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Project SFR 1 SAR-08

Update of priority of FEPs from Project SAFE

Svensk Kärnbränslehantering AB

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Preface

This report describes the outcome of revisiting the qualitative FEP analysis carried out within Project SAFE for the SFR 1 repository. This report is a further development of the Scenario and system analysis report /SKB 2001a/ presented within Project SAFE. Some changes in methodology of the FEP analysis have been implemented, as the methodology of scenario selection in Project SFR 1 SAR-08 differs from that of Project SAFE.

Anna Gordon, SKB, and Martin Löfgren and Maria Lindgren, Kemakta Konsult AB have compiled the report and the document constitutes one of the references used in the safety analysis SFR 1 SAR-08.

This document has been reviewed and all comments have been documented in accordance with SKIFS 2004:1.

Stockholm, Mars 2008

Anna Gordon

Project leader, SFR 1 SAR-08

Foreword

This report describes the outcome of revisiting the qualitative FEP analysis carried out within Project SAFE for the SFR 1 repository. The main rational for conducting this work is to identify interactions that should be assigned a higher priority, as a consequence of the prerequisites of Project SFR 1 SAR-08 including a prolonged time period for which repository safety should be demonstrated. In Project SFR 1 SAR-08, repository safety should be demonstrated for 100,000 years, compared to 10,000 years in Project SAFE. This creates the need to address some FEPs differently in the quantitative assessment.

This report is a further development of the Scenario and system analysis report /SKB 2001a/ presented within Project SAFE. Some changes in methodology of the FEP analysis have been implemented, as the methodology of scenario selection in Project SFR 1 SAR-08 differs from that of Project SAFE. Main authors of this report are Anna Gordon, SKB, and Martin Löfgren and Maria Lindgren, Kemakta Konsult AB, but many other persons have been involved in the work and contributed to the results (see Table 3-1).

Contents

1 Introduction

1.1 Background

SFR 1 is a repository for final disposal of low and intermediate level radioactive waste produced at Swedish nuclear power plants, as well as at Swedish industrial, research, and medical treatment facilities. The repository obtained operational license in March 1988.

The aim of Project SFR 1 SAR-08 is to perform an updated safety analysis, according to requirements in the regulations. A major difference between this and previous safety analyses is that repository safety should be demonstrated for 100,000 years after repository closure. This should be compared with the time frame of the safety assessment in Project SAFE that was 10,000 years. Due to the extended time frame, permafrost and glaciation have to be considered in the reference evolution of Project SFR 1 SAR-08. Other rationales for the update are recent input from the authorities concerning SAFE documents and the SFR 1 repository, as well as new data concerning the SFR 1 inventory.

During glaciation, conditions differ considerably from those of the tempered period considered in Project SAFE. This is not only true for the biosphere, but also for the shallow geosphere and the repository. The evolving climate during the timeframe of the assessment, together with new regulatory input, requires a revisit of the qualitative FEP (Features, Events and Processes) analysis carried out within Project SAFE, in order to identify those interactions that should be assigned a higher priority.

This report documents the result of revisiting the FEP analysis of Project SAFE, as documented in the Scenario and system analysis report /SKB 2001a/, and can be seen as a further development of /SKB 2001a/. The results are intended for used in the scenario selection of Project SFR 1 SAR-08, and the report constitutes one of the main references to Project SFR 1 SAR-08. It should be noted that unless the priority of an interaction is updated in this work, the priority given in Project SAFE still applies.

In the remaining of this report, Project SFR 1 SAR-08 is denoted SAR-08 and Project SAFE is denoted SAFE.

1.2 Objectives and scope

The overall objective of this report is to revisit the priority of interactions that were earlier considered to be of negligible, limited, or uncertain consequence for repository safety in SAFE, and identify those whose priority needs to be upgraded in SAR-08. One of the expected outcomes is lists of the interactions with upgraded priority. The work of revisiting interaction priorities has been made in the context of the main scenario and less probable scenarios of SAR-08 (see Section 1.3 for definitions), for with the updated priorities are intended.

As a consequence of changes in priority, the interaction matrices of /SKB 2001a/ have been updated. In addition, the external FEPs (EFEPs) of SAFE have been considered and assigned a priority. EFEPs that are judged as potentially important for setting up the main scenario and less probable scenarios have been mapped to the SAR-08 interaction matrices.

The FEP analysis has been made by the main authors of this report, aided by experts, with the aim at:

- Considering all EFEPs described in /SKB 2001a/ and assign them priority A (of importance for scenario selection in SAR-08) or B (negligible consequence for scenario selection in SAR-08).
- Judging whether priority A EFEPs are of potential importance for setting up the main scenario and less probable scenarios, or for setting up residual scenarios in SAR-08. This sorting is based on general recommendations in SKIFS 2002:1 /SKI 2002/, where the frameworks for the different scenarios are described. EFEPs of potential importance for setting up the main scenario and less probable scenarios are also used as one of the bases for the initial and boundary conditions used in the subsequent prioritisation of interactions.
- Mapping priority A EFEPs of potential importance for setting up the main scenario and less probable scenarios to leading diagonal elements of the SAR-08 interaction matrices.
- Examining whether the definition of each and every SAFE interaction is applicable in SAR-08.
- Considering all interactions previously judged to be of priority 1 (negligible consequence for repository safety) in /SKB 2001a/.
- Considering many of the interactions previously judged to be of priority 2 (limited or uncertain consequence for repository safety) in /SKB 2001a/. See Section 3.2 for details on selecting interactions in this category.
- Judge whether the priority of each considered interaction needs to be raised due to the defined initial and boundary conditions, including the extended time frame of the safety analysis and the evolving climate.
- Judge whether the priority of each considered interaction needs to be raised due to recent input from authorities concerning SAFE documents and the SFR 1 repository, or due to new inventory data.

As part of responding to recent input from the authorities, the FEPs developed for the SFR repository and included in the SKI report /Miller et al. 2002/ have been carefully examined with the aim to check that no relevant information has been overlooked in the SAR-08 FEP analysis.

It has not been an objective to downgrade the priority of any interaction, or to reconsider the priority of interactions that were given high priority (3 or 4) and deemed to be *"part of the performance assessment"* in SAFE /SKB 2001a/. Neither has it been an objective to define new or redefine existing FEPs and EFEPs. Consequently, the same FEP definitions as used in SAFE still apply in SAR-08 and so does the interaction priority, and underlying motivation to the priority, for those interactions that have not been upgraded.

There are a few exceptions from the above, as a need has been identified to define a few new interactions, handling the effect of water composition on freezing and vice versa. In addition there is a need to handle boreholes drilling into the system, which gives rise to a few more interactions.

1.3 Use of results in SAR-08

This report is intended to be an input to scenario selection of SAR-08, where the methodology and results of the scenario selection is described in the SAR-08 main report /SKB 2008/. In the regulatory requirements SKIFS 2002:1 /SKI 2002/, it is requested that scenarios assessing repository safety should be divided into the different categories main scenario, less probable scenarios, and residual scenarios. The following descriptions are excerpts from SKIFS 2002:1 /SKI 2002/:

*"**The main scenario** should be based on the probable evolution of external conditions and realistic, or where justified, pessimistic assumptions with respect to the internal conditions. It should comprise future external events which have a significant probability of occurrence or which cannot be shown to have a low probability of occurrence during the time covered in the safety assessment. Furthermore, it should be based, as far as possible, on credible assumptions with respect to internal conditions, including substantiated assumptions concerning the occurrence of manufacturing defects and other imperfections…*

***Less probable scenarios** should be prepared for the evaluation of scenario uncertainty… This includes variations on the main scenario with alternative sequences of events as well as scenarios that take into account the impact of future human activities such as damage inflicted on barriers….*

***Residual scenarios** should include sequences of events and conditions that are selected and studied independently of probabilities in order to, inter alia, illustrate the significance of individual barriers and barrier functions. The residual scenarios should also include cases to illustrate damage to humans intruding into the repository as well as cases to illustrate the consequences of an unclosed repository that is not monitored."*

In SAR-08, the scenario selection is performed based on a method using safety functions. A safety function is defined qualitatively as a role through which a repository component contributes to safety. Safety functions of the system can be evaluated by means of a set of function indicators that are, in principle, measurable or calculable properties of the system. For each safety function, an assessment is made as to whether any reasonable situation where it is not maintained can be identified. Uncertainties in the performance of safety functions may give rise to scenarios.

As an early step of assessing the performance of safety functions, events and processes described in this report are studied with the aim at identifying those that may give rise to violation of safety functions. Attention is given to events and processes of interactions that have been assigned priority 2 or higher (see Table 2-1) in this work, whereas those assigned low priority (0 and 1) are judged to be of insignificant relevance for the assessment.

A prerequisite for using the assigned interaction priorities in the scenario selection is that the prioritisation and scenario selection are made in the context of similar initial and boundary conditions. The initial and boundary conditions used as bases for prioritising interactions in this work are consistent with those of the descriptions of the initial state of the repository and surroundings at closure, and the reference evolution, which can be found in the main report of SAR-08 /SKB 2008/. These descriptions also function as bases for setting up the main scenario and less probable scenarios in SAR-08. In addition, both the FEP analysis and scenario selection take into account a number of EFEPs presented of this report (see Table 4-1). A summary of the initial and boundary conditions considered when prioritising interactions in this work is given in subsection 3.2.3.

As a consequence of the above, the interaction priorities assigned in this work can be used when setting up the main scenario and less probable scenarios of SAR-08, but should not be used for setting up residual scenarios, as such scenarios may be based on other prerequisites.

In this report, external FEPs that are judged to be of potential importance for setting up the main scenario and less probable scenarios are coupled to one or more leading diagonal elements in the SAR-08 repository and geosphere interaction matrices. This should aid the scenario selection as it gives entry points into the interaction matrices. Thus one can go from an external FEP to a diagonal element of an interaction matrix and therefrom further on to off-diagonal interactions that may affect the safety functions. The reason for not coupling external FEPs to the SAR-08 biosphere interaction matrix is that no safety function is defined for the biosphere, wherefore the biosphere matrix is not used when assessing violation of safety functions.

It should be noted that the interaction matrices can be used when setting up residual scenarios if other priorities, suitable for the specific initial and boundary conditions, are made. However, such prioritisation is outside the scope of this report.

1.4 Structure of report

This report is divided into six chapters:

- Chapter 1 describes the background, aim and scope of this work.
- Chapter 2 briefly describes the methodology used within SAFE for FEP and EFEP analysis. This chapter can be seen as an introduction to FEPs, EFEPs, and interaction matrices and is primarily intended for those without in-depth knowledge on the subject.
- Chapter 3 describes the methodology of assigning priority to EFEPs, sorting EFEPs to different scenarios, and mapping EFEPs to the SAR-08 interaction matrices. It also describes the methodology of examining interaction descriptions and updating the priority of certain interactions.
- Chapter 4 presents the results of this work concerning EFEPs. The results include tables of EFEPs of potential importance either when setting up the main scenario and less probable scenarios, or when setting up the residual scenarios. EFEPs of potential importance for setting up the main scenario and less probable scenarios are mapped to the interaction matrices. Such EFEPs are also used as one of the bases for initial and boundary conditions for the subsequent FEP analysis.
- Chapter 5 presents the conclusions of this work concerning FEPs, including lists of interactions with upgraded priority intended for use when setting up the SAR-08 main scenario and less probable scenarios. Motivations for the upgrades are given. Furthermore, changes in the updated interaction matrices are illustrated.
- Chapter 6 presents the result of examining the SFR FEPs in the SKI report Encyclopaedia of Features, Events and Processes (FEPs) for the Swedish SFR and Spent Fuel Repositories – Preliminary Version. /Miller et al. 2002/.
- In Appendices A and B, lists of all considered interactions and EFEPs are given, together with comments concerning their judged priority. Appendix C illustrates the updated SAR-08 interaction matrices intended for use when setting up the main scenario and less probable scenarios.

2 Methodology for FEP and EFEP analysis in safe

This chapter aims only at giving the very basics for understanding FEPs, EFEPs and interaction matrices, and how they were handled in SAFE. Most of the text is excerpts from, or summaries of, the descriptions in the SAFE Scenario and system analysis report /SKB 2001a/ in which more detailed information can be found.

2.1 FEPs and interaction matrices

This section contains a description of the construction of interaction matrices in SAFE. Terms such as interaction matrix, FEP, and EFEP are described.

2.1.1 Introduction to constructing interaction matrices

The basic principle of an interaction matrix is to list the variables defining the properties and conditions in the physical components of the system studied. This is done along the leading diagonal elements of a square matrix. Figure 2-1 shows an excerpt of such a matrix, taken from /SKB 2001a/ where leading diagonal elements are coloured grey. Examples of physical components of the SFR 1 repository are waste/cement, waste/bitumen, etc (see Figure 2-1).

In the remaining of this report, leading diagonal elements are referred to as diagonal elements. In the off-diagonal elements of the matrix, events and processes that are influenced by the properties and conditions of the diagonal elements are listed. The events and processes in the off-diagonal elements may in turn affect the properties and conditions of the diagonal element.

An interaction matrix for the SFR 1 repository should cover the Silo and the repository rock vaults, the rock around and above the repository, and the surface environment. Instead of compiling all information into one matrix, three sub-matrices were constructed in SAFE: one repository/near-field matrix, one geosphere matrix, and one biosphere matrix. The development of the interaction matrices was generally made by different expert groups through a series of documented meetings.

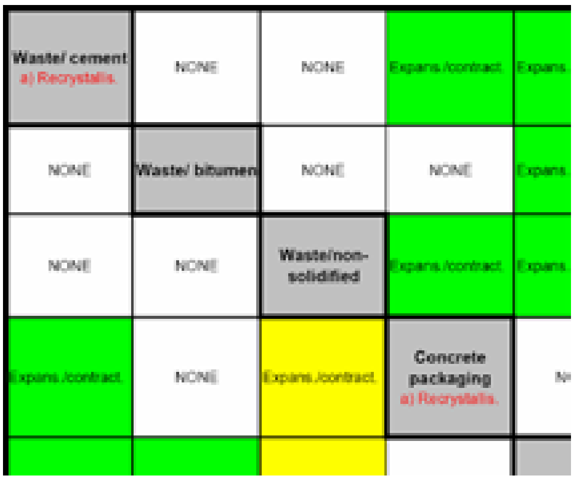

Figure 2-1. *Excerpt of an interaction matrix. Taken from /SKB 2001a/.*

The development of the interaction matrices consisted of the following steps:

- Definition of the sub-systems to be included in each matrix in terms of physical components, the initial state of these components, and boundaries between the subsystem, as well as the external boundary and boundary conditions of the whole system.
- Selection of variables required to describe the properties and conditions in the physical components of the sub-systems and listing them in the diagonal elements of the matrices.
- Identification of binary interactions between diagonal elements, by going through all off-diagonal elements in the matrices and judging whether the interaction is relevant and, if so, give a short description of its relevance.
- Auditing the contents of the matrices against different international lists of FEPs in order to ensure that all FEPs that are relevant are considered in the matrices.
- Selection of scenario initiating events and conditions.
- Judging the importance of all identified interactions in the matrices using a pre-defined priority scale, both for the initial and boundary conditions selected as a base/reference scenario.

Concerning the last bullet, this could also be done for other scenario initiating events and conditions but such an effort was not undertaken in SAFE.

The matrices, and the decisions made in developing the matrices, were carefully documented in an interaction matrix database, the SAFE Matrix Database /Kemakta 2001/. For each matrix element the database contains a short description of the process or condition, its relevance (with a justification), and a record on date of entry/revision and which experts were involved.

2.1.2 Identification of diagonal elements and interactions

In SAFE, the first step of the procedure of constructing an interaction matrix was to identify and define its diagonal elements. This was done by exploring how the state of the system can be described in terms of physical components, spatial and temporal extension of the system, and initial and boundary conditions of the system. It was found practical to let the diagonal elements represent system state variables (such as chemical composition of water, or rock stress) and to let the off-diagonal elements represent processes affecting the state.

In order to save space, it was found practical to allow a diagonal element to represent a "heading" rather than a single variable. For example, a typical diagonal element could be "groundwater composition", which in turn can be divided into concentrations of various constituents, colloid content, etc.

As the diagonal elements of the matrix were specified, the interactions between the main variables of the system were identified and introduced into the appropriate off-diagonal elements of the matrix. All interactions should be binary, i.e. they should be direct interactions between variables in two diagonal elements and not a path via a variable in a third diagonal element. For interaction described in off-diagonal elements, the variable in the diagonal element on the row should affect the variable in the diagonal element on the column. Each off-diagonal element was checked for interactions and where no interaction could be found, the off-diagonal elements were left uncoloured with the marking "NONE" (see Figure 2-1).

In the process of identifying interaction, all possible interacting mechanisms were first considered without making any evaluation of the probability of occurrence or the significance of the effect. Only fully irrelevant or totally unreasonable interactions were discarded. For each off-diagonal element the question was asked whether there are any potential events or processes that are affecting any of the variables assigned to the target diagonal element (found on the column) and at the same time are affected by any of the variables in the source diagonal element (found on the row). If the answer was yes, a short description of the interaction was documented together with the variables in the two diagonal elements that are involved in the interaction.

Each off-diagonal element could include a more than one interaction. If the answer was no, this was also documented and if possible also the reason for not finding any interacting event or process.

As there is a need to introduce more than one variable in each diagonal element, it is not possible to display all interacting events and processes in the off-diagonal elements of the matrices. Therefore also the diagonal elements have to be checked for events and processes that are affected by, and/or affect, the variables within the element. When such processes were identified they were introduced as ‘internal’ interactions in the diagonal elements and documented in the same way as the interactions in the off-diagonal elements.

To assure that no interactions had been neglected, the NEA Project FEP Database version 1.0 /NEA 1997/ was audited. The database contains 1,261 FEPs whereof 978 were identified to be of relevance for a SRF 1 type of repository. Each of the 978 FEPs was checked against the three interaction matrices in /SKB 2001a/ and if a match was found, it was categorised into repository, geosphere, and/or biosphere. Figure 2-2 shows an excerpt of such a categorisation taken from /SKB 2001a/. In the figure there is the additional category EFEP that is described in Section 2.2.

2.1.3 Prioritisation of interactions

The next step was to set priorities to the importance of identified interactions in the interaction matrix. This required a well-defined priority scale that is displayed in Table 2-1.

Each interaction of an off-diagonal element was assigned one of the priorities 0 to 4 and a colour coding was used to display the priorities in the interaction matrices. In cases where the off-diagonal element contained more than one interaction, the interaction with the highest priority determined the colour of the element. It should be noted that the prioritisations made are valid only for the initial states and boundary conditions defined for the reference scenario.

2.1.4 Example of how to read a interaction matrix

In the above subsections the construction of interaction matrices is briefly described. To clarify how to read the matrices, an example is given here. In Figure 2-3 a hypothetical interaction matrix is given. As in a SAFE matrix, diagonal elements are given the colour grey while off-diagonal elements may have any of the colours defined in Table 2-1.

NEA Projects FEPs considered in SFR matrices or as EFEPs

NEA project FEP	Unique number	Interaction matrix			EFEP
Arable farming	W 3.053			Biosphere	
Archaeological investigation	N 2.3.9				EFEP
Archeological excavations	W 3.017				EFEP
Archeological intrusion	J 5.37				EFEP
Archeological investigations	W 3.006				EFEP
Ashes and sewage sludge fertilizers	A 3.006			Biosphere	
Atmosphere	K 8.27			Biosphere	
Backfill characteristics	A 1.01	Repository	Geosphere		
Backfill chemical composition	W 2.010	Repository	Geosphere		
Backfill material deficiencies	J 3.2.11				EFEP
Backfill physical composition	W 2.009	Repository	Geosphere		
Bacteria and microbes in soil	A 3.007			Biosphere	
Basement alteration	K 9.08		Geosphere	Biosphere	

Figure 2-2. Excerpt of division of NEA FEPs. Taken from /SKB 2001a, Appendix C/.

1.1	Interaction 1.2	Interaction 1.3
Interaction 2.1 *a) 2.1a* *b) 2.1b*	2.2	Interaction 2.3 NONE
Interaction 3.1	Interaction 3.2	3.3

Figure 2-3. *Hypothetical interaction matrix for illustrative purpose.*

Table 2-1. Definition of priorities used in the matrices. Taken from /SKB 2001a/.

Priority No	Colour	Description
4	Pink	**Important interaction only in the water saturation phase – part of the Performance Assessment.** It can influence other parts of the process system included in this matrix, or other parts of the repository system not included in this matrix.
3	Red	**Important interaction – part of the Performance Assessment.** Could also influence other parts of the process system, (defined in this matrix), or other parts of the repository system. The interaction can be either a prerequisite for the PA or handled by assumptions or modelling efforts in the PA.
2	Yellow	**Interaction present – probably part of the Performance Assessment.** Limited or uncertain influence directly or via this interaction on other parts of the process system, or other parts of the repository system. However, this interaction can be in main focus in other matrices.
1	Green	**Interaction present – do not have to be considered in the Performance Assessment.** Negligible influence on other parts of the process system, (defined in this matrix) and other parts of the repository system.
0	White	**No identified interactions.**

For this example let us say that the heading of diagonal element 1.1 is "Bentonite barriers" while diagonal elements 2.2 is "Water composition". The water composition will affect the bentonite barrier in many ways. For example, the water composition variable *ionic strength* affects the bentonite barrier variable *swelling pressure* through the process *swelling*. As a variable in diagonal element 2.2 affects a variable in diagonal element 1.1, the interaction is found in off-diagonal element 2.1. Here, the rule should be remembered that the diagonal element on the same row (as the off-diagonal element) should affect the diagonal element on the same column. The bentonite barrier may also affect the water composition, for example by the process *dissolution* causing increased concentrations of dissolved species in the water. In this case the bentonite barrier variable *buffer composition* in diagonal element 1.1 affects the water composition variable *concentration of dissolved species* in diagonal element 2.2, and the interaction is shown in off-diagonal element 1.2.

