situ stress field	Fracture movement induced by excavation, thermal pulse and glacial loads.		
M 3.3.04 Subsidence/collapse		No aspects relevant to backfilled openings in well confined crystalline rock.	
S 036 Faulting	Seismically induced (secondary) slip across deposition holes.		
S 047 Glaciation	Change of load on fractures and following fracture movements.		
S 064 Properties of far-field rock	Change of load on fractures and following fracture movements.		
S 065 Properties of near-field rock	Change of load on fractures and following fracture movements.		

SR-Site FEP Ge06 Reactivation - Displacement along existing discontinuities

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 086 Stress field	Initial stress is input to all analyses relevant to fracture movements. Stress change is output and is used to forecast scope and extent of fracture movements.		
W 1.010 Formation of new faults		Site-specific FEP, which mainly address fault movement covered by FEP W1.011.	
W 1.011 Fault movement	Secondary displacements induced by fault movements.		
W 2.029 Thermal effects on material properties		Temperature dependence of crystalline rock properties (in relevant temperature range) is too small to be of importance.	
Recorded by: Harald Hökmark			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Ge07 Fracturing

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.08 Cave ins	Reference to near-field rock discrete fracture stress-deformation analyses to assess scope and extent of stress-induced fracturing.		,
A 2.01 Blasting and vibration	Schematically assumed EDZ properties .		
A 2.13 Damaged zone	Schematically assumed EDZ properties .		
A 2.21 Earthquakes		Fracturing effects overshadowed by effects of reactivation.	Addressed in "Reactivation - displacements along existing discontinuities" Ge06.
A 2.30 Glaciation	The change in the existing fracture geometry caused by fracture propagation or formation of new fractures will be too small to be of importance to the host rock permeability. Fracturing in the near-field: see A 1.08 (Cave ins).		
A 2.71 Vault heating effects	Mechanical aspects: Reference to near-field rock discrete fracture stress-deformation analyses to assess scope and extent of stress-induced fracturing.		
E GEN-03 Cave-in	Reference to near-field rock discrete fracture stress-deformation analyses to assess scope and extent of stress-induced fracturing.		
E GEN-14 Enhanced rock fracturing	Spalling in walls of deposition holes, formation of tunnel EDZ.		
H 1.4.2 Vault collapse		No aspects relevant to backfilled openings in well confined crystalline rock.	

SR-Site FEP Ge07 Fracturing

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 1.5.2 Disturbed zone (hydro-mechanical) effects	Transmissivity effects of excavation.		
H 2.1.7 Faulting/fracturing	Changes in fracture geometry caused by fracturing are concluded to be too minor to be of any concern (compared with effects of reactivation).		
I 022 Explosions/bombs /blasting/collision /impacts/vibration	Impact of excavation discussed.		
J 4.2.02.1 Excavation/backfilling effects on nearby rock	Transmissivity effects of excavation.		
J 4.2.07 Thermo-hydro-mechanical effects	Reference to near-field rock discrete fracture stress-deformation analyses to assess effects of stress cycle (excavation, thermal, ice-load) on fracture apertures.		FEP does not concern fracturing.
J 4.2.08 Enhanced rock fracturing	Reference to near-field rock discrete fracture stress-deformation analyses to assess scope and extent of stress-induced fracturing.		
J 5.42 Glaciation	Glaciation treated as load case in near-field rock discrete fracture stress-deformation analyses.		
K 4.01 Excavation-disturbed zone (EDZ)	Schematically assumed EDZ properties.		
M 3.1.03 Host rock fracture aperture changes		No aspects relevant to fracturing process.	
M 3.3.05 Fracturing	Thermally induced spalling.		
S 004 Cave in	Reference to near-field rock discrete fracture stress-deformation analyses to assess scope and extent of stress-induced fracturing.		There is no indication that fracturing, even with complete loss of the support pressure, could be sufficiently extensive that deposition holes could collapse.
S 030 Enhanced rock fracturing	Reference to near-field rock discrete fracture stress-deformation analyses to assess scope and extent of stress-induced fracturing.		
S 032 Excavation effects on nearby rock	Reference to near-field rock discrete fracture stress-deformation analyses to assess scope and extent of stress-induced fracturing.		
S 036 Faulting		Fracturing effects overshadowed by effects of reactivation.	Addressed in "Reactivation - displacements along existing discontinuities" Ge06.
S 047 Glaciation	Glaciation treated as load case in near-field rock discrete fracture stress-deformation analyses.		

SR-Site FEP Ge07 Fracturing

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 065 Properties of near-field rock	Reference to near-field rock discrete fracture stress-deformation analyses to assess scope and extent of stress-induced fracturing.		
S 086 Stress field	Initial stress is input to all analyses relevant to fracturing. Stress change is output and is used to forecast scope and extent of fracturing.		
W 1.008 Formation of fractures		Stress changes will not be large enough to create new fractures.	
W 2.018 Disturbed rock zone	Schematically assumed EDZ properties.		
W 2.019 Excavation-induced changes in stress	Schematically assumed EDZ properties.		FEP regards fracturing in salt.
W 2.022 Roof falls		FEP relevant to conditions in salt.	
W 2.029 Thermal effects on material properties		FEP relevant to conditions in salt.	
Recorded by: Harald Hökmark			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Ge08 Creep

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.08 Cave ins	Convergence of repository openings.		
E GEN-03 Cave-in	Convergence of repository openings.		
E GEN-05 Creeping of the rock mass	Creep in discontinuities.		
J 4.2.01 Mechanical failure of repository	Creep in discontinuities.		
J 4.2.09 Creeping of rock mass	Creep in discontinuities.		
S 004 Cave in	Creep in discontinuities.		
S 015 Creeping of rock mass, near-field	Creep in discontinuities.		
W 2.022 Roof falls		FEP does not match the process definition.	Not relevant for Swedish conditions as FEP regards repository in salt.
Recorded by: Harald Hökmark			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Can FEP Ge09 Surface erosion and weathering has been transferred to a Climate FEP in SR-Site (Cli11).

SR-Site FEP Ge10 Erosion/sedimentation in fractures

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.06 Cavitation		Cavitation due to rapid groundwater flows is not expected during construction or operation of the repository. Safe tunnel construction practices require grouting where large groundwater flows may be expected, i.e. in places where the tunnel will intercept highly conductive fracture-zones. Not expected after repository closure either.	
E SFL-43 Sedimentation of the buffer and backfill	Sedimentation of bentonite is mentioned.		
Recorded by: Kristina Skagius			**Date:** Dec 2010
Checked and revised by:			**Date:**

SR-Site FEP Ge11 Advective transport/mixing of dissolved species

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.22 Convection	Convection of solutes in the groundwater is described.		See also "Transport of radionuclides in the water phase" (Ge24).
A 1.28 Dispersion	Dispersion of solutes in the groundwater is described.		See also "Transport of radionuclides in the water phase" (Ge24).
A 1.67 Recharge groundwater	Different types of recharge waters are considered. These types vary as a function of time.		
A 2.11 Convection	Convection of solutes in the groundwater is described.		Equivalent to NEA FEP A 1.22
A 2.18 Dispersion	Dispersion of solutes in the groundwater is described.		Equivalent to NEA FEP A 1.28
A 2.53 Recharge groundwater	Different types of recharge waters are considered. These types vary as a function of time.		Equivalent to NEA FEP A 1.67
E GEN-06 Groundwater salinity changes	Changes in groundwater salinity in relation to advection and mixing are described.		
E GEN-10 Radionuclide dispersion	Dispersion of solutes is described.		
E GEN-11 Distribution and release of radionuclides from the far-field	Transport of radionuclides in both near field and far field included in the analysis.		
E GEN-12 Earth tides		The tidal effects are not discernible in the site modelling. These effects are expected to be minor when compared with long-time climate effects, such as shore displacements and glaciations.	
E GEN-22 Far-field groundwater chemistry	The groundwater chemistry, in relation to advection and mixing, in the far-field is described.		

SR-Site FEP Ge11 Advective transport/mixing of dissolved species

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E GEN-24 Interfaces between different waters	Interfaces between different water types are addressed by the hydrogeological models.		
E GEN-37 Surface water chemistry	The effect of the recharge of surface waters is addressed and described.		
E SFL-38 Redox fronts	Redox fronts are described. For SR-Site the process with potentially the highest impact is the infiltration of oxygen-rich glacial melt waters, and this is addressed.		
E SFL-55 Evolving water chemistry in the near-field rock		The evolution of water chemistry in the vicinity of deposition holes is not dealt with separately or in a different manner than the groundwater chemistry of the far field rock. Some aspects however are considered specially: the effect of grouting and the operation phase.	
H 1.5.1 Desaturation (pumping) effects		The geochemical effects of unsaturated conditions in the rock are not considered. There are no expected effects on advection or mixing of solutes in the geosphere as a consequence of the drying-out of the rock during repository operation (e.g. the EDZ)	
H 1.5.5 Transport of chemically-active substances into the near-field	Transport of solutes is described. Introduction of organics, colloids and microbes from the geosphere into the buffer (= near field) and consequences of this are neglected.		
H 2.3.7 Far-field transport: Changes in groundwater chemistry and flow direction	Changes in water chemistry as a result of climate change are considered.	Effects of changes of groundwater chemistry on sorption properties are discussed under sorption (radionuclide transport).	See "Speciation and sorption" Ge13.
I 040 Farfield chemical interactions	The effect of salinity on groundwater flow is described. Effects of advection on groundwater composition are also described.		Consequences for colloid formation etc are described in the text for the corresponding processes (Ge14, Ge15, Ge18).
J 5.01 Saline (or fresh) groundwater intrusion	The effect of salinity on groundwater flow is described.		See also "Groundwater flow" (Ge03). Consequences for colloid formation etc are described in the text for the corresponding process (Ge13, Ge18).
J 6.04 Dispersion	Dispersion of solutes is described.		
K 5.08 Groundwater chemistry	The effect of salinity on groundwater flow is described. Effects of advection on groundwater composition are also described.		

SR-Site FEP Ge11 Advective transport/mixing of dissolved species

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 5.11 Intrusion of saline groundwater		Site-specific FEP (intrusion from sedimentary Permo-Caboniferous Trough) not relevant for SR-Site.	
K 6.08 Groundwater chemistry	The effect of salinity on groundwater flow is described. Effects of advection on groundwater composition are also described.		Equivalent to NEA FEP K 5.08.
K 6.11 Intrusion of saline groundwater		Site-specific FEP (intrusion from sedimentary Permo-Caboniferous Trough) not relevant for SR-Site.	
K 7.08 Groundwater chemistry	The effect of salinity on groundwater flow is described. Effects of advection on groundwater composition are also described.		Equivalent to NEA FEP K 5.08.
M 1.5.08 Effects at saline-freshwater interface	Advective transport and mixing results in volumes of rock predominantly occupied by waters of different salinity, but sharp interfaces do not arise.	No such sharp interface has been observed in the granitic rock in the Fennoscandian sites.	
M 1.6.01 Advection and dispersion	Both advection and dispersion are described.		
S 018 Deep saline water intrusion	The effect of salinity on groundwater flow is described.		Equivalent to J 5.01
S 026 Dispersion	Dispersion of solutes is described.		See also "Transport of radionuclides in the water phase" (Ge24).
S 048 Groundwater chemistry	Effects of advection on groundwater composition are described.		
S 052 Interface different waters		No such sharp interface has been observed in Fennoscandian sites. The effect (colloid formation) is considered instead to be dependent on low salinity conditions.	
S 103 Water chemistry in near-field rock		The evolution of water chemistry in the vicinity of deposition holes is not dealt with separately or in a different manner than the groundwater chemistry of the far field rock. Some aspects however are considered specially: the effect of grouting and the operation phase.	See SKB FEPs Ge15, Ge17, Ge19.
W 1.030 Freshwater intrusion	The effect of changes in recharge waters is described Effects of advection on groundwater composition are described.		
W 1.034 Saline intrusion	The effect of changes in recharge waters is described. Effects of advection on groundwater composition are described.		
W 1.035 Freshwater intrusion	The effect of changes in recharge waters is described. Effects of advection on groundwater composition are described.		
W 2.090 Advection	Advection is described.		

SR-Site FEP Ge11 Advective transport/mixing of dissolved species

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 3.035 Borehole-induced mineralization		The effects due to a borehole (future human action), on changes in advection-mixing-dispersion, are expected to be local. These effects can be neglected when compared with other advection-mixing factors from future climate conditions, such as glaciations.	For impact of drilling of future boreholes, see SKB FHA FEPs.
W 3.036 Borehole-induced geochemical changes		The effects due to a borehole (future human action), on changes in advection-mixing-dispersion, are expected to be local. These effects can be neglected when compared with other advection-mixing factors from future climate conditions, such as glaciations.	For impact of drilling of future boreholes, see SKB FHA FEPs.
Recorded by: Ignasi Puigdomenech			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Ge12 Diffusive transport of dissolved species in fractures and rock matrix

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.36 Galvanic coupling		Electrokinetic effects are discussed under "earth currents"	See SKB FEP Ge23.
A 2.16 Diffusion	Diffusion is described.		
A 2.41 Matrix diffusion	Diffusion into the rock matrix is described.		
E GEN-01 Alteration and weathering along flow paths	Mineral precipitation and dissolution is described.	The overall effect on porosity and diffusivity from weathering of rock minerals is expected to be small as on the whole the weathering reactions consist of mineral transformations, i.e. dissolution of granite minerals with subsequent formation of secondary solids.	
E GEN-02 Anion exclusion	Anion exclusion in rock is addressed through the choice of diffusion coefficients.		
E GEN-09 Diffusion	Diffusion in fractures and in the rock matrix is described.		
E GEN-12 Earth tides		The tidal effects are not discernible in the site modelling. These effects are expected to be minor when compared with yearly variations and long-time climate effects, such as shore displacements and glaciations.	
E GEN-25 Matrix diffusion	Matrix diffusion is described.		
E SFL-55 Evolving water chemistry in the near-field rock		The evolution of water chemistry in the vicinity of deposition holes is not dealt with separately or in a different manner than the groundwater chemistry of the far field rock. Some aspects however are considered specially: the effect of grouting and the operation phase.	

SR-Site FEP Ge12 Diffusive transport of dissolved species in fractures and rock matrix

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 2.3.2 Far-field transport: Diffusion	Diffusion in water and in the rock matrix is addressed.	Surface diffusion is not considered because it is thought to be not significant for groundwater geochemistry.	
J 3.2.06 Diffusion - surface diffusion	Diffusion is addressed.	Surface diffusion is not considered because it is thought to be not significant for groundwater geochemistry.	
J 3.2.10 Soret effect		FEP primarily concerns effects in bentonite. No significant chemical consequences are foreseen in the geosphere. The effect on radionuclide transport is certainly negligible in the geosphere - too small temperature gradients.	
J 4.1.05 Matrix diffusion	Matrix diffusion and implications of fracture fillings and the rock mass (porosity and mineralogy) is addressed.		
K 5.05 Radionuclide transport through LPD	Retardation of advective transport due to matrix diffusion is addressed.		See also SKB FEP Ge24.
K 5.06 Matrix diffusion	Matrix diffusion and impact of pore geometry (formation factor), charge of pore surfaces and size and charge of diffusing species, extent of connected porosity, fracture infill and altered zones are addressed.		
K 6.05 Radionuclide transport through MWCF	Retardation of advective transport due to matrix diffusion is addressed.		Equivalent to NEA FEP K 5.05
K 6.06 Matrix diffusion	Matrix diffusion and impact of pore geometry (formation factor), charge of pore surfaces and size and charge of diffusing species, extent of connected porosity, fracture infill and altered zones are addressed.		Equivalent to NEA FEP K 5.06
M 1.6.02 Diffusion	Diffusion is described.		
M 1.6.03 Matrix diffusion	Matrix diffusion is described.		
S 001 Alteration/weathering of flow paths	Mineral precipitation and dissolution is described.		
S 002 Anion-exclusion	Anion exclusion in rock is addressed through the choice of diffusion coefficients.		
S 023 Diffusion	Anion exclusion in the rock matrix is addressed.	Surface diffusion takes place in compacted clay minerals, and the amounts in the rock fractures are too small for this process to be of any significance.	
S 028 Earth tides		The effects of tides are not discernible in the site modelling. These effects are expected to be minor when compared with yearly variations and long-time climate effects, such as shore displacements and glaciations.	

SR-Site FEP Ge12 Diffusive transport of dissolved species in fractures and rock matrix

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 054 Matrix diffusion	Anion exclusion and characteristics affecting matrix diffusion are addressed.		
S 083 Soret effect		FEP primarily concerns effects in bentonite. No significant chemical consequences are foreseen in the geosphere. The effect on radionuclide transport is certainly negligible in the geosphere- too small temperature gradients.	
W 2.091 Diffusion	Molecular diffusion in pores of the rock is addressed.		
W 2.092 Matrix diffusion	Matrix diffusion and factors controlling matrix diffusion are addressed.		
W 2.093 Soret effect		No significant chemical consequences are foreseen. The effect on radionuclide transport is certainly negligible in the geosphere - too small temperature gradients.	
Recorded by: Ignasi Puigdomenech			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Ge13 Speciation and sorption

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.14 Complexation by organics	The effect of humic and fulvic acids on sorption characteristics is addressed.		Not considered important at repository depth and therefore has not been quantified.
A 1.37 Geochemical pump	Immobilisation processes such as surface complexation and co-precipitation and subsequent dissolution of solid phases containing radionuclides, if chemical conditions change, is discussed in SR-Site.		
A 1.77 Speciation	Effects of temperature and pressure addressed.		Effect of temperature discussed as a data uncertainty although the effect is considered minor. Effect of pressure is expected to be even smaller.
A 2.09 Complexation by organics	The effect of humic and fulvic acids on sorption characteristics is addressed.		Not considered important at repository depth and therefore has not been quantified although discussed qualitatively.
A 2.26 Fulvic acid	The effect of humic and fulvic acids on sorption characteristics is addressed.		Not considered important at repository depth and therefore has not been quantified although discussed qualitatively.
A 2.34 Humic acid	The effect of humic and fulvic acids on sorption characteristics is addressed.		Not considered important at repository depth and therefore has not been quantified although discussed qualitatively.

SR-Site FEP Ge13 Speciation and sorption

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.58 Saturation	The possibility of sorption saturation and the use of non-linear isotherms are addressed.		Saturation and non-linear effects not quantified directly. Concentrations used in sorption studies are typically greater than those encountered in far field transport and therefore underestimate sorption due to isotherm non-linearity/site saturation effects.
A 2.62 Sorption	Different processes described as sorption are discussed. Covered: minerals involved, mineral surface area, electro-chemical potential, salinity, pH, competing solutes and available complexing ligands.		
A 2.63 Sorption - nonlinear	The possibility of sorption saturation and the use of non-linear isotherms are addressed.		Saturation and non-linear effects not quantified directly. Concentrations used in sorption studies are typically greater than those encountered in far field transport and therefore underestimate sorption due to isotherm non-linearity/site saturation effects.
A 2.64 Speciation	Speciation as a function of in-organic and organic components of water is discussed.		
E GEN-01 Alteration and weathering along flow paths		Not directly included in SR-Site, but properties along full flow path chosen in a conservative manner.	
E GEN-04 Colloid behaviour in the host rock	Bentonite colloids included in the quantitative assessment of radionuclide transport in the geosphere. Natural colloids discussed.		
E GEN-22 Far-field groundwater chemistry	The effect of groundwater chemistry on speciation and sorption is considered in derivation of K_d values.		
E GEN-27 Radionuclide precipitation and dissolution	Precipitation/dissolution mentioned.		
E GEN-31 Radionuclide reconcentration	Immobilisation processes are addressed.		
E GEN-34 Radionuclide sorption	Sorption is handled through the K_d approach using supporting analyses.		
H 2.3.4 Far-field transport: Solubility constraints	Solubility constraints due to high ionic strength groundwater indirectly taken care of as K_d values specified for relevant salinities.	Solubility constraints in the far-field due to the alkaline (high pH) plume not considered, since low pH grouting assumed to be available for the construction of the repository.	

SR-Site FEP Ge13 Speciation and sorption

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 2.3.5 Far-field transport: Sorption including ion-exchange	Different processes described as sorption are discussed as well as different aspects limiting or hindering sorption.		
H 2.3.6 Far-field transport: Changes in sorptive surfaces	The fracture surface area through which the inner surfaces of the matrix is reached is discussed in a sorption context.	Changes in surface area not explicitly handled in SR-Site, but mentioned in process report.	See "Transport of radionuclides in the water phase" (Ge24).
H 2.3.7 Far-field transport: Changes in groundwater chemistry and flow direction	Impact of changes in groundwater composition is considered in derivation of K_d values.		
H 2.3.12 Far-field transport: Thermal effects on hydrochemistry		Not discussed; relevance considered low.	
I 040 Farfield chemical interactions	Impact of groundwater composition on sorption is considered in derivation of K_d values.		
J 4.1.04 Sorption	Different processes described as sorption are addressed.		
J 4.1.06 Reconcentration	Immobilisation processes such as surface complexation and co-precipitation and subsequent dissolution of solid phases containing radionuclides, if chemical conditions change, is discussed in SR-Site.		
J 4.1.09 Complexing agents	The effect of humic and fulvic acids on sorption characteristics are addressed.		Not considered important at repository depth and therefore has not been quantified although discussed qualitatively.
J 7.05 Isotopic dilution	Implicit in discussions of sorption non-linearity and impact of naturally occurring isotopes on sorption. Also mentioned in relation to solid solution formation in the transport report.		
K 0.2 Speciation	Speciation is addressed.		
K 4.10 Elemental solubility		Precipitation of nuclides with colloids not considered.	
K 5.07 Mineralogy	The effect of mineralogy on sorption is addressed.		
K 5.08 Groundwater chemistry	The effect of groundwater chemistry on speciation and sorption is considered in derivation of K_d values.		
K 5.09 Sorption	Different processes described as sorption are discussed.		
K 5.10 Non-linear sorption	Non-linear sorption is addressed. Only linear sorption employed in calculations of SR-Site, based on arguments in the process description.		

SR-Site FEP Ge13 Speciation and sorption

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 5.11 Intrusion of saline groundwater	Impact of salinity on chemical equilibria and sorption characteristics is addressed.		
K 5.16 Solubility limits/colloid formation	Precipitation and coprecipitation is mentioned.		See also "Transport of radionuclides in the water phase" Ge24.
K 5.22 Microbial activity	Impact of microbial activity on sorption mentioned.		See also "Transport of radionuclides in the water phase" Ge24.
K 6.07 Mineralogy	The effect of mineralogy on sorption is addressed.		Equivalent to NEA FEP K 5.07.
K 6.08 Groundwater chemistry	The effect of groundwater chemistry on speciation and sorption is considered in derivation of K_d values.		Equivalent to NEA FEP K 5.08.
K 6.09 Sorption	Different processes described as sorption are discussed.		Equivalent to NEA FEP K 5.09.
K 6.10 Non-linear sorption	Non-linear sorption is addressed. Only linear sorption employed in calculations of SR-Site.		Equivalent to NEA FEP K 5.10.
K 6.11 Intrusion of saline groundwater	Impact of salinity on chemical equilibria and sorption characteristics is addressed.		Equivalent to NEA FEP K 5.11.
K 6.16 Solubility limits/colloid formation	Precipitation and coprecipitation is mentioned		See also "Transport of radionuclides in the water phase" (Ge24).
K 7.08 Groundwater chemistry	The effect of groundwater chemistry on speciation and sorption is considered in derivation of K_d values.		Equivalent to NEA FEP K 5.08.
K 7.09 Radionuclide sorption	Different processes described as sorption are discussed.		Equivalent to NEA FEP K 5.09.
M 1.2.11 Rock heterogeneity	The impact of rock heterogeneity analysed as part of the SDM-Site model. The importance shown to be minor relative to variation in flow-related transport properties, and hence not explicitly included in SR-Site.		
S 001 Alteration/weathering of flow paths	Impact of alteration on sorption is addressed.		
S 018 Deep saline water intrusion	Impact of salinity on chemical equilibria and sorption characteristics is addressed.		
S 048 Groundwater chemistry	Impact of groundwater chemistry on speciation and sorption is considered in derivation of K_d values.		
S 060 Precipitation/dissolution	Precipitation/dissolution as a type of sorption reaction is discussed.		See also "Transport of radionuclides in the water phase" (Ge24).
S 073 Reconcentration	Immobilisation processes such as surface complexation and co-precipitation and subsequent dissolution of solid phases containing radionuclides, if chemical conditions change, is discussed in SR-Site.		See also "Transport of radionuclides in the water phase" (Ge24).

SR-Site FEP Ge13 Speciation and sorption

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 084 Sorption	Different processes described as sorption are addressed.		
W 1.034 Saline intrusion	Effect of groundwater chemistry on sorption is considered in derivation of K_d values.		See also "Transport of radionuclides in the water phase" (Ge24).
W 1.035 Freshwater intrusion	Effect of groundwater chemistry on sorption is considered in derivation of K_d values.		See also "Transport of radionuclides in the water phase" (Ge24).
W 1.036 Changes in groundwater Eh	Effect of groundwater chemistry on sorption is considered in derivation of K_d values.		See also "Transport of radionuclides in the water phase" (Ge24).
W 1.037 Changes in groundwater pH	Effect of groundwater chemistry on sorption is considered in derivation of K_d values.		See also "Transport of radionuclides in the water phase" (Ge24).
W 2.056 Speciation	Speciation as a function of temperature, pressure, and salinity is addressed.		
W 2.057 Kinetics of speciation	Kinetics of sorption addressed, but handled; deemed to be of minor relevance (speciation is fast).		
W 2.060 Kinetics of precipitation and dissolution	Precipitation-dissolution is discussed. Kinetics of precipitation-dissolution not handled since precipitation-dissolution not included in quantitative manner in analyses.		
W 2.061 Actinide sorption	Different processes described as sorption are discussed.		
W 2.062 Kinetics of sorption	The fact that sorption may be kinetic is discussed. Kinetic sorption models not utilized in the quantitative analyses for SR-Site; however, indirectly accounted for when K_d data is suggested (by conservative choices and uncertainty ranges).		
W 2.071 Kinetics of organic complexation	The effect of humic and fulvic acids on sorption characteristics is addressed.		Not considered important at repository depth and therefore has not been quantified although discussed qualitatively.
Recorded by: Jan-Olof Selroos, James Crawford			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Ge14 Reactions groundwater/rock matrix

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E GEN-01 Alteration and weathering along flow paths	Mineral precipitation and dissolution is described.		
E GEN-22 Far-field groundwater chemistry	The interaction between groundwater chemistry and mineral precipitation-dissolution is considered.		
E GEN-37 Surface water chemistry	The effects of recharging water chemistry on mineral precipitation-dissolution are considered.		
E SFL-38 Redox fronts	Redox fronts close to the surface and after immediately after repository closure are considered. For SR-Site the process with potentially the highest impact is the infiltration of oxygen-rich glacial melt waters, and this is addressed.		
E SFL-55 Evolving water chemistry in the near-field rock		The evolution of water chemistry in the vicinity of deposition holes is not dealt with separately or in a different manner than the groundwater chemistry of the far field rock. Some aspects however are considered specially: the effect of grouting and the operation phase.	
H 1.5.1 Desaturation (pumping) effects		Desaturation of the rock might expand the oxidizing zone a few metres into the rock matrix. Because the overall porosity of the rock or EDZ is so low (compared with the backfill) the increased amount of O_2 on repository closure is negligible.	
I 040 Farfield chemical interactions	Chemistry changes due to dissolution precipitation are described.		
J 3.1.11 Redox front	There are three types of redox fronts described in this FEP. Type 1) recharge of surface waters: this will depend on the climatic conditions. When the site is above sea level under temperate climate the redox front is close to the surface, i.e. it may be assumed that reducing conditions prevail already a short distance from the ground surface. During glaciation the redox front might be deeper, and this is modelled in SR-Site. Type 2) conditions shortly after repository closure: the consumption of oxygen in the backfill are modelled in SR-Site. Type 3) radiolysis close to the spent fuel: this does not concern the geosphere.		Type 3) redox front due to radiolysis close to the spent fuel is addressed in SKB FEP F10.
J 4.1.02 pH-deviations	The effect of pH on dissolution precipitation is described.		

SR-Site FEP Ge14 Reactions groundwater/rock matrix

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 6.06 Weathering of flow paths	Dissolution and precipitation reactions are considered.	The overall effect of weathering of the rock matrix on fracture porosity is expected to be small as on the whole the weathering reactions produce mineral transformations, i.e. dissolution of granite minerals with subsequent formation of secondary solids, e.g. fracture filling minerals.	
K 4.05 Geochemical alteration		The main geochemical alterations in the EDZ during excavation and backfilling are expected to be limited to the oxidation of Fe(II) minerals if the EDZ becomes water un-saturated. These changes are not expected to affect substantially the chemical properties of the geosphere.	
K 4.06 Groundwater chemistry		In case of de-saturation of the EDZ during excavation and backfilling it is to be expected a change to oxidizing conditions in the matrix porewater. The conditions will however return to reducing after re-saturation of the backfill. This effect may be neglected when considering the large amount of air entrapped in the backfill.	
K 5.07 Mineralogy	The effect of mineralogy on groundwater chemistry through dissolution and precipitation is described.		
K 5.08 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		
K 5.19 Influx of oxidising water	The possible effect of the influx of oxidizing surface waters during repository operation is described.		
K 6.07 Mineralogy	The effect of mineralogy on groundwater chemistry through dissolution and precipitation is described.		Equivalent to NEA FEP K 5.07.
K 6.08 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		Equivalent to NEA FEP K 5.08.
K 6.19 Influx of oxidising water	The possible effect of the influx of oxidizing surface waters during repository operation is described.		Equivalent to NEA FEP K 5.09.
K 7.08 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		Equivalent to NEA FEP K 5.08.
S 001 Alteration/weathering of flow paths	The effect of minerals on groundwater chemistry through dissolution and precipitation is described. Effects on fracture flow are not discussed.		

SR-Site FEP Ge14 Reactions groundwater/rock matrix

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 048 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		
S 064 Properties of far-field rock	Changes in rock properties due to dissolution-precipitation reactions are described.		
S 065 Properties of near-field rock	Changes in rock properties due to dissolution-precipitation reactions are described.		
S 074 Redox front	Equivalent to NEA FEP J 3.1.11.		
W 1.038 Effects of dissolution	Dissolution of minerals is described.		It is not clear in this FEP what dissolution means: dissolution of what?
W 2.057 Kinetics of speciation		The rate of most reactions in aqueous solutions may be considered instantaneous in this context. Some redox re-actions are on the contrary hindered unless mediated by microbes, e.g. sulphate reduction, and their kinetics may also be disregarded.	
W 2.065 Reduction-oxidation fronts	A large scale intrusion of oxidizing waters can only be envisaged under a glaciation period, and this is described.		
W 3.035 Borehole-induced mineralization		This concerns future human actions: drilling. The precipitation-dissolution effects from a borehole, due to changes in advection-mixing-dispersion, are expected to be minor and local. These effects can be neglected when compared with other advection-mixing factors from future glaciations.	For impact of drilling of future boreholes, see SKB FHA FEPs.
W 3.036 Borehole-induced geochemical changes		This concerns future human actions: drilling. The precipitation-dissolution effects from a borehole, due to changes in advection-mixing-dispersion, are expected to be minor and local. These effects can be neglected when compared with other advection-mixing factors from future glaciations.	For impact of drilling of future boreholes, see SKB FHA FEPs.
Recorded by: Ignasi Puigdomenech			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Ge15 Dissolution/precipitation of fracture-filling minerals

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.29 Geochemical interactions	The chemical interactions between groundwater and fracture filling minerals are described.		
A 2.33 Groundwater - evolution		The temperature effects on groundwater chemical evolution are expected to be minor, as discussed in the description of this FEP.	
A 2.35 Hydraulic properties - evolution		The temperature effects on mineral dissolution-precipitation and its effects on groundwater flow are expected to be minor, as discussed in the description of this FEP.	
A 2.49 Precipitation and dissolution		The temperature effects on mineral dissolution-precipitation and its effects on groundwater flow are expected to be minor. This FEP will affect the near vicinity of the repository, and the overall effect on the geosphere chemical properties is minor.	
A 2.53 Recharge groundwater	Different types of recharge waters are discussed in SR-Site. These types vary as a function of time.		
E GEN-01 Alteration and weathering along flow paths	Mineral precipitation and dissolution is described.		
E GEN-22 Far-field groundwater chemistry	The interaction between groundwater chemistry and mineral precipitation-dissolution is considered.		
E GEN-37 Surface water chemistry	The effects of recharging water chemistry on mineral precipitation-dissolution are considered.		
E SFL-38 Redox fronts	Redox fronts close to the surface and after immediately after repository closure are considered. For SR-Site the process with potentially the highest impact is the infiltration of oxygen-rich glacial melt waters, and this is addressed.		
E SFL-55 Evolving water chemistry in the near-field rock		The evolution of water chemistry in the vicinity of deposition holes is not dealt with separately or in a different manner than the groundwater chemistry of the far field rock. Some aspects however are considered specially: the effect of grouting and the operation phase.	
H 1.5.1 Desaturation (pumping) effects		Desaturation of the rock might expand the oxidizing zone a few metres into the rock matrix. Because the overall porosity is so low (compared with the backfill) the increased amount of O_2 on repository closure is negligible.	

SR-Site FEP Ge15 Dissolution/precipitation of fracture-filling minerals

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 2.3.6 Far-field transport: Changes in sorptive surfaces	Changes in mineralogy due to dissolution-precipitation reactions are described.		See also "Degradation of grout" (Ge17) and "Transport of radionuclides in the water phase" (Ge24).
H 2.3.7 Far-field transport: Changes in groundwater chemistry and flow direction	Changes in mineralogy due to dissolution-precipitation reactions are described.		
I 040 Farfield chemical interactions	The interaction between ground-water chemistry and minerals due to dissolution-precipitation reactions is described.		
J 4.1.02 pH-deviations	The effect of pH on dissolution precipitation is described.		
J 6.06 Weathering of flow paths	Precipitation-dissolution reactions are described.	The overall effect of weathering of the fracture minerals on fracture porosity is expected to be small as the on the whole the weathering reactions produce mineral transforma-tions, i.e. dissolution of granite minerals with subsequent formation of secondary solids, e.g. fracture filling minerals.	
K 4.05 Geochemical alteration		The main geochemical alterations in the EDZ during excavation and backfilling are expected to be limited to the oxidation of Fe(II) minerals if the EDZ becomes water un-saturated. These changes are not expected to affect substantially the chemical properties of the geosphere.	
K 4.06 Groundwater chemistry		In case of de-saturation of the EDZ during excavation and backfilling it is to be expected a change to oxidizing conditions in the matrix porewater. The conditions will however return to reducing after re-saturation of the backfill. This effect may be neglected when considering the large amount of air entrapped in the backfill.	
K 5.07 Mineralogy	The effect of mineralogy on groundwater chemistry through dissolution and precipitation is described.		
K 5.08 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		
K 5.19 Influx of oxidising water	The possible effect of the influx of oxidizing surface waters during repository operation is described.		
K 6.07 Mineralogy	The effect of mineralogy on groundwater chemistry through dissolution and precipitation is described.		Equivalent to NEA FEP K 5.07.

SR-Site FEP Ge15 Dissolution/precipitation of fracture-filling minerals

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 6.08 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		Equivalent to NEA FEP K 5.08.
K 6.19 Influx of oxidising water	The possible effect of the influx of oxidizing surface waters during repository operation is described		Equivalent to NEA FEP K 5.19.
K 7.08 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		Equivalent to NEA FEP K 5.08.
M 1.6.11 Fracture mineralisation and weathering	Mineral precipitation and dissolution in fractures is described.		
S 001 Alteration/weathering of flow paths	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		Effects on fracture geometry are described, but the consequences for groundwater flow are not discussed here.
S 048 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		
S 064 Properties of far-field rock	Changes in rock properties due to dissolution-precipitation reactions are described.		
S 065 Properties of near-field rock	Similar to NEA FEP S 064		
S 103 Water chemistry in near-field rock	Impact of water composition on dissolution-precipitation reactions is described.		
W 1.009 Changes in fracture properties	Changes in rock properties due to dissolution-precipitation reactions are described.		Effects on fracture geometry are described, but the consequences for groundwater flow are not discussed here.
W 1.022 Fracture infills	The interaction between minerals and groundwater through dissolution and precipitation is described.		Effects on fracture geometry are described, but the consequences for groundwater flow are not discussed here.
W 1.038 Effects of dissolution	Dissolution of minerals is described.		It is not clear in this FEP what dissolution means: dissolution of what?
W 2.057 Kinetics of speciation		The rate of most reactions in aqueous solutions may be considered instantaneous in this context. Some redox reactions are on the contrary hindered unless mediated by microbes, e.g. sulphate reduction, and their kinetics may also be disregarded.	
W 2.059 Precipitation	The interaction between minerals and groundwater through dissolution and precipitation is described.		

SR-Site FEP Ge15 Dissolution/precipitation of fracture-filling minerals

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 2.065 Reduction-oxidation fronts	A large scale intrusion of oxidizing waters can only be envisaged under a glaciation period, and this is described.		
W 3.035 Borehole-induced mineralization		This concerns future human actions: drilling. The precipitation-dissolution effects from a borehole, due to changes in advection-mixing-dispersion, are expected to be minor and local. These effects can be neglected when compared with other advection-mixing factors from future glaciations.	For impact of drilling of future boreholes, see SKB FHA FEPs.
W 3.036 Borehole-induced geochemical changes		This concerns future human actions: drilling. The precipita-tion-dissolution effects from a borehole, due to changes in advection-mixing-dispersion, are expected to be minor and local. These effects can be neglected when compared with other advection-mixing factors from future glaciations.	For impact of drilling of future boreholes, see SKB FHA FEPs.
Recorded by: Ignasi Puigdomenech			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Ge16 Microbial processes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.03 Biological activity	Microbial processes in the geosphere are described.		
A 1.35 Formation of gases	Microbial processes involving gaseous components are described.		
A 1.53 Methylation	The process is described. Note that methylation of metals is not considered important for the chemical properties of the geosphere. Only a few metals are susceptible of methylation: As(V) , Cd(II), Te(IV), Se(IV), Sn(II), Hg(II), Pb(IV).		
A 1.54 Microbes	Microbial processes in the geosphere are described.		
A 1.55 Microorganisms	Microbial processes in the geosphere are described.		
A 2.45 Microbes	Microbial processes affecting radionuclide transport are described.		
A 2.49 Precipitation and dissolution	Microbial processes affecting radionuclide transport are described.		
E GEN-04 Colloid behaviour in the host rock	Viruses are described as being of colloidal size.	The microbial effects on colloids are negligible for a KBS-3 repository where large amounts of bentonite colloids are available.	
E GEN-18 Gas flow in the far-field	Microbial processes involving gaseous components are described.		

SR-Site FEP Ge16 Microbial processes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E GEN-19 Gas generation in the far-field	Microbial processes involving gaseous components are described.		
E GEN-20 Gas generation in the near-field rock	Microbial processes involving gaseous components are described.		
E GEN-22 Far-field groundwater chemistry	The interaction between microbes and groundwater chemistry is described.		
E SFL-32 Microbial activity	Microbial processes in the geosphere, including those affecting gaseous components and processes influencing radionuclide behaviour, are described.		
H 2.2.2 Rock property changes	Microbial processes in the geosphere are described.		
H 2.3.9 Far-field transport: Transport of radionuclides bound to microbes	Microbial processes affecting radionuclide transport are described.		
H 2.3.13 Far-field transport: Biogeochemical changes	This is discussed. Microbial activities at repository depth are expected to occur even in the event of a glaciation, as some microbes are expected to be energetically independent of surface conditions: they will consume methane and hydrogen emanating from the Earth's mantle.		
I 012 Biological activity (bacteria & microbes)	Microbial processes in the geosphere, including those affecting radionuclide behaviour, are described.		
I 015 Gas generation (CH4, CO2, H2)	Microbial processes involving gaseous components are described.		
J 2.1.10 Microbes	Microbial processes in the geosphere, including those affecting radionuclide behaviour, are described.		
K 3.17 Microbial activity	Microbial processes in the geosphere, including those affecting radionuclide behaviour, are described.		
K 5.22 Microbial activity	Microbial processes in the geosphere, including those affecting radionuclide behaviour, are described.		
K 6.22 Microbial activity	Microbial processes in the geosphere, including those affecting radionuclide behaviour, are described.		
M 3.2.07 Microbiological effects	Microbial effects in the geosphere are described.		
S 043 Gas generation and gas sources, far-field	Microbial processes involving gaseous components are described.		

SR-Site FEP Ge16 Microbial processes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 046 Gas generation, near-field rock	Microbial processes involving gaseous components are described.		
S 048 Groundwater chemistry	Microbial processes in the geosphere, including those affecting gaseous components and processes influencing radionuclide behaviour, are described.		
S 057 Microbial activity	Microbial processes in the geosphere, including those affecting gaseous components and processes influencing radionuclide behaviour, are described.		
W 2.044 Degradation of organic material	Microbial processes in the geosphere, including degradation of organic matter, are described.		
W 2.048 Effect of biofilms on microbial gas generation	Microbial processes involving gaseous components are described.		
W 2.076 Microbial growth on concrete		The effect of microbes on grout (the only cement component of the geosphere) is described in the grout degradation process (Ge17).	
W 2.087 Microbial transport	Microbial processes in the geosphere, including those affecting radionuclide behaviour, are described.		
W 2.088 Biofilms	Microbial processes in the geosphere, including those affecting radionuclide behaviour, are described.		
Recorded by: Ignasi Puigdomenech			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Ge17 Degradation of grout

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.15 Concrete	The processes and consequences of concrete degradation are described. Low pH concrete and grouts (porewaters with pH less or equal to 11) will be used at the repository, in order to ensure clay stability.		
A 1.71 Seal evolution	The processes and consequences of concrete degradation are described. Low pH concrete and grouts (porewaters with pH less or equal to 11) will be used at the repository, in order to ensure clay stability.		
A 1.72 Seal failure	The processes and consequences of concrete degradation are described. Low pH concrete and grouts (porewaters with pH less or equal to 11) will be used at the repository, in order to ensure clay stability.		The consequences of seal degradation on repository safety are not addressed here.

SR-Site FEP Ge17 Degradation of grout

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.04 Borehole seal failure	The processes and consequences of concrete degradation are described. Low pH concrete and grouts (porewaters with pH less or equal to 11) will be used at the repository, in order to ensure clay stability.		Borehole seals are not a geosphere component.
A 2.60 Shaft seal failure	The processes and consequences of concrete degradation are described. Low pH concrete and grouts (porewaters with pH less or equal to 11) will be used at the repository, in order to ensure clay stability.		Tunnel and shaft seals are not a geosphere component.
E GEN-01 Alteration and weathering along flow paths	The processes and consequences of concrete degradation are described. The formation of calcium-silicate-hydrates when cement porewaters react with rock minerals is mentioned.		
E GEN-08 Degradation of the rock reinforcement and grout	The processes and consequences of concrete and grout degradation are described.		
E SFL-55 Evolving water chemistry in the near-field rock	The processes and consequences of concrete degradation are described. The diffusion of calcium and hydroxide from the cement matrix into the surrounding groundwater is mentioned.		
H 1.1.2 Physico-chemical degradation of concrete	The processes and consequences of concrete degradation are described. Low pH concrete and grouts (porewaters with pH less or equal to 11) will be used at the repository, in order to ensure clay stability.		
H 2.2.2 Rock property changes	The effect of an alkaline plume from cement degradation is discussed.		
I 061 Concrete (influence on vault chemistry)	The effect of an alkaline plume from cement degradation is discussed.		
J 1.2.07 Recrystallization	The processes and consequences of concrete degradation are described.		
J 3.1.07 Reactions with cement pore water	The processes and consequences of concrete degradation are described.		
J 4.1.08 Change of groundwater chemistry in nearby rock	The processes and consequences of concrete degradation are described.		
M 3.2.02 Interactions of host materials and ground water with repository materials	The processes and consequences of concrete degradation are described.		
M 3.2.03 Interactions of waste and repository materials with host materials	The processes and consequences of concrete degradation are described. The formation of calcium-silicate-hydrates when cement porewaters react with rock minerals is mentioned.		

SR-Site FEP Ge17 Degradation of grout

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
M 3.2.07 Microbiological effects	The role of microbial processes on cement and grout degradation is described.		
S 021 Degradation of rock reinforcement and grout	The processes and consequences of concrete degradation are described. Rock bolts are not part of the geosphere, but the corrosion process is mentioned.		
S 065 Properties of near-field rock	The processes and consequences of concrete degradation are described. The formation of calcium-silicate-hydrates when cement porewaters react with rock minerals is mentioned.		
S 103 Water chemistry in near-field rock	The processes and consequences of concrete degradation are described. The diffusion of calcium and hydroxide from the cement matrix into the surrounding groundwater is mentioned.		
W 2.037 Mechanical degradation of seals	The processes and consequences of concrete degradation are described.	Asphalt and compacted salt are not addressed because these materials are not relevant for a KBS-3 repository.	
W 2.074 Chemical degradation of seals	The processes and consequences of concrete degradation are described. Low pH concrete and grouts (porewaters with pH less than or equal to 11) will be used at the repository, in order to ensure clay stability.		
W 2.076 Microbial growth on concrete	The effect of microbes on grout is described.		
W 2.097 Chemical gradients	The processes and consequences of concrete degradation are described. The diffusion of calcium and hydroxide from the cement matrix into the surrounding groundwater is mentioned.		
Recorded by: Ignasi Puigdomenech			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Ge18 Colloidal processes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.13 Colloids	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
A 1.63 Psuedo-colloids	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere.		
A 2.08 Colloid formation	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
A 2.45 Microbes	Bacteria as colloids is mentioned.		Microbial processes affecting radionuclide transport are described elsewhere, see e.g. SKB FEP Ge16.
A 2.50 Pseudo-colloids	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
E GEN-04 Colloid behaviour in the host rock	Colloids, colloid stability and transport are discussed.		
E GEN-22 Far-field groundwater chemistry	Colloids, colloid stability and transport are discussed.		
H 1.5.1 Desaturation (pumping) effects	The formation of colloidal Fe(III) hydrous oxides or hydroxides is mentioned.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
H 1.5.5 Transport of chemically-active substances into the near-field		Transport of salt and oxygen are described elsewhere. Introduction of organics, colloids and microbes from the geosphere into the buffer are disregarded.	See SKB FEP Ge11.
H 2.3.8 Far-field transport: Colloid transport	Sorption of radionuclides on colloids is mentioned.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
I 058 Colloid formation (natural and vault generated)	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
J 5.45 Colloid generation and transport	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).

SR-Site FEP Ge18 Colloidal processes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 4.12 Colloids	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
K 5.15 Natural colloids	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere.		
K 6.15 Natural colloids	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere.		
S 008 Colloid generation and transport	Colloids and colloid stability are discussed. Colloid formation is of no consequence for the chemical properties of the geosphere. Sorption of radionuclides on colloids is mentioned.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
S 018 Deep saline water intrusion	The influence of salinity on colloid stability is mentioned. Saline waters will de-stabilize colloids.		
S 074 Redox front	The formation of colloidal Fe(III) hydrous oxides or hydroxides is mentioned.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
W 1.034 Saline intrusion	The influence of salinity on colloid stability is mentioned. Saline waters will de-stabilize colloids.		
W 1.035 Freshwater intrusion	The influence of salinity on colloid stability is mentioned. Colloid concentrations from e.g. bentonite might increase in diluted waters. However, these colloids are of no consequence for the overall chemical properties of the geosphere.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
W 2.078 Colloid transport	Colloids, colloid stability and transport are discussed.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
W 2.079 Colloid formation and stability	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere. Sorption of radionuclides on colloids is mentioned.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
W 2.080 Colloid filtration	Colloids, colloid stability and transport are discussed.		
W 2.081 Colloid sorption	Sorption of radionuclides on colloids is mentioned.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).

SR-Site FEP Ge18 Colloidal processes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 2.087 Microbial transport	The transport of colloids is mentioned.	Microbe-facilitated radionuclides transport is described in "Microbial processes" (Ge16).	
W 2.097 Chemical gradients	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere. Sorption of radionuclides on colloids is mentioned.		

Recorded by: Ignasi Puigdomenech **Date:** Dec 2010
Checked and revised by: Kristina Skagius **Date:** Dec 2010

SR-Site FEP Ge19 Formation/dissolution/reaction of gaseous species

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.35 Formation of gases	Gases originating from microbial processes are discussed. Water radiolysis is mentioned in "radiation effects" (Ge22). Corrosion of metals is not considered.		No metal parts are assumed to be present in the geosphere. Rock bolts are part of the backfill.
A 2.27 Gases and gas transport	Gaseous groundwater components and their behaviour are described.		Radionuclide gas transport is discussed elsewhere, see SKB FEP Ge25
E GEN-15 Excavation effects on the near field rock	The possible desaturation of the EDZ during excavation and backfilling is described. The amount of gas involved is negligible compared with the porosity of the backfill.		
E GEN-18 Gas flow in the far-field	Gaseous groundwater components and their reactions and behaviour are described.	The flow of gases is described elsewhere.	
E GEN-19 Gas generation in the far-field	Gaseous groundwater components and their reactions and behaviour are described.		
E GEN-20 Gas generation in the near-field rock		The evolution of gaseous species in the vicinity of deposition holes is not dealt with separately or in a different manner than in the far field rock. Although some desaturation may occur during the operation phase, the porosity of the rock and EDZ is negligible compared with the porosity and amounts of gases in the backfill.	
E GEN-22 Far-field groundwater chemistry	Gaseous groundwater components and their reactions and behaviour are described.		
E SFL-55 Evolving water chemistry in the near-field rock		The evolution of gaseous species in the vicinity of deposition holes is not dealt with separately or in a different manner than in the far field rock. Although some desaturation may occur during the operation phase, the porosity of the rock and EDZ is negligible compared with the porosity and amounts of gases in the backfill.	

SR-Site FEP Ge19 Formation/dissolution/reaction of gaseous species

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 2.1.9 Effects of natural gases.	Natural gases are addressed.		The formation of methane clathrates is described in "Methane hydrate formation" (Ge20).
H 2.3.11 Far-field transport: Gas induced ground-water transport	Change in groundwater chemistry as gases dissolve during upward movement of groundwater covered.		Radionuclide gas transport is discuss-ed elsewhere, see SKB FEP Ge25
J 5.43 Methane intrusion	Methane hydrates as a possible source of methane is mentioned.		The formation of methane clathrates is described in "Methane hydrate formation" (Ge20).
J 6.02 Gas transport	See handling of NEA FEP A 1.35 for geosphere chemical processes associated with gas production.		Gas transport discussed in "Gas flow/ dissolution" (Ge04).
K 4.06 Groundwater chemistry	The possible desaturation of the EDZ during excavation and backfilling is described. The amount of gas involved is negligible compared with the porosity of the backfill.		
M 1.2.13 Natural gas intrusion	Natural gaseous species and their reactions are described.		
S 042 Gas flow and transport, near-field rock/far-field	Gaseous groundwater components and their behaviour are described.		Radionuclide gas transport is discus-sed in "Transport of radionuclides in the gas phase" (Ge25).
S 043 Gas gene-ration and gas sources, far-field	Gaseous groundwater components and their behaviour are described.		
S 046 Gas generation, near-field rock	Gaseous groundwater components and their behaviour are described. Various sources of gas are mentioned.		
S 048 Groundwater chemistry	The interactions between groundwater chemistry and reactive gases are described.		
S 103 Water chemistry in near-field rock	Impact of dissolution of entrapped air on groundwater chemistry is addressed.		
W 1.032 Natural gas intrusion		This FEP is very specific to the WIPP repository. Contrary to the WIPP site, no large source of hydrocarbons or natural gas has been identified under or near the investigated sites in Sweden.	
Recorded by: Ignasi Puigdomenech			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Ge20 Methane hydrate formation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 2.1.9 Effects of natural gases.	The formation of methane clathrates is described.		
J 5.22 Accumulation of gases under permafrost	The formation of methane clathrates is described.		Accumulation of gases under permafrost is described in "Gas flow/ dissolution" (Ge04).
J 5.43 Methane intrusion	The formation of methane clathrates is described.		Accumulation of gases under permafrost is described in "Gas flow/ dissolution" (Ge04).
Recorded by: Ignasi Puigdomenech			**Date:** Dec 2010
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SR-Site FEP Ge21 Salt exclusion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 1.5.5 Transport of chemically-active substances into the near-field	The generation of saline groundwaters as a consequence of a permafrost event is described.		Transport of salt and oxygen is described in "Advection/mixing" (Ge11).
S 059 Permafrost	The generation of saline groundwaters as a consequence of a permafrost event is described.		
Recorded by: Ignasi Puigdomenech			**Date:** Dec 2010
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SR-Site FEP Ge22 Radiation effects (rock and grout)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.64 Radiation damage	The possible effects of radioactivity are discussed.		
A 2.52 Radiation effects	The possible effects of radioactivity are discussed.		
M 3.4.02 Material propertiy changes	The possible effects of radioactivity are discussed.		
S 046 Gas generation, near-field rock	The possible generation of H_2 by radiolysis in the geosphere is mentioned.		
Recorded by: Ignasi Puigdomenech			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Ge23 Earth currents

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E GEN-13 Electrochemical effects	Possible processes in the geosphere are described.		
J 2.1.06.2 Natural telluric electrochemical reactions	Possible processes in the geosphere are described.		This FEP affects canister corrosion and transport of solutes in the buffer, see SKB FEPs C13, Bu11 and Bft10.
S 029 Electrochemical effects/gradients	Possible processes in the geosphere are described.		This FEP affects canister corrosion and transport of solutes in the buffer, see SKB FEPs C13, Bu11 and Bft10.
W 2.094 Electrochemical effects	Possible processes in the geosphere as a consequence of electric potential gradients are described.		
W 2.096 Electrophoresis		The electric potential fields arising from galvanic cells due to canister corrosion are deemed to be too small to have any effect in the surrounding rock.	The first part of this NEA FEP is identical to NEA FEP W2.094. The second part deals with galvanic corrosion as possible source of electric potential to produce electrophoresis (see SKB FEP C13).
Recorded by: Ignasi Puigdomenech			**Date:** Dec 2010
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SR-Site FEP Ge24 Transport of radionuclides in the water phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.37 Geochemical pump	Immobilisation and mobilisation of radionuclides addressed.		See also "Speciation and sorption" (Ge13).
A 1.65 Radioactive decay	Radioactive decay included, with reference to process as such in fuel and canister process report.		See SKB FEP F01.
A 2.45 Microbes	Effect of micro-organisms on mobility of radionuclides is mentioned.		See also "Speciation and sorption" (Ge13) and "Microbial processes" (Ge16).
A 2.51 Radioactive decay	Radioactive decay included, with reference to process as such in fuel and canister process report.		See SKB FEP F01.
E GEN-04 Colloid behaviour in the host rock	Colloids are considered; bentonite colloids are included quantitatively in the assessment.		
E GEN-10 Radionuclide dispersion	Is discussed as one of the mechanisms for radionuclide transport. Distinction made between dispersion along flow paths and macro-dispersion due to varying velocity field.		
E GEN-11 Distribution and release of radionuclides from the far-field	Transport of radionuclides in both near field and far field included in the analysis.		

SR-Site FEP Ge24 Transport of radionuclides in the water phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E GEN-25 Matrix diffusion	Matrix diffusion is included as one of the main retention mechanisms in the geosphere.		
E GEN-28 Radioactive decay	Radioactive decay included, with reference to process as such in fuel and canister process report.		
E GEN-31 Radionuclide reconcentration	One example of the process is included in the far field where a sudden increase in groundwater flow during a glacial cycle may imply a flushing of radionuclides accumulated in the matrix during periods of lower flow.		
E GEN-35 Fast transport pathways	Fast transport pathways are created in the hydrogeological modelling based on relevant site characteristics.		
H 1.3.1 Radioactive decay and ingrowth	Radioactive decay included, with reference to process as such in fuel and canister process report.		See SKB FEP F01.
H 2.3.1 Far-field transport: Advection	Is discussed as one of the main mechanisms for radionuclide transport.		
H 2.3.3 Far-field transport: Hydrodynamic dispersion	Is discussed as one of the mechanisms for radionuclide transport. Distinction made between dispersion along flow paths and macro-dispersion due to varying velocity field.		
H 2.3.4 Far-field transport: Solubility constraints	Is discussed in context of precipitation/dissolution.		
H 2.3.5 Far-field transport: Sorption including ion-exchange	Sorption in the context of radionuclide transport is described.		See also "Speciation and sorption" (Ge13).
H 2.3.6 Far-field transport: Changes in sorptive surfaces	The fracture surface area through which the inner surfaces of the matrix is reached is discussed in a sorption context.		See also "Speciation and sorption" (Ge13).
H 2.3.8 Far-field transport: Colloid transport	Colloid facilitated transport included.		
H 2.3.9 Far-field transport: Transport of radionuclides bound to microbes	Colloid facilitated transport in case of micro-organisms acting as colloids discussed.		
H 2.3.12 Far-field transport: Thermal effects on hydrochemistry		Not discussed; relevance considered low.	
I 045 Progency nuclides (critical radionuclides)	Radioactive decay included, with reference to process as such in fuel and canister process report.		See SKB FEP F01.
I 058 Colloid formation (natural and vault generated)	Colloid-facilitated transport included.		See also "Colloid formation and transport" (Ge18).
J 4.1.06 Reconcentration	Immobilisation processes are addressed.		See also "Speciation and sorption" (Ge13).

SR-Site FEP Ge24 Transport of radionuclides in the water phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 7.05 Isotopic dilution	Implicit in discussions of sorption non-linearity and impact of naturally occurring isotopes on sorption. Also mentioned in relation to solid solution formation in the transport report.		See FEP Ge13.
K 0.1 Radioactive decay	Radioactive decay included, with reference to process as such in fuel and canister process report.		See SKB FEP F01.
K 4.01 Excavation-disturbed zone (EDZ)	Retention in EDZ is discussed, but not quantitatively handled in SR-Site (conservative assumption).		
K 4.08 Radionuclide migration	Retention in EDZ is discussed, but not quantitatively handled in SR-Site (conservative assumption).		
K 4.09 Radionuclide retardation	Retention in EDZ is discussed, but not quantitatively handled in SR-Site (conservative assumption).		
K 5.05 Radionuclide transport through LPD	Sorption, matrix diffusion, dispersion, channeling, sorption onto colloids are addressed in the process description.		
K 5.15 Natural colloids	Colloids in the context of radionuclide transport are addressed.		See also "Colloid formation and transport" (Ge18).
K 5.22 Microbial activity	Effect of micro-organisms on mobility of radionuclides is mentioned.		See also "Speciation and sorption" (Ge13) and "Microbial processes" (Ge16).
K 6.05 Radionuclide transport through MWCF	Sorption, matrix diffusion, dispersion, channeling, sorption onto colloids are addressed in the process description.		
K 6.15 Natural colloids	Colloids in the context of radionuclide transport are addressed.		See also "Colloid formation and transport" (Ge18).
K 6.16 Solubility limits/colloid formation	Solubility limits mentioned in process description.		
K 6.22 Microbial activity	Effect of micro-organisms on mobility of radionuclides is mentioned.		See also "Microbial processes" (Ge16).
M 1.6.01 Advection and dispersion	Advection is discussed as one of the main mechanisms for radionuclide transport. Dispersion is also discussed as a mechanism for radionuclide transport. Distinction made between dispersion along flow paths and macro-dispersion due to varying velocity field.		
M 3.4.04 Radioactive decay ingrowth	Radioactive decay included, with reference to process as such in fuel and canister process report.		
S 060 Precipitation/dissolution	Precipitation/dissolution mentioned.		See also "Speciation and sorption" (Ge13).
S 070 Radioactive decay of mobile nuclides	Radioactive decay included, with reference to process as such in fuel and canister process report.		See SKB FEP F01.