As mentioned in subsection 2.1.2, an off-diagonal element can include more than one interaction. A variable of the water composition may also, for example, affect the chemical and microbial degradation of organics in the bentonite. The possibility of multiple interactions within a single element is displayed in Figure 2-3 in element 2.1 by the interactions *2.1a* and *2.1b*.

The process *swelling*, for example, in the bentonite barrier as a result of changes in water composition may significantly affect repository safety. Therefore, element 2.1 has a red background colour indicating that *swelling* is an interaction that must be considered in a safety analysis. Other interactions may be of limited, uncertain, or negligible importance for repository safety and are given lower priority and another colour code (see Table 2-1).

2.1.5 Diagonal elements in SAFE

The diagonal elements defined for the three interaction matrices developed in SAFE /SKB 2001a/ are listed in Tables 2-2 to 2-4. For motivations to, and additional information of the chosen diagonal elements, /SKB 2001a/ is recommended.

Table 2-2. Definition of the diagonal elements in the repository matrix. Taken from /SKB 2001a, Table 4-1/.

<table>
<tr><th>Element name</th><th>Short description</th><th>Variables</th></tr>
<tr><td>1.1 Waste/cement</td><td>Waste and cement matrix of all waste types that are stabilised in cement, i.e. ion-exchange resin, sludge, scrap and trash allocated to the Silo, BMA and 1BTF.</td><td rowspan="9">Volume, dimensions, voids
Porosity, pore characteristics
Amount, characteristics of fractures
Amount, composition, surface characteristics of materials
Type, amount of chemicals
Type, amount of organic materials and components that can be utilised by microbes as nutrients and energy sources
Extent of cement hydration in cement/concrete components
Amount and composition of surface coating on steel packaging</td></tr>
<tr><td>2.2 Waste/ bitumen</td><td>Waste and bitumen matrix of all waste types that are stabilised in bitumen, i.e. ion-exchange resins and evaporator concentrates allocated to the Silo, BMA and BLA.</td></tr>
<tr><td>3.3 Waste/ nonsolidified</td><td>All non-solidified waste in the different repository parts, i.e. ionexchange resins in 1BTF and 2BTF, ashes in 1BTF, trash and scrap in BLA.</td></tr>
<tr><td>4.4 Concrete packaging</td><td>Concrete packaging with reinforcement and expansion cassettes, when present, in concrete moulds in the Silo and BMA. Concrete packaging, reinforcement and rubber liners in concrete tanks in BTF.

The two steel drums and the concrete in between the steel drums that are used as packaging for ashes in 1BTF.</td></tr>
<tr><td>5.5 Steel packaging</td><td>All types of steel packaging that are used in the different repository parts, i.e. drums, boxes and containers, except the ash drums in 1BTF (included in element 4.4). .It also includes surface coating on the drums when present, e.g. paint.</td></tr>
<tr><td>6.6 Concrete backfill</td><td>Concrete backfill surrounding the waste packages in the Silo and in BMA. Concrete that will be filled in the void between the concrete tanks and the vault walls in 2BTF, and the concrete that will be filled in between the drums in 1BTF.</td></tr>
<tr><td>7.7 Concrete structures</td><td>Concrete structures in the different repository parts in terms of bottom, lid and outer as well as inner walls in the Silo and BMA and concrete floor in BTF and BLA. It also includes shotcrete and rock bolts in the rock walls in all repository parts.</td></tr>
<tr><td>8.8 Bentonite barriers</td><td>Sand/bentonite in the bottom and top of the Silo and the bentonite surrounding the cylindrical concrete walls.</td></tr>
<tr><td>9.9 Vaults and backfill</td><td>Voids and backfill in the Silo cupola, outside the concrete structures in BMA and outside the waste packages in 1BTF, 2BTF and BLA. It also includes the sand layer above the concrete lid and the gas release devices in the Silo.</td></tr>
<tr><td>10.10 Water composition</td><td>Water composition, including colloids/ particles and dissolved gas, in waste and barriers in the Silo, BMA, 1BTF, 2BTF and BLA.</td><td>Redox, pH, ionic strength, concentration of dissolved species, type and amount of colloids/particles, amount and composition of dissolved gas, density and viscosity</td></tr>
</table>

Element name	Short description	Variables
11.11 Hydrology	Water and water movement in waste and barriers in the Silo, BMA, 1BTF, 2BTF and BLA.	Magnitude, direction and distribution of water flow, Degree of saturation, Amount of water, Water pressure, Aggregation state (water/ice)
12.12 Gas	Gas and gas movement in waste and barriers in the Silo, BMA, 1BTF, 2BTF and BLA.	Amount, composition, volume, pressure, degree of saturation Magnitude, direction and distribution of gas flow
13.13 Temperature	Temperature in waste and barriers in the Silo, BMA, 1BTF, 2BTF and BLA.	Temperature
14.14 Stress conditions	Stress and strain in waste and barriers in the Silo, BMA, 1BTF, 2BTF and BLA.	Stress and strain, Swelling pressure in bentonite barriers
15.15 Biological state	The biological state of waste and barriers in the Silo, BMA, 1BTF, 2BTF and BLA.	Type, amount, mobility of microbes and bacteria (and other types of biomass)
16.16 Radio-nuclides and toxicants	Radionuclides and toxicants in solid, aqueous and gas phase in waste and barriers in the Silo, BMA, 1BTF, 2BTF and BLA.	Amount, type, chemical and physical form, concentration
17.17 Tunnels (Boundary condition)	*The geometry of access tunnels and all physical components in tunnels, i.e. backfill, plugs and rock reinforcements (e.g. shotcrete, rock bolts etc). The definition also includes water and gas in the tunnels.*	*Those variables assigned to diagonal elements 5.5, 6.6, 7.7, 8.8, 10.10, 11.11, 12.12, 13.13, 14.14, 15.15 and 16.16 in the geosphere matrix (see Table 4-2)*
18.18 Repository rock (Boundary condition)	*Rock and fracture system in between as well as around the vaults and the Silo to a distance of about 20 to 30 m from the repository. The definition includes all solid phases as well as water and gas.*	

Table 2-3. Definition of the diagonal elements in the geosphere matrix. Taken from /SKB 2001a, Table 4-2/.

Element name	Short description	Variables
1.1 Silo (Boundary condition)	*The geometry of the Silo repository and the physical components in the Silo that via interactions can affect and be affected by properties and conditions in the physical components of the geosphere, i.e. bentonite barriers, sand/gravel, water and gas.*	*Those variables assigned to diagonal elements 7.7, 8.8, 10.10, 11.11, 12.12, 13.13, 14.14, 15.15 and 16.16 in the repository matrix (see Table 4-1)*
2.2 BMA (Boundary condition	*The geometry of the BMA vault and the physical components in the BMA that via interactions can affect and be affected by properties and conditions in the physical components of the geosphere.*	
3.3 BTF (Boundary condition)	*The geometry of the BTF vaults and the physical components in 1BTF and 2BTF that via interactions can affect and be affected by properties and conditions in the physical components of the geosphere.*	
4.4 BLA (Boundary condition)	*The geometry of the BLA vault and the physical components in the BLA that via interactions can affect and be affected by properties and conditions in the physical components of the geosphere.*	
5.5 Tunnel/ boreholes/backfill	The physical components included in this diagonal element are the access tunnels with their backfill (crushed rock) and rock reinforcements (shotcrete and rock bolts) and investigation boreholes and ventilation shafts and backfill in these.	Geometry, dimensions, volume Density, homogeneity Voids, pore and fracture characteristics Amount, composition, mineralogy, surface characteristics

Element name	Short description	Variables
6.6 Plugs	Plugs at the entrance of the Silo and repository vaults and at the entrance of the access tunnels, made of concrete and bentonite.	Type and amount of organic materials and components that can be utilised by microbes as nutrients and energy sources
7.7 Repository rock matrix	The matrix of the rock in between as well as around the vaults and the Silo to a distance of about 20 to 30 m from the repository. The matrix of the rock in the disturbed zone around vaults and tunnels is also included.	Type and amount of naturally occurring radionuclides in rock minerals
8.8 Repository rock fracture system	The fracture systems, including fracture coatings, in the rock in between as well as around the vaults and the Silo to a distance of about 20 to 30 m from the repository. The fractures in the disturbed zone around vaults and tunnels are also included.	
9.9 Rock	Rock matrix, fracture systems and coating materials on fracture surfaces in the rock outside the repository rock.	
10.10 Water composition	Water composition, including colloids/particles and dissolved gas, in tunnels, plugs, and investigation boreholes and in rock matrix and fractures in all rock in the geosphere system.	Redox, pH, ionic strength, Concentration of dissolved species, Type and amount of colloids/particles, Amount and composition of dissolved gas, Density and viscosity
11.11 Hydrology	Water in all physical components of the geosphere system and water movement in plugs, tunnels boreholes, and fracture systems in the rock.	Magnitude, direction and distribution of water flow, Degree of saturation, Amount of water, Water pressure, Aggregation state (water/ice)
12.12 Gas	Gas and movement of gas in tunnels, plugs, investigation boreholes and in the matrix and fractures in rock. Naturally occurring radionuclides in gaseous phase are also included here.	Amount, composition, volume, pressure, degree of saturation Magnitude, direction and distribution of gas flow
13.13 Temperature	Temperature in plugs, tunnels, investigation boreholes, rock and fracture systems.	Temperature
14.14 Stress conditions	Stress and strain in tunnels, plugs, investigation boreholes, rock and fracture systems.	Stress and strain, Swelling pressure in bentonite
15.15 Biological state	The biological state of plugs, tunnels, investigation boreholes, rock and fracture systems.	Type, amount, mobility of microbes and bacteria (and other types of biomass)
16.16 Radionuclides and toxicants	Radionuclides and toxicants, originating from the repository, in solid, aqueous and gas phase in plugs, tunnels, investigation boreholes, rock and fracture systems.	Amount, type, chemical and physical form, concentration
17.17 Biosphere (Boundary condition)	*Physical and biological components in the biosphere that via interactions can affect and be affected by properties and conditions in the physical components of the geosphere.*	*Those variables assigned to diagonal elements 2.2 to 7.7 and 10.10 to 15.15 in the biosphere matrix (see Table 4-3)*
18.18 External rock (Boundary condition)	*Rock beneath and around the rock included in the geosphere system. Variables that can affect water composition, hydrology, gas, temperature, stress conditions and biological state in the geosphere components.*	

Table 2-4. Definition of the diagonal elements in the biosphere matrix. Taken from /SKB 2001a, Table 4-3/.

Element name	Short description	Variables
1.1 Geosphere (Boundary condition)	*The physical components in the geosphere that via interactions can affect and be affected by properties and conditions in the components of the biosphere, i.e. rock, backfill in tunnels and boreholes and ventilation shafts, plugs, water and gas.*	*Those variables assigned to diagonal elements 5.5, 6.6, 9.9, 10.10, 11.11, 12.12, 13.13, 14.14, 15.15 and 16.16 in the geosphere matrix (see Table 3-2)*
2.2 Quaternary deposits	Loose deposits including recent materials (e.g. soil, fine grain sediments, large grain sediments and till) and surface rock (out crops). In addition, buildings and structures such as roads, roadbanks, bridges and houses are included. Interface between rock or sediments and air, and rock or sediments and surface waters.	Amount, depth, location, spatial distribution, grain size distribution, pore- and fracture characteristics, composition, mineralogy, surface characteristics Baseline topography, e.g. land and bottom contours
3.3 Primary producers	Primary producers of organic matter (plants, algae, trees etc). Particles and solids deposited on surfaces of primary producers are also included.	Type and amount Location and size
4.4 Decomposers	Bacteria, worms, snails, fungi etc that decomposes dead organic matter. The decomposers live usually in the Quaternary deposits. Particles and solids deposited on surfaces of the decomposers are also included.	Number of humans living at different places Behaviour, e.g. living habits, culture, technical development etc
5.5 Filter feeders	Mussels, hydroids, sponges, insect larvae etc that filter water. Filter feeders are living on rock surfaces and on loose deposits in water.	Rate of growth and life time Radiologic and toxic effects
6.6 Herbivores	Plant eaters (e.g. snails, insects, cow, sheep etc) that live both on land and in water. Omnivores are included here and in 7.7, e.g. bear.	
7.7 Carnivores	Animal eaters (e.g. fish, eagle, seal, fox, birds etc) that live both on land and in water. Mosquitoes, parasites and tics are also included. Omnivores are included here and in 6.6, e.g. bear.	
8.8 Humans	All humans living in the affected area.	
9.9 None	Comment: Originally topography that later was moved into 2.2	
10.10 Water in Quaternary deposits	The hydrology in Quaternary deposits in terms of the pore water flow characteristics in the unsaturated zone and the groundwater flow characteristics in the saturated zone. The physical state of the water is also included, i.e. water/frost/ice.	Level of groundwater table, water content, degree of saturation, water pressure, magnitude, direction and distribution of water flow, quantity of water in different physical states, i.e. water/frost/ice
11.11 Surface water	All surface waters except water in Quaternary deposits, i.e. Öregrundsgrepen and other water recipients such as rivers, lakes etc. Rainwater on surface rock and "droplets" sorbed on other surfaces, e.g. primary producers are also included as well as snow and ice on land.	Size, location, amount, pressure, wave lengths and velocities, water level, layering Magnitude, direction, distribution of water flow Amounts and movements of ice/snow on surfaces
12.12 Water composition	Composition of water in Quaternary deposits and of surface waters. Includes particles in the water as well as the composition of snow and ice.	Redox, pH, salinity, Concentration of dissolved species, Type and amount and size of colloids/particles, Amount and composition of dissolved gas, Density and viscosity

Element name	Short description	Variables
13.13 Gas/ Atmosphere	All gases in the biosphere including the atmosphere in terms of composition and movement. Composition includes the content of particulate (e.g. ice crystals, water droplets, pollen, etc).	Amount, pressure, movements, composition, particulate content and type, wind velocity, wind field
14.14 Temperature	Temperature in the physical components of the biosphere system.	Temperature
15.15 Radionuclides and toxicants	Radionuclides and toxicants in all physical and biological components of the system. 1) from the repository, 2) background levels (e.g. from Tjernobyl and the Forsmark Power plant	Amount, type, chemical and physical form Concentration Location
16.16 External conditions (Boundary condition)	*All external conditions that affect the local conditions that are considered in the biosphere matrix.*	*Human behaviour, wind conditions, Large scale weather systems, Large scale water movements and water composition*

2.2 External FEPs (EFEPs)

The interactions shown in Section 2.1 and covered by the interaction matrices occur within the system, in this case the repository, the surrounding rock formation, and the local biosphere. External FEPs are features, events and processes acting outside the defined system. Some of these EFEPs may impact the repository system significantly and thus constitute a scenario initiating event or condition. EFEPs may for example concern global warming and future human actions, but also manufacturing defects and other imperfections of the system.

2.2.1 EFEPs and scenario initiators

The evolution of the SFR 1 repository will be influenced by future events, such as re-saturation, land rise, climate change, human actions, etc, and by the initial state of the repository at closure. In SAFE it was necessary to identify the scenario initiating events and conditions that could have a significant impact on the system behaviour, as well as to motivate why others needed no further analysis.

A broad identification of different scenario initiators was made where experience from a number of earlier SKB safety assessments and other sources was taken into consideration. For further information on the exact procedure, /SKB 2001a/ is referred to. The identification of scenario initiators was followed by a screening process, where only those initiators with potential relevance for repository safety were retained. When performing the screening, the following criteria were considered.

- is the initiator relevant for the considered type of waste (i.e. LLW/ILW reactor waste),
- is the initiator relevant for the type of geology and geographic setting of SFR 1,
- is the initiator relevant within the selected time cut-off at 10,000 years after repository closure?

The remaining list of scenario initiators was assessed and a few initiators were selected and developed to encompass the future evolution of the SFR 1 repository.

As part of identifying external FEPs in SAFE, the FEPs of the NEA Project FEP Database /NEA 1997/ were carefully examined. After screening out those of no relevance for the SFR 1 repository, the remaining were classified either as covered by the three interaction matrices or as external FEPs. An example of the result of this classification is shown in Figure 2-2. The external FEPs to be considered within SAFE were thereafter sorted into the following six categories:

1. Climate.
2. Human-induced climate changes.
3. Initial defect.
4. Human actions.
5. Tectonics.
6. Others.

The resulting list of EFEPs that were considered in SAFE is reported in Appendix C in /SKB 2001a/. In addition, the list shown in Table 2-5 was compiled as a basis for scenario selection in SAFE.

Table 2-5. EFEPs sorted into categories in SAFE. Taken from /SKB 2001a/.

1. Climate

- **Permafrost** including **Accumulation of gases under permafrost, Arctic desert, Denudation (glacial, fluvial, aeolian erosion), Drought and Tundra climate**
- Effects on sea levels due to **Glaciation** at the mountains.
- **Flood** due to increase in meteoric precipitation

2. Human-induced climate change

- **Acid rain**
- **Greenhouse effect** including **Warmer climate – arid, Warmer climate – equable humid Warmer climate – seasonal humid**

3. Initial defect

- **Material defects** such as **Backfill material deficiencies, Inadequate backfill or compaction, voidage**
- **Open boreholes** including **Flow through undetected boreholes**
- **Inadvertent inclusion of undesirable materials** such as **Oil or organic fluid spill, Organics/contamination of bentonite, Decontamination materials left Stray materials left**
- **(Unmodelled design features** – differences between designed and constructed, unforeseen modifications in design, features required for operation but not considered part of the conceptual design)

4. Human actions

- **Accidental intrusion** in terms of drilling into the repository covering aspects such as; **Hydro and chemical effects** of drilling fluid flow and drilling fluid loss**,** drilling-induced geochemical changes, fluid injection-induced geochemical changes, **Blowouts** of fluid during drilling, **Cavings and Cuttings** – material brought to surface during drilling

5. Tectonics

- **Earthquakes** including **Hydrological response to earthquakes, Mechanical failure of repository**
- **Fault movement**
- **Faulting**

6. Others

- **Deviation in RN inventory**
- **Gas explosions** – hydrogen, methane, air – early after closure. (Probably not important, but a written motivation is needed)

3 Methodology for considering FEPs and EFEPs in SAR-08

This chapter describes the methodology of assigning priority to EFEPs, sorting EFEPs to different scenarios, and mapping EFEPs to diagonal elements of the SAR-08 interaction matrices. It also describes the methodology of examining interaction descriptions and updating the priority of certain interactions. The assigned interaction priorities are intended for use when setting up the main scenario and less probable scenarios, and should not be used when setting up residual scenarios.

The work has been carried out by the main authors of this report with the aid from experts listed in Table 3-1.

3.1 Methodology used when considering EFEPs

3.1.1 Prioritising EFEPs

As a first step, the priorities of all EFEPs identified in SAFE /SKB 2001a/ were examined with the aim at reconsider their relevance in relation to the new prerequisites that apply for SAR-08. Important prerequisites are that repository safety should be demonstrated for 100,000 years and that climatic and repository evolution during this time should be considered /e.g. SSI 2005/, as well as initial defects and imperfections of the repository and future human intrusion /e.g. SKI 2002/. The prerequisites of SAR-08 is further described in the main report of SAR-08 /SKB 2008/. Here, one can also find descriptions of the initial state of the repository at closure and the reference evolution of the system.

The prioritisation of EFEPs was made in a Boolean manner where those assigned priority A are judged to be of potential importance for the scenario selection, whereas those of priority B need not to be considered when setting up scenarios in SAR-08. All EFEPs that were considered in this work are listed in Appendix B together with a short motivation to its assigned priority.

Table 3-1. Specialists consulted in the FEP and/or EFEP work.

Experts	Subject areas were aid was given	Expertise
Patrik Sellin, SKB	Repository and geosphere interactions and interaction matrices.	Technical barriers Safety assessment
Jan-Olof Selroos, SKB	Repository and geosphere interactions and interaction matrices.	Hydrogeology Safety assessment
Ignasi Puigdomenech, SKB	Repository and geosphere interactions and interaction matrices.	Hydrogeochemistry Safety assessment
Fredrik Vahlund, SKB	Repository and geosphere interactions and interaction matrices. EFEP sorting and mapping.	Transport processes Safety assessment
Jens-Ove Näslund, SKB	Repository and geosphere interactions and interaction matrices. EFEP prioritisation.	Climate processes Safety assessment
Ulla Bergström, Swepro AB	Biosphere interactions and interaction matrix.	Radiochemistry Safety assessment
Ulrik Kautsky, SKB	Biosphere interactions and interaction matrix.	Systems ecology Radioecology Safety assessment
Raymond Munier, SKB	EFEP prioritisation.	Geology Safety assessment

For each expert, the subject areas were aid was given, as well as their expertise are noted.

3.1.2 Sorting of EFEPs into scenarios

Each EFEP given priority A was sorted to either be of potential importance for setting up the SAR-08 main scenario and less probable scenarios, or for setting up residual scenarios. The basis for this sorting is the descriptions of the main scenario, less probable scenarios, and residual scenarios given in SKIFS 2002:1 /SKI 2002, comments on §9 and appendix/ and summarised in Section 1.3. EFEPs judged to be of potential importance for setting up the main scenario and less probable scenarios constitute one of the bases for the initial and boundary conditions considered when prioritising interactions, as described in Section 3.2.

In SAFE the identified EFEPs were sorted into different categories, as can be seen in Table 2-5. The same categories have been used in SAR-08, even though their headings have been somewhat modified. Categories used in SAR-08 are:

- Climatic changes.
- Climate – human actions.
- Tectonics.
- Initial defects.
- Human actions.
- Others.

Due to the prerequisites of SAR-08, all EFEPs assigned priority A in the categories climatic changes, climate – human actions, and tectonics were sorted to be of potential importance for setting up the main scenario and less probable scenarios in SAR-08. The same applies for initial defect EFEPs that do not involve an unclosed repository and human action EFEPs involving drilling, as oppose to tunnelling, into the system.