SR-Site FEP Ge24 Transport of radionuclides in the water phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 073 Reconcentration	Immobilisation processes addressed.		See also "Speciation and sorption" (Ge13).
S 098 Transport and release of nuclides, near-field rock	Transport processes described.		
W 1.034 Saline intrusion	Effect of groundwater chemistry on sorption is discussed (salinity effect).		See also "Speciation and sorption" (Ge13).
W 1.035 Freshwater intrusion	Effect of groundwater chemistry on sorption is discussed (salinity effect).		See also "Speciation and sorption" (Ge13).
W 1.036 Changes in groundwater Eh	Effect of groundwater chemistry on sorption is included in the derivation of K_d values.		See also "Speciation and sorption" (Ge13).
W 1.037 Changes in groundwater pH	Effect of groundwater chemistry on sorption is included in the derivation of K_d values.		See also "Speciation and sorption" (Ge13).
W 2.078 Colloid transport	Colloid-facilitated transport is included.		See also "Colloid formation and transport" (Ge18).
W 2.080 Colloid filtration	Colloid-facilitated transport including filtration is mentioned.		See also "Colloid formation and transport" (Ge18).
W 2.081 Colloid sorption	Colloid-facilitated transport including sorption is included.		See also "Colloid formation and transport" (Ge18).
W 2.087 Microbial transport	Effect of micro-organisms on mobility of radionuclides is mentioned.		See also "Speciation and sorption" (Ge13) and "Microbial processes" (Ge16).
Recorded by: Jan-Olof Selroos			**Date:** Dec 2010
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SR-Site FEP Ge25 Transport of radionuclides in the gas phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.88 Unsaturated transport		Transport for unsaturated conditions not addressed. Unsaturated vaults not relevant for KBS-3.	
A 2.27 Gases and gas transport	Transport of radionuclides in gas phase discussed.		
E GEN-11 Distribution and release of radionuclides from the far-field	Transport of radionuclides in gas phase discussed.		In the assessment, the geosphere is neglected as a barrier for transport of radionuclides in the gas phase.
E GEN-18 Gas flow in the far-field	Transport of radionuclides in gas phase discussed.		In the assessment, the geosphere is neglected as a barrier for transport of radionuclides in the gas phase.
E GEN-28 Radioactive decay	Radioactive decay included, with reference to process as such in fuel and canister process report.		

SR-Site FEP Ge25 Transport of radionuclides in the gas phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 1.2.4 Radioactive gases	Transport in gas phase addressed.	Biological degradation of waste forming gases not relevant for SR-Site application.	
H 2.3.10 Far-field transport: Transport of radioactive gases	Transport of radionuclides in gas phase covered.		Gas trapped during permafrost conditions discussed in "Gas flow/dissolution" (Ge04).
H 2.3.11 Far-field transport: Gas induced groundwater transport	Transport of radionuclides in gas phase discussed.		Change in groundwater chemistry as gases dissolve during upward movement of groundwater covered in "Formation/dissolution/ reaction of gaseous species" (Ge19).
H 4.1.3 Gas discharge		No specific gas modelling transport done to identify gas discharge locations and not specifically addressed in process description.	
K 0.3 Gaseous and volatile isotopes	Transport of radionuclides in gas phase discussed.		
K 5.24 Geogas	Transport in gas phase and with colloids discussed.		Natural gas content and the gas flow characteristics are discussed in "Gas flow/dissolution" (Ge04).
K 6.24 Geogas	Transport in gas phase and with colloids discussed.		Natural gas content and the gas flow characteristics are discussed in "Gas flow/dissolution" (Ge04).
S 098 Transport and release of nuclides, near-field rock	Transport of radionuclides in gas phase covered for all of geosphere.		In the assessment, the geosphere is neglected as a barrier for transport of radionuclides in the gas phase. Release from engineered barriers addressed in SKB FEP Bu25.
W 2.055 Radioactive gases	Gaseous radionuclides identified and their transport in gas phase addressed.		See also "Formation/dissolution/ reaction of gaseous species" (Ge19).
W 2.089 Transport of radioactive gases	Transport of radionuclides in gas phase covered.		
Recorded by: Jan-Olof Selroos			**Date:** Dec 2010
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Appendix 9

Handling of NEA Project FEPs sorted to SR-Site External factors

SR-Site FEP Cli01 Climate system - Components of the climate system

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.07 Climate change	Natural climate variability, and human induced global warming.		The atmosphere's importance for the radiation balance and climate are covered.
A 2.31 Greenhouse effect	The increased greenhouse effect could lead to changes in e.g. temperature and precipitation.		Changes at the studied sites are described in the climate scenarios with variations. See also NEA FEP A 2.07.
A 2.40 Magnetic poles (reversal)		Changes in the Earth's ionization layer are not considered since they are considered insignificant for the radiation balance.	
A 2.48 Ozone layer	Destruction or damage to the earth's ozone layer may lead to changes in the climate.	Changes in groundwater flow patterns are not considered. Groundwater flow is a geosphere process.	See also SKB FEP Ge03.
A 3.051 Flipping of earth's magnetic poles		Temporary changes in the Earth's ionization layer and increased solar radiation are not considered since they are considered insignificant for the radiation balance.	See NEA FEP A 2.40.
A 3.059 Greenhouse effect	Carbon dioxide and other greenhouse gases in the atmosphere that allow solar radiation through to the Earth's surface but absorbs parts of the outgoing radiation, resulting in global warming.		See NEA FEP A 2.07.
A 3.078 Ozone layer failure	Destruction of the earth's ozone layer. Reflection of ultraviolet (UV) radiation by the ozone layer and possible increase in solar radiation if the ozone layer is destroyed.	UV radiation can induce skin cancer. Only cancers that are caused by the repository is included in the safety assessment.	Coverage see comment to NEA FEP A 2.07
M 1.1.02 Solar insolation	Glacial cycles caused by natural variability in solar insolation.		
M 1.2.02 Changes in Earth's magnetic field		Reversal of magnetic poles is not covered. It is considered to be of minor importance for the climate system.	
M 1.3.04 Sea-level change	Sea level changes caused by glaciations and by human induced global warming, and its effect on e.g. landscape development and ground water flow.		
W 3.049 Damage to the ozone layer	Destruction of the earth's ozone layer and its possible effects on climate.	Alteration of the climate in the vicinity of the WIPP repository (Carlsbad, New Mexico, USA).	
Recorded by: Jens-Ove Näslund			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Cli02 Climate system - Climate forcing

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.07 Climate change	Natural climate variability and human induced global warming.	Reversal of magnetic poles is not covered. It is considered to be of minor importance for the climate system.	
A 2.40 Magnetic poles (reversal)		Reversal of magnetic poles is not covered. It is considered to be of minor importance for the climate system.	
A 3.051 Flipping of earth's magnetic poles		Reversal of magnetic poles is not covered. It is considered to be of minor importance for the climate system.	
E GEN-21 Glaciation	Glacial conditions associated with future ice sheet coverage at the repository site. Associated changes in permafrost distribution, hydrostatic pressure, groundwater flow and chemistry, hydraulic jacking, glacial erosion, shore line displacement.		
J 5.20 Changes of the magnetic field		Reversal of magnetic poles is not covered. It is considered to be of minor importance for the climate system.	
J 5.42 Glaciation	Orbital forcing parameters obliquity, the eccentricity of the Earth's orbit, and the precession of the equinoxes induce repeated glacial cycles.		
M 1.1.02 Solar insolation	Glacial cycles caused by natural variability in solar insolation.		
M 1.2.02 Changes in Earth's magnetic field	Reversal of magnetic poles is not covered. It is considered to be of minor importance for the climate system.		
M 1.3.04 Sea-level change	Sea level changes caused by glaciations and by human induced global warming, and its effect on e.g. landscape development and ground water flow.		
M 1.3.05 Periglacial effects and glaciation	Permafrost development under various climate assumptions, and associated changes in ground water flow and chemistry. Moderate and severe glaciations are considered.		Fluvial and glacial erosion is considered under FEP Cli11
S 047 Glaciation	Periodic changes in the Earth's orbit and corresponding alteration of the amount and distribution of solar radiation reaching the Earth induce repeated glacial cycles.		
W 1.061 Climate change	Climate changes due to changes in the earth's orbit around the sun, fluctuations in radiation intensity from the sun.	Alteration of the groundwater table and groundwater flow in the vicinity of the WIPP repository (Carlsbad, New Mexico, USA).	Feedback mechanisms within the atmosphere and hydrosphere.
Recorded by: Jens-Ove Näslund			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Cli03 Climate system - Climate dynamics

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.12 Climate change	Increased or decreased rates of meteoric precipitation.	Volume and rate of groundwater flow past the disposal vault is a geosphere process (Ge03).	The hydrological cycle, formation of groundwater and its dependence on climate conditions are covered.
A 2.07 Climate change	Natural climate variability, global warming and destruction of the ozone layer.		The radiation balance and how it is affected by the state of the climate system components is covered.
A 2.19 Drought	The current levels of meteoric precipitation could change leading to reduced flow of water through the geosphere.	Changes to the biosphere are biosphere processes.	Coverage - see comment to NEA FEP A 1.12.
A 2.25 Flood	The current levels of meteoric precipitation could change, leading to greater flows of water through the geosphere.	Changes to the biosphere are biosphere processes.	Coverage - see comment to NEA FEP A 1.12.
A 2.31 Greenhouse effect	Increased concentrations of carbon dioxide and other greenhouse gases in the atmosphere.		Feedback processes for example temperature-carbon dioxide due to decreases solubility of carbon dioxide in water with increasing water temperatures and release of methane from melting permafrost are covered.
A 3.043 Dust storms and desertification		Deforestation, disappearance of grassland, transport of contaminants in soil, dispersion of contaminants due to wind erosion, no human habitats and formation of alkali flats are biosphere processes. Erosion is a geosphere process including wind erosion and dust storms.	Coverage - see comment to NEA FEP A 1.12.
A 3.059 Greenhouse effect	Human-produced increase in greenhouse gases in the atmosphere over the last 150 years. The duration of human induced greenhouse effect on the climate and the rate of disappearance of the greenhouse gases from the atmosphere.	Conditions in North America are not covered since the repository site is located in Sweden.	Effects on the global and Scandinavian climate conditions are handled.
E GEN-21 Glaciation	Glacial conditions associated with future ice sheet coverage at the repository site. Associated changes in permafrost distribution, hydrostatic pressure, groundwater flow and chemistry, hydraulic jacking, glacial erosion, shore line displacement.		
H 3.1.1 Climate change: Human induced	Changes to the climate and climate system due to human activities e.g. release of greenhouse gases to the atmosphere. Impact of the increased greenhouse effect on the initiation of the next glaciation.	Ecological consequences of a warmer climate are biosphere processes.	Alterations of the initiation of glacials are included in the climate scenarios with variations.

SR-Site FEP Cli03 Climate system - Climate dynamics

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 3.1.2 Climate change: Natural	Glacial/interglacial cycles. Changes in temperature, sea-level, precipitation, evaporation, groundwater recharge and ecosystems.		
H 3.1.3 Exit from glacial/interglacial cycling	Causes to the current situation with glacial cycles and factors that may disturb it.	At present groundwater storage is basically at its maximum, the additional water during deglaciations would not alter groundwater flow significantly.	
H 3.1.4 Intensification of natural climate change	Alteration of the periodicity of glacial cycles.		Alterations of the length of glacial periods are included in the climate scenarios with variations.
I 049 Climate change	The greenhouse effect. Increase of greenhouse gases due to human activities and immobilization of the gases into peat, the seas and sedimentary deposits. Substances that may lead to the thinning or destruction of the ozone layer. Short-term natural fluctuations in climatic conditions. Changes in the current levels of meteoric precipitation. Periods of drought.	The influence of temperature on heating fuel needs and radionuclide concentrations in indoor air. Climate changes in the vicinity of the IRUS repository (Canada) and their possible impact on the IRUS repository. Alteration of groundwater flow is a geosphere process. The impact of climate changes on the biosphere is included among the biosphere processes. Deforestation, disappearance of grassland, transport of contaminants in soil, dispersion of contaminants due to wind erosion, no human habitats and formation of alkali flats are biosphere processes.	Initiation of the next period of glacial conditions is part of the main scenario. See also SKB FEPs Ge03 and Cli11.
J 5.32 Desert and unsaturation	Dry climate and lowering of groundwater surface.	Deep wells are regarded as future human actions at the repository site. Unsaturated flow and the effects of unsaturated conditions on technical and geological barriers are not external processes.	Coverage - see comment to NEA FEP A 1.12.
J 5.42 Glaciation	The possible impact of the increased Greenhouse effect on the initiation of the next glaciation.		Alterations of the initiation of glacials are included in the climate scenarios with variations. Possible variations of the Swedish climate in a 100 000 year perspective are discussed in "Climate and climate related issues for the safety assessment SR-Site" TR-10-49 (see also SKB FEP Cli04).
K 10.07 Warmer climate - arid	Arid climate conditions and why and where they may exist.	Ecological consequences of a warmer arid climate are biosphere processes.	

SR-Site FEP Cli03 Climate system - Climate dynamics

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 10.08 Warmer climate - seasonal humid	Warm humid climate conditions with marked seasonality between warm, humid, rainy seasons and cool, dry seasons and why and where they may exist.		
K 10.09 Warmer climate - equable humid	Climate with high temperatures, precipitation and moderate evapotranspiration with minor seasonality, why and where such conditions may exist.		
K 10.10 Greenhouse effect	Global climate changes due to emissions of greenhouse gases.		
K 11.09 Human-induced climate change	The impact of anthropogenic greenhouse gases (e.g. CO_2, CH_4 etc.) on the climate.		Consequences for onset of next period of permafrost or glacial conditions are included in the main scenario with variations.
M 1.3.05 Periglacial effects and glaciation	Permafrost development under various climate assumptions, and associated changes in ground water flow and chemistry. Moderate and severe glaciations are considered.		Fluvial and glacial erosion is considerd under FEP Cli11
M 2.4.09 Anthropogenic climate changes (greenhouse effect)	Results of low-to intermediate, as well as long-term effects of global warming are considered.		
W 1.056 Changes in groundwater recharge and discharge	Groundwater recharge and discharge given different climate conditions.	Alteration of the groundwater table and groundwater flow in the vicinity of the WIPP repository (Carlsbad, New Mexico, USA).	
W 1.061 Climate change	Feedback mechanisms within the Earth's climate system.	Alteration of the groundwater table and groundwater flow in the vicinity of the WIPP repository (Carlsbad, New Mexico, USA).	
W 3.047 Greenhouse gas effects	Alteration of the climate due to emissions of greenhouse gases.	Alteration of the climate in the vicinity of the WIPP repository (Carlsbad, New Mexico, USA).	
Recorded by: Jens-Ove Näslund			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Cli04 Climate system - Climate in Sweden and Forsmark

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.12 Climate change	Changes to the current climate that may affect the performance of the repository.		General succession of climate related conditions that can be expected in Sweden in a 100 000 year time perspective and their possible impact on the repository are covered.
A 2.07 Climate change	Changes of the current climate to wetter, drier, warmer, cooler and/or permafrost conditions, affecting flow properties of the geosphere (including recharge volumes). Glaciation.		Coverage - see comment to NEA FEP A 1.12.
A 3.024 Climate change	Climate changes due to anthropogenic and natural causes. Occurrence of continental glaciations.		Coverage - see comment to NEA FEP A 1.12.
E GEN-21 Glaciation	Glacial conditions associated with future ice sheet coverage at the repository site. Associated changes in permafrost distribution, hydrostatic pressure, groundwater flow and chemistry, hydraulic jacking, glacial erosion, shore line displacement.		
I 049 Climate change	Changes of the current climate to wetter, drier, warmer, cooler and/or permafrost conditions and/or glacial conditions. Possible subsurface impact.	The influence of temperature on heating fuel needs and radionuclide concentrations in indoor air. Climate changes in the vicinity of the IRUS repository (Canada) and their possible impact on the IRUS repository. Alteration of groundwater flow is a geosphere process. The impact of climate changes on the biosphere is included among the biosphere processes. Deforestation, disappearance of grassland, transport of contaminants in soil, dispersion of contaminants due to wind erosion, no human habitats and formation of alkali flats are biosphere processes. Increase of skin cancer if the ozone layer is destroyed.	Initiation of the next period of glacial conditions is part of the main scenario. See also SKB FEPs Cli11 and Ge03 as well as SKB biosphere FEPs.
J 6.10 No ice age	Temperate climate conditions for the coming c. 100 kyrs		It is unclear what the authors of the FEP mean by no ice age, it is said to be "a variation of ice age". It is assumed that the FEP refers to interglacial periods and warm phases (interstadials) of glacial periods.

SR-Site FEP Cli04 Climate system - Climate in Sweden and Forsmark

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 10.03 Seasonality of climate		The effect on biosphere conditions by alterations of the length of temperate periods are biosphere processes.	Alterations of the length of temperate/boreal periods are included in the climate scenarios with variations.
K 10.04 Future climatic conditions	Conceivable variations of climate related conditions during the assessment period.		Evolution of climate related conditions are included in the main scenario. Possible alterations are included in variations of the main scenario.
K 10.05 Tundra climate	Tundra climate, general conditions and possible subsurface impact.		
K 10.06 Glacial climate	Glacial climate, general conditions and possible subsurface impact.		Initiation of the next period with glacial conditions is included in the main scenario. Glacial erosion and weathering is discussed in SKB FEP Cli11.
W 1.062 Glaciation	Description of the glacial climate domain.	Glaciations in the vicinity of the WIPP repository (Carlsbad, New Mexico, USA) are unrealistic.	
W 1.063 Permafrost	Description of the periglacial climate domain with permafrost.	Permafrost in the vicinity of the WIPP repository (Carlsbad, New Mexico, USA) is unrealistic.	
Recorded by: Jens-Ove Näslund			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Cli05 Climate related issues - Development of permafrost

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.30 Glaciation	Permafrost could affect rock and groundwater flow characteristics.		Aggradation and degradation of permafrost and its potential impact on the repository are covered.
A 2.38 Isostatic rebound	The presence of ice sheets may compress the underlying rock.		Altered pressures are considered in calculations of sub-glacial frozen depths. Changes in relative sea-level are considered.
E GEN-21 Glaciation	Glacial conditions associated with future ice sheet coverage at the repository site. Associated changes in permafrost distribution, hydrostatic pressure, groundwater flow and chemistry, hydraulic jacking, glacial erosion, shore line displacement.		
E GEN-26 Permafrost	Development of permafrost and frozen ground. Associated effects on groundwater flow and chemistry. Effects of freezing on the repository.		
H 3.1.2 Climate change: Natural	Seasonally and permanently frozen ground.		
J 5.17 Permafrost	Permafrost in Sweden in a glacial time scale. Current occurrence of permafrost. Relationship between mean annual air temperature and permafrost depth. Effect of surface conditions on development of permafrost. Effect of geothermal heat flow on development of permafrost. Potential subsurface effects of permafrost. Temperature gradients. Groundwater flow in areas of permafrost.	Accumulation of gas and radionuclides below the lower surface of the permafrost. Groundwater flow, accumulation of gas and radionuclides are not external processes.	See also SKB FEPs Ge02, Ge03 and Ge04
K 10.13 Permafrost	Development of permafrost and its dependence on surface temperature and conditions and geological conditions. Current occurrence of permafrost. Possible permafrost depths given defined surface and subsurface conditions. Active layer, groundwater recharge/discharge in unfrozen zones, "taliks".		
M 1.3.05 Periglacial effects and glaciation	Permafrost development under various climate assumptions, and associated changes in ground water flow and chemistry. Moderate and severe glaciations are considered.		
S 059 Permafrost	Permafrost in Sweden in a glacial time scale. Current occurrence of permafrost. Relationship between mean annual air temperature and permafrost depth. Effect of surface conditions on development of permafrost. Groundwater flow in areas of permafrost. Effect of geothermal heat flow on development of permafrost. Potential subsurface effects of permafrost. Temperature gradients.	Accumulation of gas and radionuclides below the lower surface of the permafrost. Groundwater flow, accumulation of gas and radionuclides are not external processes.	See also SKB FEPs Ge02, Ge03, Ge04 and Ge21.
Recorded by: Jens-Ove Näslund			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Cli06 Climate related issues – Ice-sheet dynamics

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.38 Glaciation	Changes of stress fields, flow regimes and temperatures. Many complex effects on processes occurring in the repository.		The development of the Scandinavian ice sheet and the basal conditions of the ice sheet. Ice sheet mass-balance, ice flow, ice load, basal temperatures, basal melt-rates and basal sliding and their impact on the repository are covered.
A 2.30 Glaciation	Glaciation may cause changes in topography, changes in hydraulic heads, changes in groundwater recharge and discharge zones. These effects may significantly change rock and flow characteristics.		The development of the Scandinavian ice sheet and the basal conditions of the ice sheet. Ice sheet mass-balance, ice flow, ice load, basal temperatures, basal melt-rates and basal sliding and their impact on the repository are covered.
A 3.057 Glaciation	Glaciation may influence the disposal system.	Massive disruptions in the biosphere since they are biosphere processes.	Coverage - see comment to NEA FEP A 1.38.
E GEN-21 Glaciation	Glacial conditions associated with future ice sheet coverage at the repository site. Associated changes in permafrost distribution, hydrostatic pressure, groundwater flow and chemistry, hydraulic jacking, glacial erosion, shore line displacement.		
S 047 Glaciation	Basal frozen conditions.		Glacial erosion is mainly covered by the geosphere process weathering and erosion (Ge09). The FEP says "The ice will constitute a shielding barrier layer which will bind most of the precipitation, thus limiting recharge and flow through the (most probably permafrosted) bedrock." It is assumed that this refers to a cold based ice where there is no liquid water available.

Recorded by: Jens-Ove Näslund **Date:** Dec 2010

Checked and revised by: Kristina Skagius **Date:** Dec 2010

SR-Site FEP Cli07 Climate related issues – Ice-sheet hydrology

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.30 Glaciation	Glaciation may cause changes in hydraulic heads, changes in groundwater recharge and discharge zones. These effects may significantly change flow characteristics.		The hydrological system of the ice sheet with its supra-, en- and sub-glacial system components, melt-water rates and its diurnal and yearly variation, storage of water in the ice sheet and flow between the system components and related groundwater heads and the potential impact on groundwater flow are covered.
E GEN-21 Glaciation	Glacial conditions associated with future ice sheet coverage at the repository site. Associated changes in permafrost distribution, hydrostatic pressure, groundwater flow and chemistry, hydraulic jacking, glacial erosion, shore line displacement.		
H 3.1.2 Climate change: Natural	The potential impact of ice sheets on groundwater flow.		
J 5.42 Glaciation	Groundwater heads at the ice margin, alterations of inflow and outflow areas.	The effect of the isostatic processes on groundwater flow at depth and at the surface. Since the isostatic depression happens over a large area the direct impact of this process on groundwater flow can be neglected, the impact on gradients is in the order of per mille. Indirectly the process influence groundwater flow via shore line migration, this is discussed in the SKB Climate FEP "Shore-line migration" (Cli09).	The NEA FEP claims that the depression of the earth crust "may also cause extreme groundwater heads at the ice edge, change the position of the inflow and outflow areas and cause sea level changes." The impact of depression of the earth crust on groundwater heads can be neglected, however the presence of the ice sheet will alter groundwater heads, inflow and outflow areas. Isostatic depression does not cause sea level change, however if and when the crust is depressed below the contemporary sea level it will be covered by the sea.
K 10.16 Ice sheet effects (loading, melt water recharge)	Groundwater recharge from basal melting of the ice sheet. Occurrence of sub-glacial rivers and other conductive features in the ice/bed interface. Hydrological conditions if permafrost occurs at the ice margin. Ice sheet loading is considered in relation to increases in hydrostatic pressures at repository depth.		
M 1.3.05 Periglacial effects and glaciation	Permafrost development under various climate assumptions, and associated changes in ground water flow and chemistry. Moderate and severe glaciations are considered.		

SR-Site FEP Cli07 Climate related issues – Ice-sheet hydrology

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 047 Glaciation	Melt water discharged at the ice margin driven by the slope of the ice. Occurrence of glacier lakes on the ice sheet surface and their connection to en- and sub-glacial systems. Excessive recharge, of possibly oxidizing water, at the ice margin. Rise of water pressures to levels equalling and even exceeding the ice pressure and formation of conduits in the subglacial layer. The effect of low bed permeability on water pressures. Hydrofracturing of the ice.	Hydrofracturing of the bedrock and alteration of fracture aperture due to freezing of subglacial meltwater are not external processes.	See also SKB FEPs Ge02, Ge03, Ge06 and Ge07.
Recorded by: Jens-Ove Näslund			**Date:** Dec 2010
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SR-Site FEP Cli08 Climate related issues - Glacial isostatic adjustment

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.30 Glaciation	Glaciations cause isostatic depression. These effects may significantly change rock stresses and groundwater flow characteristics. During interglacial periods isostatic rebound affects rock and flow characteristics.		Isostatic adjustment due to the redistribution of water masses from the oceans to land based ice sheets and vice versa and its potential impact on the repository are covered.
A 2.38 Isostatic rebound	The presence of ice sheets will depress the crust followed later by rebound effects when the load is removed.		Associated changes in relative sea-level are covered.
E GEN-39 Uplift and subsidence	Isostatic changes due to loading and unloading from continental glaciation. Associated changes in sea-level and shore line displacement and landscape and biosphere development. Glacially induced faulting. Long term denudation, as result of theoretical future uplift ina 1 Myr time perspective is considered.	Tectonic uplift and crustal movements are not considered except for registration of current uplift rates which include both isostatic and tectonic components.	
H 2.1.1 Regional tectonic activity	Isostatic adjustment		
J 5.16 Uplift and subsidence	Ongoing isostatic uplift in Sweden. Current rate of uplift. Largest isostatic uplift in connection to retreat of the ice sheet. Total isostatic uplift since LGM. Remaining isostatic uplift.	Tectonic uplift and crustal movements are not considered except for registration of current uplift rates which include both isostatic and tectonic components.	Coverage - see comment to NEA FEP A 2.30.
J 5.31 Change in sealevel	Redistribution of water masses during a glacial cycle. The effect of redistribution of soil material due to erosion and sedimentation on isostatic adjustment.	It is said that exposed sea bottoms suffers extensive erosion close to the ice rim during interglacial periods, but during interglacial periods there are only ice sheets on Greenland and in Antarctica and sea levels are high. Consequently this aspect has not been considered.	It is unclear whether the NEA FEP refers to the eustatic or isostatic process or their combined effect on shore-line migration.

SR-Site FEP Cli08 Climate related issues - Glacial isostatic adjustment

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 5.42 Glaciation	The weight of the ice sheet will cause an isostatic depression of the Earth's crust.		
M 1.2.06 Uplift and subsidence	Long term denudation, as result of theoretical future uplift in a 1 Myr time perspective is considered.	Tectonic uplift and crustal movements are not considered except for registration of current uplift rates which include both isostatic and tectonic components.	
S 047 Glaciation	Isostatic depression of the Earth's crust.		
W 1.005 Regional uplift and subsidence	Isostatic uplift in Sweden (see handling of NEA FEP J 5.16).		
Recorded by: Jens-Ove Näslund			**Date:** Dec 2010
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SR-Site FEP Cli09 Climate related issues - Shore-line migration

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.59 Sea level change	Climate changes and different stages of glacial cycles will raise and lower sea levels, possibly affecting groundwater flow and contaminant transport.		It is assumed that "different stages of glacial cycles" refers to the resulting shore line migration due to the eustatic and isostatic processes. See also comments to NEA FEP A 2.30.
E GEN-33 Sea level changes	Sea level changes due to natural and anthropogenic causes (the latter through global warming). Changes from terrestrial to marine conditions. Effects on hydrological and chemical conditions. Shore line migration, and associated changes in landscape development and biosphere**.**		
H 2.2.1 Changes in geometry and driving forces of the flow system	Changes caused by glacial conditions, permafrost development and sea level change.		See also SKB FEP Ge03.
H 3.1.3 Exit from glacial/interglacial cycling	Alteration of sea level if glaciers and icecaps melt.		
I 266 Sea level (rising)	The combined effect of isostatic and eustatic processes on the shoreline.	The affect on groundwater flow and contaminant transport of shore-line migration are geosphere processes. Shore-line migration in the vicinity of the IRUS repository (Canada).	See also SKB FEP Ge03.

SR-Site FEP Cli09 Climate related issues - Shore-line migration

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 5.31 Change in sealevel	Resulting shore-level migration from isostatic and eustatic processes and their coupling to climate and ice sheet extent.	Shore-level migration due to erosion/sedimentation is not covered. Along the Swedish Baltic coasts this process is considered to be of minor importance in the studied time perspective and in relation to shore-line migration due to glaciations. Changes in groundwater flow and salinity due to shore-line migration are not external processes.	See also Glacial isostatic adjustment (Cli08). Erosion and sedimentation are also described as geosphere and biosphere processes.
J 5.42 Glaciation	Impact of the isostatic process on shore-level migration.		See also geosphere processes; Ge03, Ge06, Ge07.
M 1.3.04 Sea-level change	Sea level changes caused by glaciations and by human induced global warming, and its effect on e.g. landscape development and ground water flow.		
M 1.3.05 Periglacial effects and glaciation	Permafrost development under various climate assumptions, and associated changes in ground water flow and chemistry. Moderate and severe glaciations are considered.		
S 047 Glaciation	The combined effect of isostatic and eustatic processes on the shore-level.		See also geosphere processes; Ge03, Ge06, Ge07.
S 081 Sea level changes	Resulting shore-level migration from isostatic and eustatic processes and their coupling to climate and ice sheet extent. The impact of temperature on sea level.	Changes in groundwater flow and salinity due to shore-line migration are not external processes. Alteration of biosphere conditions due to shore line migration is a biosphere process. Exposed sea bottoms suffers extensive erosion close to the ice rim during interglacial periods, but during interglacial periods there are only ice sheets on Greenland and in Antarctica and sea levels are high. Consequently this aspect has not been considered.	
W 1.068 Sea level changes	Sea level change due to build up of inland ice sheets. Sea level change if the climate gets warmer for instance due to anthropogenic global warming.	Short-term changes in sea level, brought about by events such as meteorite impact, tsunamis, seiches, and hurricanes as their impact on sea levels in the Baltic are neglectable for the safety of the repository. Shore-level migration will not impact the WIPP repository (Carlsbad, New Mexico, USA).	
Recorded by: Jens-Ove Näslund			**Date:** Dec 2010
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SR-Site (SR-Can) FEP Cli10 Climate related issues – End-glacial faulting

Comment: Included in SR-Site FEP LSGe02 Earthquakes.

SR-Site FEP Cli11 Climate related issues – Denudation

Comment: New FEP in SR-Site including the SR-Can FEP Geo09 Surface weathering and erosion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.22 Erosion	Erosion during temperate/boreal, permafrost and glacial conditions.		
E GEN-21 Glaciation	Glacial conditions associated with future ice sheet coverage at the repository site. Associated changes in permafrost distribution, hydrostatic pressure, groundwater flow and chemistry, hydraulic jacking, glacial erosion, shore line displacement.		
E GEN-29 Erosion and weathering	Surface denudation (erosion (fluvial, glacial eolian etc) and weathering) are considered in a 100 kyr and 1 Myr time perspective. Glacial erosion in relation to topography.		
H 2.1.8 Major incision	Glacial erosion of ice streams in valleys.		
H 2.2.1 Changes in geometry and driving forces of the flow system		In Sweden erosion is of minor significance in this context in relation to glaciation and related isostatic and eustatic processes.	See also SKB FEP Ge03.
H 2.4.1 Generalised denudation	Denudation during temperate/boreal, permafrost and glacial conditions.		
H 2.4.2 Localised denudation	Denudation during temperate/boreal, permafrost and glacial conditions.		
H 4.1.2 Solid discharge via erosional processes		Erosion and redistribution of contaminated sediments.	See SKB FEP Bio38.
I 049 Climate change	Different types of erosion processes are discussed.		See also SKB Climate FEPs Cli03 and Cli04.
I 112b Denuding of the site	Long-term surface denudation is discussed.		
I 305 Topography (changes)		Wetland located in the IRUS hydrological flowpath, Duke Swamp, is not of relevance for the present assessment.	
J 5.26 Erosion on surface/sediments	Sediment and bedrock erosion during temperate/boreal, permafrost and glacial conditions.		
K 5.18 Hydraulic gradient changes (magnitude, direction)		In Sweden erosion is of minor significance in this context in relation to glaciation and related isostatic and eustatic processes.	See also SKB FEP Ge03.
K 6.18 Hydraulic gradient changes (magnitude, direction)	See NEA FEP H 2.2.1		
K 7.11 Erosion	See NEA FEP A 2.22		
K 8.22 Erosion/deposition	See NEA FEP A 2.22		
K 9.07 Erosion/denudation	See NEA FEPs A 2.22, J 5.26, H 2.4.1 and H 2.4.2		

SR-Site FEP Cli11 Climate related issues – Denudation

Comment: New FEP in SR-Site including the SR-Can FEP Geo09 Surface weathering and erosion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 10.06 Glacial climate	Glacial erosion and weathering are discussed.		See also SKB Climate FEP Cli04.
K 10.12 Surface denudation	See NEA FEPs A 2.22, J 5.26, H 2.4.1 and H 2.4.2		
K 10.14 Glacial erosion/sedimentation	Loosening of rock fragments, including previous weathering, fracturing and crushing; evacuation of fragments from sediments and the bedrock and their entrainment in the ice, transport in the ice and by melt water in the ice/bed interface and deposition, sorting and sedimentation of transported material.		
K 10.15 Glacial-fluvial erosion/sedimentation	Evacuation of fragments from sediments and the bedrock, transport by melt water in the ice/bed interface and deposition, sorting and sedimentation of transported material.		
M 1.3.05 Periglacial effects and glaciation	Moderate and severe glaciations are considered.		
M 1.4.02 Denudation	Surface denudation (erosion (fluvial, glacial eolian etc) and weathering) are considered in a 100 kyr and 1 Myr time perspective.		
M 1.4.08 Frost weathering and chemical denudation		More a biosphere FEP	See SKB FEP Bio28
S 047 Glaciation	Glacial erosion is discussed.		
W 1.009 Changes in fracture properties		There is no direct impact of surface erosion on fracture properties. However, erosion of the bedrock and erosion/redistribution of sediments will alter the stress field and cause compression/dilatation of fractures. This process is considered insignificant in the studied time frame.	Erosion/sedimentation in fractures described separately, see SKB FEP Ge10.
W 1.041 Mechanical weathering	Long-term weathering, including mechanical weathering.		
W 1.042 Chemical weathering	Long-term weathering, including chemical weathering. hydration, hydrolysis, reduction and oxidation.		
Recorded by: Jens-Ove Näslund			**Date:** Dec 2010
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SR-Site FEP LSGe01 Mechanical evolution of the Shield

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
E GEN-05 Creeping of the rock mass	Occurrence of threshold strength		
E GEN-36 Stress field	Thermal and glacial impact on stress field		
E GEN-39 Uplift and subsidence		Uplift not important to the mechanical conditions at repository depth	
H 2.1.1 Regional tectonic activity	Regional tectonic activity		
J 4.2.06 Faulting	Large-scale changes in tectonic conditions.		See also SKB FEP LSGe02
J 5.16 Uplift and subsidence		Uplift not important to the mechanical conditions at repository depth	See also SKB FEP Cli08
M 1.2.01 Plate movement tectonic change	Estimates of Baltic Shield tectonic strain rates.		
M 1.2.06 Uplift and subsidence	Thermal and glacial impact on stress field		
M 1.2.10 Fault generation	Regional tectonics and changes in stress in the Baltic Shield.	Tectonics at the Mol site is not representative for Swedish rock.	
W 1.003 Changes in regional stress	Regional tectonics and changes in stress in the Baltic Shield.	Tectonics in the Delaware Basin is not representative for Swedish rock.	
W 1.004 Regional tectonics	Regional tectonics and changes in stress in the Baltic Shield.	Tectonics in the Delaware Basin is not representative for Swedish rock.	
W 1.005 Regional uplift and subsidence	Regional tectonics and changes in stress in the Baltic Shield.	Tectonics in the Delaware Basin is not representative for Swedish rock.	
W 1.010 Formation of new faults		Site-specific FEP, which mainly address fault movement covered by FEP W1.011.	
W 1.011 Fault movement	Regional tectonics (Baltic Shield) including fault movement.		

Recorded by: Harald Hökmark **Date:** Dec 2010
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SR-Site FEP LSGe02 Earthquakes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.29 Earthquakes	Seismic activity in Scandinavia.		See also SKB FEP Ge06.
A 2.21 Earthquakes	Seismic activity in Scandinavia.		See also SKB FEP Ge06.
A 3.045 Earthquakes	Seismic activity in Scandinavia.		See also SKB FEP Ge06.
H 2.1.6 Seismicity	Seismic activity in Scandinavia.		
I 100 Seismic events	Seismic activity in Scandinavia.		
J 4.2.01 Mechanical failure of repository	Seismic activity in Scandinavia.		See also SKB FEP Ge06.
J 4.2.06 Faulting	Seismic activity in Scandinavia.		See also SKB FEP Ge06.
J 5.15 Earthquakes	Seismic activity in Scandinavia.		

SR-Site FEP LSGe02 Earthquakes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 5.42 Glaciation	Post-glacial faulting		
K 9.05 Seismic activity	Seismic activity in Scandinavia.		
K 9.06 Stress changes - hydrogeological effects	Seismic activity in Scandinavia.		See also SKB FEP Ge03 and Ge06.
M 1.2.08 Seicmicity	Seismic activity in Scandinavia.		
M 1.2.10 Fault generation	Seismic activity in Scandinavia.	Tectonics at the Mol site is not representative for Swedish rock.	
S 036 Faulting	Seismic activity in Scandinavia.		See also SKB FEP Ge06.
W 1.011 Fault movement	Seismic activity in Scandinavia.		See also SKB FEP Ge06.
W 1.012 Seismic activity	Seismic activity in Scandinavia.		
W 1.031 Hydrological response to earthquakes	Seismic activity in Scandinavia.		See also SKB FEP Ge03.
Recorded by: Harald Hökmark			**Date:** Dec 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP FHA01 General considerations

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.69 Retrievability		Requirement to retrieve the spent fuel. This issue is not discussed within the long-term safety assessment.	
A 2.56 Sabotage	Intent and responsibilities.		
A 3.070 Intrusion (deliberate)	Intent and responsibilities.		
A 3.071 Intrusion (inadvertent)	Intent and responsibilities.		
H 5.2.2 Deliberate intrusion	Intent and responsibilities.		
H 5.2.3 Malicious intrusion	Intent and responsibilities.		
I 008b Archaeology (a find during post-closure period)	Intent (deliberate intrusion due to discovery of archaeological findings)		
I 167 Intrusion (human/deliberate)	Intent and responsibilities.		
I 169 Intrusion (human/inadvertent)	Intent and responsibilities.		
I 190 Loss of records	Conservation of information, countermeasures against unintentional intrusion.		
I 253 Retrievability	Intent and responsibilities.		Only intent and responsibility is discussed, the question of whether it should be possible to retrieve canisters from the repository is discussed elsewhere.
J 5.33 Waste retrieval, mining	Intent and responsibilities, knowledge of the repository.		
J 5.38 Explosions	Intent and responsibilities.		The FEP concerns sabotage
K 11.10 Repository records, markers	Conservation of information, countermeasures against unintentional intrusion.		
K 11.11 Planning restrictions	Countermeasures against unintentional intrusion.		
M 2.3.02 Malicious intrusion	Intent and responsibilities.		
W 3.012 Deliberate drilling intrusion	Intent and responsibilities.		
W 3.018 Deliberate mining intrusion	Intent and responsibilities.		
Recorded by: Fred Karlsson			**Date:** Sept 2009
Checked and revised by: Kristina Skagius			**Date:** Nov 2009

SR-Site FEP FHA02 Societal analysis, considered societal aspects

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.49 Intrusion (human)	Access useful material.		
I 189 Loss of markers (misinterpretation)	Knowledge of the repository.		
I 200 Minerals (exploration, exploitation)	Possible purposes of unintentional intrusion.		
I 223 Political (loss of institutional control)	Capacity of society's information system, legitimacy of government and degree of governability.		
J 5.37 Archeological intrusion	Possible purposes of unintentional intrusion.		
J 7.09 Loss of records	Knowledge of the repository.		
M 2.4.01 Loss of records	Knowledge of the repository.		
M 2.4.08 Demographic change, urban development	Human settlements and demographic pattern		
W 3.056 Demographic change and urban development	Human settlements and demographic pattern.		
W 3.057 Loss of records	Knowledge of the repository.		
Recorded by: Fred Karlsson			**Date:** Sept 2009
Checked and revised by: Kristina Skagius			**Date:** Nov 2009

SR-Site FEP FHA03 Technical analysis, general aspects

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.49 Intrusion (human)	Access useful material.		
A 2.61 Solution mining		Solution mining.	Solution mining is used for extracting soluble ores such as potash and salt, these kinds of minerals are not available at the repository site.
A 3.071 Intrusion (inadvertent)	Explorations.		
J 5.35 Other future uses of crystalline rock	Granite as a valuable raw material.		
Recorded by: Fred Karlsson			**Date:** Sept 2009
Checked and revised by: Kristina Skagius			**Date:** Nov 2009

SR-Site FEP FHA04 Technical analysis, actions with thermal impact and/or purpose

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.061 Heat storage in lakes or underground	Build heat store.		
J 5.34 Geothermal energy production	Extract geothermal energy, build heat pump system.		
K 11.03 Geothermal exploitation	Extract geothermal energy, build heat pump system.		
M 1.5.09 Natural thermal effects	Explore geothermal energy.		
M 2.3.05 Geothermal energy production	Extract geothermal energy.		
W 3.007 Geothermal	Extract geothermal energy.		
Recorded by: Fred Karlsson			**Date:** Sept 2009
Checked and revised by: Kristina Skagius			**Date:** Nov 2009

SR-Site FEP FHA05 Technical analysis, actions with hydraulic impact and/or purpose

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.03 Borehole - well	Construct well.		
A 2.14 Dams	Build dam.		
A 3.068 Industrial water use	Construct well, build dam, irrigation, drainage or infiltration system, change the course or extent of surface water bodies (streams, lakes, sea) and their connections with other surface water bodies.		
A 3.115 Water management projects	Build dam, hydropower or irrigation system,		
J 5.27 Human induced actions on groundwater recharge	Change conditions for groundwater recharge by changes in land use, construct well or dam.		
J 7.07 Human induced changes in surface hydrology	Construct well, build dam, irrigation, drainage or infiltration system, change the course or extent of surface water bodies (streams, lakes, sea) and their connections with other surface water bodies. Change conditions for groundwater recharge by changes in land use.		
J 7.11 City on the site	Change conditions for groundwater flow by changes in land use.		
K 11.05 Deep groundwater abstraction	Construct well.		
K 11.06 Water management schemes	Construct well, build dam, irrigation, drainage or infiltration system, change the course or extent of surface water bodies (streams, lakes, sea) and their connections with other surface water bodies.		

SR-Site FEP FHA05 Technical analysis, actions with hydraulic impact and/or purpose

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
M 2.3.07 Tunneling	Build rock cavern, tunnel, shaft, etc.		
M 2.3.08 Underground construction	Build rock cavern, tunnel, shaft, etc.		
M 2.3.11 Ground water abstraction	Construct well.		
M 2.4.02 Dams and reservoirs, built/drained	Build dam.		
W 3.005 Groundwater exploitation	Construct well.		
W 3.021 Drilling fluid flow	The transport of radionuclides with the bore fluid (water) during drilling.	Loss of bore fluid to an under pressurized subsurface unit. Outflow of brine from isolated over pressurized volumes. These kinds of features do not exist at the candidate sites.	
W 3.022 Drilling fluid loss		Borehole fluid lost to (thief) fracture zones, If contaminated borehole fluid is lost to fracture zones, this would mitigate the consequences of an unintentional drilling through a canister. Since this effect is hard to quantify it is neglected. The escape of borehole fluid in boreholes not intersecting a canister is omitted since the duration of drilling is short, the affected area deemed to be limited in space and the fluid generally consist of water.	
W 3.023 Blowouts		During drilling, fluid could flow from pressurized zones through the borehole to the land surface (blowout). If isolated pressurized zones exist in crystalline rock the amount of water in them is limited and the effect on groundwater flow can be neglected.	
W 3.026 Groundwater extraction	Construct well.		
W 3.028 Enhanced oil and gas production		Injection of fluids altering fluid-flow patterns. Oil and gas is not available at the candidate sites.	
W 3.037 Changes in groundwater flow due to mining	Build rock cavern, tunnel, shaft, etc.		
W 3.039 Changes in groundwater flow due to explosions		Direct effect on groundwater flow due to an explosion. The direct effect on groundwater flow due to an explosion is of very short duration and can be neglected.	
Recorded by: Fred Karlsson			**Date:** Sept 2009
Checked and revised by: Kristina Skagius			**Date:** Nov 2009

SR-Site FEP FHA06 Technical analysis, actions with mechanical impact and/or purpose

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.32 Explosions	Subsurface and surface explosions (bomb or blast).		
A 1.49 Intrusion (human)	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
A 2.02 Bomb blast	Surface explosions (bomb or blast).		
A 2.05 Boreholes - exploration	Drill in the rock.		
A 2.20 Earthmoving	Construct quarry or landfill.		
A 2.37 Intrusion (mines)	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
A 2.46 Mines	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
A 3.044 Earthmoving projects	Construct quarry or landfill.		
A 3.025 Collisions, explosions and impacts	Subsurface and surface explosions (bomb or blast).	Collision by aircraft has no impact on repository safety. Meteorite impact is not a human action.	
H 5.2.4 Accidental intrusion	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
I 022 Explosions/bombs/ blasting/collision/ impacts/vibration	Surface explosions (bomb or blast).	Collision by aircraft has no impact on repository safety.	See NEA FEP A 3.025.
I 099 Earth moving projects (civil)	Construct quarry or landfill.		
J 5.28 Underground dwellings	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
J 5.30 Underground test of nuclear devices	Subsurface bomb or blast.		
J 6.07 Nuclear war	Surface explosions (bomb or blast).		
J 7.11 City on the site	Build rock cavern, tunnel, shaft, etc.		
K 8.37 Earthworks (human actions, dredging, etc.)	Construct quarry or landfill.		
K 11.01 Exploratory drilling	Drill in the rock.		
K 11.02 Mining activities	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
M 2.3.01 Recovery of repository materials	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
M 2.3.03 Exploratory drilling	Drill in the rock.		
M 2.3.04 Explotation drilling	Drill in the rock.		
M 2.3.06 Resource mining	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
M 2.3.07 Tunneling	Drill in the rock, build rock cavern, tunnel, shaft, etc.		

SR-Site FEP FHA06 Technical analysis, actions with mechanical impact and/or purpose

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
M 2.3.08 Underground construction	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
M 2.3.09 Archaeological investigation	Drill in the rock.		
M 2.3.12 Underground nuclear testing	Subsurface explosions (bomb or blast).		
W 2.028 Nuclear explosions		The spent fuel explodes as a nuclear bomb. Not physically possible.	
W 2.084 Cuttings	Drill in the rock.		The amount of cuttings and doses from cuttings are analysed in the SR-Site FHA report.
W 2.085 Cavings	Drill in the rock.		The amount of cavings and doses from cavings are analysed in the SR-Site FHA report.
W 2.086 Spallings		The particulate material introduced into drilling mud by the movement of gas from the waste into the borehole annulus. Neither the content of gas nor the gas flow from the canister is large enough to cause erosion.	
W 3.001 Oil and gas exploration	Drill in the rock.		
W 3.002 Potash exploration	Drill in the rock.		
W 3.003 Water resources exploration	Drill in the rock.		
W 3.004 Oil and gas exploitation		Oil and gas exploitation. Oil and gas is not available at the candidate sites.	
W 3.006 Archeological investigations	Drill in the rock,	Archeological investigations at the surface. Activities at the surface do not impact the repository.	
W 3.008 Other resources	Drill in the rock.		
W 3.009 Enhanced oil and gas recovery		Oil and gas recovery. Oil and gas is not available at the candidate sites.	
W 3.011 Hydrocarbon storage	Drill in the rock, build rock cavern, tunnel, shaft, etc.		Primarily an activity related to oil and gas exploitation and thus not relevant for the Swedish case.
W 3.013 Potash mining	Drill in the rock, build rock cavern, tunnel, shaft, etc.	Solution mining, potash exploitation. Solution mining see NEA FEP A 2.61. Potash is not available at the candidate site.	
W 3.014 Other resources	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
W 3.015 Tunneling	Build rock cavern, tunnel, shaft, etc.		

SR-Site FEP FHA06 Technical analysis, actions with mechanical impact and/or purpose

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 3.016 Construction of underground facilities (for example storage, disposal, accomodation)	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
W 3.017 Archeological excavations	Drill in the rock, build rock cavern, tunnel, shaft, etc.	Archeological excavations close to the surface. Activities at the surface do not impact the repository.	
W 3.019 Explosions for resource recovery	Subsurface explosions (bomb or blast).		
W 3.020 Underground nuclear device testing	Subsurface explosions (bomb or blast).		
W 3.025 Oil and gas extraction		Removal of confined fluid from oil- or gas-bearing units causing compaction, subvertical fracturing and surface subsidence. There are no confinements of oil or gas available at the candidate sites.	
W 3.041 Surface disruptions	Construct quarry or landfill.		
Recorded by: Fred Karlsson			**Date:** Sept 2009
Checked and revised by: Kristina Skagius			**Date:** Nov 2009

SR-Site FEP FHA07 Technical analysis, actions with chemical impact and/or purpose

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.001 Acid rain	Acidify air, soil and bedrock.		
H 5.2.4 Accidental intrusion	Store waste in the rock.		
I 001 Acid rain	Acidify or in other way pollute air, water, soil and/or bedrock.		
I 046a Waste management sites adjacent (additive effects of contaminants)	Store waste in the rock, construct sanitary landfill.	Effects (doses) of contaminants from other facilities. It is unclear whether "effects" refer to doses from adjacent facilities or the possible impact of contaminants on the analysed repository. Only impact on the analysed repository is considered in the SKB FEP. Doses from other facilities are considered in the dose acceptance criteria.	
I 046b Waste management sites adjacent (effects on vault)	Store waste in the rock, construct sanitary landfill.		
J 5.12 Near storage of other waste	Store waste in the rock, construct sanitary landfill.		
J 7.08 Altered surface water chemistry by humans	Acidify air, soil and/or bedrock or cause accident resulting in chemical contamination.		

SR-Site FEP FHA07 Technical analysis, actions with chemical impact and/or purpose

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 11.04 Liquid waste injection	Store waste in the rock.		
K 11.07 Groundwater pollution	Acidify or in other way pollute air, water, soil and/or bedrock, cause accident resulting in chemical contamination.		
K 11.08 Surface pollution (soils, rivers)	Acidify or in other way pollute air, water, soil and/or bedrock, cause accident resulting in chemical contamination.		
M 2.2.03 Co-disposal of reactive wastes (deliberate)		Co-disposal of other waste in the repository is not relevant to the Swedish case	
M 2.3.10 Injection of liquid wastes	Store waste in the rock.		
W 3.010 Liquid waste disposal	Store waste in the rock.		
W 3.011 Hydrocarbon storage	Store waste in the rock.		Primarily an activity related to oil and gas exploitation and thus not relevant for the Swedish case.
W 3.024 Drilling-induced geochemical changes	Fluid flow during drilling that pollute the bedrock.	Flow through abandoned boreholes. The alteration of groundwater composition due to the presence of abandoned boreholes is deemed to be negligible in crystalline rock.	
W 3.027 Liquid waste disposal	Store waste in the rock.		
W 3.029 Hydrocarbon storage	Store waste in the rock.		Primarily an activity related to oil and gas exploitation and thus not relevant for the Swedish case.
W 3.030 Fluid injection-induced geochemical changes		Injection of fluids through a leaking borehole. The escape of borehole fluid in boreholes is omitted since the duration of drilling is short, the affected area deemed to be limited in space and the fluid generally consists of water.	
W 3.038 Changes in geochemistry due to mining		Hydrological disturbances altering groundwater composition. The drainage of a mine may cause enhanced groundwater flow during a limited period. However, the resulting alterations of groundwater composition are expected to lie within the range of naturally occurring alterations in the studied time frame.	
W 3.046 Altered soil or water surface chemistry by human activities	Acidify or in other way pollute air, water, soil and/or bedrock.	Surface activities associated with potash mining. Potash is not available at the candidate sites.	
W 3.048 Acid rain	Acidify or in other way pollute air, water, soil and/or bedrock.		
Recorded by: Fred Karlsson			**Date:** Sept 2009
Checked and revised by: Kristina Skagius			**Date:** Nov 2009

Appendix 10

Handling of NEA Project FEPs sorted to SR-Site Biosphere process FEPs

SR-Site FEP Bio01 Bioturbation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.014 Bioturbation of soil and sediment	Bioturbation is considered in the biosphere interaction matrix and in the radionuclide model. In the radionuclide model the depth of the bioturbated layer is identified for agricultural land, wetlands, marine basins, lakes and streams.		
A 3.042 Dispersion	Dispersion refers to the movement of radionuclides away from its source and includes advection, diffusion, water and air transport. These processes are considered in the biosphere interaction matrix and radionuclide model.		
H 4.2.3 Sediment transport including bioturbation	Transport of elements including bioturbation is considered in the biosphere interaction matrix and included in the radionuclide model where processes such as resuspension and deposition are parameterised.		Other aspects of this FEP are treated in Bio38 Relocation, and Bio39 Resuspension.
I 009 Sediments (in water bodies)	The sorption/desorption of radionuclides to particles is considered in the radionuclide model by Kd-values for different radionuclides. In additions, the transport of particles between the water column and the sediment is dependent on sedimentation/ resuspension processes which are also included in the radionuclide model.		Treated in Bio27, Bio34 and Bio 39
I 021 Bioturbation (soil & sediment)	Same as NEA FEP A 3.014.		
K 8.35 Bioturbation	Same as NEA FEP A 3.014.		
M 1.7.04 Soil and sediment bioturbation	Same as NEA FEP A 3.014.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio02 Consumption

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.003 Animal diets	Domestic and wild animals have different diets which may affect the radionuclide concentrations in the animals. Animal diets are included in the biosphere interaction matrix and in the radionuclide model.		
A 3.004 Animal grooming and fighting	Animal fighting and grooming my lead to exposure if the animals take up radionuclides that have been attached to their fur/skin during fighting. This is indirectly considered as concentration ratios of animals are estimated based on measurements on wild animals. These animals have due to a natural life style experienced grooming and fighting.		
A 3.005 Animal soil ingestion	Soil may be used as a food source for some organisms. This is considered in the biosphere interaction matrix, radionuclide model and in the assessment of dose to biota.		
A 3.009 Bioconcentration	Bioconcentration is considered by the use of concentration ratios used in the radionuclide model of the safety assessment		
A 3.012 Biomagnification	Bioconcentration is considered by the use of concentration ratios used in the radionuclide model of the safety assessment		
A 3.016 Burrowing animals	Burrowing animals may consume soils (or have soil adhered to their surface). The burrowing animals may be consumed by other animals and humans, thus posing a pathway for radionuclides in the soils to humans. This is considered in the biosphere interaction matrix and in calculating dose to non-human biota by the use of concentration ratios for different animals, i.e. taking into account where they spend their life (burrowing or on the surface).		
A 3.050 Fish farming	Fish farming is considered in the biosphere interaction matrix but is not included in the radionuclide model. This is a cautious assumption since fish farming demand input of food (e.g. pellets) for the aquaculture and import of food from an area outside the contaminated model area would lead to a dilution of radionuclides		
A 3.054 Food preparation	Food preparation is considered in the biosphere interaction matrix. However, it is likely unimportant in determining the total dose to humans and is thus not included in the radionuclide model.		
A 3.065 Human diet	Human diet is considered in the biosphere interaction matrix and in the radionuclide model. In the model human diet has been assumed to be represented by the production in the biosphere objects, i.e. the contribution of different food sources are assumed to be proportional to the production of different food sources. Thus the production represents the food supply that may be utilized. The diet changes over time as the proportion of sea/lakes/mires/and agricultural lands changes over time due to landscape development processes and thereby different diets are included in the safety assessment.		
A 3.066 Human soil ingestion	Humans may consume soil unintentionally when consuming e.g. carrots and potatoes. This is considered in biosphere interaction matrix and in the radionuclide model.		

SR-Site FEP Bio02 Consumption

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.069 Intake of drugs		Drugs may be locally produced and may then be contaminated with radionuclides. This is assumed to be covered by the ingestion of other food sources that are not considered to be drugs and the aspect of drugs is not further considered	
A 3.089 Scavengers and predators	Scavengers and predators may have larger radionuclide concentrations since radionuclides tend to accumulate at higher trophic levels. This is accounted for by the concentration ratios used in the safety assessment.		
A 3.110 Tree sap	All potential food sources are considered in the biosphere interaction matrix. Tree sap is not extracted from trees in Forsmark at present conditions. Even if utilized at a later stage it will most likely contribute only minor to dose and is thus not considered in the radionuclide model.		
H 4.3.1 Land and surface water use: Terrestrial	The land use is considered in the biosphere interaction matrix and in the radionuclide model.		
H 4.3.4 Land and surface water use: Seas	Use of seas is considered in the biosphere interaction matrix. Shipping and sailing is not assumed to give any significant dose and is thus not considered in the radionuclide model. Food supply from seas is included.		
I 003 Animal diets (domestic and wild)	Same as NEA FEP A 3.003.		
I 007 Animals (external contamination)	External contamination of animals may become internal if the contaminants are taken up. This is considered in the concentration ratios used to calculate radionuclide concentration in animals.		
I 014 Bioaccumulation/ bioconcentration/ biomagnification	Same as NEA FEP A 3.009 and A 3.012.		
I 113 Food chain (dose pathway)	Same as NEA FEP A 3.065.		
I 163 Insect pathways	Insects may be consumed by other animals and this pathway is considered in the biosphere interaction matrix. It is unlikely that insects will be consumed by humans since the effort to handle (catch) insects are large and thus insects are not included as a pathway for dose to humans in the radionuclide model.		
K 8.44 Consumption of uncontaminated products	Consumption of all available sources is considered in the biosphere interaction matrix. The food supply in the radionuclide model is cautiously considered to be derived exclusively from the model area, i.e. being contaminated with radionuclides.		