EFEPs assigned priority A in the categories initial defect, concerning an unclosed repository, and human actions, concerning tunnelling, were sorted to be of potential importance for setting up residual scenarios in SAR-08. So were also the EFEPs of the category others, due to reasons stated in Section 4.2. The result of the EFEP sorting is shown in Tables 4-1 and 4-3.

3.1.3 Mapping EFEPs to interaction matrices

All EFEPs of potential importance for setting up the main scenario and less probable scenarios were subjected to mapping to appropriate diagonal elements of the SAR-08 repository and geosphere interaction matrices. To exemplify, the EFEP "earthquakes" may be mapped to the diagonal element stress conditions of the geosphere interaction matrix (GEO 14.14), as an earthquake directly would affect the stress state of the rock mass surrounding the repository. This gives an entry point into the geosphere interaction matrix and from this diagonal element, it is possible to proceed to associated events and processes of off-diagonal elements that may affect the safety functions. As the origin of the earthquake will be outside the repository, it will not affect the repository stress conditions directly but through the stress conditions of the geosphere, wherefore no mapping is made from the EFEP earthquake to the repository interaction matrix.

The reason for not mapping EFEPs to the biosphere interaction matrix is that no safety function is defined for the biosphere in SAR-08, wherefore the biosphere interaction matrix is not used when assessing violation of safety functions. As no mapping is made to the biosphere interaction matrix, the biosphere is short-circuited in the mapping and EFEPs that should directly affect the biosphere are instead mapped to the geosphere.

To exemplify, a tundra climate would lower the temperature of the biosphere, compared to present day conditions, which in turn would affect the temperature of the geosphere. However, due to the short-circuiting the EFEP tundra climate is directly mapped to the diagonal element temperature of the geosphere interaction matrix (GEO 13.13). However, no mapping is made to the diagonal element temperature of the repository interaction matrix, as such an interaction would go through the geosphere interaction matrix.

EFEPs of potential importance for setting up residual scenarios have not been mapped to the interaction matrices, as the interaction priorities assigned in this work are not intended for use when setting up residual scenarios. The result of the EFEP mapping is shown in Chapter 4, Table 4-1. Further considerations made in relation to future human actions are described below.

3.1.4 Further considerations on future human actions

If people in the future for some reason deliberately enter the repository they are responsible for the consequences of their actions. Society today cannot protect future societies from their own actions if the latter are aware of the consequences /OECD/NEA 1995, ICRP 1998/. However, in developing a system for final disposal of radioactive waste, as much consideration as possible should be given to future generations. These generally accepted principles are also expressed in the background comments to SSI's regulations (see SSI FS 1998:1 /SSI 1998/). In line with the above discussion, the FEP analysis performed in SAFE, and the FEP analysis performed in SR-Can /SKB 2006a/ it is therefore decided to restrict the analysis to human activities that take place without knowledge of the existence of the repository, e.g. unintentional activities.

A problem when discussing future human actions is that the future of man and society cannot be predicted. On time spans of tens of years or more, the best we can do is to identify some important parameters or factors and combine them to explore possible outcomes. On time spans of hundreds of years and longer the future of man and society is, however, unpredictable and the uncertainties are indeterminate or unspecified, i.e. the outcome space is not known and cannot be described. It is for instance impossible to determine what scientific discoveries will be made the next 1,000 years. One commonly applied approach to handle this and to avoid speculation as to the future is to assume that the future conditions of society and technical practice are essentially the same as today /OECD/NEA 1995/. This provides a practical and comprehensible procedure to illustrate the potential hazards related to future human actions at the repository site, which is applied in this assessment.

In the general guidance to their regulations, SSI /SSI 2005/ recommends the inclusion of direct intrusion by means of drilling as well as examples of activities that indirectly may affect the safety functions in the safety assessment. They also recommend basing the future human activity scenarios on current habits and technical practise.

There are a large number of human activities that could be relevant for the SFR repository area and it is very difficult to predict human behaviour in the future. In the handling of future human actions in the safety assessment SR-Can /SKB 2006a/ it was concluded that drilling and/or construction of underground facilities have the highest potential for affecting the function of the repository. One can also conclude that construction of an underground facility only would commence after borehole investigations, which leaves a borehole scenario as the more likely of the two scenarios. Previous safety assessment of SFR /SKB 1993, SKB 1991, SKB 2001b/ analysed the consequence of a well drilled into the repository. This type of intrusion scenario will be chosen also here as a representative scenario for human activities.

3.2 Methodology used when considering FEPs

This section describes the methodology used when revisiting the SAFE interaction description, priorities, and matrices.

3.2.1 Examining interaction descriptions

As part of this work, the SAFE description of each and every interaction, regardless of its priority, has been examined. This was done to assure that the SAFE interactions and interaction matrices are applicable also for SAR-08, with its new prerequisites. As an input to this examination, the EFEPs sorted to be of potential importance for setting up the main scenario and less probable scenarios (shown in Table 4-1) have been used. It was found that the SAFE interactions and interaction matrices can be used in SAR-08, if subjected to minor modifications. These modifications include the addition of four new interactions concerning the influence of water composition on freezing and vice versa, and three new interactions handling the possibility of boreholes drilled into the repository system.

It was found that the interaction descriptions of SAFE do not explicitly refer to initial defects and damages inflicted by future human actions. Instead more general phrasing is used such as REP 4.11a: *"The dimensions and physical properties of the concrete packaging will affect the magnitude, direction and distribution of the water flow…"* As the descriptions are so general, they should also to be valid in the event of initial defects, damages due to human actions, etc.

3.2.2 Prioritising interactions

As a result of the aim and scope of this work (Section 1.2), only the priority of certain interactions needed to be examined.

The interactions whose priority has been examined are the following:

- Interactions with the priority 1 (negligible influence, see Table 2-1) in the SAFE interaction matrices.
- Interactions with the priority 2 (limited or uncertain influence, see Table 2-1), located in matrix elements of yellow colour in the SAFE interaction matrices.
- Interactions defined in this work (see subsection 3.2.1).

In examining the priority of the interactions, the aspects in Table 3-2 were considered, in addition to the initial and boundary conditions given in subsection 3.2.3.

The regulatory requirements of SKIFS 2002:1 /SKI 2002/, has had a significant impact on this work, mainly due to its definitions of the main scenario, less probable scenario, and residual scenario found in comments on §9 and appendix in /SKI 2002/. For /SSI 2005/ the paragraphs of most importance for this work are §5–7 (concerning dose, risk, and scenarios) and §10–12 (concerning the time frame of the safety assessment). This has already been internalised in the prerequisites of SAR-08, for example with its extended time frame and inclusion of evolving climate. Concerning the SKI/SSI review of the long term performance of SFR 1, as described in SAFE, found in Chapter 5 of /SKI and SSI 2004/, especially sections 5.4 – System description and 5.5 – Scenario selection have bearing on this present work.

Table 3-2. Aspects to be considered when prioritising interactions.

Aspect
The extended time period of the SAR-08 safety assessment, compared to that of SAFE, leading to the need to consider climatic conditions such as permafrost and glaciation.
New data about the SFR 1 inventory /Almkvist and Gordon 2007/.
The need to address issues raised in regulatory requirements SKIFS 2002:1 /SKI 2002/ and /SSI 2005/, which did not exist at the time of the last analysis (see below for details).
The need to address issued raised by regulators in their review of the SAFE assessment following the authorities' review of the SAFE documentation /SKI and SSI 2004/ (see below for details).
The need to consider aspects and processes described in the SFR FEPs included in the SKI Encyclopaedia of FEPs /Miller et al. 2002/.

In addition to assigning a SAR-08 priority to each interaction, short comments valid for SAR-08 are given for the following interactions:

- Each interaction whose priority has been upgraded in SAR-08. In addition one of the aspects of Table 3-2 is ascribed as the main motive for the upgrade.
- Each new interaction defined in this work.
- Each interaction given the SAR-08 priority 1. As such interactions are judged to have negligible influence on the main scenario and less probable scenarios, there is a need to justify their exclusion from further consideration in these scenarios. Some of these comments are written for SAR-08 and some were produced for SAFE but are also valid for SAR-08.
- Some interactions where either the SAFE description does not properly describe the situation of SAR-08 with its prerequisites, or where guidance how to use the interaction matrix is needed.

The result from this work is shown in Chapter 5 and Appendix A. Updated interactions are shown in Tables 5-1 to 5-3.

3.2.3 Boundary and initial conditions of FEP analysis in SAR-08

As stated in Section 1.3, a prerequisite for using the interaction priorities of this work in scenario selection is that similar initial and boundary conditions are used in both the scenario selection and FEP analysis. General prerequisites that lay ground for both the FEP analysis and the scenario selection are described in the main report of SAR-08 /SKB 2008/, in the discussions on the initial state and reference evolution of the repository and its surroundings.

For the purpose of this report, details in the reference evolution, for example the duration and sequence of events, or numerical parameter values, are of minor interest. By using the reference evolution in a qualitative manner, general boundary conditions for a broader span of possible repository evolutions can be extracted.

Furthermore, the EFEPs considered to be of potential importance for setting up the main scenario and less probable scenarios (see Table 4-1), are one of the bases for initial and boundary conditions. This applies both for FEP analysis and scenario selection. In Table 3-3, the most important initial and boundary conditions of the FEP analysis are summarised. Only qualitative boundary conditions have been considered in the FEP analysis.

Table 3-3. Qualitative initial and boundary conditions of the FEP analysis in SAR-08.

The time for assessing the evolution of the system is restricted to 100,000 years.
The state of barriers and plugs at repository closure does not differ remarkably from design criteria. Minor initial defects are considered. The inventory does not differ remarkably from that intended. Degradation of barriers and plugs during repository evolution is considered. Damage of barriers due to human activity is considered, but removal of barriers to the extent that humans can intrude is not considered.
Evolution of the climate over 100,000 years is considered. The three climatic conditions of relevance are tempered, periglacial, and glacial climate. The climatic evolution may or may not be influenced by anthropogenic activities.
Shoreline displacement is considered for different climatic evolutions.
Evolution of climate, isostatic rebound, and other events may give rise to tectonic events.
The types of ecosystems in the biosphere system will evolve with climate and shoreline displacement.
Evolution of the repository, its surroundings, and the climate will give rise to changes in thermal, hydrogeological, mechanical, and chemical conditions of the repository and its surroundings. This will affect the function of the repository.
Present day boreholes (including water wells) do not penetrate the repository barriers but future boreholes may.

3.2.4 Comparison of SAFE and SAR-08 boundary and initial conditions

In accordance with the aim and scope of this work, the interaction priority assigned in SAFE has only been revisited for part of the interactions. For the remaining part, the prioritisation made in SAFE is adapted without further considerations. As a consequence, the initial and boundary conditions that lay ground for the priorities of many interactions are established for SAFE and not for SAR-08. This calls for a comparison of the initial and boundary conditions in SAFE and SAR-08. In Table 3-4 the general initial and boundary conditions of the base case of SAFE are displayed /SKB 2001a, Section 3.2.1/, which can be compared to those of Table 3-3.

As can be seen, the prerequisites of the safety assessments differ on a number of issues. It is judged that the new prerequisites of the SAR-08 puts more demand on the safety assessment, compared to that of SAFE. With the methodology used it cannot be excluded that interactions of priority 3 and 4, as well as some of priority 2, should have been assigned a different priority if SAR-08 initial and boundary conditions were applied. As interactions of priority 2, 3, and 4 are part of the safety assessment, the main concern would be if any of these interactions should receive priority 0 or 1 (not part of safety assessment) if subjected to SAR-08 prerequisites. However, it is judged that this presents no real obstacle, except for an increased work load. The consequence is limited to the fact that safety functions must be investigated in the context of a few more events and processes that may be insignificant. The opposite, that is that safety functions are investigated in the context of too few events and processes, is judged as unlikely.

Table 3-4. Initial and boundary conditions of FEP analysis in SAFE (for Base case).

The state of barriers and plugs at repository closure is in accordance with design criteria.
Present day climate maintains for 10,000 years after repository closure.
The best estimate of the future land rise /Påsse 1997/ is considered.
The types of ecosystems in the biosphere system are the same as those present today, but succession due to land rise is considered.
Present day wells and future wells that do not penetrate the repository barriers are considered.
The time considered for the evolution of the system is restricted to 10,000 years.

4 Results of analysis of external FEPs for SAR-08

This chapter presents the results of the analysis of external FEPs. The aim is to identify the EFEPs that should be considered when setting up scenarios in the SAR-08 safety assessment, to sort EFEPs into different scenario categories, and to map EFEPs to the repository and geosphere interaction matrices of SAR-08. The methodology for doing this is described in Section 3.1. In Appendix B, all EFEPs considered are listed together with their assigned priority and comment valid for SAR-08. More effort was devoted to comment EFEPs that were deemed as insignificant for scenario selection, as the choice of neglecting them must be motivated.

4.1 EFEPs of concern for the main scenario and less probable scenarios

In accordance to the methodology, all priority A EFEPs concerning climate and tectonics were judged to be of potential importance for setting up the main scenario and less probable scenarios. In addition, all initial defect EFEPs that do not concern an unclosed repository were sorted to this category, as well as human action EFEPs that concern drilling but not tunneling into the system. In Table 4-1 the EFEPs judged to be of potential importance for setting up the main scenario and less probable scenarios are shown. As in SAFE, each EFEP is coupled to unique FEP numbers of the NEA Project FEP Database /NEA 1999/.

Table 4-1. EFEPs – factors to be considered in the main scenario and/or less probable scenarios.

	NEA Project FEP	Unique number	Mapped to diagonal element	Comment in Table 4-2
Climate changes	Climate change	A 2.07, A 3.024, W 1.061, A 1.12, H 3.1.2	GEO 10.10, GEO 11.11 GEO 13.13, GEO 14.14	1
	Exit from glacial/interglacial cycling	H 3.1.3	GEO 10.10, GEO 11.11 GEO 13.13, GEO 14.14	2
	Faulting	A 2.24, S 036, J 4.2.06, H 2.1.7	GEO 10.10, GEO 11.11 GEO 13.13, GEO 14.14	2
	Future climatic conditions	K 10.04	GEO 10.10, GEO 11.11 GEO 13.13, GEO 14.14	1
	Glacial climate – Glaciation	K 10.06, A 3.057, A 1.38, A 2.30, J 5.42, N 1.3.6, S 047, W 1.062	GEO 10.10, GEO 11.11 GEO 13.13, GEO 14.14	2
	Ice sheet effects	K 10.16	GEO 10.10, GEO 11.11 GEO 13.13, GEO 14.14	2
	Intensification of natural climate change	H 3.1.4	GEO 10.10, GEO 11.11 GEO 13.13, GEO 14.14	1
	Isostatic rebound	A 2.38	GEO 10.10, GEO 11.11 GEO 13.13	3, 4
	No ice age	J 6.10, N 1.3.7	GEO 10.10, GEO 11.11 GEO 13.13	3, 4
	Permafrost	J 5.17, S 059, K 10.13, W 1.063	GEO 10.10, GEO 11.11 GEO 13.13	3
	Tundra climate	K 10.05	GEO 10.10, GEO 11.11 GEO 13.13	3
	Warmer climate – equable humid	K 10.09	GEO 10.10, GEO 11.11 GEO 13.13	4
	Warmer climate – seasonal humid	K 10.08	GEO 10.10, GEO 11.11 GEO 13.13	4

	NEA Project FEP	Unique number	Mapped to diagonal element	Comment in Table 4-2
Climate – Human actions	Future biosphere conditions	K 8.02	GEO 10.10, GEO 11.11 GEO 13.13, GEO 14.14	1
	Global effects	A 1.39	GEO 10.10, GEO 11.11 GEO 13.13, GEO 14.14	1
	Greenhouse effect	K 10.10, A 2.31, A 3.059, W 3.047	GEO 10.10, GEO 11.11 GEO 13.13	4
	Human-induced climate change	K 11.09, N 2.4.9, H 3.1.1, J 6.08	GEO 10.10, GEO 11.11 GEO 13.13	4
Initial defects	Backfill material deficiencies	J 3.2.11	REP 6.6, REP 8.8 REP 9.9, GEO 5.5	8
	Decontamination materials left	J 5.04	REP 1.1, REP 2.2 REP 3.3, REP 10.10 REP 16.16	9
	Inadequate backfill or compaction, voidage	N 2.2.2	REP 6.6, REP 8.8 REP 9.9, GEO 5.5	8
	Inadvertent inclusion of undesirable materials	N 2.2.4	REP 1.1, REP 2.2 REP 3.3, REP 16.16	9
	Material defects	N 2.1.6	REP 1.1, REP 2.2, REP 4.4, REP 5.5 REP 7.7	10
	Organics/contamination of bentonite	K 3.24	REP 8.8, REP 10.10 REP 16.16	11
	Poor emplacement of buffer	K 3.23	REP 8.8	12
	Stray materials left	J 5.03	REP 6.6, REP 7.7 REP 8.8, REP 9.9 REP 10.10, REP 16.16	13
Human actions	Accidental intrusion – drilling and pumping	H 5.2.4, A 3.071	REP 11.11, GEO 11.11 REP 16.16, GEO 16.16	14
	Blowouts	W 3.023	REP 16.16	15
	Cavings	W 2.085	REP 16.16	15
	Cuttings	W 2.084	REP 16.16	15
	Drilling fluid flow	W 3.021, W 3.022, W 3.024	REP 10.10, GEO 10.10	16
	Drilling-induced geochemical changes			
	Exploratory drilling	K 11.01, A 2.05, J 5.21, W 3.032	REP 16.16	17
	Fluid injection-induced geochemical changes	W 3.030	REP 10.10, GEO 10.10	16
	Geothermal energy production	J 5.34, W 3.007, N 2.3.5, K 11.03	REP 11.11, GEO 11.11 REP 16.16, GEO 16.16	14
	Heat storage in lakes or underground	A 3.061	REP 11.11, GEO 11.11 REP 16.16, GEO 16.16	14
	Liquid waste disposal	W 3.010, W 3.027, K 11.04	REP 10.10, GEO 10.10	16
	Reuse of boreholes	J 5.36, A 2.03	REP 11.11, GEO 11.11 REP 16.16, GEO 16.16	14

	NEA Project FEP	Unique number	Mapped to diagonal element	Comment in Table 4-2
Tectonics	Earthquakes	A 1.29, A 2.21, A 3.045, J 5.15	GEO 14.14	5
	Fault movement	W 1.011, K 9.03, K 9.04, K 9.01, K 9.02	GEO 14.14	5
	Faulting	A 2.24, S 036, J 4.2.06, H 2.1.7, W 1.010	GEO 14.14	5
	Hydrological response to earthquakes	W 1.031	GEO 14.14	6
	Mechanical failure of repository	J 4.2.01	GEO 14.14	7
	Regional tectonic activity	H 2.1.1, W 1.004, J 6.14, W 1.003	GEO 14.14	5
	Seismic activity	K 9.05, W 1.012, N 1.2.8, H 2.1.6	GEO 14.14	5
	Stress changes – hydrogeo-logical effects	K 9.06	GEO 14.14	6

Each EFEP in Table 4-1 is mapped to one or more diagonal elements of the repository and/or geosphere interaction matrices. In accordance with the methodology described in Section 3.1 the biosphere was short-circuited in the mapping. Furthermore, references to comments on the mapping, found in Table 4-2, are given. A comment may be valid for more than one EFEP, as well as an EFEP may refer to more than one comment.

Table 4-2. Comments to Table 4-1.

Number in Table 4-1	Comments concerning…
1	Very general climatic change EFEPs that do not specify whether the climate is getting warmer or colder, dryer or more humid, etc. Changes in climate are likely to affect precipitation and vegetation, which in turn will affect groundwater flow and chemistry. In addition glaciation, and its associated ice sheet, affects the load. Diagonal elements judged to be potentially affected include temperature (GEO 13.13), hydrology (GEO 11.11), groundwater composition (GEO 10.10), and stress conditions (GEO 14.14) of the geosphere.
2	Climatic change EFEPs of a glacial period. Generally one can expect lower temperatures, increased stress due to the load of the ice sheet, changed hydraulic situation for example as hydraulic gradients are altered, and changed groundwater composition for example as oxygenated water may infiltrate the geosphere. Diagonal elements judged to be potentially affected include temperature (GEO 13.13), hydrology (GEO 11.11), groundwater composition (GEO 10.10), and stress conditions (GEO 14.14) of the geosphere.
3	Climatic change EFEPs of cooler climate with permafrost but no ice sheet. Generally one can expect lower temperatures, changed hydraulic situation for example as flowpaths freeze, and changed groundwater composition for example as precipitation may be subjected to different reduction capacity of the biosphere. Diagonal elements judged to be potentially affected include temperature (GEO 13.13), hydrology (GEO 11.11), and groundwater composition (GEO 10.10) of the geosphere.
4	Climatic change EFEPs of temperate climate, including greenhouse effect induced climate. Generally one can expect present day temperatures with a few degrees deviation and similar or deviating hydrology and groundwater composition, depending on precipitation and the shoreline displacement. Diagonal elements judged to be potentially affected include temperature (GEO 13.13), hydrology (GEO 11.11), and groundwater composition (GEO 10.10) of the geosphere.

Number in Table 4-1	Comments concerning…
5	EFEPs handling tectonic events affecting the rock mass surrounding the repository, and its stress conditions. The origin of the tectonic event would be outside the repository wherefore only mapping to the geosphere interaction matrix is made. The diagonal element judged to be potentially affected is stress conditions (GEO 14.14) of the geosphere.
6	EFEPs handling tectonic events with focus on effects on the hydrogeology of the site, as oppose to EFEPs focusing on the stress situation of the rock. The tectonic event would directly affect the hydrology of the geosphere but not that of the repository. The diagonal element judged to be potentially affected is hydrology (GEO 11.11) of the geosphere.
7	EFEP handling tectonic events affecting the repository structures. Even so, the origin of the tectonic event would be outside the repository wherefore only mapping to the geosphere interaction matrix is made. Diagonal element judged to be potentially affected is stress conditions (GEO 14.14) of the geosphere.
8	EFEPs handling inadequate or deficient backfill, including the bentonite around the silo. The material in itself may be deficient or its emplacement and packing may be inadequately performed. Diagonal elements judged to be potentially affected include the bentonite and backfill structural elements of the repository and geosphere (REP 6.6, REP 8.8, REP 9.9, and GEO 5.5).
9	EFEPs handling decontamination materials left and inadvertent inclusion of undesirable materials in the waste packages. Such decontamination agents, which may be toxic, can also be dissolved in water associated with the waste. Contaminating agents and stray materials left outside the waste packages are handled in other EFEPs. Diagonal elements judged to be potentially affected include the waste (REP 1.1, REP 2.2, and REP 3.3), the repository water composition (REP 10.10), and repository toxicants and radionuclides (REP 16.16).
10	EFEPs handling material defects of structural elements of the repository, except for bentonite and backfill components. Diagonal elements judged to be potentially affected include the solidified waste (REP 1.1 and REP 2.2), and the steel and concrete structural elements (REP 4.4, REP 5.5, and REP 7.7).
11	EFEPs handling the presence of organic and contaminating agents in the bentonite of the silo. These agents, which may be toxic, may also be dissolved in the water associated with the bentonite. Diagonal elements judged to be potentially affected include the bentonite (REP 8.8), the water composition (REP 10.10) and toxicants and radionuclides (REP 16.16) of the repository.
12	EFEPs handling poor emplacement of the bentonite of the silo. The diagonal element judged to be potentially affected is bentonite (REP 8.8).
13	EFEPs handling stray material left in the repository, except for in the waste and the concrete and steel packings. Components of the stray material, which may be toxic, can also be dissolved in the water. Diagonal elements judged to be potentially affected include the structural elements (REP 6.6, REP 7.7, REP 8.8, REP 9.9), the repository water composition (REP 10.10), and repository radionuclides and toxicants (REP 16.16).
14	EFEP handling accidental intrusion in the context of drilling followed by pumping, for example in case of a water wells. The borehole may penetrate the host rock as well as the repository. Also abandoned boreholes may be reused in activities involving pumping. The disturbance from the pumping may affect the hydraulic situation of the system, and in addition provide a fast route for radionuclides and toxicants at depth to the surface. Diagonal elements judged to be potentially affected include hydrology in the repository and geosphere (REP 11.11, GEO 11.11) and radionuclides and toxicants in the repository and geosphere (REP 16.16, GEO 16.16).
15	EFEP handling future drilling into the repository. During the drilling material/waste from the repository may be mechanically brought to the surface by the drill bit or drilling fluid (cuttings and cavings). Furthermore, in association with the drilling, blowouts may occur. These processes give rise to a temporary fast route for radionuclides and toxicants in the repository to the surface. As the disturbance is temporary, no mapping is made to the diagonal element hydrology. The diagonal element judged to be potentially affected is radionuclides and toxicants in the repository (REP 16.16).

Number in Table 4-1	Comments concerning…
16	EFEP handling boreholes that are injected with fluids (such as liquid waste), or are affected by drilling fluid flow, so that the geochemistry is disturbed. The diagonal element judged to be potentially affected is the water composition of the repository (REP 10.10) and geosphere (GEO 10.10).
17	EFEP handling boreholes drilled into the repository that are not pumped (for example drilled for the purpose of exploring ore bodies), which presents fast routes for radionuclides and toxicants in the repository to the surface. As the boreholes are not pumped they will not affect the hydrology of the system. As they do not affect the hydrology they need to penetrate the repository to be of potential interest for the safety assessment. The diagonal element judged to be potentially affected is radionuclides and toxicants in the repository (REP 16.16).

4.2 EFEPs of concern for residual scenarios

The EFEPs that are considered to be of potential importance for selection of residual scenarios are shown in Table 4-3.

These include initial defect EFEPs concerning an unclosed repository, and human action EFEPs involving potential tunnelling down to the repository. The following considerations are made for the EFEPs of the category others.

A remarkably deviating inventory would not be in line with the initial state of the repository at closure, as described in the SAR-08 main report /SKB 2008/. Therefore the EFEP deviant inventory flask is sorted to only be of potential importance for selection of residual scenarios. This does not exclude handling minor uncertainties in the inventory in the main scenario and less probable scenarios. Concerning flow through undetected boreholes, such boreholes cannot be pumped (and still be unknown) and therefore they do not affect the hydrology. For this reason they need to penetrate the repository to be of any consequence for repository safety. Furthermore, to constitute a fast route from the repository to the biosphere they must also be open, wherefore they fall under the category unclosed repository.

Table 4-3. EFEPs – factors to be considered in the residual scenarios of SAR-08.

	NEA Project FEP	Unique number
Initial defects	Abandonment of unsealed repository	N 2.2.9
	Incomplete closure	A 1.45
	Non-sealed repository	J 5.02
	Open boreholes	A 2.47
	Unsealed boreholes and/or shafts	J 5.09
	Vault closure (incomplete)	A 2.70
Human actions	Accidental intrusion – tunnelling	H 5.2.4, A 3.071
	Archaeological investigation	N 2.3.9, W 3.017, J 5.37, W 3.006
	Construction of underground facilities	W 3.016, N 2.3.8, W 3.015, N 2.3.7, J 5.28
	Intrusion (mines)	A 2.37, W 3.018, A 2.46, K 11.02, J 5.33, N 2.3.6, A 2.61
	Other future uses of crystalline rock	J 5.35
	Other resources	W 3.008, W 3.014
Others	Deviant inventory flask	K 1.27
	Flow through undetected boreholes	W 3.033

5 Results of analysis of FEPs in SAR-08

This chapter presents the results of the FEP analysis in SAR-08. In accordance with the aim and scope of this work (Section 1.2), the main result is the upgraded priorities of certain interactions, intended for use when setting up the main scenario and less probable scenarios. A main conclusion is that only a limited number of interactions, in total 48 out of more than a thousand, have been given an upgraded priority in SAR-08, compared to in SAFE. Most of these interactions are associated with temperature, groundwater flow and speciation, and ice load changes, resulting from the fact that changes in climatic conditions have to be considered as a result of the extended time frame of the safety analysis.

Interactions with upgraded priority are presented in three tables, given for each of the subsystems repository, geosphere, and biosphere in Section 5.1 to 5.3. The tables display the interaction name and number, SAFE description, SAR-08 comment/motivation, and SAR-08 priority. Concerning the SAFE description, it has been a criterion to only use the exported text from the SAFE Matrix Database /Kemakta 2001/, without any editing (even spelling).

As a result of the upgraded priorities, the SAR-08 interaction matrices are differently coloured compared to the SAFE interaction matrices. In addition a few new interactions are defined. The resulting SAR-08 interaction matrices, intended for use when setting up the main scenario and less probable scenarios, are shown in Appendix C.

All interactions whose priority has been considered in this work are presented in Appendices A1 (repository), A2 (geosphere), and A3 (biosphere). The appendices include the interaction name and number, SAFE description, SAR-08 comment/motivation, and SAR-08 priority. There was a request from the SAR-08 team to display all interactions (of all priorities) of the repository and geosphere matrices, which is done in Appendices A1 and A2.

5.1 Repository interactions

In Table 5-1, the repository interactions that have been given an upgraded priority are shown. In total, 10 repository interactions are upgraded in priority. The main motive for all upgrades is the extended time frame for which repository safety should be assessed, giving rise to an evolving climate. Especial attention should been given off-diagonal elements associated with the diagonal elements water composition (REP 10.10), hydrology (REP 11.11), temperature (REP 13.13), and stress conditions (REP 14.14). Definitions of the diagonal elements are given in Table 2-2.

In addition, a need to define two new interactions has been identified, even if this is not included in the aim and scope of this report. The two interactions concern the water composition's influence on the water freezing point (REP 10.11d) and the influence of freezing on the water composition (REP 11.10d). The new interactions are shown in Table 5-1.

A similar table is shown in Appendix A1 for all interactions of the SAR-08 repository interaction matrix.

Figure 5-1 shows a version of the SAR-08 repository interaction matrix where elements containing interactions that have been upgraded in priority or defined in this work are highlighted. All other elements are shaded. A non-shaded version of the SAR-08 repository interaction matrix is shown in larger format in Appendix C.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	**Waste/ cement** a) Recrystallis.	NONE	NONE	Expans./contract.	Expans./contract.	NONE	NONE	NONE	NONE	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Diffusion e) Sorption f) Colloid filtering	a) Water flow b) Capillary suct.	a) Corrosion b) Degrad.organic c) Gas flow	a) Cement hydration b) Heat conduction c) Exothermic reactions	Expans./contract.	Microbial activity	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Diffusion e) Sorption f) Colloid filtering	NONE	NONE
2	NONE	**Waste/ bitumen**	NONE	NONE	Expans./contract.	NONE	NONE	NONE	NONE	a) Dissol./precip. b) Degrad.organic c) Diffusion d) Sorption e) Colloid filtering	a) Water flow b) Capillary suct.	a) Degrad.organic b) Gas flow	a) Heat conduction b) Exothermic reactions	Expans./contract.	Microbial activity	a) Dissol./precip. b) Degrad.organic c) Diffusion d) Sorption e) Colloid filtering	NONE	NONE
3	NONE	NONE	**Waste/non-solidified**	Expans./contract.	Expans./contract.	NONE	NONE	NONE	NONE	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Diffusion e) Sorption f) Colloid filtering	a) Water flow b) Capillary suct.	a) Corrosion b) Degrad.organic c) Gas flow	a) Heat conduction b) Exothermic reactions	Expans./contract.	Microbial activity	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Diffusion e) Sorption f) Colloid filtering	NONE	NONE
4	Expans./contract.	NONE	Expans./contract.	**Concrete packaging** a) Recrystallis.	NONE	Expans./contract.	NONE	NONE	Expans./contract.	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Diffusion e) Sorption f) Colloid filtering g) Erosion	a) Water flow b) Capillary suct.	a) Corrosion b) Degrad.organic c) Gas flow	a) Cement hydration b) Heat conduction	Expans./contract.	Microbial activity	a) Diffusion b) Sorption c) Colloid filtering	NONE	NONE
5	Expans./contract.	Expans./contract.	Expans./contract.	NONE	**Steel packaging**	Expans./contract.	NONE	NONE	Expans./contract.	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Diffusion e) Sorption f) Colloid filtering g) Erosion	a) Water flow b) Capillary suct.	a) Corrosion b) Degrad.organic c) Gas flow	Heat conduction	Expans./contract.	Microbial activity	a) Diffusion b) Sorption c) Colloid filtering	NONE	NONE
6	NONE	NONE	NONE	Expans./contract.	Expans./contract.	**Concrete backfill** a) Recrystallis.	Expans./contract.	NONE	Expans./contract.	a) Dissol./precip. b) Degrad.organic c) Diffusion d) Sorption e) Colloid filtering f) Erosion	a) Water flow b) Capillary suct.	a) Degrad.organic b) Gas flow	a) Cement hydration b) Heat conduction	Expans./contract.	Microbial activity	a) Diffusion b) Sorption c) Colloid filtering	NONE	NONE
7	NONE	NONE	NONE	NONE	NONE	Expans./contract.	**Concrete structures** a) Recrystallis.	a) Expans/ contraction b) Bentonite expansion	Expans./contract.	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Diffusion e) Sorption f) Colloid filtering g) Erosion	a) Water flow b) Capillary suct.	a) Corrosion b) Degrad.organic c) Gas flow	a) Cement hydration b) Heat conduction	Expans./contract.	Microbial activity	a) Diffusion b) Sorption c) Colloid filtering	NONE	NONE
8	NONE	NONE	NONE	NONE	NONE	NONE	Bentonite expansion	**Bentonite barriers**	Bentonite expansion	a) Dissol./precip. b) Degrad.organic c) Diffusion d) Sorpt/ion-exch. e) Colloid filtering f) Colloid formation	a) Water flow b) Capillary suct.	a) Degrad.organic b) Gas flow	a) Heat conduction b) Exothermic reactions	Expans./contract.	Microbial activity	a) Diffusion b) Sorption/ion-exch. c) Colloid filtering	NONE	a) Bent. expans. b) Erosion
9	NONE	NONE	NONE	Expans./contract.	Expans./contract.	Expans./contract.	Expans./contract.	a) Expans./ contraction b) Bentonite expansion	**Vaults and backfill**	a) Dissol./precip. b) Degrad.organic c) Diffusion d) Sorption e) Colloid filtering f) Erosion	a) Water flow b) Capillary suct.	a) Degrad.organic b) Gas flow	a) Heat conduction b) Exothermic reactions	Expans./contract.	Microbial activity	a) Diffusion b) Sorption c) Colloid filtering	NONE	NONE
10	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Water uptake	a) Dissol./precip. b) Degrad.organic c) Water uptake	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Water uptake	a) Dissol./precip. b) Corrosion c) Degrad.organic	a) Dissol./precip. b) Corrosion c) Degrad.organic	a) Dissol./precip. b) Degrad.organic	a) Dissol./precip. b) Corrosion c) Degrad.organic	a) Dissol./precip. b) Degrad.organic c) Ion-exchange d) Water uptake e) Expans/dispers. f) Montmorillonite transformation	a) Dissol./precip. b) Degrad.organic	**Water composition** a) Colloid formation/stability	a) Water flow b) Convection c) Osmosis d) Phase changes	a) Gas dissol./ degassing b) Chem. react. c) Corrosion d) Degrad.organic	Heat transport	NONE	Microbial activity	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Diffusion e) Sorption f) Colloid trsp.	Mass flow	Mass flow
11	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Water uptake	a) Dissol./precip. b) Degrad.organic c) Water uptake	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Water uptake e) Redistribution	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Erosion	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Erosion	a) Dissol./precip. b) Degrad.organic c) Erosion	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Erosion	a) Dissol./precip. b) Degrad.organic c) Ion-exchange d) Water uptake e) Erosion	[illegible]	a) Advection and mixing b) Chem. equilibr. c) Erosion d) Conc./dilution	**Hydrology**	a) Saturation b) Diss./degass. c) Two phase flow d) Expansion/ contraction	Heat advection	Water pressure interaction	Advection	a) Advection b) Dispersion c) Gas dissol./ degassing	a) Mass flow b) Disch./rech and pressure c) Biomass flow d) Contamin. trsp	a) Mass flow b) Disch./rech and pressure c) Biomass flow d) Contamin. trsp
12	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	a) Gas dissolution degassing [illegible]	[illegible] b) Two phase flow	**Gas**	a) Heat advection b) Heat conduction	Gas pressure interaction	a) Micr. activity b) Advection-gas	a) Advection-gas b) Colloid trsp	Gas transport	Gas transport
13	a) Kinetics and equlibria b) Expansion/ contraction	a) Kinetics and equlibria b) Expansion/ contraction	a) Kinetics and equlibria b) Expansion/ contraction	a) Kinetics and equlibria b) Expansion/ contraction	a) Kinetics and equlibria b) Expansion/ contraction	a) Kinetics and equlibria b) Expansion/ contraction	a) Kinetics and equlibria b) Expansion/ contraction	a) Kinetics and equlibria b) Expansion/ contraction	a) Kinetics and equlibria b) Expansion/ contraction	a) Kinetics and equlibria b) Prop. changes c) Diffusion	Phase changes	a) Exp./contract. b) Convection	**Temperature**	Thermal stress interaction	Microbial activity	a) Kinetics and equlibria b) Diffusion c) Soret effect	Heat transport	Heat transport
14	Cracking	Cracking	Redistribution	Cracking	Deformation	Cracking	a) Cracking b) Redistribution	Redistribution (subsidence)	Redistribution (subsidence)	NONE	Water pressure interaction	NONE	NONE	**Stress conditions**	NONE	NONE	Stress and strain changes	Stress and strain changes
15	Microbial growth	Microbial growth	Microbial growth	Microbial growth	Microbial growth	Microbial growth	Microbial growth	Microbial growth	Microbial growth	Microbial activity	NONE	Microbial activity	Microbial activity	NONE	**Biological state**	a) Microbial trsp b) Methylation/ transformation	Biomass flow	Biomass flow
16	Irradiation	Irradiation	Irradiation	Irradiation	Irradiation	Irradiation	Irradiation	Irradiation	Irradiation	a) Radiolysis b) Radionuclide decay c) Degradation	NONE	a) Radiolysis b) Degradation	Heat from decay	NONE	Irradiation (mutation)	**Radionuclides and toxicants** a) Radionuclide decay	Contaminant transport	Contaminant transport
17	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	Mass flow	Rech./disch. and pressure	Gas transport	Heat transport	Stress and strain changes	Biomass flow	Contaminant transport	**Tunnels (B.C.)**	NONE
18	NONE	NONE	NONE	NONE	Rock fall out	NONE	Rock fallout	a) Bent. expans. b) Erosion c) Rock creep d) Rock fallout	a) Rock fallout b) Rock creep	Mass flow	Rech./disch. and pressure	Gas transport	Heat transport	Stress and strain changes	Biomass flow	Contaminant transport	NONE	**Repository rock (B.C.)**

Figure 5-1. *SAR-08 repository interaction matrix where elements featuring interactions with changed priority are highlighted.*

Table 5-1. Repository interactions which priority has been upgraded in SAR-08.

Interaction name and number	SAFE description	Priority and comment, intended for use when setting up the SAR-08 main scenario and less probable scenarios
REP 10.11d Phase Changes Not defined in SAFE		Set to: Priority 2. Description: The water composition (salinity) affects the freezing point of water and may thus affect its aggregate state. Comment: Even a small change in freezing point may under specific conditions be of some importance.
REP 11.8e Erosion	Water flowing around and through the bentonite barriers in the Silo may cause mechanical erosion of these. This could affect the composition, geometry, density and porosity of the bentonite barriers in the Silo.	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Increased groundwater flow will affect bentonite erosion by way of transport of species and constituents to and from the bentonite barrier. Increased groundwater flow is e.g. expected as the ice sheet of a glacial period melts.
REP 11.10d Concentration/ dilution Not defined in SAFE		Set to: Priority 2 Description: Concentration and dilution of water occurring as result of change in water aggregate state. Comment: A common example is salt rejection giving rise to cryogenic brine.
REP 11.14 Water pressure interaction	The water pressure in the different components of the repository system, e.g. due to phase changes, affects the stress conditions in the components of the repository system.	Priority: Changed from 2 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Phase changes due to permafrost are expected in the different components of the repository system.
REP 13.10a Kinetics and equilibria	The temperature in the different components of the repository system will affect the kinetics and equilibria of chemical reactions and gas solubilities and thereby the composition of the water in the different components of the repository system.	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Changes in temperature by a number of degrees may cause precipitation, dissolution, changed reaction rates, and changes in speciation.
REP 13.11 Phase changes	The temperature in the different components of the repository system affects the water pressure in the components. Extreme changes in temperature will lead to phase changes like freezing or evaporation. These extreme changes will affect both the water pressure and the amount of water.	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Phase changes are expected due to permafrost at repository depth. Temperatures giving rise to freezing no longer considered as extreme.
REP 13.16a Kinetics and equilibria	The temperature in the different components of the repository system will affect the kinetics and equilibria of sorption and dissolution/precipitation reactions and thereby the distribution between mobile and immobile radionuclides and toxicants in the different components of the repository system.	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Changes in temperature may to some extent affect equilibria in waste packages and other parts of the repository affecting the speciation and mobility of radionuclides and toxicants.
REP 17.16 Contaminant transport	Transport of radionuclides and toxicants in water and gas phase from the tunnels into the silo, BMA, BTF or BLA will affect the amount of these in the silo, BMA, BTF and BLA. The origin of these contaminants may be the waste and barrier materials in the other repository parts and contaminated water, gas and solids in the biosphere. (GEO 16.1, GEO 16.2, GEO 16.3, GEO 16.4, GEO 11.1, GEO 11.2, GEO 11.3, GEO 11.4)	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Toxicants (for example ISA) moving from one vault to another must be considered. Toxicants coming from the biosphere are judged to be negligible. It is a positive effect if the radionuclides return to the repository. ISA is formed in a very slow process. Thus, there is a risk of higher ISA-concentrations accumulating over longer time frames.

Interaction name and number	SAFE description	Priority and comment, intended for use when setting up the SAR-08 main scenario and less probable scenarios
REP 18.8d Rock fallout	Changes in stress conditions in the repository rock may cause rock creep that may affect the geometry, homogeneity, density etc of the bentonite barriers in the Silo. (GEO 14.1)	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Longer time frames and stress redistribution due to ice loading increase the risk of rock fallout.
REP 18.9a Rock fall out	Changes in stress conditions in the repository rock may cause rock fall out that affects the dimensions of the silo and the vaults as well as geometry and homogeneity of the backfill in the vaults and in the silo. (GEO 14.1b, GEO 14.2b, GEO 14.3b, GEO 14.4b)	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Longer time frames and stress redistribution due to ice loading increase the risk of rock fallout.
REP 18.13 Heat transport	Heat transport in the repository rock will affect the temperature in the silo, BMA, BTF and BLA. (GEO 13.1, GEO 13.2, GEO 13.3, GEO 13.4)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Heat transport properties of the rock will affect the temperature and permafrost depth in the geosphere.
REP 18.16 Contaminant transport	Transport of radionuclides and toxicants in water and gas phase from the repository rock into the silo, BMA, BTF or BLA will affect the amount of these in the silo, BMA, BTF and BLA. The origin of these contaminants may be the waste and barrier materials in the other repository parts and contaminated water, gas and solids in the biosphere. (GEO 16.1, GEO 16.2, GEO 16.3, GEO 16.4, GEO 11.1, GEO 11.2, GEO 11.3, GEO 11.4)	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Toxicants (for example ISA) moving from one vault to another must be considered. Toxicants coming from the biosphere are judged to be negligible. It is a positive effect if the radionuclides return to the repository. ISA is formed in a very slow process. Thus, there is a risk of higher ISA-concentrations accumulating over longer time frames.