Recorded by: Eva Andersson **Date:** Nov 2010

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SR-Site FEP Bio03 Death

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.079 Peat and leaf litter harvesting	Human utilisation of the environment for other purposes than feeding and water use is considered in the biosphere interaction matrix and in the radionuclide model. External exposure is included in the radionuclide model, but has limited importance for a few and non dominating radionuclides. The external dose is considered by all sources.		
H 4.2.5 Bioaccumulation and translocation	Translocation of radionuclides concentrated in organisms to e.g. sediments is considered in the biosphere interaction matrix and in the radionuclide model. In the latter, organisms that are not consumed by other organisms may upon death contribute to soil or sediments.		
I 102 Ecological successions	Succession is considered in the biosphere interaction matrix, landscape development model and radionuclide model. Marine basins are developed to lake and thereafter to mires. The latter can thereafter be used as agricultural land.		
M 1.6.12 Accumulation in soils and organic debris	Deposited material may accumulate in soils and organic debris. This is considered in the biosphere interaction matrix, landscape development model and in the radionuclide model.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio04 Decomposition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.007 Bacteria and microbes in soil	Decomposers are considered in the biosphere interaction matrix, ecosystem models, and radionuclide model. Bacteria decompose organic matter and thereby liberate radionuclides, which may then become available and recycled. The breakdown of primary incorporated radionuclides is considered in the radionuclide model.		
A 3.018 Carcasses	The release of substances to the environment due to decomposition is considered in the biosphere interaction matrix and radionuclide model. Humans does not usually eat carcasses but if they did the effect would be the same as if feeding o animals killed on purpose so this is not considered in the safety assessment.		
H 4.2.5 Bioaccumulation and translocation	Translocation of radionuclides concentrated in organisms to e.g. sediments is considered in the biosphere interaction matrix and in the radionuclide model. In the latter, organisms that are not consumed by other organisms may upon death contribute to soil or sediments.		
H 4.2.6 Biogeochemical processes	Biogeochemical processes are included in the biosphere interaction matrix and radionuclide model.		
Recorded by: Eva Andersson			**Date:** Nov 2010
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SR-Site FEP Bio05 Excretion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.009 Bioconcentration	Elements may become concentrated in higher organisms. The bioconcentration is considered by the use of dependent on excretion of elements and bioconcentration is considered by the use of concentration ratios in the radionuclide model.		
A 3.018 Carcasses	Elements may be excreted when animals are rotting, and thereby the elements may be recycled. The excess of production in the radionuclide model is assumed to be available to recycling. In the terrestrial part of the radionuclide model, excretion is considered in the estimates of the pool of litter and decomposition of litter.		
H 4.2.5 Bioaccumulation and translocation	Translocation of radionuclides concentrated in organisms to e.g. sediments is considered in the biosphere interaction matrix and in the radionuclide model. In the latter, organisms that are not consumed by other organisms may upon death contribute to soil or sediments.		
H 4.2.6 Biogeochemical processes	Biogeochemical processes are included in the biosphere interaction matrix and radionuclide model.		
I 010 Recycling process (biomass)	Ashes and sewage sludge may increase crop yield due to an extra supply of essential elements. In the safety assessment, values of crop production from fertilized land are used to calculate production of food and thereby this process is considered.		
I 014 Bioaccumulation /bioconcentration/ biomagnification	See NEA FEP A 3.009		
Recorded by: Eva Andersson			**Date:** Nov 2010
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SR-Site FEP Bio06 Food supply

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.003 Animal diets	Domestic and wild animals have different diets which may affect the radionuclide concentrations in the animals. Animal diets are included in the biosphere interaction matrix and in the radionuclide model.		
A 3.050 Fish farming	Fish farming is considered in the biosphere interaction matrix but is not included in the radionuclide model. This is a cautious assumption since fish farming demand input of food (e.g. pellets) for the aquaculture and import of food from an area outside the contaminated model area would lead to a dilution of radionuclides		

SR-Site FEP Bio06 Food supply

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.065 Human diet	Human diet is considered in the biosphere interaction matrix and in the radionuclide model. In the model human diet has been assumed to be represented by the production in the biosphere objects, i.e. the contribution of different food sources are assumed to be proportional to the production of different food sources. Thus the production represents the food supply that may be utilized. The diet changes over time as the proportion of sea/lakes/mires/and agricultural lands changes over time due to landscape development processes and thereby different diets are included in the safety assessment.		
A 3.067 Hydroponics		The raising of certain crops without soil on water and on medium consisting of nutrients and microelements are not considered since it is not a common way of agriculture and it is not assumed to pose any increase radionuclide concentrations compared to conventional agricultural production.	
A 3.080 Plant roots	The uptake by plats is considered by the use of concentration ratios. The uptake by plants is not assumed to be limited by element supply but is assumed to be dependent on the rate of primary production. The uptake into tuber e.g. potatoes, carrots etc) can then be directly utilised by humans.		Belong to Bio22 Element supply
A 3.096 Soil	Soil is considered in the biosphere interaction matrix and in the radionuclide model. In the radionuclide model, stratification, characteristics and composition of regolith (e.g. porosity, density, and carbon content) are included. Soil function as a habitat for soil organisms thereby supplying a living habitat for these. This is considered in the calculations of biomass and production.Soil may be used as a food source for some organisms. This is considered in the concentration ratios used to calculate transfer of radionuclides form the food to the organisms.		
H 4.3.3 Land and surface water use: Coastal waters	Use of coastal water is considered in the biosphere interaction matrix. Swimming is assumed to give insignificant dose compared to internal doses from ingestion and inhalation as is thus not included in the radionuclide model. Food production is included in the radionuclide model.		See also Bio10
H 4.3.4 Land and surface water use: Seas	Use of seas is considered in the biosphere interaction matrix. Shipping and sailing is not assumed to give any significant dose and is thus not considered in the radionuclide model. Food supply from seas is included.		

SR-Site FEP Bio06 Food supply

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 003 Animal diets (domestic and wild)	Same as NEA FEP A 3.003.		
I 113 Food chain (dose pathway)	Same as NEA FEP A 3.065.		
I 157 Hydroponics (dose pathway)		See NEA FEP A 3.067.	
I 163 Insect pathways	Insects may be consumed by other animals and this pathway is considered in the biosphere interaction matrix. It is unlikely that insects will be consumed by humans since the effort to handle (catch) insects are large and thus insects are not included as a pathway for dose to humans in the radionuclide model.		
K 8.10 Uptake by livestock	Uptake by live stock is considered in the biosphere interaction matrix and in the radionuclide model. The uptake by livestock is assumed to not be limited by the supply of water or aerosols in the air.		Belong to Bio15 Uptake
K 8.11 Uptake in fish	Radionuclides may be taken up by fish as a result of ingestion of water, gases, or food. This is considered in the biosphere interaction matrix and included in the radionuclide model and assessment of dose to biota as concentration ratios. The uptake by fish is assumed to not be limited by the supply of water or gases in water.		Belong to Bio15 Uptake
K 8.13 Exposure pathways	Exposure pathways are considered in the biosphere interaction matrix and in the radionuclide model. Ingestion of various food sources, water inhalation of dust and external exposure are considered.		Belong to Bio42 Exposure
K 8.40 Natural and semi-natural environments	Food supply is dependent on which types of ecosystem that is present in the model area. Natural environments with wild crops and game give rise to another amount of food (food supply) than agriculture area. This is considered in the radionuclide model as both natural and agricultural land is considered. As the object develop with time the amount of agricultural and natural land changes over time and both type of land (and subsequent food supply) is considered.		
K 8.41 Hunter/gathering lifestyle	Gathering life style is considered in the biosphere interaction matrix. In the radionuclide model, gathering of food is only considered within biosphere objects and neither humans nor food are exported out from the model area. This is a cautious assumption since gathering life style would most likely dilute dose to humans due to humans gathering food from a larger area than the contaminated biosphere objects.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio07 Growth

No NEA FEPs associated with this SR-Site FEP.

SR-Site FEP Bio08 Habitat supply

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.096 Soil	Soil is considered in the biosphere interaction matrix and in the radionuclide model. In the radionuclide model, stratification, characteristics and composition of regolith (e.g. porosity, density, and carbon content) are included. Soil function as a habitat for soil organisms thereby supplying a living habitat for these. This is considered in the calculations of biomass and production.		This is not a process but a component, belongs to the diagonal component CompBio02 Regolith
A 3.112 Urbanization on the discharge site	Whether humans are urbanized or rural influence the exposure. In the safety assessment, as a cautious assumption, human populations are assumed to be rural and to only feed on products produced within the biosphere objects, i.e. the contaminated area.		See also Bio42 Exposure
I 227 Urbanization (demographics)	See NEA FEP A 3.112.		See also Bio42 Exposure
K 8.25 Soil	See NEA FEP A 3.096.		
M 2.4.03 River rechannelling	River erosion and channel erosion is considered in the biosphere interaction matrix and in the radionuclide model. At the site the regolith consists of till and rivers are small, which gives a low potential for any substantial river erosion of the river banks are expected. In the radionuclide model no long-term accumulation is assumed to occur in streams and thereby the annual sedimentated material is assumed to be resuspended (eroded) and transported downstream, i.e. the sizes of the rivers are assumed to remain throughout the modeling time period.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio09 Intrusion

No NEA FEPs associated with this SR-Site FEP.

SR-Site FEP Bio10 Material supply

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.006 Ashes and sewage sludge fertilizers	Ashes in building material may contribute to external exposure External exposure is included in the radionuclide model, but has limited importance for a few and non dominating radionuclides. The external dose is considered by all sources.		

SR-Site FEP Bio10 Material supply

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.010 Biogas production	Heating needs may be met with biogas from biological reactors fuelled by plant materials, faeces and refuse, or from trapping natural methane from garbage disposal sites, bogs and sediments. These fuels may be contaminated with radionuclides leading to external exposure. External exposure is considered in the biosphere interaction matrix and included in the radionuclide model, but has limited importance for a few and non dominating radionuclides. The external dose is considered by all sources.		
A 3.015 Building materials	Wood etc used as building material may expose humans to external exposure. External exposure is considered in the biosphere interaction matrix and included in the radionuclide model, but has limited importance for a few and non dominating radionuclides. The external dose is considered by all sources.		
A 3.095 Smoking		Tobacco is not cultivated at Forsmark at present and this FEP is not considered in the radionuclide model. However, any contribution to dose from smoking is likely to be minor compared to the amounts ingested through food and water.	
A 3.102 Space heating	Space heating when burning contaminated materials such as trees may contribute to external exposure. External exposure is considered in the biosphere interaction matrix and included in the radionuclide model, but has limited importance for a few and non dominating radionuclides. The external dose is considered by all sources.		
H 4.3.3 Land and surface water use: Coastal waters	Use of coastal water is considered in the biosphere interaction matrix. Swimming is assumed to give insignificant dose compared to internal doses from ingestion and inhalation as is thus not included in the radionuclide model. Food production is included in the radionuclide model.		See also Bio06
I 276 Smoking (dose pathway)		See NEA FEP A 3.095.	
K 8.13 Exposure pathways	Exposure pathways are considered in the biosphere interaction matrix and in the radionuclide model. Ingestion of various food sources, water inhalation of dust and external exposure are considered.		Belong to exposure Bio42
K 8.42 Contaminated products (non-food)	External exposure is considered in the biosphere interaction matrix and included in the radionuclide model, but has limited importance for a few and non dominating radionuclides. The external dose is considered by all sources.		

SR-Site FEP Bio10 Material supply

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 3.040 Land use changes	Land use is considered in the biosphere interaction matrix, landscape development model and in the radionuclide model. Forsmark is situated in an area where there is shore-line development, i.e. new land is uplifted and new areas may be used for agriculture. Water extraction is considered in the model as use of well for irrigation. Mining and drilling is considered in supporting calculations.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio11 Movement

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 4.3.3 Land and surface water use: Coastal waters	Human use of the coastal waters for industries or energy generation may induce movement of the surface waters. Since the water column is assumed to be completely mixed in the radionuclide model this is accounted for although not explicitly included.		
W 3.045 Lake usage	Human use of the lakes for freshwater use in industries, recreation with boats etc. may induce movement of the surface waters. Since the water column is assumed to be completely mixed in the radionuclide model this is accounted for although not explicitly included.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio12 Particle release/trapping

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.005 Animal soil ingestion	Soil may be used as a food source for some organisms. This is considered in the biosphere interaction matrix, radionuclide model and in the assessment of dose to biota.		
A 3.026 Colloids	Colloids in water, i.e. particulate matter, are considered in the biosphere interaction matrix and are included in the radionuclide model as these influence sorption/desorption and thereby transport and accumulation of radionuclides.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio13 Primary production

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.007 Bacteria and microbes in soil	Decomposers are considered in the biosphere interaction matrix, ecosystem models, and radionuclide model. Bacteria decompose organic matter and thereby liberate radionuclides, which may then become available and recycled. The breakdown of primary incorporated radionuclides is considered in the radionuclide model.		
A 3.090 Seasons	Seasons are considered in the biosphere interaction matrix. In the radionuclide model, annual mean values are used for parameterization. These values are based on site specific measurements considering seasonal variations.		
I 292 Surface water bodies (physical/chemical changes)	Physical and chemical changes of water bodies are considered in the biosphere interaction matrix and in the radionuclide model. For example, in the radionuclide model changes in chemistry is considered by use of different parameter sets for marine and limnic stages of the aquatic objects and physical changes are considered by use of time specific values of the geometry of the objects.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio14 Stimulation/inhibition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.006 Ashes and sewage sludge fertilizers	Ashes and sewage sludge are considered in the biosphere interaction matrix and in the radionuclide model. Ashes and sewage sludge may increase crop yield, In the radionuclide model, values of crop production from conventional agriculture including both fertilizers and pesticides are used to calculate production of food. This is cautious due to the fact that adding material leads to dilution of matter. And also a larger crop yield allows for more people to live in the contaminated area.		
A 3.036 Crop fertilizers and soil conditioners	See NEA FEP A 3.006.		
A 3.055 Game ranching	During game ranching, animals could become contaminated through the intake of contaminated food, water, soil or air. These sources of contamination are similar to those for domestic animals, as are other considerations. Thus game ranching is just another type of animal husbandry that that is included in the radionuclide model.		
A 3.058 Greenhouse food production	Greenhouse production demands addition of nutrients, most often received from outside the model area. In addition, soil and soil conditioners may be derived from areas outside the model area. The one aspect that may concentrate radionuclides in primary producers due to green house farming is irrigation with water. Irrigation are used for agricultural land and thereby this effect of greenhouse farming is included in the safety assessment whereas other aspects (such as import of uncontaminated nutrients, soils and soil conditioners), as cautious assumption, are not included.		

SR-Site FEP Bio14 Stimulation/inhibition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.062 Herbicides, pesticides and fungicides	See NEA FEP A 3.006.		
A 3.079 Peat and leaf litter harvesting	Peat is used in agriculture in the radionuclide model as agriculture is allowed on drained wetlands. As a conservative estimate, radionuclides are not removed from the soil with harvesting but radionuclides are available also for the next human utilizing the peat land.		
A 3.113 Vault heating effects	The repository for spent nuclear fuel at Forsmark will be placed at such a depth that decay from radionuclides will not alter the temperature at the surface in such a way that biota will be affected. Nevertheless, a wide temperature range is considered in the safety assessment. Due to the long time aspect of the safety assessment, temperature changes over time in Forsmark will range from a few degrees warmer than today to glacial conditions.		
H 4.2.6 Biogeochemical processes	Biogeochemical processes are included in the biosphere interaction matrix and radionuclide model.		
I 010 Recycling process (biomass)	See NEA FEP A 3.006.		
I 148 Herbicides, pesticides & fungicides (dose pathway)	See NEA FEP A 3.006.		
K 8.39 Agricultural practices	Humans may be exposed to radionuclides through various sources e.g. agricultural products. Different products may expose humans with different doses. This is considered in the biosphere interaction matrix and in the radionuclide model.		
W 3.054 Ranching	Ranching is considered in the biosphere interaction matrix and in the radionuclide model.		
W 3.055 Fish farming	Fish farming is considered in the biosphere interaction matrix but is not included in the radionuclide model. This is a cautious assumption since fish farming demand input of food (e.g. pellets) for the aquaculture and import of food from an area outside the contaminated model area would lead to a dilution of radionuclides.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio15 Uptake

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.006 Ashes and sewage sludge fertilizers	Ashes and sewage sludge may increase crop yield, In the radionuclide model, values of crop production from fertilized land are used to calculate production of food and thereby this process is indirectly included. Ashes of burned peat may concentrate radionuclides in the soil. In the safety assessment, each object is assumed to receive the entire radionuclide release and thus radionuclides are already present within the object and ashes will not introduce an extra source of contaminants.		
A 3.008 Bioaccumulation	Radionuclides may accumulate in different organism groups. This is considered by the different concentration ratios used for different organism groups in radionuclide model and assessment of dose to biota.		
A 3.009 Bioconcentration	Radionuclides may accumulate in different organism groups. This is considered by the different concentration ratios used for different organism groups in radionuclide model and assessment of dose to biota.		
A 3.012 Biomagnification	See NEA FEP A 3.009.		
A 3.016 Burrowing animals	Burrowing animals may consume soils (or have soil adhered to their surface). The burrowing animals may be consumed by other animals and humans, thus posing a pathway for radionuclides in the soils to humans. This is considered in the biosphere interaction matrix and in calculating dose to non-human biota by the use of concentration ratios for different animals, i.e. taking into account where they spend their life (burrowing or on the surface).		
A 3.029 Critical group - agricultural labour	Inhalation of dust by farmers is considered in the safety assessment by including inhalation of dust		
A 3.036 Crop fertilizers and soil conditioners	Fertilizers and soil conditioners increase the yield from agricultural land but may also dilute the concentration of radionuclides in the crop if radionuclides that are essential elements are diluted with uncontaminated elements in the fertilizers. In the safety assessment, values of crop production from fertilized land are used to calculate production of food and thereby this process is considered. As a cautious assumption, fertilizers are not considered when estimating concentration of radionuclides in the crop but then all elements are assumed to be taken up from the soil.		

SR-Site FEP Bio15 Uptake

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.037 Crop storage		When crop is stored radionuclide concentration may increase if seepage or flooding wet the crop. Decay of the radionuclides in the stored crop may also decrease the exposure. If crop is wetted it is most likely discarded as food and decay of radionuclides are only important for short-lived isotopes considering the length of storage of crops. For radionuclides entering from a deep repository this is thus irrelevant.	
A 3.040 Dermal sorption (except tritium)	Dermal sorption is considered in the biosphere interaction matrix. However, Dermal sorption in general is likely of minor importance for humans, compared to the direct ingestion and inhalation of radio-nuclides. Cautious assumptions built into these major pathways in the radionuclide model could readily include dermal sorption, and therefore, no explicit quantitative treatment of dermal sorption is required.		
A 3.041 Dermal sorption (tritium)	Dermal sorption is considered in the biosphere interaction matrix. Dermal sorption in general is likely of minor importance for humans, compared to the direct ingestion and inhalation of radio-nuclides. Cautious assumptions built into these major pathways in the radionuclide model could readily include dermal sorption, and therefore, no explicit quantitative treatment of dermal sorption is required.		
A 3.050 Fish farming	Fish farming is considered in the biosphere interaction matrix but is not included in the radionuclide model. This is a cautious assumption since fish farming demand input of food (e.g. pellets) for the aquaculture and import of food from an area outside the contaminated model area would lead to a dilution of radionuclides.		
A 3.058 Greenhouse food production	Greenhouse production demands addition of nutrients, most often received from outside the model area. In addition, soil and soil conditioners may arise from areas outside the model area. The one aspect that may concentrate radionuclides in primary producers due to green house farming is irrigation with water. Irrigation are used for agricultural land and thereby this effect of greenhouse farming is included in the safety assessment whereas other aspects (such as import of uncontaminated nutrients, soils and soil conditioners), as cautious assumption, are not included.		

SR-Site FEP Bio15 Uptake

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.062 Herbicides, pesticides and fungicides	Herbicides, pesticides and fungicides may stimulate crop production and increase the yield from agricultural land. This is considered in the radionuclide model as values of crop production are from conventional agricultural land where herbicides, pesticides and fungicides are used. In FEP A 3.062 it is suggested that agricultural chemicals can become contaminated and pass contaminants onto plants and into various food chains. However, in the safety assessment, objects are assumed to receive the entire radionuclide release and thus, no extra import of radionuclides are assumed to occur via addition of pesticides, fungicides and herbicides.		
A 3.067 Hydroponics		The raising of certain crops without soil on water and on medium consisting of nutrients and microelements are not considered since it is not a common way of agriculture and it is not assumed to pose any increase radionuclide concentrations compared to conventional agricultural production.	
A 3.069 Intake of drugs		Drugs may be locally produced and may then be contaminated with radionuclides. This is assumed to be covered by the ingestion of other food sources that are not considered to be drugs and the aspect of drugs is not further considered.	
A 3.073 Irrigation	Irrigation may increase radionuclide concentrations in crops and therefore irrigation has been included in the radio-nuclide model in the safety assessment.		
A 3.080 Plant roots	The uptake by plats is considered by the use of concentration ratios. The uptake by plants is not assumed to be limited by element supply but is assumed to be dependent on the rate of primary production. The uptake into tuber e.g. potatoes, carrots etc) can then be directly utilised by humans.		
A 3.094 Showers and humidifiers	Showers and humidifiers may release radionuclides indoors. However, the dose from this source is assumed to be very small in comparison to the radionuclide source from ingestions and this pathway is not included in the radionuclide model.		
A 3.095 Smoking		Tobacco is not cultivated at Forsmark at present and this FEP is not considered in the radio-nuclide model. However, any contribution to dose from smoking is likely to be minor compared to the amounts ingested through food and water.	

SR-Site FEP Bio15 Uptake

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.103 Surface water bodies	Surface water is a diagonal element in the biosphere interaction matrix and influences other diagonal elements by processes such as convection, uptake, sorption/desorption, etc. Surface water bodies are considered in several areas of the safety assessment and are included in the radionuclide model as marine basins, lakes and streams.		
A 3.110 Tree sap	All potential food sources are considered in the biosphere interaction matrix. Tree sap is not extracted from trees in Forsmark at present conditions. Even if utilized at a later stage it will most likely contribute only minor to dose and is thus not considered in the radionuclide model.		
H 4.2.5 Bioaccumulation and translocation	Translocation of radionuclides concentrated in organisms to e.g. sediments is considered in the biosphere interaction matrix and in the radionuclide model. In the latter, organisms that are not consumed by other organisms may upon death contribute to soil or sediments.		
H 4.4.2 Human exposure: Ingestion	Human exposure due to drinking and feeding is considered in the biosphere interaction matrix and included in the radionuclide model. Drinking is the uptake from surface water and water extracted from the well. Ingestion of food is further described in the biosphere synthesis report.		
H 4.4.3 Human exposure: Inhalation	Human exposure due to inhalation is considered in the biosphere interaction matrix and in the radionuclide model as inhalation of dust.		
I 003 Animal diets (domestic and wild)	Domestic and wild animals have different diets which may affect the radionuclide concentrations in the animals. Animal diets are included in the biosphere interaction matrix, and in the radionuclide model.		
I 007 Animals (external contamination)	External contamination of animals may become internal if the contaminants are taken up. This is considered in the concentration ratios used to calculate radionuclide concentration in animals.		
I 010 Recycling process (biomass)	Ashes and sewage sludge may increase crop yield due to an extra supply of essential elements. In the safety assessment, values of crop production from fertilized land are used to calculate production of food and thereby this process is considered.		See also Bio05.
I 014 Bioaccumulation/ bioconcentration/ biomagnification	See NEA FEP A 3.009.		
I 082 Crop storage		See NEA FEP A 3.037.	
I 090 Dermal sorption (tritium and others)	See NEA FEPs A 3.040 and A 3.041.		
I 148 Herbicides, pesticides & fungicides (dose pathway)	See NEA FEP A 3.062.		
I 157 Hydroponics (dose pathway)	See NEA FEP A 3.067.		

SR-Site FEP Bio15 Uptake

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 175 Irrigation (dose pathway)	See NEA FEP A 3.073.		
I 272 Showers and humidifiers (atmospheric dose pathway)	See NEA FEP A 3.094.		
I 276 Smoking (dose pathway)		See NEA FEP A 3.095.	
K 8.08 Filtration	Filtration is considered in the biosphere interaction matrix. In the radionuclide model, as a cautious assumption, particles are not filtrated out of water before it is used by humans. This is cautious since filtration decrease the exposure of humans since many radionuclides are associated with particles.		
K 8.09 Uptake by crops	Uptake by crops of radionuclides via water is considered in the biosphere interaction matrix and is also included in the radionuclide model by the use of concentration rations that take into account the radionuclide concentration in water.		
K 8.10 Uptake by livestock	Uptake by live stock is considered in the biosphere interaction matrix and in the radionuclide model. Radionuclides may be taken up as a result of ingestion of water, food or inhalation. This is considered by the use of concentration ratios in the radionuclide model.		
K 8.11 Uptake in fish	Radionuclides may be taken up by fish as a result of ingestion of water, gases, or food. This is considered in the biosphere interaction matrix and included in the radionuclide model and assessment of dose to biota as concentration ratios.		
K 8.13 Exposure pathways	Exposure pathways are considered in the biosphere interaction matrix and in the radionuclide model. Ingestion of various food sources, water inhalation of dust and external exposure are considered.		
M 1.7.01 Plant uptake	Uptake of radionuclides by plants is considered in the biosphere interaction matrix and in the radionuclide model. It is also considered in the assessment of dose to non-human biota.		
M 1.7.02 Animal uptake	Animal uptake of radionuclides is considered in the biosphere interaction matrix and in the radionuclide model.		
M 1.7.03 Uptake by deep rooting species	Uptake by deep rooting species is considered in the biosphere interaction matrix and radionuclide model. Deep rooted species is not separated from other primary producer. However, in the radionuclide model, the upper regolith is assumed to be mixed so it is irrelevant if the roots are long or short for the uptake of radionuclides.		
W 2.101 Plant uptake	See NEA FEP M 1.7.01.		
W 2.102 Animal uptake	See NEA FEP M 1.7.02.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio16 Anthropogenic release

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.006 Ashes and sewage sludge fertilizers	Ashes and sewage sludge may increase crop yield, In the radionuclide model, values of crop production from fertilized land are used to calculate production of food and thereby this process is indirectly included. Ashes of burned peat may concentrate radionuclides in the soil. In the safety assessment, each object is assumed to receive the entire radionuclide release and thus radionuclides are already present within the object and ashes will not introduce an extra source of contaminants.		
A 3.020 Charcoal production	Charcoal production is considered in the biosphere interaction matrix. However, as the dose from charcoal production is considered to become insignificant in comparison to ingestion of contaminated food this process is not included in the radionuclide model.		
A 3.036 Crop fertilizers and soil conditioners	Fertilizers and soil conditioners increase the yield from agricultural land but may also dilute the concentration of radionuclides in the crop if radionuclides that are essential elements are diluted with uncontaminated elements in the fertilizers. In the safety assessment, values of crop production from fertilized land are used to calculate production of food and thereby this process is considered. As a cautious assumption, fertilizers are not considered when estimating concentration of radionuclides in the crop but then all elements are assumed to be taken up from the soil.		
A 3.102 Space heating	Space heating when burning contaminated materials such as trees may contribute to external exposure. External exposure is considered in the biosphere interaction matrix and included in the radionuclide model, but has limited importance for a few and non dominating radionuclides. The external dose is considered by all sources.		
I 261 Salt (road salt, CaCl2, etc.)	All kinds of anthropogenic release including salts are considered in the biosphere interaction matrix. Road salts may influence the ion strength of water. As water composition used in the radionuclide model is based on in situ measurement s, the effects of road salts are indirectly included.		
S 087 Surface water chemistry	Surface water chemistry is considered in the biosphere interaction matrix, site descriptions, and in the radionuclide model where site specific water chemistry characteristics are considered. Human actions may influence the water composition by e.g. release of substances. Release of toxins are not considered as a cautious assumptions as this would most likely decrease human utilization of surface waters for drinking and feeding.		Belongs also to CompBio11 Water composition.
W 3.053 Arable farming	Human affecting the environment through farming is considered in the biosphere interaction matrix. Farming is also considered in the radionuclide model.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio17 Material use

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.010 Biogas production	Heating needs may be met with biogas from biological reactors fuelled by plant materials, faeces and refuse, or from trapping natural methane from garbage disposal sites, bogs and sediments. These fuels may be contaminated with radionuclides leading to external exposure. External exposure is considered in the biosphere interaction matrix and included in the radionuclide model, but has limited importance for a few and non dominating radionuclides. The external dose is considered by all sources.		
A 3.020 Charcoal production	Charcoal production is considered in the biosphere interaction matrix. However, as the dose from charcoal production is considered to become insignificant in comparison to ingestion of contaminated food this process is not included in the radionuclide model.		
A 3.034 Critical group - leisure pursuits	Activities such as hockey, curling on contaminated ice or swimming in contaminated water may expose humans to external exposure. In the radionuclide model, the concern is mainly long-lived radionuclides and these gives the highest external dose from ground, and time spent in lakes swimming or on ice skating has not to be considered. Instead, as a cautious assumption, humans are assumed to spend their entire time (100%) outdoors receiving external exposure from the ground.		
A 3.054 Food preparation	Food preparation is considered in the biosphere interaction matrix. However, it is likely unimportant in determining the total dose to humans and is thus not included in the radionuclide model.		
A 3.064 Houseplants	External exposure is included in the biosphere interaction matrix and in the radionuclide model, but has limited importance for a few and non dominating radionuclides. The external dose is considered by all sources although contribution from household plants is assumed to be small.		
A 3.079 Peat and leaf litter harvesting	Human utilisation of the environment for other purposes than feeding and water use is considered in the biosphere interaction matrix. External exposure is included in the radionuclide model, but has limited importance for a few and non dominating radionuclides. The external dose is considered by all sources.		
A 3.117 Wetlands	Wetlands may be used in several ways; they may be used for wild berries and game, they may be drained and used for agricultural sources, and peat from wetlands may be utilised for fuel and as building material. Wetlands are considered in the biosphere interaction matrix and are included in the radionuclide model where occurrence, sizes, and peat depths of wetlands in the model area is included.		
H 4.3.1 Land and surface water use: Terrestrial	The land use is considered in the biosphere interaction matrix and in the radionuclide model.		