5.2 Geosphere interactions

The geosphere interactions that were given an upgraded priority in SAR-08 are shown in Table 5-2. In total, 26 geosphere interactions are upgraded in priority. The main motive for all upgrades is the extended time frame of the safety assessment. Especial attention should be given off-diagonal elements associated with diagonal elements water composition (GEO 10.10), hydrology (GEO 11.11), temperature (GEO 13.13), and stress conditions (REP 14.14).

A difference between the SAFE base scenario and SAR-08 reference evolution is that the latter includes the possibility of future drilling into the repository system. For this reason, the interaction GEO 17.5b was defined handling the penetration of open boreholes from the biosphere into the geosphere. Also the interaction GEO 5.11c was defined handling the effect on the hydrology of open boreholes where active pumping is performed.

As for the repository matrix there was a need to define two new interactions handling the water composition's influence on the water freezing point (GEO 10.11d) and the influence of freezing on the water composition (GEO 11.10d).

A similar table is shown in Appendix A2 for all interactions of the SAR-08 geosphere interaction matrix.

Figure 5-2 shows a version of the SAR-08 repository interaction matrix where elements containing interactions that have been upgraded in priority or defined in this work are highlighted. All other elements are shaded. A non-shaded version of the SAR-08 geosphere interaction matrix is shown in larger format in Appendix C.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	**SILO (B.C.)**	NONE	NONE	NONE	NONE	NONE	NONE	Bentonite expansion	NONE	a) Mass flow b) Erosion	Disch/recharge and pressure	Gas transport	Heat transport	Stress and strain changes	Biomass flow	Contaminant transport	NONE	NONE
2	NONE	**BMA (B.C.)**	NONE	NONE	NONE	NONE	NONE	NONE	NONE	Mass flow	Disch/recharge and pressure	Gas transport	Heat transport	Stress and strain changes	Biomass flow	Contaminant transport	NONE	NONE
3	NONE	NONE	**BTF (B.C.)**	NONE	NONE	NONE	NONE	NONE	NONE	Mass flow	Disch/recharge and pressure	Gas transport	Heat transport	Stress and strain changes	Biomass flow	Contaminant transport	NONE	NONE
4	NONE	NONE	NONE	**BLA (B.C.)**	NONE	NONE	NONE	NONE	NONE	Mass flow	Disch/recharge and pressure	Gas transport	Heat transport	Stress and strain changes	Biomass flow	Contaminant transport	NONE	NONE
5	NONE	NONE	NONE	NONE	**Tunnel/ borehole/ backfill**	Bentonite expansion	NONE	Bentonite expansion	Bentonite expansion	a) Dissol./precip. b) Corrosion c) Diffusion d) Sorption e) Colloid filtering f) Erosion g) Degr. of organics	a) Water flow b) Capillary suct. c) Flow in boreholes	a) Gas flow b) Corrosion c) Microbial activity	Heat conduction	Stress and strain changes	Microbial activity	a) Sorption b) Diffusion	NONE	NONE
6	NONE	NONE	NONE	NONE	a) Redistribution b) Bentonite exp.	**Plugs** a) Recrystallis.	NONE	Bentonite expansion	NONE	a) Diss/prec. Concr. b) Diss/prec. Bent. c) Diffusion d) Sorption/ion-exch e) Corrosion f) Colloid filtering g) Colloid formation	a) Water flow b) Capillary suct.	a) Gas flow b) Corrosion c) Microbial activity	Heat conduction	a) Bentonite expansion b) Stress and strain changes	Microbial activity	a) Sorption b) Diffusion	NONE	NONE
7	NONE	NONE	NONE	NONE	NONE	NONE	**Repository rock - rock matrix**	NONE	NONE	a) Dissol./precip. b) Diffusion c) Sorption	Capillary suction	a) Microbial activity b) Radon gener.	Heat conduction	Deformation	Microbial activity	a) Matrix diffusion b) Sorption	NONE	NONE
8	Bentonite expansion	NONE	NONE	NONE	Bentonite expansion	Bentonite expansion	NONE	**Repository rock - fracture system**	NONE	a) Dissol./prec. b) Diffusion c) Sorption d) Colloid filtering e) Erosion	a) Water flow b) Capillary suct.	a) Gas flow b) Microbial activity c) Radon gener.	Heat conduction	Deformation	Microbial activity	a) Matrix diff. b) Sorption c) Diffusion	NONE	NONE
9	NONE	NONE	NONE	NONE	Bentonite expansion	NONE	NONE	NONE	**Rock - rock matrix and fracture systems**	a) Dissol./prec. b) Diffusion c) Sorption d) Colloid filtering e) Erosion	Water flow	a) Gas flow b) Microbial activity c) Radon gen.	Heat conduction	Deformation	Microbial activity	a) Matrix diff. b) Sorption c) Diffusion	Erosion/ weathering	NONE
10	Mass flow	Mass flow	Mass flow	Mass flow	a) Diss./precip. b) Corrosion c) Ionic strength effects	a) Diss./precip. b) Corrosion c) Ion-exchange d) Water uptake e) Expans/dispers	Dissolution/ precipitation	Dissolution/ precipitation	Dissolution/ precipitation	**Water composition** a) Colloid formation/stability	a) Convection b) Water flow c) Osmosis d) Phase changes	a) Gas dissol./ degassing b) Chemical reactions	Heat conduction	NONE	Microbial activity	a) Diffusion b) Sorption c) Prec./diss. d) Colloid trsp	Mass flow	Mass exchange
11	a) Mass flow b) Rech/disch and pressure c) Erosion d) Biomass flow e) Contamin.trsp	a) Mass flow b) Rech./disch and pressure c) Biomass flow d) Contamin.trsp	a) Mass flow b) Rech./disch and pressure c) Biomass flow d) Contamin.trsp	a) Mass flow b) Rech./disch and pressure c) Biomass flow d) Contamin.trsp	a) Diss./precip. b) Corrosion c) Redistribution	a) Diss./precip. b) Corrosion c) Erosion d) Water uptake	Diss./precip.	a) Diss./precip. b) Erosion	a) Diss./precip. b) Erosion	a) Advection and mixing b) Chemical equilibria c) Erosion d) Conc./dilution	**Hydrology**	a) Saturation b) Diss./degass. c) Two phase flow d) Expansion/ contraction	Heat advection	Water pressure interaction	Advection	a) Advection b) Dispersion c) Gas dissol./ degassing	a) Mass flow b) Disch./rech and pressure c) Biomass flow d) Contamin trsp	a) Mass exchange b) Disch./rech and pressure c) Biomass exch.
12	Gas transport	Gas transport	Gas transport	Gas transport	NONE	NONE	NONE	NONE	NONE	a) Gas dissol./ degassing b) Colloid trsp	a) Saturation b) Two phase flow	**Gas**	a) Heat adv. b) Heat cond.	Gas pressure interaction	a) Biological activity b) Advection-gas	a) Advection-gas b) Colloid trsp	Gas transport	Gas exchange
13	Heat transport	Heat transport	Heat transport	Heat transport	a) Kinetics and equilibria b) Expansion/ contraction	a) Kinetics and equilibria b) Expansion/ contraction	a) Kinetics and equilibria b) Expansion/ contraction	a) Kinetics and equilibria b) Expansion/ contraction	a) Kinetics and equilibria b) Expansion/ contraction	a) Kinetics and equilibria b) Property changes c) Diffusion	Phase changes	a) Expansion/ contraction b) Convection	**Temperature**	Thermal stress interaction	Microbial activity	a) Kinetics and equilibria b) Diffusion c) Soret effect	Heat transport	Heat exchange
14	a) Stress/strain changes b) Rock fallout c) Rock creep	a) Stress/strain changes b) Rock fallout c) Rock creep	a) Stress/strain changes b) Rock fallout c) Rock creep	a) Stress/strain changes b) Rock fallout c) Rock creep	a) Rock creep b) Stress redist. c) Rock fall out	a) Cracking b) Rock creep	Stress redistribution	Stress redistribution	Stress redistribution	NONE	Water pressure interaction	NONE	NONE	**Stress conditions**	NONE	NONE	Change in rock surface location	Stress and strain changes
15	Biomass flow	Biomass flow	Biomass flow	Biomass flow	Microbial growth	Microbial growth	Microbial growth	Microbial growth	Microbial growth	Microbial activity	NONE	Microbial activity	Microbial activity	NONE	**Biological state**	a) Microbial trsp b) Methylation/ transformation	Biomass exchange	Biomass exchange
16	Contaminant transport	Contaminant transport	Contaminant transport	Contaminant transport	Irradiation	Irradiation	Irradiation	a) Irradiation b) Precipitation	Irradiation	a) Radiolysis b) Radionuclide decay c) Degradation	NONE	a) Radiolysis b) Degradation	Heat from decay	NONE	Irradiation (mutation)	**Radionuclides and toxicants** a) Radionuclide decay	Contaminant transport	NONE
17	NONE	NONE	NONE	NONE	a) Root penetration b) Borehole penetration	Root penetration	NONE	NONE	a) Consolid. b) Root penetr. c) Erosion/ weath.	Mass flow	a) Rech./disch and wells b) Press. change	Gas transport	Heat transport	a) Mechan. load b) Ice load	a) Root penetr. b) Intrusion c) Biomass exchange	Contaminant transport	**Biosphere (B.C.)**	NONE
18	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	Mass exchange	Rech./disch and pressure	Gas exchange	Heat exchange	Stress and strain changes	Biomass exchange	NONE	NONE	**External rock (B.C.)**

Figure 5-2. *SAR-08 geosphere interaction matrix where elements featuring interactions with changed priority are highlighted.*

Table 5-2. Geosphere interactions which priority has been upgraded in SAR-08.

Interaction name and number	SAFE description	Priority and comment, intended for use when setting up the SAR-08 main scenario and less probable scenarios
GEO 5.11c Flow in boreholes Not defined in SAFE		Priority: Set to 2. Description: Location, geometry and pump rate of open boreholes, for example water wells, and its effect on hydrology. Comment: Such boreholes are conceivable and may penetrate through the host rock affecting the local hydrology of part of the system.
GEO 7.13 Heat conduction	The mineralogy of the rock matrix in the repository rock affects the heat conduction in the rock and thereby the temperature in the repository rock, tunnels and rock outside the repository area.	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The heat transport properties of the rock will affect the repository temperature and permafrost depth.
GEO 9.13 Heat conduction	The mineralogy of fracture coatings and the rock matrix as well as the frequency, apertures and connectivity of fractures in the rock outside the repository area affect the heat conduction in the rock and thereby the temperature in the rock outside the repository area, in the repository rock and in the tunnels	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The heat transport properties of the rock will affect the repository temperature and permafrost depth.
GEO 10.5c Ionic strength effects	Bentonite used as backfill in the investigation boreholes can be altered by ion exchange processes and by expansion and dispersion of clay particles into adjacent fractures in the rock, compare 10.6c and 10.6e. This could change the homogeneity, expandability and hydraulic and gas conductivities of the bentonite in the investigation boreholes.	Priority: Changed from 2 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The bentonite will dissolve under low ionic strength conditions such as during glacial melting.
GEO 10.11d Phase Changes Not defined in SAFE		Priority: Set to 2. Description: The water composition (salinity) affects the freezing point of water and may thus affect its aggregate state. Comment: Even a small change in freezing point may under specific conditions be of some importance.
GEO 11.1c Erosion	Erosion of the external surfaces of the bentonite barriers may affect the density of the barriers by carrying away material. (REP 18.8)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Not enough is know concerning the magnitude of bentonite erosion. Therefore this process should not be overlooked when assessing repository safety.
GEO 11.6c Erosion	Water flowing in the tunnels and plugs and in the repository rock adjacent to the plugs may cause mechanical erosion of the plugs. This could affect the geometry and porosity of the plugs.	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The expected water velocities are too low for erosion to be of any importance for the properties of the concrete plugs. In case of bentonite plugs, erosion may be of importance. Especially at glacial period.
GEO 11.10d Concentration/dilution Not defined in SAFE.		Priority: Set to 2 Description: Concentration and dilution of water occurring as result of change in water aggregate state. Comment: A common example is salt rejection giving rise to cryogenic brine.

Interaction name and number	SAFE description	Priority and comment, intended for use when setting up the SAR-08 main scenario and less probable scenarios
GEO 11.14 Water pressure interaction	The water pressure in the different components of the geosphere system, e.g. due to phase changes, affects the stress conditions in the components of the geosphere system.	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Stress changes are expected due to phase changes during permafrost periods and glaciation.
GEO 11.17b Discharge/ recharge and pressure	The hydrology in the geosphere influences the discharge and recharge of groundwater and thereby the hydrology in the Quaternary deposits and the surface water hydrology. (BIO 1.10+BIO 1.11)	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The amount of water in Quaternary deposits could be determined by water in the geosphere if the biosphere freezes sporadically (see BIO 1.10). Precipitation and hydrology in Quaternary deposits is of more importance for surface water conditions under temperate conditions (see BIO 1.11)
GEO 13.1 Heat transport	Heat transport in the tunnels and repository rock will affect the temperature in the silo. (REP 17.13, REP 18.13)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Heat transport properties of the rock will affect the temperature and permafrost depth. Heat transport in the tunnels is judged to be negligible.
GEO 13.2 Heat transport	Heat transport in the tunnels and repository rock will affect the temperature in the BMA. (REP 17.13, REP 18.13)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Heat transport properties of the rock will affect the temperature and permafrost depth. Heat transport in the tunnels is judged to be negligible.
GEO 13.3 Heat transport	Heat transport in the tunnels and repository rock will affect the temperature in the BTF. (REP 17.13, REP 18.13)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Heat transport properties of the rock will affect the temperature and permafrost depth. Heat transport in the tunnels is judged to be negligible.
GEO 13.4 Heat transport	Heat transport in the tunnels and repository rock will affect the temperature in the BLA. (REP 17.13, REP 18.13)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Heat transport properties of the rock will affect the temperature and permafrost depth. Heat transport in the tunnels is judged to be negligible.
GEO 13.10a Kinetics and equilibria	The temperature in the tunnels, plugs, repository rock and rock outside the repository area will affect the kinetics and equilibria of chemical reactions and gas solubilities and thereby the composition of the water in the tunnels, plugs, repository rock and rock outside the repository area.	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Changes in temperature may cause precipitation, dissolution, changed reaction rates, and changes in speciation.
GEO 13.11 Phase changes	The temperature in the different components of the geosphere system affects the water pressure in the components. Extreme changes in temperature will lead to phase changes like freezing or evaporation. These extreme changes will affect both the water pressure and the amount of water.	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Phase change in the form of freezing due to permafrost and glaciation must be considered. In SAR-08 temperatures causing freezing are not considered as extreme.

Interaction name and number	SAFE description	Priority and comment, intended for use when setting up the SAR-08 main scenario and less probable scenarios
GEO 13.16a Kinetics and equilibria	The temperature in the different components of the geosphere system will affect the kinetics and equilibria of sorption and dissolution/precipitation reactions and thereby the distribution between mobile and immobile radionuclides and toxicants in the different components of the geosphere system.	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Changes in temperature by a few degrees may cause fracture coatings to precipitate or dissolve. Radionuclides and toxicants may co-precipitate.
GEO 13.17 Heat transport	The heat exchange between geosphere and biosphere will affect the temperature in the biosphere. (BIO1.14)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Surface temperature determines mainly the temperature in Quaternary deposits and surface waters. Is of importance during permafrost conditions. (see BIO 1.14)
GEO 14.1a Stress and strain changes	Changes in stress and strain at the boundary between the tunnels or repository rock and the silo affects the stress conditions in the silo. (REP 17.14, REP 18.14)	Priority: Changed from 2 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Stress and strain changes are expected due to redistribution due to ice loading.
GEO 14.1b Rock fallout	Changes in stress conditions in the repository rock may cause rock fallout that affects the dimensions, geometry and homogeneity of the backfill in the silo. (REP 18.9)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Longer time frames and stress redistribution due to ice loading increase the risk of rock fallout.
GEO 14.2a Stress and strain changes	Changes in stress and strain at the boundary between the tunnels or repository rock and the BMA affects the stress conditions in the BMA. (REP 17.14, REP 18.14)	Priority: Changed from 2 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Stress and strain changes are expected as a result of redistribution due to ice loading
GEO 14.2b Rock fallout	Changes in stress conditions in the repository rock may cause rock fallout that affects the dimensions and geometry of the vault and backfill and concrete structures as well as homogeneity of the backfill and pore and fracture characteristics of the structures in the BMA. (REP 18.7, REP 18.9)	Priority: Changed from 2 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Longer time frames and stress redistribution due to ice loading increase the risk of rock fallout.
GEO 14.3a Stress and strain changes	Changes in stress and strain at the boundary between the tunnels or repository rock and the BTF affects the stress conditions in the BTF. (REP 17.14, REP 18.14)	Priority: Changed from 2 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Stress and strain changes are expected as a result of redistribution due to ice loading
GEO 14.3b Rock fallout	Changes in stress conditions in the repository rock may cause rock fallout that affects the vault dimensions as well as dimensions, geometry and properties of backfill and concrete structures in the BTF. (REP 18.7, REP 18.9)	Priority: Changed from 2 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Longer time frames and stress redistribution due to ice loading increase the risk of rock fallout.
GEO 14.8 Stress redistribution	Redistribution of the stress in the repository rock may change the fracture frequency, apertures and the location of fractures in the repository rock.	Priority: Changed from 2 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Stress redistribution due to ice loading must be considered in safety assessment.
GEO 14.9 Stress redistribution	Redistribution of the stress in the rock may change the porosity of the rock matrix and the fracture frequency, apertures and the location of fractures in the rock outside the repository area.	Priority: Changed from 2 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Stress redistribution due to ice loading must be considered in safety assessment.

Interaction name and number	SAFE description	Priority and comment, intended for use when setting up the SAR-08 main scenario and less probable scenarios
GEO 14.11 Water pressure interaction	The stress conditions in the different components of the geosphere system affects the porewater pressure in the system components.	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Includes water pressure effects on freezing point that may affect water aggregation state.
GEO 17.5b Borehole penetration Not defined in SAFE		Priority: Set to 3 Description: The penetration of future open boreholes used as water wells, adding to the inventory of boreholes in the geosphere. Comment: Such wells are conceivable.
GEO 17.13 Heat transport	The heat exchange between geosphere and biosphere will affect the temperature in the geosphere. (BIO14.1a)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The temperature in the biosphere, set by the climate, will affect the temperature in the shallow geosphere. This must be considered as a result of considered climate changes.
GEO 17.14b Ice load	Changes in thickness of the ice sheet due to seasonal variations and during periods of glaciation and deglaciation will affect the mechanical stress in the rock. (BIO 11.1e) (glaciation treated as a scenario)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Ice load effects must be considered due to expected glaciation.

5.3 Biosphere interactions

In Table 5-3, the biosphere interactions that have been given an upgraded priority are shown. In total 12 biosphere interactions are upgraded in priority. The main motive for 11 of the upgrades is the extended time frame of the safety assessment.

For one interaction the upgrade in priority is due to concerns raised by the regulatory authorities. For the food supply interaction (BIO 4.8b) it is stated in subsection 5.4.1 of /SKI and SSI 2004/ that not including this interaction in the assessment *"means that an important exposure pathway to man can be overlooked"*.

Due to the possibility of future drilling of boreholes into the system in the reference evolution of SAR-08, interaction BIO 8.1 has been defined handling human activities in terms of drilling that affects the geosphere.

A similar table is shown in Appendix A3 for all interactions in the SAR-08 biosphere interaction matrix whose priority has been considered in this work.

Figure 5-3 shows a version of the SAR-08 repository interaction matrix where elements containing interactions that have been upgraded in priority or defined in this work are highlighted. All other elements are shaded. A non-shaded version of the SAR-08 biosphere interaction matrix is shown in larger format in Appendix C.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	**GEOSPHERE (B.C.)**	a)Erosion/weath. b)Change in rock surface location	NONE	NONE	NONE	NONE	NONE	a)Material supply b)Settlement		Discharge/ recharge	Discharge/ recharge	Mass flux	Gas transport	Heat transport	Contaminant transport	NONE
2	a) Mech. load b) Consolidation	**Quaternary deposits** a)Relocation	a)Settlement b)Deposition	a)Settlement b)Consumption	a)Settlement b)Consumption	a)Settlement b)Consumption	a)Settlement b)Consumption	a)Settlement b)Consumption c)Material supply		a) Water transport b) Dehydration	a)Water transport b)Wave formation	a)Resuspension b)Leaching c)Sorpt./desorpt.	a)Resuspension b)Non-biol decomp c)Wind field changes	a)Radiation b)Heat transport c)Heat storage	a)Sorption/desorpt. b)Dissolution	Export
3	Root penetration a) Rock b) Tunnels c) Biological	Root growth	**Primary producers** a)Stimul/Inhib.	a)Stimul./Inhib. b)Food supply	a)Stimul./Inhib. b)Food supply	a)Stimul./Inhib. b)Food supply	a)Stimul./Inhib.	a)Stimul./Inhib. b)Food supply d)Material supply		Root uptake	a)Interception b)Retard./Accel. c)Uptake/Excret. d)Covering	a)Uptake./Excret. b)Particle prod	a)Gas uptake/rel b)Part. trap/prod c)Wind retard.	a)Radiation b)Exo/Endo react. c)Heat transp.	a) Uptake/sorpt. b) Excretion c) Degradation d) Growth	Export *detached outflow of plankton*
4	Potential intrusion	a)Decomposition b)Bioturbation	a)Stimul./Inhib.	**Decomposers** a)Stimul/Inhib. b)Food supply c)Feeding	a)Stimul./Inhib. b)Food supply	a)Stimul./Inhib. b)Food supply	a)Stimul./Inhib. b)Food supply	a)Stimul./Inhib. b)Food supply d)Material supply		Decomposition	a)Decomposition b)Retard./Accel. c)Uptake/Excret. d)Movement	a)Uptake./Excret. b)Particle prod	a)Gas uptake/rel b)Part. trap/prod	a)Radiation b)Exo/Endo react. c)Heat transp.	a) Uptake/sorpt. b) Excretion c) Degradation d) Growth	Export
5	Potential intrusion	Bioturbation	a)Stimul/Inhib. c)Feeding	a)Stimul./Inhib. b)Food supply c)Feeding	**Filter feeders** a)Stimul/Inhib. b)Food supply c)Feeding	a)Stimul./Inhib. c)Feeding	a)Stimul./Inhib. b)Food supply c)Feeding	a)Stimul./Inhib. b)Food supply d)Material supply		NONE	a)Water-pumping b)Retard./Accel. c)Uptake/Excret.	a)Uptake./Excret. b)Particle prod	NONE	a)Radiation b)Exo/Endo react. c)Heat transp.	a) Uptake/sorpt. b) Excretion c) Degradation d) Growth	Export *detachment spawn*
6	Potential intrusion	Bioturbation	a)Stimul./Inhib. c)Feeding	a)Stimul./Inhib. b)Food supply c)Feeding	a)Stimul./Inhib. b)Food supply	**Herbivores** a)Stimul/Inhib.	a)Stimul./Inhib. b)Food supply	a)Stimul./Inhib. b)Food supply d)Resource		NONE	a)Movement b)Retard./Accel. c)Uptake/Excret.	a)Uptake./Excret. b)Particle prod	a)Gas uptake/rel b)Part. trap/prod	a)Radiation b)Exo/Endo react. c)Heat transp.	a) Uptake/sorpt. b) Excretion c) Degradation d) Growth	Export
7	Potential intrusion	Bioturbation	a)Stimul./Inhib.	a)Stimul./Inhib. b)Food supply c)Feeding	a)Stimul./Inhib. b)Food supply c)Feeding	a)Stimul./Inhib. c)Feeding	**Carnivores** a)Stimul/Inhib. b)Food supply c)Feeding	a)Stimul./Inhib. b)Food supply c)Feeding d)Resource		NONE	a)Movement b)Retard./Accel. c)Uptake/Excret.	a)Uptake./Excret. b)Particle prod	a)Gas uptake/rel b)Part. trap/prod	a)Radiation b)Exo/Endo react. c)Heat transp.	a) Uptake/sorpt. b) Excretion c) Degradation d) Growth	Export *swimming running*
8	Borehole intrusion	Disturbance *(dredging, digging)*	a)Stimul./Inhib. c)Feeding d)Dispersal/ Extermination	a)Stimul./Inhib. b)Food supply c)Feeding d)Dispersal/ Extermination	a)Stimul./Inhib. c)Feeding d)Dispersal/ Extermination	a)Stimul./Inhib. c)Feeding d)Dispersal/ Extermination	a)Stimul./Inhib. b)Food supply c)Feeding d)Dispersal/ Extermination e)Material use	**Humans** a)Stimul/Inhib.		a)Water extraction b)Artific.infiltr.	a)Movement b)Retard./Accel. c)Uptake/Excret. d)Covering	a)Excretion b)Filtering c)Pollution	a)Gas uptake/rel b)Part. trap/prod c)Pollution d)Wind retard/acc.	a)Radiation b)Exo/Endo react. c)Heat transp. d)Antropogen eff	a) Uptake/sorpt. b) Excretion c) Degradation d) Growth	a)Export of energy b)Emigration?
9									**NONE (former topography)**							
10	a) Rech./disch. b) Press. change c) Mass flux d) Erosion/weath.	a)Erosion b)Water content change	a) Settlement b) Water uptake	a) Settlement b) Water uptake	NONE	a) Settlement b) Water uptake	a) Settlement b) Water uptake	a) Settlement b) Water use		**Water in quarternary deposits**	Discharge (recharge)	a) Erosion b) Mixing c) Dens. effects	a)Evapo./Cond. b)Sublimation	a)Heat transp. b)Heat storage	Mixing	Export
11	a) Rech./disch. b) Press. change c) Mass flux d) Erosion/weath. e) Ice-load	Erosion *(icescoring)*	a)Settlement b)Relocation c)Water uptake	a)Settlement b)Relocation c)Water uptake	a)Settlement b)Relocation c)Water uptake	a)Settlement b)Relocation c)Water uptake	a)Settlement b)Relocation c)Water uptake	a)Settlement b)Relocation c)Water use		Recharge (discharge)	**Surface water**	a) Mixing b)Dens. effects	a)Evapo./Cond. b)Sublimation c)Erosion *(seaspray/snowdrift)*	a)Radiation b)Exo/Endo react. c)Heat transp. d)Heat storage e)Light reflection	Mixing	Export/import
12	a) Mass flux b)Erosion/weath.	a) Sedimentation b) Precip./dissol. c) Erosion/weath.	a)Settlement b)Stimul./Inhib. c)Light attenu.	a)Settlement b)Stimul./Inhib.	a)Settlement b)Stimul./Inhib.	a)Settlement b)Stimul./Inhib.	a)Settlement b)Stimul./Inhib.	a)Settlement b)Stimul./Inhib.		Water transport	Water transport	**Water composition**	a)Spray/Snowdrift b)Dissol./Degas.	a)Exo/Endo react. b)Light absorb. c)Light reflect./scatt. d)Adiab. compr.	a) Sorpt./desorpt. b) Dissol./precip. c) Sedimentation	Export
13	Gas transport	a)Erosion b)Deposition c)Oxidation	a)Settlement b)Stimul./Inhib. c)Relocation d)Depos./Remov.	a)Settlement b)Stimul./Inhib. c)Relocation d)Depos./Remov.	NONE	a)Settlement b)Stimul./Inhib. c)Relocation d)Depos./Remov.	a)Settlement b)Stimul./Inhib. c)Relocation d)Depos./Remov.	a)Settlement b)Stimul./Inhib. c)Relocation d)Depos./Remov.		a)Water transport b)Evapo./cond. c)Sublimation	a)Water transport b)Evapo./Cond. c)Precipitation d)Wind stress e)Sublimation	a)Precipitation b)Deposition c)Evapo./Cond. d)Dissol./Degas.	**Gas** **--------------** **Atmosphere**	a)Radiation b)Exo/Endo react. c)Heat transp. d)Heat storage e)Adiab.temp. change f)Phase changes	a)Mixing b)Sorpt./desorpt. c)Photochem. reactions	Export
14	a)Heat transport b)Erosion/weath.	a)Weathering b)Thermal expans/contr	a)Settlement b)Stimul./Inhib.	a)Settlement b)Stimul./Inhib.	a)Settlement b)Stimul./Inhib.	a)Settlement b)Stimul./Inhib.	a)Settlement b)Stimul./Inhib.	a)Settlement b)Stimul./Inhib.		Phase transitions	a)Phase transitions b)Convection	a)Kinetics & chem equil. b)Property changes c)Mixing	a)Pressure change b)Phase transitions	**Temperature**	a)Kinetics & chem equil. b)Phase transitions	Export of heat
15	Contaminant transport	a) Surface dep./uptake b) Irradiation	a) Int. exposure b) Ext. exposure	a) Int. exposure b) Ext. exposure	a) Int. exposure b) Ext. exposure	a) Int. exposure b) Ext. exposure	a) Int. exposure b) Ext. exposure	a) Int. exposure b) Ext. exposure		NONE	NONE	a) Radiolysis b) Stab. isotopes c) Chem. react.	Phase transition	Heat from decay	**Radionuclides and toxicants** a) Decay	Export
16	NONE	a) Import b) Land rise	a) Import b) Insolation	Import	Import	Import	Import	a)Import of energy b)Immigration		Import	a) Sea level changes b) Sea currents	Import	a)Import b)Photochem-reactions	a) Import of heat b) Insolation	External load of contaminants	**External conditions (B.C.)**

Figure 5-3. *SAR-08 biosphere interaction matrix where elements featuring interactions with changed priority are highlighted.*

Table 5-3. Biosphere interactions which priority has been upgraded in SAR-08.

Interaction name and number	SAFE description	Priority and comment, intended for use when setting up the for SAR-08 main scenario and less probable scenarios
BIO 1.10 Discharge/ recharge	The hydrology in the geosphere influences the discharge and recharges of groundwater and thereby the hydrology in the Quaternary deposits. (GEO 11.17b)	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The amount of water in Quaternary deposits could be determined by water in the geosphere if the biosphere freezes sporadically.
BIO 1.11 Discharge/ recharge	The hydrology in the geosphere influences the discharge and recharge of groundwater and thereby the surface water hydrology. (GEO 11.17)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Precipitation and hydrology in Quaternary deposits are of more importance for surface water conditions during temperate conditions. During permafrost conditions talik formation can affect surface waters.
BIO 1.14 Heat transport	The heat exchange between geosphere and biosphere will affect the temperature in the biosphere. (GEO 13.17)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The surface temperature determines mainly the temperature in Quaternary deposits and surface waters, and is of importance during permafrost conditions.
BIO 3.13a Gas uptake and release	Primary producers will by their respiration (uptake of CO_2, H_2O gas and N_2 and the release of O_2) influence the amount of gas and the gas composition. Here is also included the root uptake in the unsaturated zone.	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The gas is affected by primary producers, but due to the high exchanges of gas there are small concentration gradients. This is considered for ^{14}C in terrestrial ecosystems.
BIO 4.8b Food supply	Amount and production rate, mushrooms etc.	Priority: Changed from 1 to 2 Motivated by: Review comments on Project SAFE documents by authorities. Comment: Priority 1 was questioned in /SKI and SSI 2004/ as neglecting it "means that an important exposure pathway to man can be overlooked".
BIO 8.1 Borehole intrusion Not defined in SAFE		Priority: Set to 3 Description: Future human action resulting in the penetration of open boreholes, such as water wells, into the geosphere. Comment: Such boreholes are conceivable.
BIO 8.14c Heat transport	Isolation, greenhouse influenced heat transport.	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: It is assumed that this already is given in the climate situation from assessment context. Greenhouse influence is considered.
BIO 8.14d Anthropogenic effects	Human activities such as industrial activities may have a direct influence on the temperature in the biosphere. Treated as an alternative scenario	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: It is assumed that this already is given in the climate situation from assessment context. Greenhouse influence is considered.
BIO 11.1e Ice load	Changes in thickness of the ice sheet due to seasonal variations and during periods of glaciation and deglaciation will affect the mechanical stress in the rock. (GEO 17.14b)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Must be accounted for during periods of glaciation, see GEO 17.14b.

Interaction name and number	SAFE description	Priority and comment, intended for use when setting up the for SAR-08 main scenario and less probable scenarios
BIO 14.1a Heat transport	The heat exchange between geosphere and biosphere will affect the temperature in the geosphere. (GEO 17.13)	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Influence on the geosphere from temperature in the biosphere must be considered.
BIO 14.3a Settlement	The temperature will affect the settlement of plants	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The estimated species distribution is assumed to reflect the temperature dependence on settlement during temperate conditions. During permafrost condition this must be considered explicitly or through water availability.
BIO 14.10 Phase transitions	Freezing of water, melting of snow and evaporation of water in Quaternary deposits as a result of changes in temperature will affect the water content, water pressure and water flow in the Quaternary deposits.	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: This is an important process, which however is included in most annual averages in normal climate scenario. In a cooler climate this interaction is important as it influences the groundwater movement.
BIO 14.11a Phase transitions	Freezing and evaporation of surface waters as a result of changes in temperature will affect water movement and amounts of water and ice. Temperature affects the aggregation state of water (gas, ice and water)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: This is an important process, which however is included in most annual averages in the normal climate scenario. In a cooler climate this interaction is important and must be considered due to occurrence of permafrost.

6 Handling of SKI FEPs for the SFR repository

After the completion of the scenario and system analysis work of the SAFE project, the Swedish Nuclear Power Inspectorate (SKI) has published an encyclopaedia of Features, Events and Processes (FEPs) for the Swedish SFR and Spent fuel repositories /Miller et al. 2002/. This encyclopaedia contains 24 FEPs that are specific for the SFR 1 repository. In order to check that no significant aspects of these FEPs are neglected in SAR-08, a thorough examination of relevant text of /Miller et al. 2002/ was carried out. In the following section the notation SKI FEP is used and therefore it is fair to point out that even though /Miller et al. 2002/ is a SKI publication, the viewpoints of the authors do not necessarily coincide with those of the SKI.

6.1 Methodology of handling SKI FEPs for the SFR repository

Each of the SKI FEPs, labelled SFR-1 to SFR-24 (see Table 6-1), has been thoroughly examined by one of the main authors (Maria Lindgren). Thereafter, an attempt has been made to match each of them to at least one of the three interaction matrices of SAR-08. A SKI FEP generally does not describe a single binary interaction, but consist of a number of significant aspects and processes. Therefore, a single SKI FEP could match more than one of the interaction matrices of SAR-08, as well as concern more than one interaction within a matrix.

The aim of the task was to check that no significant aspect or process of the SKI FEPs is neglected. However, it was not an aim to match each single aspect or process to SAR-08 FEPs.

A list (Table 6-1) has been made wherein matches between the interaction matrices and the SKI FEPs are ticked. In addition, it has been checked that there are no major inconsistency between aspects and processes of the SKI FEPs and the SAR-08 FEPs.

In case it had been found that an aspect or process of an SKI FEP is not sufficiently well acknowledged in the process of prioritising the SAR-08 FEPs, the assigned priority of the concerned SAR-08 interaction was intended to be reconsidered. However, the examination of the SKI FEPs showed that this is not needed.

6.2 Result of handling SKI FEPs for the SFR repository

In Table 6-1 the SKI SFR FEPs are listed together with short descriptions as taken from /Miller et al. 2002/. As can be seen, each SKI FEP could be matched with at least one of the SAR-08 interaction matrices. No major inconsistency could be found between the SKI and SAR-08 FEPs. The minor inconsistencies found were judged to be of little importance for the SAR-08 safety assessment.

Table 6-1. SKI SFR FEPs and SAR-08 interaction matrices containing matching FEPs.

SKI FEP	SKI FEP Name and description	Interaction matrix REP	 GEO	 BIO	No major inconsistency
SFR-1	Colloid generation in the waste package Colloids may be generated by chemical, physical and microbiological processes in the waste package. Radionuclides can sorb onto these colloids which may affect their subsequent transport out of the near-field.	√			√
SFR-2	Colloid generation in the shell and grout Colloids may be generated by chemical, physical and microbiological processes in the shell and grout of the silo. Radionuclides can sorb onto these colloids which may affect their subsequent transport out of the near-field.	√			√
SFR-3	Degradation of the cement mortar and the silo shell The cementitious backfills and the concrete shell of the silo will be affected by physical and chemical degradation processes. These processes will affect the porewater chemistry, the solubility and sorption of radionuclides, and the mechanical stability of the silo shell. Together, these effects will impact on the radionuclide transport processes and rates.	√			√
SFR-4	Degradation of steel reinforcements in the silo shell The shell of the silo is made of reinforced concrete. Degradation of the reinforcing rods may occur by a combination of physical and chemical processes leading to gas generation, colloid generation and possible impacts on the structural integrity of the silo.	√			√
SFR-5	Degradation of the concrete packages and the cement matrix The concrete waste packages and the cementitious immobilisation matrix will be affected by physical and chemical degradation processes. These processes will affect the porewater chemistry, the solubility and sorption of radionuclides, and the mechanical stability of the packages. Together, these effects will impact on the radionuclide transport processes and rates.	√			√
SFR-6	Degradation of the bitumen matrix The SFR repository will house many diverse waste types, both inorganic and organic. The inorganic wastes may degrade by a combination of physical, chemical and microbial processes. This degradation may have a limited impact on the release and transport of radionuclides from the near-field.	√			√
SFR-7	Degradation of the inorganic waste The SFR repository will house many diverse waste types, both inorganic and organic. The inorganic wastes may degrade by a combination of physical, chemical and microbial processes. This degradation may have a limited impact on the release and transport of radionuclides from the near-field.	√			√
SFR-8	Degradation of the organic waste The SFR repository will house many diverse waste types, both inorganic and organic. The organic wastes may degrade by a combination of physical, chemical and microbial processes. This degradation is likely to create large volumes of gas and a variety of organic compounds which may influence radionuclide solubilities. Consequently, degradation of organic wastes may impact on the release and transport of radionuclides from the near-field.	√			√
SFR-9	Diffusion in the near-field Diffusion in the near-field may occur through water-filled cracks and voids in the mass of the immobilisation matrices and through the compacted bentonite layer surrounding the silo structure. Diffusion will be an important process controlling porewater chemistry in the nearfield and the radionuclide release rate to the far-field.	√			√

SKI FEP	SKI FEP Name and description	Interaction matrix REP	 GEO	 BIO	No major inconsistency
SFR-10	Colloid filtration in the near-field Colloids formed in the silo of the SFR will be filtered by the bentonite layer around the silo structure for as long as the bentonite provides a barrier to advective groundwater flow. This will cause a reduction in the release of radionuclides to the near-field rock. No other material in the SFR provides a significant colloid filtration role.	√			√
SFR-11	Gas generation in the repository Gases can be generated in the repository by three processes: corrosion of steel, radiolysis and microbial activity. The gas generated may form a free gas phase and this could impact on the transport and release of radionuclides. In some cases, radionuclides may be directly associated with the gas molecules whilst, in other cases, the gas phase will impact on the movement of groundwaters containing dissolved radionuclides.	√			√
SFR-12	Gas flow in the near-field Gases can be generated in the near-field by three processes: corrosion of steel, radiolysis and microbial activity. The gas generated may form a free gas phase which could be mobile. The flow of gas from the near-field could have a significant impact on the transport and release of radionuclides and the structural integrity of the engineered barriers.	√			√
SFR-13	Mechanical impact on the engineered barriers Mechanical impacts on the near-field can arise due to a range of internal and external stresses. These stresses will act on the repository excavations and support structures and can be partially responsible for failure of the engineered barriers. Mechanical impacts thus can affect radionuclide releases rates and times to the far-field.	√	√	√	√
SFR-14	Radiation effects in the near-field Radiation emitted from the waste will impinge on all materials in the near-field and potentially radiation effects could accelerate material degradation and dissolution. However, at the relatively low activity levels in the SFR these effects are mostly insignificant for repository safety. The only potentially important process will be radiolysis of the groundwaters and organic materials.	√			√
SFR-15	Radionuclide release from the waste Radionuclides will be released from the wasteforms by a variety of mechanisms either to solution, to secondary solid alteration phases, as colloids or in the gaseous phase. The nature and abundance of the released species will depend on the chemistry of the near-field pore-waters and the degradation rate of the wasteform. Radionuclide release from the wasteform is a fundamental control on the safety of the repository.	√			√
SFR-16	Hydraulic resaturation of the near-field After closure of the repository, groundwater will flow from the saturated far-field rock into the void spaces in the near-field and will cause it to become hydraulically resaturated. This inflow of water will impact on the thermal and stress fields and, when in contact with the engineered barrier materials, will cause them to begin to degrade. During the resaturation process, the groundwater chemical condition will shift from oxidising in the near-field rock to increasingly reducing conditions.	√	√		√
SFR-17	Temperature of near-field The temperature of the near-field is controlled by heat generation in the waste and engineered barriers, superimposed on natural geothermal conditions. Elevated temperatures in the near-field can affect the rates of chemical and microbiological processes, and can influence groundwater flow, diffusion coefficients and, hence, radionuclide transport.	√	√		√

SKI FEP	SKI FEP Name and description	Interaction matrix REP	 GEO	 BIO	No major inconsistency
SFR-18	Radionuclide release from the waste package Radionuclides released from the waste will initially be located inside the waste packages. The packages themselves are not designed with any specific post-closure containment role and will degrade relatively quickly after repository closure. Consequently, radionuclide release from the waste packages will occur quickly after release from the wasteform. The release process from the waste packages does not, therefore, afford any particular role in repository safety.	√			√
SFR-19	Transport and release from the silo Radionuclides may be transported out of the silo in groundwater or in gaseous form. While the bentonite layer around the silo remains intact, dissolved radionuclides can be released only by diffusion through the bentonite layer. Gases can permeate through the bentonite/sand layer at the top of the silo. Radionuclide release from the silo is a primary control on the safety of the repository because of the high activity content of the silo.	√	√		√
SFR-20	Groundwater chemistry in the near-field The groundwater chemistry in the near-field will be substantially altered by changes to recharge chemistry and by direct reaction with the waste and with the materials used in the engineered barriers, particularly cement and steel. Alterations to the groundwater chemistry will affect radionuclide solubility and sorption, may affect barrier performance and, consequently, will impact on radionuclide release.	√	√		√
SFR-21	Groundwater movement in the near-field Post-closure water movement in the SFR repository will depend on location. In the silo, water movement across the silo walls will occur by diffusion because of the compacted bentonite layer. However, in the rock vaults, water may flow freely between the vaults and the nearfield rock, driven by head gradients in the rock mass.	√	√		√
SFR-22	Changes in the radionuclide inventory The initial radionuclide inventory defines the abundance of every radionuclide species in the waste at the time of emplacement. After emplacement, the initial radionuclide inventory will change due to radioactive decay and migration of radionuclides out of the near-field.	√			√
SFR-23	Groundwater chemistry in the near-field rock The water chemistry in the near-field rock is controlled by the composition of the ambient natural groundwater, the composition of waters leaving the repository excavations having interacted with the engineered barriers and the degree of mixing between these two waters. The water chemistry of the near-field rock is a control on the transport and retardation processes affecting radionuclide released from the engineered barriers.	√	√		√
SFR-24	Evolution of the bentonite layer in the silo The bentonite layer of the silo provides a barrier to groundwater flow. It also acts as a mechanical barrier to protect the concrete shell of the silo. The bentonite will degrade over time by physical and chemical processes and thus its barrier functions will diminish. This will have an impact on radionuclide release processes and rates from the silo.	√	√		√

The minor inconsistencies found could be divided into three categories:

1. Components and/or processes addressed in the SKI SFR FEPs are not outlined in the SAR-08 FEPs. However, for all these cases it is stated in /Miller et al. 2002/ that the aspect is likely to be of little importance for repository safety.
2. Components and processes match on a general level, but on a detailed level some aspects are not outlined in the SAR-08 FEPs and therefore differences are found.
3. The aspect match, but the importance of the specific aspect for repository safety is, to a minor degree, judged differently in /Miller et al. 2002/ and SAR-08.