SR-Site FEP Bio17 Material use

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 4.3.4 Land and surface water use: Seas	Use of seas is considered in the biosphere interaction matrix. Shipping and sailing is not assumed to give any significant dose and is thus not considered in the radionuclide model. Food supply from seas is included.		
I 010 Recycling process (biomass)	Ashes and sewage sludge may increase crop yield due to an extra supply of essential elements. In the safety assessment, values of crop production from fertilized land are used to calculate production of food and thereby this process is considered.		
I 150 Household plants (dose pathway)	See NEA FEP A 3.064.		
M 2.4.10 Qurries, near surface	Extraction from quarries may give rise to external exposure. External exposure is considered in the biosphere interaction matrix and in radionuclide model. The external dose is considered by all sources.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio18 Species introduction/extermination

No NEA FEPs associated with this SR-Site FEP.

SR-Site FEP Bio19 Water use

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.03 Borehole - well	The borehole may be used as a well. This is considered in the safety assessment.		
A 2.14 Dams	Dam constructions may influence hydraulic heads and may affect surface water flows. Dams are a form of thresholding which is included in the biosphere interaction matrix, landscape development model, and in the radionuclide model.		
A 2.73 Wells	Wells are assumed to be utilised for drinking. The amount of water (water supply) is not assumed to limit the utilisation of water from the well but the amount used is based on the human demand.		
A 2.74 Wells (high-demand)	See NEA FEP A 2.73.		
A 3.042 Dispersion	Dispersion refers to the movement of radionuclides away from its source and includes advection, diffusion, water and air transport. These processes are considered in the biosphere interaction matrix and radionuclide model.		
A 3.073 Irrigation	Irrigation may increase radionuclide concentrations in crops and therefore irrigation has been included in the radionuclide model in the safety assessment.		

SR-Site FEP Bio19 Water use

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.075 Lake mixing (artificial)	Artificial lake mixing (such as aeration and wave maker may affect contaminant concentrations in lakes by accelerating mixing of the water column or stirring up sediment particles) is considered in the biosphere interaction matrix. In the radionuclide model, dose is calculated on an annual basis and although the water column may be stratified in winter and/or summer it is completely mixed at least at two occasions each year, i.e. spring and autumn. Thus, artificial mixing is not specifically addressed in the radionuclide model since the water is already assumed to be completely mixed.		
A 3.077 Outdoor spraying of water	Water and dust intake is handled in the biosphere interaction matrix and radionuclide model.		
A 3.094 Showers and humidifiers	Showers and humidifiers may release radionuclides indoors. However, the dose from this source is assumed to be very small in comparison to the radionuclide source from ingestions and this pathway is not included in the radionuclide model.		
I 085a Dams (filling, draining)	See NEA FEP A 2.14.		
I 175 Irrigation (dose pathway)	Same as NEA FEP A 3.073.		
I 211 Ooutdoor spraying of water (atmospheric dose pathway)	Same as NEA FEP A 3.077.		
I 272 Showers and humidifiers (atmospheric dose pathway)	Same as NEA FEP A 3.094.		
J 5.27 Human induced actions on groundwater recharge	Human induced changes in land use that affect recharge are not considered in the hydrological modelling. Contamination through irrigation is considered in the dose calculations, but not as recharge in the flow modelling.		
J 5.36 Reuse of boreholes	Same as NEA FEP A 2.03		
J 5.41 Water producing well	Wells are assumed to be utilised for drinking in the biosphere interaction matrix and in the radionuclide model. The amount of water (water supply) is not assumed to limit the utilisation of water from the well but the amount used is based on the human demand.		
J 7.07 Human induced changes in surface hydrology	Human induced changes in surface hydrology are addressed in the landscape modelling, to some extent. Irrigation is considered in the dose calculations in the radionuclide model.		
K 8.07 Water resource exploitation	Water resource exploitation s considered in the biosphere interaction matrix and radionuclide model. The source of water for human utilisation (lake, rivers well) may have an influence on the exposure as different sources may have different concentrations of radionuclides.		
K 8.33 Irrigation	See NEA FEP A 3.073.		

SR-Site FEP Bio19 Water use

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 11.05 Deep groundwater abstraction	See NEA FEPs A 2.03 and A 2.73.		
M 2.4.02 Dams and reservoirs, built/drained	See NEA FEP A 2.14.		
M 2.4.04 Irrigation	See NEA FEP A 3.073.		
W 3.005 Groundwater exploitation	See NEA FEPs A 2.03 and A 2.73.		
W 3.026 Groundwater extraction	See NEA FEPs A 2.03 and A 2.73.		
W 3.042 Damming of streams or rivers	See NEA FEP A 2.14.		
W 3.043 Reservoirs	See NEA FEP A 2.14.		
W 3.044 Irrigation	See NEA FEP A 3.073.		
W 3.045 Lake usage	Water use is the use of water for other purpose than drinking and is considered in the biosphere interaction matrix and radionuclide model. In the radionuclide model, irrigation is included whereas recreational purposes and industrial use are assumed to be insignificant compared to internal exposure due to ingestion, and also smaller than external exposure from terrestrial ground and therefore this is not further considered.		
W 3.050 Coastal water use	Water use is the use of water for other purpose than drinking and is considered in the biosphere interaction matrix. Coastal waters are available for recreational utilization, and industrial uses. Although this may pose exposure to humans it is assumed to be insignificant compared to internal exposure due to ingestion, and also smaller than external exposure from terrestrial ground and therefore this is not further considered in the radionuclide model.		
W 3.051 Sea water use	Water use is the use of water for other purpose than drinking and is considered in the biosphere interaction matrix. Sea waters are available for recreational utilization, shipping etc. Although this may pose exposure to humans it is assumed to be insignificant compared to internal exposure due to ingestion, and also smaller than external exposure from terrestrial ground and therefore this is not further considered in the radionuclide model.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio20 Change of pressure

No NEA FEPs associated with this SR-Site FEP.

SR-Site FEP Bio21 Consolidation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 2.1.4 Diagenesis	Consolidation and diagenesis is addressed in the biosphere interaction matrix and considered not of importance due to that the bedrock consists of archean crystalline rock and the regular scoring by ice will prevent accumulation of looser rock during these conditions.		
J 7.10 Diagenesis	See NEA FEP H 2.1.4.		
M 1.2.05 Diagenesis	See NEA FEP H 2.1.4.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio22 Element supply

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.006 Ashes and sewage sludge fertilizers	Ashes and sewage sludge may increase crop yield, In the radionuclide model, values of crop production from fertilized land are used to calculate production of food and thereby this process is indirectly included. Ashes of burned peat may concentrate radionuclides in the soil. In the safety assessment, each object is assumed to receive the entire radionuclide release and thus radionuclides are already present within the object and ashes will not introduce an extra source of contaminants.		
A 3.036 Crop fertilizers and soil conditioners	Fertilizers and soil conditioners increase the yield from agricultural land but may also dilute the concentration of radionuclides in the crop if radionuclides that are essential elements are diluted with uncontaminated elements in the fertilizers. In the safety assessment, values of crop production from fertilized land are used to calculate production of food and thereby this process is considered. As a cautious assumption, fertilizers are not considered when estimating concentration of radionuclides in the crop but then all elements are assumed to be taken up from the soil.		
A 3.080 Plant roots	Plants can take up contaminating radionuclides in the soil via their roots. The uptake is dependent on supply in the regolith. The uptake is considered in the safety assessment as production and also by CR-factors used to determine the concentration of radionuclides in plants.		
K 8.13 Exposure pathways	Exposure pathways are considered in the biosphere interaction matrix and in the radionuclide model. Ingestion of various food sources, water inhalation of dust and external exposure are considered.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio23 Loading

No NEA FEPs associated with this SR-Site FEP.

SR-Site FEP Bio24 Phase transitions

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.002 Alkali flats		Alkali flats may be formed in arid regions of the world. This climate conditions are not assumed to occur in Forsmark even at altered climate and thus this process is not necessary to consider in the safety assessment SR-Site.	
A 3.021 Chemical precipitation	Chemical precipitation influences the phase of elements and thereby transport of radionuclides. This is considered in the biosphere interaction matrix and in the radionuclide model.		
A 3.090 Seasons	Seasons are considered in the biosphere interaction matrix. In the radionuclide model, annual mean values are used for parameterization. These values are based on site specific measurements considering seasonal variations.		
A 3.094 Showers and humidifiers	Showers and humidifiers may release radionuclides indoors. However, the dose from this source is assumed to be very small in comparison to the radionuclide source from ingestions and this pathway is not included in the radionuclide model.		
A 3.098 Soil leaching	Soil leaching is considered in the biosphere interaction matrix and for agricultural land in the radionuclide model.		
A 3.105 Suspension in air	One pathway for radionuclides from soil and water to become part of the air is by degassing. This is considered in the biosphere interaction matrix and included in the radionuclide model.		
H 4.2.1 Soil moisture and evaporation	This process is considered in the biosphere interaction matrix and in hydrological modeling that calculates input parameters to the radionuclide model.		
H 4.2.4 Sediment/water/gas interaction with the atmosphere	Exchange over the air-water interface is considered in the biosphere interaction matrix and the exchange of 14-C is included in the radionuclide model.		
H 4.2.6 Biogeochemical processes	Biogeochemical processes are included in the biosphere interaction matrix and radionuclide model.		
I 002 Alkali Flats		See NEA FEP A 3.002.	
I 112a Fire (atmospheric dose pathway)	Fires are considered in the biosphere interaction matrix.		
I 115 Flooding (localized, short-term surface flooding)	Flooding of terrestrial areas may lead to a transport of radionuclides from the water to terrestrial areas. This is considered in the biosphere interaction matrix and included in the radionuclide model by the use of a specific flooding coefficient.		

SR-Site FEP Bio24 Phase transitions

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 272 Showers and humidifiers (atmospheric dose pathway)	See NEA FEP A 3.094.		
K 8.12 Radionuclide volatilisation/aerosol/ dust production	Volatilisation/aerosol/dust are considered in the biosphere interaction matrix and in the radionuclide model. Inhalation of contaminated soil dust is an exposure pathway and thus volatilisation/aerosol/dust is considered in the radionuclide model.		
K 8.28 Interface effects	Interactions between the geosphere and biosphere are considered in the biosphere interaction matrix.		
K 8.30 Evapotranspiration	Evapotranspiration is included in the hydrological modelling. Water balance results from the hydrological modelling are used in the radionuclide model. Evapotranspiration is also considered in the biosphere interaction matrix.		
W 2.103 Accumulation in soil	Deposited material may accumulate in soils and organic debris. This is considered in the biosphere interaction matrix and in the radionuclide model both as deposition and permanent accumulation.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio25 Physical properties change

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.090 Seasons	Seasons are considered in the biosphere interaction matrix. In the radionuclide model, annual mean values are used for parameterization. These values are based on site specific measurements considering seasonal variations.		
K 8.28 Interface effects	Interactions between the geosphere and biosphere are considered in the biosphere interaction matrix.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio26 Reactions

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.002 Alkali flats		Alkali flats may be formed in arid regions of the world. This climate conditions are not assumed to occur in Forsmark even at altered climate and thus this process is not necessary to consider in the safety assessment SR-Site.	
A 3.010 Biogas production	Heating needs may be met with biogas from biological reactors fuelled by plant materials, faeces and refuse, or from trapping natural methane from garbage disposal sites, bogs and sediments. These fuels may be contaminated with radionuclides leading to external exposure. External exposure is considered in the biosphere interaction matrix and included in the radionuclide model, but has limited importance for a few and non dominating radionuclides. The external dose is considered by all sources.		
A 3.020 Charcoal production	Charcoal production is considered in the biosphere interaction matrix. However, as the dose from charcoal production is considered to become insignificant in comparison to ingestion of contaminated food this process is not included in the radionuclide model.		
A 3.021 Chemical precipitation	Chemical precipitation influences the phase of elements and thereby transport of radionuclides. This is considered in the biosphere interaction matrix and in the radionuclide model.		
A 3.048 Fires (agricultural)	Fires are considered in the biosphere interaction matrix but they are not included in the radionuclide model. Although fires may give rise to high concentration in the atmosphere on a short time scale the contribution to dose on a 50 year perspective is assumed to be small.		
A 3.049 Fires (forest and grass)	Fires are considered in the biosphere interaction matrix but they are not included in the radionuclide model. Although fires may give rise to high concentration in the atmosphere on a short time scale the contribution to dose on a 50 year perspective is assumed to be small.		
A 3.102 Space heating	Space heating when burning contaminated materials such as trees may contribute to external exposure. External exposure is considered in the biosphere interaction matrix and included in the radionuclide model, but has limited importance for a few and non dominating radionuclides. The external dose is considered by all sources.		

SR-Site FEP Bio26 Reactions

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.104 Surface water pH	The surface water pH affects reactions, sorption of radionuclides etc. and may change over time due to landscape development processes. This is thoroughly discussed in site descriptions. The effects of changing pH transport of radionuclides are considered in the radionuclide model by the use of specific Kd values for till and organic soils/sediments. These Kd values are based on site measurements and thereby take into account different pH values as well as other important characteristics of regolith types that affect Kd. Surface water pH also affects other parameters such as biomass of biota and degassing, which is also accounted for by site-specific measurements.		
E GEN-31 Radionuclide reconcentration	Remobilisation of radionuclides due to changed conditions, due to shore-level displacement, bioturbation, ploughing is considered in the biosphere interaction matrix and in the radionuclide model.		
I 112a Fire (atmospheric dose pathway)	See NEA FEP 3.049.		
I 112b Denuding of the site	Denuding of the site may remove upper regolith and thereby affecting the dispersion of radionuclides. This is considered in the biosphere interaction matrix, landscape model and radionuclide model since we considered a glacial cycle thereby conditions when the ice has removed upper regolith layers. In addition, by modeling many objects, many different depths of regolith is considered.		
I 292 Surface water bodies (physical/chemical changes)	Physical and chemical changes of water bodies are considered in the biosphere interaction matrix and in the radionuclide model. For example, in the radionuclide model changes in chemistry is considered by use of different parameter sets for marine and limnic stages of the aquatic objects and physical changes are considered by use of time specific values of the geometry of the objects.		
K 8.28 Interface effects	Interactions between the geosphere and biosphere are considered in the biosphere interaction matrix.		

SR-Site FEP Bio26 Reactions

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 1.042 Chemical weathering	Chemical weathering has little effect on the overall erosion, Nevertheless, any effects of weathering on chemical composition of water and soil is assumed to be included in the site investigations since measurements are performed in situ and thereby including effects of weathering. Weathering is not assumed to change over time and thus this process does not have to be further explored in the models.		
W 2.071 Kinetics of organic complexation	Kinetics and organic complexation is considered in the biosphere interaction matrix and is also included in the radionuclide model, where Kd and CR-values used are based on site specific measurements thereby including the effect of organic complexation that occur *in situ*.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio27 Sorption/desorption

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.026 Colloids	Colloids are considered in the biosphere interaction matrix and in the radionuclide model. Particles suspended in water are included in the radionuclide model as these influence sorption/desorption and thereby transport and accumulation of radionuclides.		
A 3.072 Ion exchange in soil	Ion exchange in soils is considered in the biosphere interaction matrix and by the use of site specific properties of the regolith and Kd values in the radionuclide modeling.		
A 3.092 Sedimentation in water bodies	Sedimentation of radionuclides is dependent on the sorption/desorption of radionuclide to particles. This is considered in the biosphere interaction matrix and included in the radionuclide model as modeled sedimentation (in dry weight per area and year) and Kd values.		
A 3.098 Soil leaching	Soil leaching is considered in the biosphere interaction matrix and for agricultural land in the radionuclide model.		

SR-Site FEP Bio27 Sorption/desorption

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.099 Soil porewater pH	The pH affects reactions, sorption of radionuclides etc. The effects of changing pH on transport of radionuclides are considered in the radionuclide model by the use of specific Kd values for till and organic soils/sediments. These Kd values are based on site measurements and thereby take into account different pH values as well as other important characteristics of regolith types that affect transport of radionuclides in regolith.		
A 3.100 Soil sorption	Soil sorption is considered in both the biosphere interaction matrix and in the radionuclide model. Sorption to soils and sediments are estimated by the use of Kd values in the radionuclide model.		
E GEN-31 Radionuclide reconcentration	Remobilisation of radionuclides due to changed conditions, due to shore-level displacement, bioturbation, ploughing is considered in the biosphere interaction matrix and in the radionuclide model.		
H 4.2.6 Biogeochemical processes	Biogeochemical processes are included in the biosphere interaction matrix and radionuclide model.		
I 009 Sediments (in water bodies)	The sorption/desorption of radionuclides to particles is considered in the radionuclide model by Kd-values for different radionuclides. In additions, the transport of particles between the water column and the sediment is dependent on sedimentation/ resuspension processes which are also included in the radionuclide model.		
I 174 Ion exchanges in soil	See NEA FEP A 3.072.		
K 8.17 Radionuclide sorption	The sorption/desorption of radionuclides to particles and sediment is considered in the biosphere interaction matrix and included in the radionuclide model by Kd-values for different radionuclides.		
K 8.36 Suspended sediment transport	See NEA FEP A 3.026.		
M 1.6.07 Sorption	See NEA FEP K 8.17.		
W 2.071 Kinetics of organic complexation	Kinetics and organic complexation is considered in the biosphere interaction matrix and is also included in the radionuclide model, where Kd and CR-values used are based on site specific measurements thereby including the effect of organic complexation that occur *in situ*.		

Recorded by: Eva Andersson **Date:** Nov 2010
Checked and revised by: Kristina Skagius **Date:** Dec 2010

SR-Site FEP Bio28 Water supply

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.03 Borehole - well	The borehole may be used as a well. This is considered in the safety assessment.		
A 2.73 Wells	Wells are assumed to be utilised for drinking. The amount of water (water supply) is not assumed to limit the utilisation of water from the well but the amount used is based on the human demand.		
A 2.74 Wells (high-demand)	See NEA FEP A 2.73.		
A 3.073 Irrigation	Irrigation may increase radionuclide concentrations in crops and therefore irrigation has been included in the radionuclide model in the safety assessment.		
A 3.116 Water source	The source of water (lake, rivers well) for human utilisation (uptake by drinking and other water use) may have an influence on the exposure as different sources may have different concentrations of radionuclides. The utilisation of different sources (e.g. surface water or water extracted from wells) has been considered in the radionuclide model.		
H 4.3.1 Land and surface water use: Terrestrial	The land use is considered in the biosphere interaction matrix and in the radionuclide model.	Terrestrial areas are not used for water supply.	
H 4.3.3 Land and surface water use: Coastal waters	Use of coastal water is considered in the biosphere interaction matrix. Swimming is assumed to give insignificant dose compared to internal doses from ingestion and inhalation as is thus not included in the radionuclide model. Food production is included in the radionuclide model.		
H 4.3.4 Land and surface water use: Seas	Water supply is the supply of water for drinking and other purposes. Food supply from seas is considered in the biosphere interaction matrix and in the radionuclide model as fish production (treated as Bio02 Consumption). Drinking of sea water is not possible and other uses, such as shipping and sailing is not assumed to give any significant dose. Thus this is not considered in the radionuclide model.		See Bio02.
I 003 Animal diets (domestic and wild)	Animals drink water and are dependent on water supply, i.e. if no water is available there will be no animals. Animals in the model are assumed to utilise surface water for drinking and this is considered in the calculations of dose to biota and in concentration ratios of biota in the radionuclide transport model.		
I 175 Irrigation (dose pathway)	Same as NEA FEP A 3.073.		
J 5.36 Reuse of boreholes	Same as NEA FEP A 2.03.		
J 5.41 Water producing well	Same as NEA FEP A 2.73.		
K 8.33 Irrigation	Same as NEA FEP A 3.073.		

SR-Site FEP Bio28 Water supply

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 11.05 Deep groundwater abstraction	Same as NEA FEP A 2.03.		
M 2.4.04 Irrigation	Same as NEA FEP A 3.073.		
W 3.005 Groundwater exploitation	Same as NEA FEP A 2.03.		
W 3.040 Land use changes	Land use is considered in the biosphere interaction matrix, landscape development model and in the radionuclide model. Forsmark is situated in an area where there is shore-line development, i.e. new land is uplifted and new areas may be used for agriculture. Water extraction is considered in the model as use of well for irrigation. Mining and drilling is considered in supporting calculations.		
W 3.044 Irrigation	Same as NEA FEP A 3.073.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio29 Weathering

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.046 Erosion - lateral transport	Erosion is considered in the biosphere interaction matrix, landscape model and radionuclide model. Erosion leads to transport of sediments and soils. The extent of erosion has formed present topography and will form the future landscape.		
A 3.047 Erosion (wind)	Erosion is considered in the biosphere interaction matrix, landscape model and radionuclide model. Erosion leads to transport of sediments and soils. The extent of erosion has formed present topography and will form the future landscape.		
E GEN-29 Erosion and weathering	See NEA FEP A 3.047.		
I 305 Topography (changes)	Changes in topography and landscape development (e.g. transformation from lake to wetland) are considered in biosphere interaction matrix, site description, landscape model and radionuclide model.		
J 5.26 Erosion on surface/sediments	Erosion leads to transport of sediments and soils. In addition erosion may affect depths of the regolith layer which influence recharge and discharge. The extent of erosion has formed present topography which is included in the radionuclide model. For future landscape erosion is considered in the sediment, regolith, and radionuclide models.		

SR-Site FEP Bio29 Weathering

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 8.22 Erosion/deposition	See NEA FEP K 10.11.		
K 8.24 Soil formation	Soil formation is considered in the biosphere interaction matrix and included in the landscape model and radionuclide model.		
K 9.07 Erosion/denudation	See NEA FEPs A 3.046 and K 10.12.		
K 10.11 Fluvial erosion/sedimentation	Erosion and sedimentation is considered in the biosphere interaction matrix, sedimentation model, landscape model and in the radionuclide model.		
K 10.12 Surface denudation	Denuding of the site may remove upper regolith and thereby affecting the dispersion of radionuclides. This is considered in the biosphere interaction matrix, landscape model and radionuclide model since we considered a glacial cycle thereby conditions when the ice has removed upper regolith layers. In addition, by modeling many objects, many different depths of regolith is considered.		
K 10.14 Glacial erosion/sedimentation	See NEA FEP K 10.11.		
K 10.15 Glacial-fluvial erosion/sedimentation	Erosion and sedimentation is considered in the biosphere interaction matrix, landscape model and radionuclide model.		
M 1.4.02 Denudation	See NEA FEP K 10.12.		
M 1.4.08 Frost weathering and chemical denudation	Denuding of the site may remove upper regolith and thereby affecting the dispersion of radionuclides. This is considered in the biosphere interaction matrix, landscape model and radionuclide model since we considered a glacial cycle thereby conditions when the ice has removed upper regolith layers. In addition, by modeling many objects, many different depths of regolith is considered.		
W 1.041 Mechanical weathering	Erosion is considered in the biosphere interaction matrix.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio30 Wind stress

No NEA FEPs associated with this SR-Site FEP.

SR-Site FEP Bio31 Acceleration

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.023 Climate	Climate may have a large impact on transport of radionuclides, e.g. by altered precipitation and runoff patterns. This has been considered in supporting calculations for the radionuclide model in SR-Site where altered conditions have been applied for a periglacial climate.		
A 3.027 Convection, turbulence and diffusion (atmospheric)	Air-borne radionuclides may be directed, diluted and dispersed by convection, turbulence and diffusion. This is considered in the radionuclide model in SR-Site by dilution in atmosphere and by export from the local atmosphere above the ecosystems to global atmosphere.		
A 3.075 Lake mixing (artificial)	Artificial lake mixing (such as aeration and wave maker may affect contaminant concentrations in lakes by accelerating mixing of the water column or stirring up sediment particles) is considered in the biosphere interaction matrix. In the radionuclide model, dose is calculated on an annual basis and although the water column may be stratified in winter and/or summer it is completely mixed at least at two occasions each year, i.e. spring and autumn. Thus, artificial mixing is not specifically addressed in the radionuclide model since the water is already assumed to be completely mixed.		
W 3.042 Damming of streams or rivers	Dam constructions may influence hydraulic heads and may affect surface water flows. Dams are a form of thresholding which is included in the biosphere interaction matrix and in the radionuclide model.		
W 3.043 Reservoirs	Dam constructions may influence hydraulic heads and may affect surface water flows. Dams are a form of thresholding which is included in the biosphere interaction matrix and in the radionuclide model.		
W 3.045 Lake usage	Water use is the use of water for other purpose than drinking and is considered in the biosphere interaction matrix and radionuclide model. In the radionuclide model, irrigation is included whereas recreational purposes and industrial use are assumed to be insignificant compared to internal exposure due to ingestion, and also smaller than external exposure from terrestrial ground and therefore this is not further considered.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio32 Convection

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.17 Discharge zones	Discharge zones of groundwater and thereby discharge zones of radio-nuclides from a deep repository in Forsmark is thoroughly considered and included in hydrological modes and radionuclide model.		
A 3.017 Capillary rise in soil	The modelling of surface hydrology (SKB R-10-02) handles variably saturated flow, which means that the unsaturated zone and capillary rise are modelled. The sensitivity to plant uptake of solutes is also studied.		
A 3.023 Climate	Climate may have a large impact on transport of radionuclides, e.g. by altered precipitation and runoff patterns. This has been considered in supporting calculations for the radionuclide model in SR-Site where altered conditions have been applied for a periglacial climate.		
A 3.026 Colloids	Colloids in water, i.e. particulate matter, are considered in the biosphere interaction matrix and are included in the radionuclide model as these influence sorption/desorption and thereby transport and accumulation of radionuclides.		
A 3.027 Convection, turbulence and diffusion (atmospheric)	Air-borne radionuclides may be directed, diluted and dispersed by convection, turbulence and diffusion. This is considered in the radionuclide model in SR-Site by dilution in atmosphere and by export from the local atmosphere above the ecosystems to global atmosphere.		
A 3.042 Dispersion	Dispersion refers to the movement of radionuclides away from its source and includes advection, diffusion, water and air transport. These processes are considered in the biosphere interaction matrix and radionuclide model.		
A 3.052 Flooding	Flooding of terrestrial areas may lead to a transport of radionuclides from the water to terrestrial areas. This is considered in the biosphere interaction matrix and included in the radionuclide model by the use of a specific flooding coefficient.		
A 3.053 Flushing of water bodies	The retention time of water in aquatic water bodies is important for the accumulation and transport of radionuclides and is consequently included in the radionuclide models and considered in the biosphere interaction matrix.		
A 3.056 Gas leakage into basements	Gas leakage is considered in the biosphere interaction matrix, e.g. as exposure to radon.		

SR-Site FEP Bio32 Convection

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.075 Lake mixing (artificial)	Artificial lake mixing (such as aeration and wave maker may affect contaminant concentrations in lakes by accelerating mixing of the water column or stirring up sediment particles) is considered in the biosphere interaction matrix. In the radionuclide model, dose is calculated on an annual basis and although the water column may be stratified in winter and/or summer it is completely mixed at least at two occasions each year, i.e. spring and autumn. Thus, artificial mixing is not specifically addressed in the radionuclide model since the water is already assumed to be completely mixed.		
A 3.084 Radon emission	Radon emission is considered in the biosphere interaction matrix.		
A 3.087 Runoff	Runoff is important for the convection of radionuclides and water balances. Runoff is included in the hydrological models and water balances and which are used for the radionuclide model. This FEP is also considered in the biosphere interaction matrix.		
A 3.090 Seasons	Seasons are considered in the biosphere interaction matrix. In the radionuclide model, annual mean values are used for parameterization. These values are based on site specific measurements considering seasonal variations.		
A 3.097 Soil depth	Soil depth is important for the retention and transport of radionuclides in the regolith. The depth of different regolith layers, including the upper soils is included in the radionuclide model.		
A 3.098 Soil leaching	Soil leaching is considered in the biosphere interaction matrix and for agricultural land in the radionuclide model.		
A 3.101 Soil type	Soil type, e.g. porosity and pH have a large influence on the mobility of radionuclides in the soil. Properties (density, porosity) of different regolith layers are included in the radionuclide model.		
A 3.103 Surface water bodies	Surface water is a diagonal element in the biosphere interaction matrix and influences other diagonal elements by processes such as convection, uptake, sorption/desorption, etc. Surface water bodies are considered in several areas of the safety assessment and are included in the radionuclide model as marine basins, lakes and streams.		

SR-Site FEP Bio32 Convection

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.105 Suspension in air	Water and soils may be suspended in air and thereby become suspended or gaseous particles in the air. Processes involved are degassing, erosion, plowing and irrigation. These processes are considered in the biosphere interaction matrix and included in the radionuclide model.		
A 3.108 Terrestrial surface	The type of terrestrial area, forest, outcrops, grasslands are important for the transport and accumulation of radionuclides. A Quaternary regolith model are used to predict the type of future landscape at Forsmark and the occurrence of wetlands and forest are mapped over time for the entire model area which is included in the radionuclide model.		
A 3.117 Wetlands	Wetlands may be used in several ways; they may be used for wild berries and game, they may be drained and used for agricultural sources, and peat from wetlands may be utilized for fuel and as building material. Wetlands are considered in the biosphere interaction matrix and are included in the radionuclide model where occurrence, sizes, and peat depths of wetlands in the model area is included.		
A 3.118 Wind	Wind affects the transport of radionuclides by affecting soil erosion, degassing and dilution and transport of radionuclide by wind. Accordingly, wind speed is considered in the biosphere interaction matrix and included in several parts of the radionuclide model and parameterisation.		
E GEN-33 Sea level changes	Sea level changes are considered in the biosphere interaction matrix and in the landscape development model. At the start of the modeling of the Forsmark landscape the entire area is situated below sea level and at the end of the modeling period the entire area is situated above sea level.		
H 2.2.1 Changes in geometry and driving forces of the flow system	Changes in geometry changes the flow pattern. This is considered in the safety assessment where shoreline displacement is included and flow to different objects is calculated for each time step in the radionuclide model.		
H 4.1.1 Groundwater discharge to soils and surface waters	The location of discharge of radionuclides is central in the safety assessment and is considered in hydrological models, landscape model, biosphere interaction matrix and radionuclide model.		
H 4.2.2 Surface water mixing	The surface mixing is considered in the biosphere interaction matrix. In the radionuclide model, water is assumed to be mixed since on the time scale of the model (i.e. 1 year) the water column will be mixed at least twice (during spring an autumn).		

SR-Site FEP Bio32 Convection

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 069 Atmospheric pathways (dispersion)	Atmospheric pathways include direction of radionuclides, dilution, dispersion and contamination of vegetation, soil and water. All these are considered as in the radionuclide model; radionuclides entering the atmosphere are diluted in the atmospheric layer above and some is exported due to wind, Gas uptake by water and primary producers are also considered.		
I 116 Flushing of water bodies	See NEA FEP A 3.053.		
I 128 Gas leakage into basements	See NEA FEP A 3.056.		
I 143 Groundwater (redirection of)	Effects on hydrology of changes in topography and regolith stratigraphy are addressed in the hydrological modelling (SKB report R-10-02). Redirection of flow under permafrost and glacial conditions are considered in the hydrogeological modelling (R-09-20, R-09-21, R-10-02). Redirection of flow due to pumping in wells is handled separately in the radionuclide assessment based on cautious assumptions. The reduced contaminant input to the biosphere objects that result from pumping in wells is not taken into account (also cautious).		
I 180 Surface water bodies (non-uniform mixing of)	Stratification, i.e. the opposite of mixing, may occur in summer and winter. This is considered in the biosphere interaction matrix and is reflected in site investigations were samples are taken from multiple depths. In the radionuclide model, the long term-average concentrations are assumed to be better represented by assuming a mixed water column.		
I 258 Surface runoff	See NEA FEP A 3.087.		
J 5.26 Erosion on surface/sediments	Erosion leads to transport of sediments and soils. In addition erosion may affect depths of the regolith layer which influence recharge and discharge. The extent of erosion has formed present topography which is included in the radionuclide model. For future landscape erosion is considered in the the sediment, regolith, and radionuclide models.		
J 5.27 Human induced actions on groundwater recharge	Human induced changes in land use that affect recharge are not considered in the hydrological modelling. Contamination through irrigation is considered in the dose calculations, but not as recharge in the flow modelling.		

SR-Site FEP Bio32 Convection

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 5.41 Water producing well	Wells are assumed to be utilised for drinking in the biosphere interaction matrix and in the radionuclide model. The amount of water (water supply) is not assumed to limit the utilisation of water from the well but the amount used is based on the human demand.		
J 7.05 Isotopic dilution	Dilution of radionuclides with stable elements are considered in the modeling in SR-Site- e.g. it is considered in the uptake of plants where C-14 is diluted with naturally occurring C-12.		
K 8.03 Exfiltration to a local aquifer	The whole system is modelled in the hydrological modelling of the biosphere, including surface water and shallow and deep aquifers and this FEP is considered in the hydrological model, radionuclide model and interaction matrix.		
K 8.04 Exfiltration to surface waters	Exfiltration is considered in supporting calculations to the radionuclide model. These calculations were done in order to understand the effect of the regolith as a barrier for the repository. In these calculations, the regolith has been excluded (i.e. exfiltration) and thus this process is considered although it is highly unlikely to occur in Forsmark.		
K 8.21 Dilution of radionuclides in surface water (aquifer, river, lake etc.)	The dilution of radionuclides in water bodies is considered in the biosphere interaction matrix and in the radionuclide model where the radionuclide release is assumed to become completely mixed within the receiving water bodies.		
K 8.27 Atmosphere	The atmosphere is considered in the biosphere interaction matrix and in the radionuclide model. Exposure from atmosphere is considered in the radionuclide model e.g. as inhalation of dust		Belongs to CompBio12. See also Bio42 Exposure.
K 8.29 Precipitation	Precipitation is considered in SR-Site in hydrological models and water balances that are used to derive input parameters to the radionuclide model.		
K 8.30 Evapotranspiration	Evapotranspiration is included in the hydrological modelling. Water balance results from the hydrological modelling are used in the radio-nuclide model. Evapotranspiration is also considered in the biosphere interaction matrix.		
K 8.31 Capillary rise	See NEA FEP A 3.017.		
K 8.32 Percolation	The downward flux of water and elements in soils are considered in the biosphere interaction matrix and in the radionuclide model.		
K 8.34 Surface run-off	Surface water runoff is considered in the biosphere interaction matrix and is included I hydrological models and radionuclide model.		

SR-Site FEP Bio32 Convection

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 8.36 Suspended sediment transport	Colloids are considered in the biosphere interaction matrix and in the radionuclide model. Particles suspended in water are included in the radionuclide model as these influence sorption/desorption and thereby transport and accumulation of radionuclides.		
K 10.02 Effective moisture (recharge)	In the surface hydrology modelling, meteorological input is used and evapotranspiration processes are quantified explicitly by the model.		
M 1.3.02 Extremes of precipitation, snow melt, and associated	Flooding which is caused by extremes in snowmelt or precipitation is considered in the biosphere interaction matrix, hydrological models and in the radionuclide model.		
M 1.3.03 Coastal surge, storms and hurricanes		Coastal storms and hurricanes are not assumed to have any large effect on the transport or accumulation of radionuclides. In the marine stage, radio-nuclides are mainly diluted due to short retention time of water.	
M 1.4.05 Freshwater sediment transport and deposition	Sediment transport and deposition is included as in several aspects of SR-site, e.g. the radionuclide model (Sediment and resuspension parameters), the sediment model describing infilling of marine basins and lakes with time, and ecosystem mass balances.		
M 1.4.06 Coastal erosion and estuarine development	Erosion in marine basins are considered in SR-Site in the modeling of future development of marine basins (e.g. distribution of accumulation and erosion bottoms are described).		
M 1.5.01 River flow and lake level changes	Changes in river flows and lake levels are considered in the biosphere interaction matrix and included in the radionuclide model as future object have different sizes of catchment areas (thereby different amounts of water passing). Moreover, terrestrialisation affects lake depths and lake levels. Changes in lake levels and sea levels are also considered in the transition from marine basins to lakes.		
M 1.5.02 Site flooding	Flooding of terrestrial areas may lead to a transport of radionuclides from the water to terrestrial areas. This is considered in the biosphere interaction matrix and included in the radionuclide model by the use of a specific flooding coefficient.		
M 1.5.03 Recharge to ground water	Recharge is included in the hydrological modelling and radionuclide model.		
M 1.5.04 Ground water discharge	Discharge is included in the hydrological modelling and radionuclide model.		

SR-Site FEP Bio32 Convection

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
M 1.6.02 Diffusion	Diffusion is considered in advection-dispersion simulations of the surface/near-surface system (SKB R-10-02).		
M 2.4.03 River rechannelling	River erosion and channel erosion is considered in the biosphere interaction matrix and in the radio-nuclide model. At the site the regolith consists of till and rivers are small, which gives a low potential for any substantial river erosion of the river banks are expected. In the radio-nuclide model no long-term accumulation is assumed to occur in streams and thereby the annual sedimentated material is assumed to be resuspended (eroded) and transported downstream, i.e. the sizes of the rivers are assumed to remain throughout the modelling time period.		
M 2.4.10 Qurries, near surface extraction	Extraction from quarries may give rise to external exposure. External exposure is considered in the biosphere interaction matrix and in SR-Site modeling. The external dose is considered by all sources.		
S 087 Surface water chemistry	Surface water chemistry is considered in the biosphere interaction matrix, site descriptions, and in the radionuclide model where site specific water chemistry characteristics are considered.		
W 1.051 Stream and river flow	Flows in streams and rivers are included in the radionuclide model in the safety assessment. It is also considered in the biosphere interaction matrix.		
W 1.057 Lake formation	Lake formation under present and future conditions is considered in the biosphere interaction matrix, the hydrological modelling, landscape development model and radionuclide model.		
W 1.058 River flooding	See NEA FEP M 1.5.02.		
W 1.059 Precipitation (for example, rainfall)	See NEA FEP K 8.29.		
W 1.060 Temperature	Temperature affects convection by e.g. influencing the amount and form of precipitation. Temperature is included in calculation of parameters from several disciplines affecting radionuclide transport of SR-Site.		
W 1.067 Marine sediment transport and deposition	Sediment transport and deposition in marine basins is considered in the biosphere interaction matrix and included in the radionuclide model and in the model describing development of the landscape in Forsmark.		

SR-Site FEP Bio32 Convection

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 3.044 Irrigation	Irrigation may increase radionuclide concentrations in crops and therefore irrigation is considered in the biosphere interaction matrix and included in the radionuclide model.		
W 3.045 Lake usage	Water use is the use of water for other purpose than drinking and is considered in the biosphere interaction matrix and radionuclide model. In the radionuclide model, irrigation is included whereas recreational purposes and industrial use are assumed to be insignificant compared to internal exposure due to ingestion, and also smaller than external exposure from terrestrial ground and therefore this is not further considered.		
W 3.050 Coastal water use	Water use is the use of water for other purpose than drinking and is considered in the biosphere interaction matrix. Coastal waters are available for recreational utilisation, and industrial uses. Although this may pose exposure to humans it is assumed to be insignificant compared to internal exposure due to ingestion, and also smaller than external exposure from terrestrial ground and therefore this is not further considered in the radionuclide model.		
W 3.051 Sea water use	Water use is the use of water for other purpose than drinking and is considered in the biosphere interaction matrix. Sea waters are available for recreational utilisation, shipping etc. Although this may pose exposure to humans it is assumed to be insignificant compared to internal exposure due to ingestion, and also smaller than external exposure from terrestrial ground and therefore this is not further considered in the radionuclide model.		
W 3.053 Arable farming	Human affecting the environment through farming is considered in the biosphere interaction matrix. Farming is also considered in the radionuclide model.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio33 Covering

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 3.045 Lake usage	Water use is the use of water for other purpose than drinking and is considered in the biosphere interaction matrix and radionuclide model. In the radionuclide model, irrigation is included whereas recreational purposes and industrial use are assumed to be insignificant compared to internal exposure due to ingestion, and also smaller than external exposure from terrestrial ground and therefore this is not further considered.		
W 3.050 Coastal water use	Water use is the use of water for other purpose than drinking and is considered in the biosphere interaction matrix. Coastal waters are available for recreational utilisation, and industrial uses. Although this may pose exposure to humans it is assumed to be insignificant compared to internal exposure due to ingestion, and also smaller than external exposure from terrestrial ground and therefore this is not further considered in the radionuclide model.		
W 3.051 Sea water use	Water use is the use of water for other purpose than drinking and is considered in the biosphere interaction matrix. Sea waters are available for recreational utilisation, shipping etc. Although this may pose exposure to humans it is assumed to be insignificant compared to internal exposure due to ingestion, and also smaller than external exposure from terrestrial ground and therefore this is not further considered in the radionuclide model.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio34 Deposition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.023 Climate	Climate may have a large impact on transport of radionuclides, e.g. by altered precipitation and runoff patterns. This has been considered in supporting calculations for the radionuclide model in SR-site where altered conditions have been applied for a periglacial climate.		
A 3.026 Colloids	Colloids in water, i.e. particulate matter is considered in the biosphere interaction matrix and included in the radionuclide model as these influence sorption/desorption and thereby transport and accumulation of radionuclides.		
A 3.039 Deposition (wet and dry)	Deposition is considered in the biosphere interaction matrix and precipitation is included in the hydrological water balances that are used in the radionuclide model.		

SR-Site FEP Bio34 Deposition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.063 Household dust and fumes	Inhalation of contaminated soil dust is included as an exposure pathway and thus volatilisation/aerosol/dust is included in the assessment. Gases and aerosols are considered as a source dissolved in water in the biosphere assessment, with the exception of the gas release scenario. Re-volatilisation is considered in the matrix and models.		
A 3.074 Lake infilling	Lake infilling is considered in the biosphere interaction matrix, sedimentation model, landscape model and radionuclide model where lakes are gradually in-filled due to succession.		
A 3.081 Precipitation (meteoric)	See NEA FEP A 3.039.		
A 3.086 Rivercourse meander	River meandering may result in agriculture on former stream beds. River meandering is not considered in SR-Site but the result would be similar to agricultural use of former lake beds (which is included in the radionuclide model) and thus the effect of this process is considered.		
A 3.088 Saltation	Saltation is considered in the biosphere interaction matrix and also in the radionuclide model where dust particles are included.		
A 3.091 Sediment resuspension in water bodies	Resuspension is considered in the biosphere interaction matrix and included in the radionuclide model.		
A 3.092 Sedimentation in water bodies	Sedimentation of radionuclides is dependent on the sorption/desorption of radionuclide to particles. This is considered in the biosphere interaction matrix and included in the radionuclide model as modeled sedimentation (in dry weight per area and year) and Kd values.		
A 3.104 Surface water pH	The surface water pH affects reactions, sorption of radionuclides etc. and may change over time due to landscape development processes. This is thoroughly discussed in site descriptions. The effects of changing pH transport of radionuclides are considered in the radionuclide model by the use of specific Kd values for till and organic soils/sediments. These Kd values are based on site measurements and thereby take into account different pH values as well as other important characteristics of regolith types that affect Kd. Surface water pH also affects other parameters such as biomass of biota and degassing, which is also accounted for by site-specific measurements.		
A 3.105 Suspension in air	One pathway for radionuclides from soil and water to become part of the air is by degassing. This is considered in the biosphere interaction matrix and included in the radionuclide model.		

SR-Site FEP Bio34 Deposition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 4.2.4 Sediment/water/gas interaction with the atmosphere	Exchange over the air-water interface is considered in the biosphere interaction matrix and the exchange of 14-C is included in the radionuclide model.		
I 009 Sediments (in water bodies)	The sorption/desorption of radionuclides to particles is considered in the radionuclide model by Kd-values for different radionuclides. In additions, the transport of particles between the water column and the sediment is dependent on sedimentation/ resuspension processes which are also included in the radionuclide model.		
I 069 Atmospheric pathways (dispersion)	Atmospheric pathways include direction of radionuclides, dilution, dispersion and contamination of vegetation, soil and water. All these are considered as in the radionuclide model; radionuclides entering the atmosphere are diluted in the atmospheric layer above and some is exported due to wind, Gas uptake by water and primary producers are also considered.		
I 112b Denuding of the site	Denuding of the site may remove upper regolith and thereby affecting the dispersion of radionuclides. This is considered in the biosphere interaction matrix, landscape model and radionuclide model since we considered a glacial cycle thereby conditions when the ice has removed upper regolith layers. In addition, by modeling many objects, many different depths of regolith is considered.		
I 115 Flooding (localized, short-term surface flooding)	Flooding of terrestrial areas may lead to a transport of radionuclides from the water to terrestrial areas. This is considered in the biosphere interaction matrix and included in the radionuclide model by the use of a specific flooding coefficient.		
I 235 Precipitation (wet deposition)	See NEA FEP A 3.039.		
I 292 Surface water bodies (physical/chemical changes)	Physical and chemical changes of water bodies are considered in the biosphere interaction matrix and in the radionuclide model. For example, in the radionuclide model changes in chemistry is considered by use of different parameter sets for marine and limnic stages of the aquatic objects and physical changes are considered by use of time specific values of the geometry of the objects.		
J 5.26 Erosion on surface/sediments	Erosion leads to transport of sediments and soils. In addition erosion may affect depths of the regolith layer which influence recharge and discharge. The extent of erosion has formed present topography which is included in the radionuclide model. For future landscape erosion is considered in the sediment, regolith, and radionuclide models.		
J 6.09 River meandering	See NEA FEP A 3.086.		

SR-Site FEP Bio34 Deposition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 8.05 Radionuclide accumulation in sediments	Radionuclide accumulation in sediments is considered in both the biosphere interaction matrix and in the radionuclide model. Deposited material may accumulate in soils and organic debris. This is considered in the radionuclide model both as deposition and permanent accumulation.		
K 8.06 Radionuclide accumulation in soils	Radionuclide accumulation in soils is considered in both the biosphere interaction matrix and in the radionuclide model. Deposited material may accumulate in soils and organic debris. This is considered in the radionuclide model both as deposition and permanent accumulation.		
K 8.09 Uptake by crops	Uptake by crops of radionuclides via water is considered in the biosphere interaction matrix and is also included in the radionuclide model by the use of concentration rations that take into account the radionuclide concentration in water.		
K 8.22 Erosion/deposition	See NEA FEP K 10.11.		
K 8.23 Sedimentation	Sedimentation is considered in the biosphere interaction matrix, landscape model and radionuclide model.		
K 8.24 Soil formation	Soil formation is considered in the biosphere interaction matrix and included in the landscape model and radionuclide model.		
K 8.29 Precipitation	Precipitation is considered in SR-Site in hydrological models and water balances that are used to derive input parameters to the radionuclide model.		
K 10.11 Fluvial erosion/sedimentation	Erosion and sedimentation is considered in the biosphere interaction matrix, sedimentation model, landscape model and in the radionuclide model.		
K 10.12 Surface denudation	Denuding of the site may remove upper regolith and thereby affecting the dispersion of radionuclides. This is considered in the biosphere interaction matrix, landscape model and radio-nuclide model since we considered a glacial cycle thereby conditions when the ice has removed upper regolith layers. In addition, by modeling many objects, many different depths of regolith is considered.		
K 10.14 Glacial erosion/sedimentation	See NEA FEP K 10.11.		
K 10.15 Glacial-fluvial erosion/sedimentation	See NEA FEP K 10.11.		
M 1.3.02 Extremes of precipitation, snow melt, and associated	Flooding which is caused by extremes in snowmelt or precipitation is considered in the biosphere interaction matrix, hydrological models, and in the radionuclide model.		
M 1.4.02 Denudation	See NEA FEP K 10.12.		

SR-Site FEP Bio34 Deposition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
M 1.4.03 River, stream, channel erosion	River erosion and channel erosion is considered in the biosphere interaction matrix and in the radionuclide model. At the site the regolith consists of till and rivers are relatively small, which gives a low potential for any substantial river erosion of the river banks are expected. In the radionuclide model no long-term accumulation is assumed to occur in streams and thereby the annual sedimentated material is assumed to be resuspended (eroded) and transported downstream, i.e. the sizes of the rivers are assumed to remain throughout the modeling time period.		
M 1.4.04 River meandering	See NEA FEP A 3.086.		
M 1.4.05 Freshwater sediment transport and deposition	Sediment transport and deposition is included as in several aspects of SR-Site, e.g. the radionuclide model (Sediment and resuspension parameters), the sediment model describing infilling of marine basins and lakes with time, and ecosystem mass balances.		
M 1.4.06 Coastal erosion and estuarine development	Erosion in marine basins are considered in SR-Site in the modelling of future development of marine basins (e.g. distribution of accumulation and erosion bottoms are described).		
M 1.4.07 Marine sediment transport and deposition	See NEA FEP K 10.11.		
M 1.5.01 River flow and lake level changes	Changes in river flows and lake levels are considered in the biosphere interaction matrix and included in the radionuclide model as future object have different sizes of catchment areas (thereby different amounts of water passing). Moreover, terrestrialisation affects lake depths and lake levels. Changes in lake levels and sea levels are also considered in the transition from marine basins to lakes.		
M 1.6.12 Accumulation in soils and organic debris	Deposited material may accumulate in soils and organic debris. This is considered in the biosphere interaction matrix and in the radionuclide model.		
M 2.4.03 River rechannelling	River erosion and channel erosion is considered in the biosphere interaction matrix and in the radionuclide model. At the site the regolith consists of till and rivers are small, which gives a low potential for any substantial river erosion of the river banks are expected. In the radionuclide model no long-term accumulation is assumed to occur in streams and thereby the annual sedimentated material is assumed to be resuspended (eroded) and transported downstream, i.e. the sizes of the rivers are assumed to remain throughout the modeling time period.		

SR-Site FEP Bio34 Deposition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 1.043 Aeolian erosion	Erosion is considered in the biosphere interaction matrix, landscape model and radionuclide model. Erosion leads to transport of sediments and soils. The extent of erosion has formed present topography and will form the future landscape.		
W 1.044 Fluvial erosion	See NEA FEP K 10.11.		
W 1.046 Aeolian deposition	See NEA FEP A 3.039.		
W 1.047 Fluvial deposition	See NEA FEP A 3.092.		
W 1.048 Lacustrine deposition	See NEA FEP A 3.092.		
W 1.058 River flooding	Flooding of terrestrial areas may lead to a transport of radionuclides from the water to terrestrial areas. This is considered in the radionuclide model by the use of a specific flooding coefficient.		
W 1.059 Precipitation (for example, rainfall)	Precipitation is considered in SR-Site in hydrological models and water balances.		
W 1.066 Coastal erosion	See NEA FEP M 1.4.06.		
W 1.067 Marine sediment transport and deposition	Sediment transport and deposition in marine basins is considered in the biosphere interaction matrix and included in the radionuclide model and in the model describing development of the landscape in Forsmark.		
W 2.103 Accumulation in soil	Deposited material may accumulate in soils and organic debris. This is considered in the biosphere interaction matrix and in the radionuclide model both as deposition and permanent accumulation.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio35 Export

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 8.41 Hunter/gathering lifestyle	Gathering life style is considered in the biosphere interaction matrix. In the radionuclide model, gathering of food is only considered within biosphere objects and neither humans nor food are exported out from the model area. This is a cautious assumption since gathering life style would most likely dilute dose to humans due to humans gathering food from a larger area than the contaminated biosphere objects.		
K 8.43 Removal mechanisms	Removal mechanisms are considered in the biosphere interaction matrix and radionuclide model. In the radionuclides model, export is considered as transport of dissolved and particulate matter in water flow out from objects.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio36 Import

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 8.41 Hunter/gathering lifestyle	Gathering life style is considered in the biosphere interaction matrix. In the radionuclide model, gathering of food is only considered within biosphere objects and neither humans nor food are exported out from the model area. This is a cautious assumption since gathering life style would most likely dilute dose to humans due to humans gathering food from a larger area than the contaminated biosphere objects.		
K 8.44 Consumption of uncontaminated products	Consumption of all available sources is considered in the biosphere interaction matrix. The food supply in the radionuclide model is cautiously considered to be derived exclusively from the model area, i.e. being contaminated with radionuclides.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio37 Interception

No NEA FEPs associated with this SR-Site FEP.

SR-Site FEP Bio38 Relocation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.14 Dams	Dam constructions may influence hydraulic heads and may affect surface water flows. Dams are a form of thresholding which is included in the biosphere interaction matrix, landscape development model, and in the radionuclide model.		
A 3.042 Dispersion	Dispersion refers to the movement of radionuclides away from its source and includes advection, diffusion, water and air transport. These processes are considered in the biosphere interaction matrix and radionuclide model.		
A 3.046 Erosion - lateral transport	Erosion is considered in the biosphere interaction matrix, landscape model and radionuclide model. Erosion leads to transport of sediments and soils. The extent of erosion has formed present topography and will form the future landscape.		
A 3.047 Erosion (wind)	Erosion is considered in the biosphere interaction matrix, landscape model and radionuclide model. Erosion leads to transport of sediments and soils. The extent of erosion has formed present topography and will form the future landscape.		
A 3.052 Flooding	Flooding of terrestrial areas may lead to a transport of radionuclides from the water to terrestrial areas. This is considered in the biosphere interaction matrix and included in the radionuclide model by the use of a specific flooding coefficient.		

SR-Site FEP Bio38 Relocation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.058 Greenhouse food production	Green house food production may influence the location of radionuclides if irrigation is performed. Irrigation may increase radionuclide concentrations in crops and therefore irrigation is considered in the biosphere interaction matrix and included in the radionuclide model.		
A 3.074 Lake infilling	Lake infilling is considered in the biosphere interaction matrix, sedimentation model, landscape model and radionuclide model where lakes are gradually in-filled due to succession.		
A 3.092 Sedimentation in water bodies	Sedimentation of radionuclides is dependent on the sorption/desorption of radionuclide to particles. This is considered in the biosphere interaction matrix and included in the radionuclide model as modeled sedimentation (in dry weight per area and year) and Kd values.		
A 3.105 Suspension in air	One pathway for radionuclides from soil and water to become part of the air is by degassing. This is considered in the biosphere interaction matrix and included in the radionuclide model.		
A 3.108 Terrestrial surface	The type of terrestrial area, forest, outcrops, grasslands are important for the transport and accumulation of radionuclides. A Quaternary regolith model are used to predict the type of future landscape at Forsmark and the occurrence of wetlands and forest are mapped over time for the entire model area which is included in the radionuclide model.		
A 3.118 Wind	Wind affects the transport of radionuclides by affecting soil erosion, degassing and dilution and transport of radionuclide by wind. Accordingly, wind speed is considered in the biosphere interaction matrix and included in several parts of the radionuclide model and parameterisation.		
E GEN-29 Erosion and weathering	See NEA FEP A 3.046.		
H 2.2.1 Changes in geometry and driving forces of the flow system	Changes in geometry changes the flow pattern. This is considered in the safety assessment where shoreline displacement is included and flow to different objects is calculated for each time step in the radionuclide model.		
H 2.4.1 Generalised denudation	Denuding of the site may remove upper regolith and thereby affecting the dispersion of radionuclides. This is considered in the biosphere interaction matrix, landscape model and radionuclide model since we considered a glacial cycle thereby conditions when the ice has removed upper regolith layers. In addition, by modelling many objects, many different depths of regolith is considered.		
H 2.4.2 Localised denudation	See NEA FEP H 2.4.1.		
H 4.1.2 Solid discharge via erosional processes	See NEA FEPs A 3.046 and H 2.4.1.		

SR-Site FEP Bio38 Relocation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 4.2.3 Sediment transport including bioturbation	Transport of elements including bioturbation is considered in the biosphere interaction matrix and included in the radionuclide model where processes such as resuspension and deposition are parameterised.		
I 085a Dams (filling, draining)	Dam constructions may influence hydraulic heads and may affect surface water flows. Dams are a form of thresholding which is included in the biosphere interaction matrix, landscape development models and in the radionuclide model.		
I 112b Denuding of the site	Denuding of the site may remove upper regolith and thereby affecting the dispersion of radionuclides. This is considered in the biosphere interaction matrix, landscape model and radionuclide model since we considered a glacial cycle thereby conditions when the ice has removed upper regolith layers. In addition, by modelling many objects, many different depths of regolith is considered.		
I 292 Surface water bodies (physical/chemical changes)	Physical and chemical changes of water bodies are considered in the biosphere interaction matrix and in the radionuclide model. For example, in the radionuclide model changes in chemistry is considered by use of different parameter sets for marine and limnic stages of the aquatic objects and physical changes are considered by use of time specific values of the geometry of the objects.		
I 305 Topography (changes)	Changes in topography and landscape development (e.g. transformation from lake to wetland) are considered in biosphere interaction matrix, site description, landscape model and radionuclide model.		
J 5.26 Erosion on surface/sediments	See NEA FEP A 3.046.		
J 5.27 Human induced actions on groundwater recharge	Human induced changes in land use that affect recharge are not considered in the hydrological modelling. Contamination through irrigation is considered in the dose calculations, but not as recharge in the flow modelling.		
K 8.22 Erosion/deposition	See NEA FEPs A 3.046 and A 3.092.		
K 8.38 Ploughing	Ploughing is considered in the biosphere interaction matrix and in the radionuclide model where ploughing depth is included in the calculations.		
K 9.07 Erosion/denudation	Erosion is considered in the biosphere interaction matrix, landscape model and radionuclide model.		
K 10.11 Fluvial erosion/sedimentation	See NEA FEP A 3.046.		