The three categories are exemplified below.

1. The SKI FEP "SFR-7 Degradation of inorganic waste" is an example where components and/or processes were not outlined in SAR-08. The SKI FEP has the following text in the detailed description:

   "Any non-metallic inorganic materials (e.g. ceramics) will be present in the waste in only small amounts and will be essentially inert, although they may be subject to slow microbially mediated degradation products. In this case, small volumes of CO_2, CH_4 and H_2 gases could be generated but they would be much smaller than the equivalent gas production from degradation of organic materials, such as cellulose."

   This aspect is not included in the SAR-08 interaction matrix for the repository, but as stated in the regulation /SKI 2002/, gas generated from inorganic materials would be much smaller than the equivalent gas production from degradation of organic materials. Therefore, such gas generation can be motivated to be of subordinate importance for the safety assessment.

2. The SKI FEP "SFR-12 Gas flow in the near-field" is an example where details of some aspects are not outlined in SAR-08. The SKI FEP include a list of how gas bubbles could affect the transport of radionuclides, where one of the mechanisms is that bubble formation may change the apparent viscosity of the groundwater and induce or accelerate groundwater movement. This mechanism is generally included in the SAR-08 interaction matrix for the repository as two phase flow (REP 12.11b)

   "The gas pressure, gas flow and saturation degree in the different components of the repository system will affect the magnitude, direction and distribution of water flow in the system components."

   However, the detailed interaction that the parameter apparent viscosity can be affected by gas bubbles can not be found in any SAR-08 FEP.

3. The SKI FEP "SFR-10 Colloid filtration in the near-field" is an example where an aspect is judged to be of different importance in /Miller et al. 2002/ and SAR-08. The short description of SFR-10 states:

   "Colloids formed in the silo of the SFR will be filtered by the bentonite layer around the silo structure for as long as the bentonite provides a barrier to advective groundwater flow. This will cause a reduction in the release of radionuclides to the near-field rock. No other material in the SFR provides a significant colloid filtration role."

   In the SAR-08 interaction matrix for the repository, not only colloid filtering in the bentonite layer but also colloid filtration in cementations materials is judged as potentially important for repository safety. Concerning colloids on a more general level, /Miller et al. 2002/ conclude that the colloids are not considered important for the safety of the SFR repository.

7 Conclusion

This report describes the outcome of revisiting the qualitative FEP analysis carried out within Project SAFE for the SFR 1 repository. Each and every interaction definition, as defined in SAFE, has been examined with the aim at assuring that the SAFE interaction matrices are also applicable for SAR-08. It was found that this is generally the case, but seven new interactions were defined in order to make the interaction matrices more applicable for SAR-08.

The priority of all interactions assigned priority 1 and many interactions assigned priority 2 in SAFE have been carefully examined. The examination has been made in the context of the general initial and boundary conditions that should also form the basis for the SAR-08 main scenario and less probable scenarios. In 48 cases, the priority of the interaction needed upgrading, compared to in SAFE. In a majority of these cases, the upgrade is due to the extended time frame of the safety assessment, from 10,000 years in SAFE to 100,000 years in SAR-08. Two major events giving rise to priority upgrades are permafrost and glaciation.

Also for EFEPs, the extended time period of the safety assessment, which lays ground for climatic changes, influence their assigned priority. The EFEPs considered to be of potential importance for scenario selection were sorted for use either in setting up of the main scenario and less probable scenarios or in setting up of residual scenarios. To provide a link between safety functions and EFEPs, the EFEPs of potential importance for the main scenario and less probable scenarios were mapped to diagonal elements of the SAR-08 repository and geosphere interaction matrices. From these diagonal elements, the scenario selection team can go further on to events and processes in off-diagonal elements that may affect the safety functions.

It was found that the methodology adapted for scenario selection in SAR-08 requires an iterative process and much communication between the main authors of this report and the scenario selection team, as similar initial and boundary conditions need to be considered when prioritising interactions and when evaluating the performance of safety functions.

Finally it is concluded that there exist no major inconsistency between the SAR-08 FEPs and the SFR FEPs presented in the SKI report Encyclopaedia of Features, Events and Processes (FEPs) for the Swedish SFR and Spent Fuel Repositories – Preliminary Version. /Miller et al. 2002/.

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Appendix A1

Repository interactions of SAR-08

Coloured fields indicate new interactions or interactions whose priority is updated in SAR-08 from that in SAFE. The SAR-08 repository interaction matrix is displayed in Appendix C. The SAFE descriptions have not been edited in this work.

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 1.1 Waste/cement	Waste and cement matrix of all waste types that are stabilised in cement, i.e. ion-exchange resin, sludge, scrap and trash allocated to the Silo, BMA and 1BTF.		
REP 1.1a Recrystallisation	Recrystallisation of the hydration products in cement in the waste matrix may change the composition and internal physical structure of the cement.	Priority: Unchanged	3
REP 1.2 None	No direct influence. Physically isolated. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 1.3 None	No direct influence. Physically isolated. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 1.4 Expansion/ contraction	Changes in volume and dimensions of the waste and matrix may cause expansion/contraction of the materials and voids in the concrete packaging thereby affecting the volume and dimensions of the materials and voids in the concrete packaging.	Priority: Unchanged Comment: Change in volume and dimensions of the waste and waste matrix will probably primarily affect the stress conditions in the waste matrix and surrounding packaging, i.e. interaction 4.14, which in turn may affect the volume and dimensions of the concrete packaging, interaction 14.4.	1
REP 1.5 Expansion/ contraction	Changes in volume and dimensions of the waste and matrix may cause expansion/contraction of the materials and voids in the steel packaging thereby affecting the volume and dimensions of the materials and voids in the steel packaging.	Priority: Unchanged Comment: Change in volume and dimensions of the waste and waste matrix will probably primarily affect the stress conditions in the waste matrix and surrounding packaging, i.e. interaction 4.14, which in turn may affect the volume and dimensions of the steel packaging, interaction 14.5.	1
REP 1.6 None	The cement conditioned waste is physically isolated from the concrete backfill. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 1.7 None	The cement conditioned waste is physically isolated from the concrete structures. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 1.8 None	The cement conditioned waste is physically isolated from the bentonite barriers. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 1.9 None	The cement conditioned waste is physically isolated from vaults and backfill. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 1.10a Dissolution/ precipitation	The type and amount of waste and cement will affect the dissolution and precipitation of cement and waste components and thus the water composition in the waste/cement matrix. Includes also colloid formation	Priority: Unchanged	3
REP 1.10b Corrosion	The type and amount of metals in the waste matrix will affect the mode and rate of corrosion of these and thus the water composition in the waste/cement matrix. The presence of different type of metals may give rise to galvanic corrosion. Includes also colloid formation.	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 1.10c Degradation of organics	The type and amount of organic materials in the waste matrix will affect the chemical and microbial degradation of organics, e.g. degradation of cellulose, and thus the water composition in the waste/cement matrix. Includes also colloid formation.	Priority: Unchanged	3
REP 1.10d Diffusion	The physical properties (porosity etc) of the waste/cement matrix affect the diffusive transport of dissolved components through the waste matrix and thereby the composition of the water in waste matrix and surrounding system components.	Priority: Unchanged	3
REP 1.10e Sorption	The type and amount of materials in the waste matrix will affect the sorption of dissolved components and colloids and thereby the composition of the water in the the waste/cement matrix.	Priority: Unchanged	3
REP 1.10f Colloid filtering	The amount and size of pores/fractures in the waste matrix will affect the filtering of colloids/particles and thus the amount of colloids/particles in the water in the waste matrix and in surrounding system components.	Priority: Unchanged	3
REP 1.11a Water flow	The permeability of the waste matrix will affect the magnitude, direction and distribution of the water flow in the waste matrix and surrounding barriers	Priority: Unchanged	3
REP 1.11b Capillary suction	The poresize distribution of the waste matrix will affect the capillary suction of water into the waste matrix and thus the degree of saturation of the waste and packagings during the saturation phase	Priority: Unchanged	4
REP 1.12a Corrosion	Type and amount of metals in the waste will affect the mechanism and rate of corrosion and thus the amount and composition of gas in the waste matrix. The presence of different type of metals may give rise to galvanic corrosion.	Priority: Unchanged	3
REP 1.12b Degradation of organics	The type and amount of organic materials in the waste matrix will affect the microbial and chemical degradation of these, e.g. degradation of cellulose, and thus the amount and composition of gas in the waste matrix.	Priority: Unchanged	3
REP 1.12c Gas flow	Dimensions and physical properties of the waste matrix will affect the magnitude, direction and distribution of gas flow in the waste matrix and in surrounding components of the repository system.	Priority: Unchanged	3
REP 1.13a Cement hydration	The hydration of cement in the waste matrix will generate heat that can affect the temperature in the waste matrix, dependent on the extent of hydration after repository closure. The extent of hydration is in turn dependent on the type and amount of cement in the waste matrix and the time since the production of the waste package.	Priority: Unchanged Comment: Time between production of the cement-conditioned waste packages and repository closure is assessed to be long enough for total decay of heat generation due to cement hydration.	1
REP 1.13b Heat conduction	The thermal properties of the waste matrix, i.e. heat capacity and heat conductivity, and dimensions will affect the heat conduction in the matrix and thereby the temperature in the waste matrix and surrounding system components	Priority: Unchanged	2
REP 1.13c Exothermic reactions	Exothermic reactions in the waste matrix that generates heat and thus affect the temperature in the waste matrix.	Priority: Unchanged	2
REP 1.14 Expansion/contraction	Changes in geometry and dimensions of the waste matrix, e.g. due to corrosion of metals and ettringite formation will affect the stress conditions in the waste matrix and surrounding packaging	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 1.15 Microbial activity	Type and amount of organic materials and nutrients and energy sources in the waste matrix and physical properties of the waste matrix will affect the microbial activity in the waste matrix and thus the type and amount of microbes in the waste matrix	Priority: Unchanged	3
REP 1.16a Dissolution/ precipitation	The type and amount of waste and cement will affect the dissolution and precipitation of radionuclides and toxicants in the cement and waste components and thus the distribution between mobile and immobile radionuclides and toxicants in the waste/cement matrix. Includes also colloid formation	Priority: Unchanged	3
REP 1.16b Corrosion	The type and amount of metals in the waste matrix will affect the mode and rate of corrosion of these and thereby the liberation of radionuclides and toxicants included in the metals. This will affect the distribution between mobile and immobile radionuclides and toxicants in the waste/cement matrix. Includes also colloid formation. The presence of different type of metals may give rise to galvanic corrosion.	Priority: Unchanged Comment: Negligible amount, if any, of induced activity in metal waste.	1
REP 1.16c Degradation of organics	The type and amount of organic materials in the waste matrix will affect the chemical and microbial degradation of organics and thereby the liberation of radionuclides and toxicants included in these. This will affect the distribution between mobile and immobile radionuclides and toxicants in the waste/cement matrix. Includes also colloid formation	Priority: Unchanged	3
REP 1.16d Diffusion	The physical properties (porosity etc) of the waste/cement matrix affect the diffusive transport of dissolved radionuclides and toxicants through the waste matrix and thereby the concentration of radionuclides and toxicants in the water in waste matrix and surrounding system components.	Priority: Unchanged	3
REP 1.16e Sorption	The type and amount of materials in the waste matrix will affect the sorption of dissolved radionuclides and toxicants and thereby the distribution between mobile and immobile radionuclides and toxicants in the waste/cement matrix. Saturation of sorption sites and non-linear sorption effects should be considered.	Priority: Unchanged	3
REP 1.16f Colloid filtering	The amount and size of pores/fractures in the waste matrix will affect the filtering of radioactive and toxic colloids/particles and thus the amount of radioactive and toxic colloids/particles in the water in the waste matrix and in surrounding system components.	Priority: Unchanged	3
REP 1.17 None	No direct effect from the waste matrix on the tunnels and backfill since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 1.18 None	No direct effect from the waste matrix on the repository rock since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 2.1 None	No direct influence. Physically isolated. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 2.2 Waste/bitumen	Waste and bitumen matrix of all waste types that are stabilised in bitumen, i.e. ion-exchange resins and evaporator concentrates allocated to the Silo, BMA and BLA.		

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 2.3 None	No direct influence. Physically isolated. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 2.4 None	Physically isolated since no bituminised waste in concrete packagings.	Priority: Unchanged	0
REP 2.5 Expansion/ contraction	Changes in volume and dimensions of the waste and matrix may cause expansion/contraction of the materials and voids in the steel packaging thereby affecting the volume and dimensions of the materials and voids in the steel packaging.	Priority: Unchanged Comment: Salt and ion exchange resins in the bitumen matrix will take up water and expand in volume. This will affect the stress conditions in the bitumen matrix and make the whole bitumen matrix to expand. This change in volume and dimensions of the waste and bitumen matrix will probably primarily affect the stress conditions, i.e. interaction 2.14, which in turn will affect the volume and dimensions of the surrounding steel packaging, interaction 14.5.	1
REP 2.6 None	The bitumen conditioned waste is physically isolated from the concrete backfill. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 2.7 None	The bitumen conditioned waste is physically isolated from the concrete structures. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 2.8 None	The bitumen conditioned waste is physically isolated from the bentonite barries. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 2.9 None	The bitumen conditioned waste is physically isolated from vaults and backfill. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 2.10a Dissolution/ precipitation	The type and amount of waste will affect the dissolution and precipitation in the waste matrix and thus the water composition in the waste matrix. Includes also colloid formation.	Priority: Unchanged	3
REP 2.10b Degradation of organics	The type and amount of bitumen and waste (ion exchange resins) in the waste matrix will affect the chemical and microbial degradation of organics and thus the water composition in the waste matrix. Includes also colloid formation.	Priority: Unchanged	3
REP 2.10c Diffusion	The physical properties (porosity etc) of the waste/ bitumen matrix affect the diffusive transport of dissolved components through the waste matrix and thereby the composition of the water in waste matrix and surrounding barriers.	Priority: Unchanged	3
REP 2.10d Sorption	The type and amount of materials in the waste matrix will affect the sorption of dissolved components and colloids and thereby the composition of the water in the the waste/bitumen matrix.	Priority: Unchanged Comment: Sorption on bitumen negligibly small, if any.	1
REP 2.10e Colloid filtering	The amount and size of pores/fractures in the waste matrix will affect the filtering of colloids/ particles and thus the amount of colloids/particles in the water in the waste matrix and in surrounding system components.	Priority: Unchanged Comment: Difficult to quantify. Furthermore a positive effect.	1
REP 2.11a Water flow	The permeability of the waste matrix will affect the magnitude, direction and distribution of the water flow in the waste matrix and surrounding barriers.	Priority: Unchanged	3
REP 2.11b Capillary suction	The poresize distribution of the waste matrix will affect the capillary suction of water into the waste matrix and thus the degree of saturation of the waste and packagings during the saturation phase.	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 2.12a Degradation of organics	The type and amount of bitumen and other organic materials in the waste matrix will affect the microbial and chemical degradation of these and thus the amount and composition of gas in the waste matrix.	Priority: Unchanged	2
REP 2.12b Gas flow	Dimensions and physical properties of the waste matrix will affect the magnitude, direction and distribution of gas flow in the waste matrix and in surrounding components of the repository system.	Priority: Unchanged	2
REP 2.13a Heat conduction	The thermal properties of the waste matrix, i.e. heat capacity and heat conductivity, and dimensions will affect the heat conduction in the matrix and thereby the temperature in the waste matrix and surrounding system components.	Priority: Unchanged	2
REP 2.13b Exothermic reactions	Exothermic reactions in the waste matrix that generates heat and thus affect the temperature in the waste matrix.	Priority: Unchanged	2
REP 2.14 Expansion/ contraction	Changes in geometry and dimensions of the waste matrix, e.g. due to water uptake, will affect the stress conditions in the waste matrix and surrounding packaging.	Priority: Unchanged	3
REP 2.15 Microbial activity	Type and amount of organic materials and nutrients and energy sources in the waste matrix and physical properties of the waste matrix will affect the microbial activity in the waste matrix and thus the type and amount of microbes in the waste matrix.	Priority: Unchanged	3
REP 2.16a Dissolution/ precipitation	The amount and composition of the waste will affect the dissolution and precipitation of radionuclides and toxicants in the waste matrix and thus the distribution between mobile and immobile radionuclides and toxicants in the waste matrix. Includes also colloid formation.	Priority: Unchanged	3
REP 2.16b Degradation of organics	The type and amount of bitumen and waste (ion exchange resins) in the waste matrix will affect the chemical and microbial degradation of organics and thereby the liberation of radionuclides and toxicants included in these. This will affect the distribution between mobile and immobile radionuclides and toxicants in the waste matrix. Includes also colloid formation.	Priority: Unchanged	3
REP 2.16c Diffusion	The physical properties (porosity etc) of the waste/bitumen matrix affect the diffusive transport of dissolved radionuclides and toxicants through the waste matrix and thereby the concentration of radionuclides and toxicants in the water in waste matrix and surrounding barriers.	Priority: Unchanged	3
REP 2.16d Sorption/ion-exchange	The amount and composition of the waste matrix will affect the sorption of radionuclides and toxicants and thus the distribution between mobile and immobile radionuclides and toxicants in the waste matrix. Saturation of sorption sites and non-linear sorption effects should be considered.	Priority: Unchanged	2
REP 2.16e Colloid filtering	The amount and size of pores/fractures in the waste matrix will affect the filtering of radioactive and toxic colloids/particles and thus the amount of radioactive and toxic colloids/particles in the water in the waste matrix and in surrounding system components.	Priority: Unchanged Comment: Difficult to quantify. Furthermore a positive effect.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 2.17 None	No direct effect from the waste matrix on the tunnels and backfill since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 2.18 None	No direct effect from the waste matrix on the repository rock since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 3.1 None	No direct influence. Physically isolated. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 3.2 None	No direct influence. Physically isolated. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 3.3 Waste/non-solidified	All non-solidified waste in the different repository parts, i.e. ion-exchange resins in 1BTF and 2BTF, ashes in 1BTF, trash and scrap in BLA.		
REP 3.4 Expansion/contraction	Changes in volume and dimensions of the waste and void may cause expansion/contraction of the materials and voids in the concrete packaging thereby affecting the volume and dimensions of the materials and voids in the concrete packaging.	Priority: Unchanged Comment: Should be enough expansion volume inside the waste package to take up any changes in waste volume that may occur without significantly affecting the stress conditions in the waste package and/or the volume and dimensions of the concrete packaging.	1
REP 3.5 Expansion/contraction	Changes in volume and dimensions of the waste and void may cause expansion/contraction of the materials and voids in the steel packaging thereby affecting the volume and dimensions of the materials and voids in the steel packaging.	Priority: Unchanged Comment: Should be enough expansion volume inside the waste package to take up any changes in waste volume that may occur without significantly affecting the stress conditions in the waste package and/or the volume and dimensions of the steel packaging.	1
REP 3.6 None	No direct influence. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 3.7 None	No direct influence. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 3.8 None	No direct influence. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 3.9 None	No direct influence. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 3.10a Dissolution/precipitation	The type and amount of waste will affect the dissolution and precipitation of waste components and thus the water composition inside the waste packaging. Includes also colloid formation. Dissolution of ashes – precipitation of minerals.	Priority: Unchanged	3
REP 3.10b Corrosion	The type and amount of metals in the waste will affect the mode and rate of corrosion of these and thus the water composition inside the waste packaging. The presence of different type of metals may give rise to galvanic corrosion. Includes also colloid formation.	Priority: Unchanged	3
REP 3.10c Degradation of organics	The type and amount of organic materials in the waste will affect the chemical and microbial degradation of organics and thus the water composition inside the waste packaging. Includes also colloid formation.	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 3.10d Diffusion	The physical properties (porosity etc) of the waste affect the diffusive transport of dissolved components through the waste and thereby the composition of the water inside the waste packaging and in surrounding system components.	Priority: Unchanged Comment: Could have some effect on the dissolution and transport in some waste types. However, difficult to quantify and probably conservative to assume immediate mixing inside the waste container.	1
REP 3.10e Sorption	The type and amount of materials in the waste will affect the sorption of dissolved components and colloids and thereby the composition of the water inside the waste packaging.	Priority: Unchanged Comment: Of negligible importance for the main constituents in the water. Sorption onto steel corrosion products could maybe be of importance for complexing agents and colloids, but small amounts and conservative to neglect.	1
REP 3.10f Colloid filtering	The amount and size of pores/voids in the waste will affect the filtering of colloids/particles and thus the amount of colloids/particles in the water inside the waste packaging and in surrounding system components.	Priority: Unchanged Comment: Probably small effect, if any, and difficult to quantify. Furthermore, a positive effect.	1
REP 3.11a Water flow	The dimensions and physical properties of the waste will affect the magnitude, direction and distribution of the water flow in the waste and surrounding barriers.	Priority: Unchanged	3
REP 3.11b Capillary suction	The poresize distribution of the waste will affect the capillary suction of water into the waste and thus the degree of saturation of the waste and packagings during the saturation phase.	Priority: Unchanged Comment: Difficult to quantify the poresize distribution of the waste and the surrounding void inside the waste packages is quite large. The size of this void will affect the time for saturation after repository closure, see 3.11a, but other effects are probably negligible.	1
REP 3.12a Corrosion	Type and amount of metals in the waste will affect the mechanism and rate of corrosion and thus the amount and composition of gas inside the waste packaging. The presence of different type of metals may give rise to galvanic corrosion.	Priority: Unchanged	3
REP 3.12b Degradation of organics	The type and amount of organic materials in the waste will affect the microbial and chemical degradation of these and thus the amount and composition of gas inside the waste packaging.	Priority: Unchanged	3
REP 3.12c Gas flow	Dimensions and physical properties of the waste will affect the distribution of gas flow inside the waste packaging and in surrounding components of the repository system.	Priority: Unchanged	3
REP 3.13a Heat conduction	The thermal properties of the waste, i.e. heat capacity and heat conductivity, and dimensions will affect the heat conduction inside the packaging and thereby the temperature in the waste and surrounding system components.	Priority: Unchanged Comment: Even if there are uncertainties regarding the importance of heat generating processes in this type of waste after repository closure (see 3.13b) this interaction is assessed as being of negligible importance for the temperature in the waste package and in the surroundings. This is because the waste is non-solidified and the temperature in the waste packages is therefore more dependent on the heat transport in the surrounding barriers.	1
REP 3.13b Exothermic reactions	Exothermic reactions in the waste that generates heat and thus affect the temperature in the waste.	Priority: Unchanged	2