SR-Site FEP Bio38 Relocation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 10.12 Surface denudation	Denuding of the site may remove upper regolith and thereby affecting the dispersion of radionuclides. This is considered in the biosphere interaction matrix, landscape model and radionuclide model since we considered a glacial cycle thereby conditions when the ice has removed upper regolith layers. In addition, by modeling many objects, many different depths of regolith is considered.		
K 10.14 Glacial erosion/sedimentation	See NEA FEP A 3.046.		
K 10.15 Glacial-fluvial erosion/sedimentation	See NEA FEPs A 3.046 and A 3.092.		
M 1.4.01 Land slide	All kind of relocation of regolith is considered in the biosphere interaction matrix. However, land-slides are assumed to not occur in the Forsmark area and this process is thus not included in the radionuclide model.		
M 1.4.02 Denudation	See NEA FEP K 10.12.		
M 1.4.03 River, stream, channel erosion	River erosion and channel erosion is considered in the biosphere interaction matrix and in the radionuclide model. At the site the regolith consists of till and rivers are relatively small, which gives a low potential for any substantial river erosion of the river banks are expected. In the radionuclide model no long-term accumulation is assumed to occur in streams and thereby the annual sedimentated material is assumed to be resuspended (eroded) and transported downstream, i.e. the sizes of the rivers are assumed to remain throughout the modeling time period.		
M 1.4.07 Marine sediment transport and deposition	See NEA FEPs A 3.046 and A 3.092.		
M 2.4.03 River rechannelling	See NEA FEP M 1.4.03.		
M 2.4.10 Qurries, near surface extraction	Extraction from quarries may give rise to external exposure. External exposure is considered in the biosphere interaction matrix and in SR-Site modelling. The external dose is considered by all sources.		
W 1.043 Aeolian erosion	See NEA FEP A 3.047.		
W 1.044 Fluvial erosion	See NEA FEP A 3.046.		
W 1.045 Mass wasting	Mass wasting (the downslope movement of material caused by the direct effect of gravity) is important only in terms of sediment erosion in regions of steep slopes. Erosion and subsequent deposition of material is considered in the biosphere interaction matrix and in the radionuclide model.		
W 1.049 Mass wasting	See NEA FEP W 1.045.		
W 1.066 Coastal erosion	See NEA FEP A 3.046.		

SR-Site FEP Bio38 Relocation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 3.050 Coastal water use	Water use is the use of water for other purpose than drinking and is considered in the biosphere interaction matrix. Coastal waters are available for recreational utilisation, and industrial uses. Although this may pose exposure to humans it is assumed to be insignificant compared to internal exposure due to ingestion, and also smaller than external exposure from terrestrial ground and therefore this is not further considered in the radionuclide model.		
W 3.051 Sea water use	Water use is the use of water for other purpose than drinking and is considered in the biosphere interaction matrix. Sea waters are available for recreational utilisation, shipping etc. Although this may pose exposure to humans it is assumed to be insignificant compared to internal exposure due to ingestion, and also smaller than external exposure from terrestrial ground and therefore this is not further considered in the radionuclide model.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio39 Resuspension

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.026 Colloids	Colloids in water, i.e. particulate matter is considered in the biosphere interaction matrix and included in the radionuclide model as these influence sorption/desorption and thereby transport and accumulation of radionuclides.		
A 3.029 Critical group - agricultural labour	Inhalation of dust by farmers is considered in the safety assessment by including inhalation of dust.		
A 3.042 Dispersion	Dispersion refers to the movement of radionuclides away from its source and includes advection, diffusion, water and air transport. These processes are considered in the biosphere interaction matrix and radionuclide model.		
A 3.046 Erosion - lateral transport	Erosion is considered in the biosphere interaction matrix, landscape model and radionuclide model. Erosion leads to transport of sediments and soils. The extent of erosion has formed present topography and will form the future landscape.		
A 3.047 Erosion (wind)	Erosion is considered in the biosphere interaction matrix, landscape model and radionuclide model. Erosion leads to transport of sediments and soils. The extent of erosion has formed present topography and will form the future landscape.		

SR-Site FEP Bio39 Resuspension

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.063 Household dust and fumes	Inhalation of contaminated dust and fumes s included as an exposure pathway and thus volatilisation/aerosol/dust is included in the assessment. Gases and aerosols are considered as a source dissolved in water in the biosphere assessment, with the exception of the gas release scenario. Re-volatilisation is considered in the matrix and models.		
A 3.077 Outdoor spraying of water	Water and dust intake is handled in the biosphere interaction matrix and radionuclide model.		
A 3.086 Rivercourse meander	River meandering may result in agriculture on former stream beds. River meandering is not considered in SR-Site but the result would be similar to agricultural use of former lake beds (which is included in the radionuclide model) and thus the effect of this process is considered.		
A 3.088 Saltation	Saltation is considered in the biosphere interaction matrix and also in the radionuclide model where dust particles are included.		
A 3.091 Sediment resuspension in water bodies	Resuspension is considered in the biosphere interaction matrix and included in the sediment model and radionuclide model.		
A 3.092 Sedimentation in water bodies	Sedimentation of radionuclides is dependent on the sorption/desorption of radionuclide to particles. This is considered in the biosphere interaction matrix and included in the radionuclide model as modelled sedimentation (in dry weight per area and year) and Kd values.		
A 3.102 Space heating	Space heating when burning contaminated materials such as trees may contribute to external exposure. External exposure is considered in the biosphere interaction matrix and included in the radionuclide model, but has limited importance for a few and non dominating radionuclides. The external dose is considered by all sources.		
A 3.105 Suspension in air	One pathway for radionuclides from soil and water to become part of the air is by degassing. This is considered in the biosphere interaction matrix and included in the radionuclide model.		
A 3.118 Wind	Wind affects the transport of radionuclides by affecting soil erosion, degassing and dilution and transport of radionuclide by wind. Accordingly, wind speed is considered in the biosphere interaction matrix and included in several parts of the radionuclide model and parameterisation.		
H 2.4.1 Generalised denudation	Denuding of the site may remove upper regolith and thereby affecting the dispersion of radionuclides. This is considered in the biosphere interaction matrix, landscape model and radionuclide model since we considered a glacial cycle thereby conditions when the ice has removed upper regolith layers. In addition, by modelling many objects, many different depths of regolith is considered.		

SR-Site FEP Bio39 Resuspension

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 2.4.2 Localised denudation	See NEA FEP H 2.4.1.		
H 4.2.3 Sediment transport including bioturbation	Transport of elements including bioturbation is considered in the biosphere interaction matrix and included in the radionuclide model where processes such as resuspension and deposition are parameterised.		
H 4.2.4 Sediment/water/gas interaction with the atmosphere	Exchange over the air-water interface is considered in the biosphere interaction matrix and the exchange of 14-C is included in the radionuclide model.		
I 009 Sediments (in water bodies)	The sorption/desorption of radionuclides to particles is considered in the radionuclide model by Kd-values for different radionuclides. In additions, the transport of particles between the water column and the sediment is dependent on sedimentation/ resuspension processes which are also included in the radionuclide model.		
I 112b Denuding of the site	Denuding of the site may remove upper regolith and thereby affecting the dispersion of radionuclides. This is considered in the biosphere interaction matrix, landscape model and radionuclide model since we considered a glacial cycle thereby conditions when the ice has removed upper regolith layers. In addition, by modelling many objects, many different depths of regolith is considered.		
I 211 Outdoor spraying of water (atmospheric dose pathway)	See NEA FEP A 3.077.		
I 292 Surface water bodies (physical/chemical changes)	Physical and chemical changes of water bodies are considered in the biosphere interaction matrix and in the radionuclide model. For example, in the radionuclide model changes in chemistry is considered by use of different parameter sets for marine and limnic stages of the aquatic objects and physical changes are considered by use of time specific values of the geometry of the objects.		
J 5.26 Erosion on surface/sediments	See NEA FEP A 3.046.		
J 6.09 River meandering	See NEA FEP A 3.086.		
K 8.22 Erosion/deposition	See NEA FEP A 3.046.		
K 8.23 Sedimentation	See NEA FEPs A 3.091 and A 3.092.		
K 9.07 Erosion/denudation	See NEA FEPs A 3.046 and I 112b.		
K 10.11 Fluvial erosion/sedimentation	See NEA FEPs A 3.046, A 3.091 and A 3.092.		
K 10.12 Surface denudation	See NEA FEP I 112b.		
K 10.14 Glacial erosion/sedimentation	See NEA FEPs A 3.046, A 3.091 and A 3.092.		

SR-Site FEP Bio39 Resuspension

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 10.15 Glacial-fluvial erosion/sedimentation	See NEA FEPs A 3.046, A 3.091 and A 3.092.		
M 1.3.02 Extremes of precipitation, snow melt, and associated	Flooding which is caused by extremes in snowmelt or precipitation is considered in the biosphere interaction matrix, hydrological models, and in the radionuclide model.		
M 1.4.02 Denudation	See NEA FEP I 112b.		
M 1.4.03 River, stream, channel erosion	River erosion and channel erosion is considered in the biosphere interaction matrix and in the radionuclide model. At the site the regolith consists of till and rivers are relatively small, which gives a low potential for any substantial river erosion of the river banks are expected. In the radionuclide model no long-term accumulation is assumed to occur in streams and thereby the annual sedimentated material is assumed to be re-suspended (eroded) and transported downstream, i.e. the sizes of the rivers are assumed to remain throughout the modelling time period.		
M 1.4.04 River meandering	See NEA FEP A 3.086.		
M 1.4.05 Freshwater sediment transport and deposition	Sediment transport and deposition is included as in several aspects of SR-Site, e.g. the radionuclide model (Sediment and re-suspension parameters), the sediment model describing infilling of marine basins and lakes with time, and ecosystem mass balances.		
M 1.4.06 Coastal erosion and estuarine development	Erosion in marine basins are considered in SR-Site in the modeling of future development of marine basins (e.g. distribution of accumulation and erosion bottoms are described).		
M 1.4.07 Marine sediment transport and deposition	See NEA FEPs A 3.046 and A 3.091.		
M 1.5.01 River flow and lake level changes	Changes in river flows and lake levels are considered in the biosphere interaction matrix and included in the radionuclide model as future object have different sizes of catchment areas (thereby different amounts of water passing). Moreover, terrestrialisation affects lake depths and lake levels. Changes in lake levels and sea levels are also considered in the transition from marine basins to lakes.		
M 2.4.03 River rechannelling	River erosion and channel erosion is considered in the biosphere interaction matrix and in the radionuclide model. At the site the regolith consists of till and rivers are small, which gives a low potential for any substantial river erosion of the river banks are expected. In the radionuclide model no long-term accumulation is assumed to occur in streams and thereby the annual sedimentated material is assumed to be re-suspended (eroded) and transported downstream, i.e. the sizes of the rivers are assumed to remain throughout the modelling time period.		

SR-Site FEP Bio39 Resuspension

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 1.043 Aeolian erosion	See NEA FEP A 3.047.		
W 1.044 Fluvial erosion	See NEA FEPs A 3.046, A 3.091 and A 3.092.		
W 1.066 Coastal erosion	See NEA FEPs A 3.046, A 3.091 and A 3.092.		
W 1.067 Marine sediment transport and deposition	Sediment transport and deposition in marine basins is considered in the biosphere interaction matrix and included in the radionuclide model and in the model describing development of the landscape in Forsmark.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio40 Saturation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 4.2.1 Soil moisture and evaporation	This process is considered in the biosphere interaction matrix and in hydrological modelling that calculates input parameters to the radionuclide model.		
K 10.02 Effective moisture (recharge)	In the surface hydrology modelling, meteorological input is used and evapotranspiration processes are quantified explicitly by the model.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio41 Decay

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.037 Crop storage		When crop is stored radionuclide concentration may increase if seepage or flooding wet the crop. Decay of the radionuclides in the stored crop may also decrease the exposure. If crop is wetted it is most likely discarded as food and decay of radionuclides are only important for short-lived isotopes considering the length of storage of crops. For radionuclides entering from a deep repository this is thus irrelevant.	
A 3.082 Radioactive decay	Radioactive decay and daughter nuclides are included in the radionuclide model.		
I 045 Progency nuclides (critical radionuclides)	The decay chain and decay products are included in the radionuclide model.		
I 082 Crop storage		See NEA FEP A 3.037.	
K 8.45 Radon pathways and doses	Radon is considered in supporting calculations in the SR-Site modelling.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio42 Exposure

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.004 Animal grooming and fighting	Animal fighting and grooming my lead to exposure if the animals take up radionuclides that have been attached to their fur/skin during fighting. This is indirectly considered as concentration ratios of animals are estimated based on measurements on wild animals. These animals have due to a natural life style experienced grooming and fighting.		
A 3.006 Ashes and sewage sludge fertilizers	Ashes and sewage sludge may increase crop yield, In the radionuclide model, values of crop production from fertilized land are used to calculate production of food and thereby this process is indirectly included. Ashes of burned peat may concentrate radionuclides in the soil. In the safety assessment, each object is assumed to receive the entire radionuclide release and thus radionuclides are already present within the object and ashes will not introduce an extra source of contaminants.		
A 3.013 Biotoxicity		In terms of the behaviour and transport of radionuclides in the environment, biotoxicity can lead to the disruption of food webs. For human dose prediction, such disruptions need not be considered quantitatively because ignoring their effects on food webs would lead to overestimates of dose (Zach and Sheppard 1992). In addition, the human dose limit is a small fraction of the natural background dose and this will likely exclude any possibility of biotoxic effects.	
A 3.015 Building materials	Wood etc used as building material may expose humans to external exposure. External exposure is considered in the biosphere interaction matrix and included in the radionuclide model, but has limited importance for a few and non dominating radionuclides. The external dose is considered by all sources.		
A 3.030 Critical group - clothing and home furnishings	Clothing, furniture etc may expose humans to external exposure and is considered in the biosphere interaction matrix. External exposure is included in the radionuclide model of SR-Site. The proportion of external exposure compared to internal is very small and therefore the effect of different materials in clothing and furniture has not been further explored.		
A 3.032 Critical group - house location	The location of house may be important for the exposure of humans. In the radionuclide model, all members of the critical group are assumed to live within the model object, and thereby be exposed to external exposure.		
A 3.033 Critical group - individuality	Critical group is considered in the radionuclide model.		

SR-Site FEP Bio42 Exposure

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.034 Critical group - leisure pursuits	Activities such as hockey, curling on contaminated ice or swimming in contaminated water may expose humans to external exposure. In the radionuclide model, the concern is mainly long-lived radionuclides and these gives the highest external dose from ground, and time spent in lakes swimming or on ice skating has not to be considered. Instead, as a cautious assumption, humans are assumed to spend their entire time (100%) outdoors receiving external exposure from the ground.		
A 3.035 Critical group - pets	If the fur of pets is contaminated by radionuclides humans may be exposed to external exposure. Pets are not specifically considered in the radionuclide model but external exposure is included in the radionuclide model. External exposure has limited importance for a few and non dominating radionuclides. The external dose is considered by all sources.		
A 3.036 Crop fertilizers and soil conditioners	Fertilizers and soil conditioners increase the yield from agricultural land but may also dilute the concentration of radionuclides in the crop if radionuclides that are essential elements are diluted with uncontaminated elements in the fertilizers. In the safety assessment, values of crop production from fertilized land are used to calculate production of food and thereby this process is considered. As a cautious assumption, fertilizers are not considered when estimating concentration of radionuclides in the crop but then all elements are assumed to be taken up from the soil.		
A 3.040 Dermal sorption (except tritium)	Dermal sorption is considered in the biosphere interaction matrix. Dermal sorption in general is likely of minor importance for humans, compared to the direct ingestion and inhalation of radionuclides. Cautious assumptions built into these major pathways could readily include dermal sorption, and therefore, no explicit quantitative treatment of dermal sorption is required.		
A 3.041 Dermal sorption (tritium)	Dermal sorption is considered in the biosphere interaction matrix. Dermal sorption in general is likely of minor importance for humans, compared to the direct ingestion and inhalation of radionuclides. Cautious assumptions built into these major pathways could readily include dermal sorption, and therefore, no explicit quantitative treatment of dermal sorption is required. Dermal sorption is considered in the biosphere interaction matrix.		
A 3.048 Fires (agricultural)	Fires are considered in the biosphere interaction matrix but they are not included in the radionuclide model. Although fires may give rise to high concentration in the atmosphere on a short time scale the contribution to dose on a 50 year perspective is assumed to be small.		

SR-Site FEP Bio42 Exposure

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.049 Fires (forest and grass)	Fires are considered in the biosphere interaction matrix but they are not included in the radionuclide model. Although fires may give rise to high concentration in the atmosphere on a short time scale the contribution to dose on a 50 year perspective is assumed to be small.		
A 3.056 Gas leakage into basements	Gas leakage is considered in the biosphere interaction matrix, e.g. as exposure to radon.		
A 3.060 Groundshine	Groundshine, is part of external exposure and is included in the radionuclide model.		
A 3.062 Herbicides, pesticides and fungicides	Herbicides, pesticides and fungicides may stimulate crop production and increase the yield from agricultural land. This is considered in the radionuclide model as values of crop production are from conventional agricultural land where herbicides, pesticides and fungicides are used. In FEP A 3.062 it is suggested that agricultural chemicals can become contaminated and pass contaminants onto plants and into various food chains. However, in the safety assessment, objects are assumed to receive the entire radionuclide release and thus, no extra import of radionuclides are assumed to occur via addition of pesticides, fungicides and herbicides.		
A 3.063 Household dust and fumes	Inhalation of contaminated soil dust is included as an exposure pathway and thus volatilisation/aerosol/dust is included in the assessment. Gases and aerosols are considered as a source dissolved in water in the biosphere assessment, with the exception of the gas release scenario. Re-volatilisation is considered in the matrix and models.		
A 3.064 Houseplants	External exposure is included in the biosphere interaction matrix and in the radionuclide model, but has limited importance for a few and non dominating radionuclides. The external dose is considered by all sources although contribution from household plants is assumed to be small.		
A 3.083 Radiotoxic contaminants		In terms of the behaviour and transport of radionuclides in the environment, radiotoxicity can lead to the disruption of food webs. For human dose prediction, such disruptions need not be considered quantitatively because ignoring their effects on food webs would lead to overestimates of dose (Zach and Sheppard 1992). In addition, the human dose limit is a small fraction of the natural background dose and this will likely exclude any possibility of radiotoxic effects.	

SR-Site FEP Bio42 Exposure

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.095 Smoking		Tobacco is not cultivated at Forsmark at resent and this FEP is not considered in the radionuclide model. However, any contribution to dose from smoking is likely to be minor compared to the amounts ingested through food and water.	
A 3.103 Surface water bodies	Surface water is a diagonal element in the biosphere interaction matrix and influences other diagonal elements by processes such as convection, uptake, sorption/desorption, etc. Surface water bodies are included in the radionuclide model as marine basins, lakes and streams.		
A 3.107 Teratogenic contaminants		Teratogenic contaminants, i.e. radionuclide concentrations high enough to cause developmental disturbances in humans and other organisms are not handled in the safety assessment since the regulatory limits are far below these concentrations.	
A 3.112 Urbanization on the discharge site	Whether humans are urbanized or rural influence the exposure. In the safety assessment, as a cautious assumption, human populations are assumed to be rural and to only feed on products produced within the biosphere objects, i.e. the contaminated area.		
A 3.114 Water leaking into basements	Water leaking into basements could lead to an increased external exposure. However, this exposure would still be small in comparison to ingestion of contaminated water and food and this pathway has been considered negligible in the radionuclide model.		
H 4.3.1 Land and surface water use: Terrestrial	The land use is considered in the biosphere interaction matrix and in the radionuclide model.		
H 4.4.1 Human exposure: External	External exposure is included in the radionuclide model.		
H 4.4.2 Human exposure: Ingestion	Human exposure due to drinking and feeding is considered in the biosphere interaction matrix and included in the radionuclide model. Drinking is the uptake from surface water and water extracted from the well. Ingestion of food is further described in the biosphere synthesis report.		
H 4.4.3 Human exposure: Inhalation	Human exposure due to inhalation is considered in the biosphere interaction matrix and in the radionuclide model as inhalation of dust.		
I 010 Recycling process (biomass)	Ashes and sewage sludge may increase crop yield due to an extra supply of essential elements. In the safety assessment, values of crop production from fertilized land are used to calculate production of food and thereby this process is considered.		

SR-Site FEP Bio42 Exposure

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 074a Lake exposure scenario	Humans may be exposed to contaminants as a result of their activities associated with a lake. This is considered both in the biosphere interaction matrix and in the radionuclide model, where ingestion of food from lakes and usage of lake water in agriculture is included.		
I 074b Well exposure scenario	Humans may be exposed to contaminants as a result of their activities associated with well. This is considered both in the biosphere interaction matrix and in the radionuclide model, where drinking of water from wells is included.		
I 074c Swamp exposure scenario	Humans may be exposed to contaminants as a result of their activities associated with a lake. This is considered both in the biosphere interaction matrix and in the radionuclide model, where ingestion of food from wetlands is included.		
I 074d Combination exposure scenario	Humans may be exposed through a combination of exposure pathways, this is considered in the biosphere interaction matrix and in the radionuclide model were exposure from different ecosystems are considered as well as external exposure and inhalation of dust.		
I 074e Artificial lake exposure scenario		Radionuclide discharge from the repository is assumed to enter low points in the environment, i.e. lakes or wetlands. Thus, the highest dose to humans is assumed to come from natural lakes and wetlands and artificial lakes are not further considered.	
I 090 Dermal sorption (tritium and others)	See NEA FEPs A 3.040 and A 3.041.		
I 102 Ecological successions	Succession is considered in the biosphere interaction matrix, landscape development model and radionuclide model. Marine basins are developed to lake and thereafter to mires. The latter can thereafter be used as agricultural land.		
I 128 Gas leakage into basements	See NEA FEP A 3.056.		
I 139 Groundshine	See NEA FEP A 360.		
I 150 Household plants (dose pathway)	See NEA FEP A 3.064.		
I 227 Urbanization (demographics)	See NEA FEP A 3.112.		
I 276 Smoking (dose pathway)		See NEA FEP A 3.095.	
K 0.3 Gaseous and volatile isotopes	Gaseous isotopes, e.g. radon are considered in the biosphere interaction matrix and in the radionuclide model.		

SR-Site FEP Bio42 Exposure

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 8.13 Exposure pathways	Exposure pathways are considered in the biosphere interaction matrix and in the radionuclide model. Ingestion of various food sources, water inhalation of dust and external exposure are considered.		
K 8.14 Human lifestyle	Human lifestyle will influence the exposure pathways to man. In the radionuclide model the cautious assumption that humans are gaining all their food and spend all their time in the contaminated biosphere object is applied.		
K 8.27 Atmosphere	The atmosphere is considered in the biosphere interaction matrix and in the radionuclide model.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio43 Heat storage

No NEA FEPs associated with this SR-Site FEP.

SR-Site FEP Bio44 Irradiation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.060 Groundshine	Groundshine, is part of external exposure and is included in the radionuclide model.		
A 3.082 Radioactive decay	Radioactive decay and daughter nuclides are included in the radionuclide model in SR-Site.		
H 4.4.1 Human exposure: External	External exposure is included in the radionuclide model in SR-Site.		
I 139 Groundshine	See NEA FEP A 3.060.		
Recorded by: Eva Andersson			**Date:** Nov 2010
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SR-Site FEP Bio45 Light-related processes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.090 Seasons	Seasons are considered in the biosphere interaction matrix. In the radionuclide model, annual mean values are used for parameterization. These values are based on site specific measurements considering seasonal variations.		
Recorded by: Eva Andersson			**Date:** Nov 2010
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SR-Site FEP Bio46 Radiolysis

No NEA FEPs associated with this SR-Site FEP.

SR-Site FEP Bio47 Radionuclide release

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.056 Gas leakage into basements	Gas leakage is considered in the biosphere interaction matrix, e.g. as exposure to radon.		
A 3.084 Radon emission	Radon emission is considered in the biosphere interaction matrix.		
E GEN-31 Radionuclide reconcentration	Remobilisation of radionuclides due to changed conditions, due to shore-level displacement, bioturbation, ploughing is considered in the biosphere interaction matrix and in the radionuclide model.		
I 128 Gas leakage into basements	See NEA FEP A 3.056.		
K 0.3 Gaseous and volatile isotopes	Gaseous isotopes, e.g. radon are considered in the biosphere interaction matrix and in the radionuclide model.		
K 8.12 Radionuclide volatilisation/aerosol/dust production	Volatilisation/aerosol/dust is considered in the biosphere interaction matrix and in the radionuclide model. Inhalation of contaminated soil dust is an exposure pathway and thus volatilisation/aerosol/dust is considered in the radionuclide model.		
K 8.21 Dilution of radionuclides in surface water (aquifer, river, lake etc.)	The dilution of radionuclides in water bodies is considered in the biosphere interaction matrix and in the radionuclide model where the radionuclide release is assumed to become completely mixed within the receiving water bodies.		
K 8.27 Atmosphere	The atmosphere is considered in the biosphere interaction matrix and in the radionuclide model. Exposure from atmosphere is considered in the radionuclide model e.g. as inhalation of dust		Belongs to CompBio12. See also Bio42 Exposure.

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SR-Site FEP Bio48 Change in rock surface location

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 305 Topography (changes)	Changes in topography and landscape development (e.g. transformation from lake to wetland) are considered in biosphere interaction matrix, site description, landscape model and radionuclide model.		
K 9.07 Erosion/denudation	Erosion and denudation is considered in the biosphere interaction matrix, landscape model and radionuclide model. Denuding of the site may remove the upper regolith and thereby affect the dispersion of radionuclides. In the radionuclide model a glacial cycle is modelled and thereby conditions when the ice has removed upper regolith layers (denudation) is considered.		

SR-Site FEP Bio48 Change in rock surface location

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 10.11 Fluvial erosion/sedimentation	Erosion and sedimentation is considered in the biosphere interaction matrix, sedimentation model, landscape model and in the radionuclide model.		
Recorded by: Eva Andersson			**Date:** Nov 2010
Checked and revised by: Kristina Skagius			**Date:** Dec 2010

SR-Site FEP Bio49 Sea level change

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.59 Sea level change	Sea level changes are considered in the biosphere interaction matrix and in the landscape development model. At the start of the modelling of the Forsmark landscape the entire area is situated below sea level and at the end of the modelling period the entire area is situated above sea level.		
E GEN-33 Sea level changes	Same as NEA FEP A 2.59.		
H 2.2.1 Changes in geometry and driving forces of the flow system	Effects of shoreline displacement, erosion and sedimentation of Quaternary deposits, changes in groundwater salinity, permafrost and glaciations on groundwater flow and solute transport are considered in the modelling of surface hydrology and near-surface hydrogeology (R-10-02) and bedrock hydrogeology (R-09-20, R-09-21).		
I 143 Groundwater (redirection of)	Effects on hydrology of changes in topography and regolith stratigraphy are addressed in the hydrological modelling (SKB report R-10-02). Redirection of flow under permafrost and glacial conditions are considered in the hydro-geological modelling (R-09-20, R-09-21, R-10-02). Redirection of flow due to pumping in wells is handled separately in the radionuclide assessment based on conservative assumptions. The reduced contaminant input to the biosphere objects that result from pumping in wells is not taken into account (also conservative).		
I 266 Sea level (rising)	See NEA FEP A 2.59.		
J 5.31 Change in sealevel	See NEA FEP A 2.59.		
M 1.4.03 River, stream, channel erosion	River erosion and channel erosion is considered in the biosphere interaction matrix and in the radionuclide model. At the site the regolith consists of till and rivers are relatively small, which gives a low potential for any substantial river erosion of the river banks are expected. In the radionuclide model no long-term accumulation is assumed to occur in streams and thereby the annual sedimentated material is assumed to be resuspended (eroded) and transported downstream, i.e. the sizes of the rivers are assumed to remain throughout the modeling time period.		

SR-Site FEP Bio49 Sea level change

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 081 Sea level changes	See NEA FEP A 2.59.		
S 087 Surface water chemistry	Surface water chemistry is considered in the biosphere interaction matrix, site descriptions, and in the radionuclide model where site specific water chemistry characteristics are considered.		
W 1.068 Sea level changes	See NEA FEP A 2.59.		
Recorded by: Eva Andersson			**Date:** Nov 2010
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SR-Site FEP Bio50 Terrestrialisation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.074 Lake infilling	Lake infilling is considered in the biosphere interaction matrix, sedimentation model, landscape model and radionuclide model where lakes are gradually in-filled due to succession.		
I 102 Ecological successions	Succession is considered in the biosphere interaction matrix, landscape development model and radionuclide model. Marine basins are developed to lakes and thereafter to mires. The latter can thereafter be used as agricultural land.		
Recorded by: Eva Andersson			**Date:** Nov 2010
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SR-Site FEP Bio51 Thresholding

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.14 Dams	Dam constructions may influence hydraulic heads and may affect surface water flows. Dams are a form of thresholding which is included in the biosphere interaction matrix, landscape development model, and in the radionuclide model.		
I 085a Dams (filling, draining	Dam constructions may influence hydraulic heads and may affect surface water flows. Dams are a form of thresholding which is included in the biosphere interaction matrix, landscape development models and in the radionuclide model.		
Recorded by: Eva Andersson			**Date:** Nov 2010
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