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 3.14 Expansion/ contraction	Changes in geometry and dimensions of the waste may affect the stress conditions in the waste and surrounding packaging.	Priority: Unchanged Comment: Should be enough expansion volume inside the waste package to take up any changes in waste volume that may occur without affecting the stress conditions in the waste package.	1
REP 3.15 Microbial activity	Type and amount of organic materials and nutrients and energy sources in the waste and physical properties of the waste will affect the microbial activity inside the waste packaging and thus the type and amount of microbes inside the waste packaging.	Priority: Unchanged	3
REP 3.16a Dissolution/ precipitation	The amount and composition of the waste will affect the dissolution and precipitation of radionuclides and toxicants in the waste components and thus the distribution between mobile and immobile radionuclides and toxicants inside the waste packaging. Includes also colloid formation.	Priority: Unchanged	3
REP 3.16b Corrosion	The type and amount of metals in the waste will affect the mode and rate of corrosion of these and thereby the liberation of radionuclides and toxicants included in these. This will affect the distribution between mobile and immobile radionuclides and toxicants inside the waste packaging. Includes also colloid formation. The presence of different type of metals may give rise to galvanic corrosion.	Priority: Unchanged Comment: Negligible amount, if any, of induced activity in metal waste.	1
REP 3.16c Degradation of organics	The type and amount of organic materials in the waste will affect the chemical and microbial degradation of organics and thereby the liberation of radionuclides and toxicants included in these. This will affect the distribution between mobile and immobile radionuclides and toxicants inside the waste packaging. Includes also colloid formation.	Priority: Unchanged	3
REP 3.16d Diffusion	The physical properties (porosity etc) of the waste affect the diffusive transport of dissolved radionuclides and toxicants through the waste and thereby the concentration of radionuclides and toxicants in the water inside the waste packaging and in surrounding system components.	Priority: Unchanged Comment: Could have some effect on the dissolution and transport in some waste types. However, difficult to quantify and probably conservative to assume immediate mixing inside the waste container.	1
REP 3.16e Sorption	The type and amount of materials in the waste will affect the sorption of radionuclides and toxicants and thereby the distribution between mobile and immobile radionuclides and toxicants inside the waste packaging. Saturation of sorption sites and non-linear sorption effects should be considered.	Priority: Unchanged	2
REP 3.16f Colloid filtering	The amount and size of pores/voids in the waste will affect the filtering of radioactive and toxic colloids/particles and thus the amount of radioactive and toxic colloids/particles in the water inside the waste packaging and in surrounding system components.	Priority: Unchanged Comment: Probably small effect, if any, and difficult to quantify. Furthermore, a positive effect.	1
REP 3.17 None	No direct effect from the waste on the tunnels and backfill since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 3.18 None	No direct effect from the waste on the repository rock since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 4.1 Expansion/ contraction	Changes in volume and dimensions of the materials and voids in the concrete packaging may cause expansion/contraction of the waste and matrix thereby affecting the volume and dimensions of the materials and voids in the waste and matrix.	Priority: Unchanged Comment: Change in volume and dimensions of the concrete packaging will probably primarily affect the stress conditions, i.e. interaction 4.14, and not the volume and dimensions of the cement-conditioned waste.	1
REP 4.2 None	No direct influence. Physically isolated. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 4.3 Expansion/ contraction	Changes in volume and dimensions of the materials and voids in the concrete packaging may cause expansion/contraction of the waste thereby affecting the volume and dimensions of the materials and voids inside the waste package.	Priority: Unchanged	2
REP 4.4 Concrete packaging	Concrete packaging with reinforcement and expansion cassettes, when present, in concrete moulds in the Silo and BMA. Concrete packaging, reinforcement and rubber liners in concrete tanks in BTF. The two steel drums and the concrete in between the steel drums that are used as packaging for ashes in 1BTF.		
REP 4.4a Recrystallisation	Recrystallisation of the hydration products in cement in the concrete packaging may change the composition and internal physical structure of the concrete.	Priority: Unchanged	3
REP 4.5 None	No direct influence. Physically isolated. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 4.6 Expansion/ contraction	Changes in volume and dimensions of the materials and voids in the concrete packaging may cause expansion/contraction of the concrete backfill thereby affecting the volume and dimensions of the concrete backfill.	Priority: Unchanged Comment: Change in volume and dimensions of the concrete packaging will probably primarily affect the stress conditions, i.e. interaction 4.14, and not the volume and dimensions of the concrete backfill.	1
REP 4.7 None	No direct influence identified. Interacts via other diagonal elements.	Priority: Unchanged	0
REP 4.8 None	No direct influence identified. Physically isolated. Interacts via other diagonal elements.	Priority: Unchanged	0
REP 4.9 Expansion/ contraction	Changes in volume and dimensions of the materials and voids in the concrete packaging may cause expansion/contraction of the backfill material and voids in the vault thereby affecting the volume and dimensions of the backfill materials and voids in the vault.	Priority: Unchanged	2
REP 4.10a Dissolution/ precipitation	The amount and composition of the concrete packaging will affect the dissolution and precipitation of packaging components and thus the water composition in the concrete packaging. Includes also colloid formation and dissolution of concrete additives.	Priority: Unchanged	3
REP 4.10b Corrosion	The type and amount of metals in the concrete packaging will affect the mode and rate of corrosion of these and thus the water composition in the concrete packaging. The presence of different type of metals, e.g. in the waste, may give rise to galvanic corrosion. Includes also colloid formation.	Priority: Unchanged	3
REP 4.10c Degradation of organics	The type and amount of organic materials in the concrete packaging will affect the chemical and microbial degradation of organics and thus the water composition in the concrete packaging. Includes also colloid formation.	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 4.10d Diffusion	The physical properties (porosity etc) of the concrete packaging affect the diffusive transport of dissolved components through the packaging and thereby the composition of the water in the concrete packaging and surrounding system components.	Priority: Unchanged	3
REP 4.10e Sorption	The type and amount of materials in the concrete packaging will affect the sorption of dissolved components and colloids and thereby the composition of the water in the concrete packaging.	Priority: Unchanged	3
REP 4.10f Colloid filtering	The amount and size of pores/fractures in the concrete packaging will affect the filtering of colloids/particles and thus the amount of colloids/particles in the water in the concrete packaging and in surrounding system components.	Priority: Unchanged	3
REP 4.10g Erosion	The chemical and physical properties of the concrete packaging affects its ability to withstand mechanical erosion and thus the amount of colloids/particles in the water in the concrete packaging.	Priority: Unchanged	2
REP 4.11a Water flow	The dimensions and physical properties of the concrete packaging will affect the magnitude, direction and distribution of the water flow in the concrete packaging and surrounding barriers.	Priority: Unchanged	3
REP 4.11b Capillary suction	The poresize distribution of the concrete packaging will affect the capillary suction of water into the concrete packaging and thus the degree of saturation of the concrete packaging, waste and concrete backfill during the saturation phase.	Priority: Unchanged	4
REP 4.12a Corrosion	Type and amount of metals in the concrete packaging will affect the mechanism and rate of corrosion and thus the amount and composition of gas in the concrete packaging. The presence of different type of metals, e.g in the waste, may give rise to galvanic corrosion.	Priority: Unchanged	3
REP 4.12b Degradation of organics	The type and amount of organic materials in the concrete packaging will affect the microbial and chemical degradation of these and thus the amount and composition of gas in the concrete packaging.	Priority: Unchanged	2
REP 4.12c Gas flow	Dimensions and physical properties of the concrete packaging will affect the magnitude, direction and distribution of gas flow in the concrete packaging and in surrounding components of the repository system.	Priority: Unchanged	3
REP 4.13a Cement hydration	The hydration of cement in the concrete packaging will generate heat that can affect the temperature in the packaging, dependent on the extent of hydration after repository closure. The extent of hydration is in turn dependent on the type and amount of cement in the packaging and the time since the production of the packaging.	Priority: Unchanged Comment: Time between production of the concrete waste packages and repository closure is assessed to be long enough for total decay of heat generation due to cement hydration.	1
REP 4.13b Heat conduction	The thermal properties of the concrete packaging, i.e. heat capacity and heat conductivity, and dimensions will affect the heat conduction in the packaging and thereby the temperature in the waste packages and surrounding system components.	Priority: Unchanged	2

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 4.14 Expansion/ contraction	Changes in geometry and dimensions of the concrete packaging, e.g. due to corrosion of metals and ettringite formation, will affect the stress conditions in the concrete packaging and adjacent system components.	Priority: Unchanged	3
REP 4.15 Microbial activity	Type and amount of organic materials and nutrients and energy sources in the concrete packaging and physical properties of the packaging will affect the microbial activity in the packaging and thus the type and amount of microbes in the packaging.	Priority: Unchanged	2
REP 4.16a Diffusion	The physical properties (porosity etc) of the concrete packaging affect the diffusive transport of dissolved radionuclides and toxicants through the packaging and thereby the concentration of radionuclides and toxicants in the water in the concrete packaging and surrounding system components.	Priority: Unchanged	3
REP 4.16b Sorption	The type and amount of materials in the concrete packaging will affect the sorption of radionuclides and toxicants and thereby the distribution between mobile and immobile radionuclides and toxicants in the concrete packaging. Saturation of sorption sites and non-linear sorption effects should be considered.	Priority: Unchanged	3
REP 4.16c Colloid filtering	The amount and size of pores/fractures in the concrete packaging will affect the filtering of radioactive and toxic colloids/particles and thus the amount of radioactive and toxic colloids/ particles in the water in the concrete packaging and in surrounding system components.	Priority: Unchanged	3
REP 4.17 None	No direct effect from the packaging on the tunnels and backfill since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 4.18 None	No direct effect from the packaging on the repository rock since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 5.1 Expansion/ contraction	Changes in volume and dimensions of the materials and voids in the steel packaging may cause expansion/contraction of the waste and matrix thereby affecting the volume and dimensions of the materials and voids in the waste and matrix.	Priority: Unchanged Comment: Change in volume and dimensions of the steel packaging will probably primarily affect the stress conditions, i.e. interaction 5.14, or the internal void in waste packages with non-solidified waste, i.e. interaction 5.3, and not the volume and dimensions of the cement-conditioned waste.	1
REP 5.2 Expansion/ contraction	Changes in volume and dimensions of the materials and voids in the steel packaging may cause expansion/contraction of the waste and bitumen matrix thereby affecting the volume and dimensions of the materials and voids in the waste and bitumen matrix.	Priority: Unchanged Comment: Change in volume and dimensions of the steel packaging will probably primarily affect the stress conditions, i.e. interaction 5.14, or the internal void in waste packages with non-solidified waste, i.e. interaction 5.3, and not the volume and dimensions of the bituminised waste.	1
REP 5.3 Expansion/ contraction	Changes in volume and dimensions of the materials and voids in the steel packaging may cause expansion/contraction of the waste thereby affecting the volume and dimensions of the materials and voids inside the waste package.	Priority: Unchanged	2

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 5.4 None	No direct influence identified. Physically isolated. Interacts via other diagonal elements.	Priority: Unchanged	0
REP 5.5 Steel packaging	All types of steel packaging that are used in the different repository parts, i.e. drums, boxes and containers, except the ash drums in 1BTF (included in element 4.4). It also includes surface coating on the drums when present, e.g. paint.		
REP 5.6 Expansion/ contraction	Changes in volume and dimensions of the materials and voids in the steel packaging may cause expansion/contraction of the concrete backfill thereby affecting the volume and dimensions of the concrete backfill.	Priority: Unchanged Comment: Change in volume and dimensions of the steel packaging will probably primarily affect the stress conditions, i.e. interaction 5.14, or the internal void in waste packages with non-solidified waste, i.e. interaction 5.3, and not the volume and dimensions of the concrete backfill.	1
REP 5.7 None	No direct influence identified. Interacts via other diagonal elements.	Priority: Unchanged	0
REP 5.8 None	No direct influence identified. Physically isolated. Interacts via other diagonal elements.	Priority: Unchanged	0
REP 5.9 Expansion/ contraction	Changes in volume and dimensions of the materials and voids in the steel packaging may cause expansion/contraction of the backfill material and voids in the vault thereby affecting the volume and dimensions of the backfill materials and voids in the vault.	Priority: Unchanged	2
REP 5.10a Dissolution/ precipitation	The amount and composition of the steel packaging will affect the dissolution and precipitation of components in the steel packaging and thus the water composition in the steel packaging. Includes also colloid formation.	Priority: Unchanged	3
REP 5.10b Corrosion	The amount, dimensions and composition of steel packagings will affect the mode and rate of corrosion of these and thus the water composition in the steel packaging. The presence of different type of metals, e.g. in the waste, may give rise to galvanic corrosion. Includes also colloid formation.	Priority: Unchanged	3
REP 5.10c Degradation of organics	The type and amount of organic materials on/in the steel packaging will affect the chemical and microbial degradation of these organics and thus the water composition in the steel packaging. Includes also colloid formation.	Priority: Unchanged Comment: The amount of organics (paint on the outside of the packaging) is assessed to be too small to be of any importance. Organics in the waste and as cement and concrete additives will be more important in this aspect.	1
REP 5.10d Diffusion	The physical properties (porosity etc) of the steel packaging affect the diffusive transport of dissolved components through the waste matrix and thereby the composition of the water in the steel packaging and in surrounding system components.	Priority: Unchanged Comment: Could be important for the release of components dissolved from cement/concrete inside the packagings, but it is conservative to neglect the potential diffusion resistance in the packaging.	1
REP 5.10e Sorption	The type and amount of materials in the steel packaging will affect the sorption of dissolved components and colloids and thereby the composition of the water in the the steel packaging.	Priority: Unchanged Comment: Of negligible importance for the main constituents in the water. Could maybe be of importance for complexing agents and colloids, but conservative to neglect.	1
REP 5.10f Colloid filtering	The amount and size of pores/fractures in the steel packaging will affect the filtering of colloids/particles and thus the amount of colloids/particles in the water in the steel packaging and in surrounding system components.	Priority: Unchanged Comment: Probably small effect and difficult to quantify. Furthermore, a positive effect.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 5.10g Erosion	The chemical and physical properties of the steel packaging affects its ability to withstand mechanical erosion and thus the amount of colloids/particles in the water in contact with the steel packaging.	Priority: Unchanged Comment: Small water velocities expected and therefore colloid formation due to mechanical erosion assessed to be negligible compared to colloids formed by dissolution/precipitation reactions.	1
REP 5.11a Water flow	The dimensions and physical properties of the steel packaging will affect the magnitude, direction and distribution of the water flow in the steel packaging and surrounding barriers.	Priority: Unchanged	3
REP 5.11b Capillary suction	The poresize distribution of the steel packaging will affect the capillary suction of water into the steel packaging and thus the degree of saturation of the steel packaging, waste and concrete backfill during the saturation phase.	Priority: Unchanged Comment: Negligible amount of corrosion products is present during the resaturation phase. Furthermore capillary suction in corrosion products assessed to be less important than capillary suction in cement/concrete.	1
REP 5.12a Corrosion	Type and amount of metals in the steel packaging will affect the mechanism and rate of corrosion and thus the amount and composition of gas inside and outside the steel packaging. The presence of different type of metals, e.g in the waste, may give rise to galvanic corrosion.	Priority: Unchanged	3
REP 5.12b Degradation of organics	The type and amount of organic materials in the steel packaging (surface coating) will affect the microbial and chemical degradation of these and thus the amount and composition of gas outside the steel packaging.	Priority: Unchanged Comment: Negligible gas source compared to corrosion.	1
REP 5.12c Gas flow	Dimensions and physical properties of the steel packaging will affect the magnitude, direction and distribution of gas flow in the steel packaging and in surrounding components of the repository system.	Priority: Unchanged Comment: Will be of negligible importance for gas generated outside the waste packages. Gas generation inside the steel waste packages requires water intrusion into the packages, e.g. the steel packaging is not water tight. If water can penetrate the steel packaging then gas can leave.	1
REP 5.13 Heat conduction	The thermal properties of the steel packaging, i.e. heat capacity and heat conductivity, and dimensions will affect the heat conduction in the packaging and thereby the temperature in the waste packages and surrounding system components.	Priority: Unchanged Comment: Heat transport in the steel packaging is important in order to keep the temperature increase in the waste packages low if there are heat generating processes in the waste packages. However, heat transport in steel is fast and the thickness is small compared to the transport distance for heat in concrete. It is therefore assessed that it is not important to address the heat transport in steel packagings in SFR.	1
REP 5.14 Expansion/contraction	Changes in geometry and dimensions of the steel packaging, e.g. due to corrosion, will affect the stress conditions in the steel packaging and adjacent system components.	Priority: Unchanged	3
REP 5.15 Microbial activity	Type and amount of organic materials and nutrients and energy sources on/in the steel packaging and physical properties of the packaging will affect the microbial activity in the packaging and thus the type and amount of microbes in the packaging.	Priority: Unchanged Comment: Microbial activity may occur on the steel packaging, but this activity will most likely not be dependent on the properties of the steel packaging.	1
REP 5.16a Diffusion	The physical properties (porosity etc) of the steel packaging affect the diffusive transport of dissolved radionuclides and toxicants through the packaging and thereby the concentration of radionuclides and toxicants in the water in the steel packaging and surroundingsystem components.	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 5.16b Sorption	The type and amount of materials in the steel packaging will affect the sorption of radionuclides and toxicants and thereby the distribution between mobile and immobile radionuclides and toxicants in the steel packaging. Saturation of sorption sites and non-linear sorption effects should be considered.	Priority: Unchanged	3
REP 5.16c Colloid filtering	The amount and size of pores/fractures in the steel packaging will affect the filtering of radioactive and toxic colloids/particles and thus the amount of radioactive and toxic colloids/particles in the water in the steel packaging and in surrounding system components.	Priority: Unchanged Comment: Probably small effect and difficult to quantify. Furthermore conservative to neglect.	1
REP 5.17 None	No direct effect from the packaging on the tunnels and backfill since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 5.18 None	No direct effect from the packaging on the repository rock since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 6.1 None	The concrete backfill is physically isolated from the cement conditioned waste. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 6.2 None	The concrete backfill is physically isolated from the bitumen conditioned waste. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 6.3 None	The concrete backfill is physically isolated from the non-solidified waste. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 6.4 Expansion/contraction	Changes in volume and dimensions of the materials and voids in the concrete backfill may cause expansion/contraction of the concrete packaging thereby affecting the volume and dimensions of the concrete packaging.	Priority: Unchanged Comment: Change in volume and dimensions of the concrete backfill will probably primarily affect the stress conditions, i.e. interaction 6.14, and not the volume and dimensions of the concrete packaging.	1
REP 6.5 Expansion/contraction	Changes in volume and dimensions of the materials and voids in the concrete backfill may cause expansion/contraction of the steel packaging thereby affecting the volume and dimensions of the steel packaging.	Priority: Unchanged Comment: Change in volume and dimensions of the concrete backfill will probably primarily affect the stress conditions, i.e. interaction 6.14, and not the volume and dimensions of the steel packaging.	1
REP 6.6 Concrete backfill	Concrete backfill surrounding the waste packages in the Silo and in BMA. Concrete that will be filled in the void between the concrete tanks and the vault walls in 2BTF, and the concrete that will be filled in between the drums in 1BTF.		
REP 6.6a Recrystallisation	Recrystallisation of the hydration products in cement in the concrete backfill may change the composition and internal physical structure of the concrete backfill.	Priority: Unchanged	3
REP 6.7 Expansion/contraction	Changes in volume and dimensions of the concrete backfill may affect the dimensions and volume of the concrete structures.	Priority: Unchanged Comment: Change in volume and dimensions of the concrete backfill will primarily affect the stress conditions, i.e. interaction 6.14, and not the volume and dimensions of the concrete structures.	1
REP 6.8 None	The concrete backfill is physically isolated from the bentonite barriers. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 6.9 Expansion/ contraction	Changes in dimensions and volume of the concrete backfill in BTF may affect the dimension and volume of vaults and backfill in BTF.	Priority: Unchanged	2
REP 6.10a Dissolution/ precipitation	The amount and composition of the concrete backfill will affect the dissolution and precipitation of backfill components in the concrete backfill and thus the water composition in the concrete backfill. Includes also colloid formation.	Priority: Unchanged	3
REP 6.10b Degradation of organics	The type and amount of organics in the concrete backfill will affect the chemical and microbial degradation of these organics and thus the water composition in the concrete backfill. Includes also colloid formation.	Priority: Unchanged	3
REP 6.10c Diffusion	The physical properties (porosity etc) of the concrete backfill will affect the diffusive transport of dissolved components through the backfill and thereby the composition of the water in the concrete backfill and in the other components of the repository system.	Priority: Unchanged	3
REP 6.10d Sorption	The amount and composition of the concrete backfill will affect the sorption of dissolved components and colloids and thereby the composition of the water in the the concrete backfill.	Priority: Unchanged	3
REP 6.10e Colloid filtering	The amount and size of pores/fractures in the concrete backfill will affect the filtering of colloids/ particles and thus the amount of colloids/particles in the water in the concrete backfill and in the other components of the repository system.	Priority: Unchanged	3
REP 6.10f Erosion	The chemical and physical properties of the concrete backfill affects its ability to withstand mechanical erosion and thus the amount of colloids/particles in the water in contact with the concrete backfill.	Priority: Unchanged	2
REP 6.11a Water flow	The dimensions and physical properties of the concrete backfill will affect the magnitude, direction and distribution of the water flow in the concrete backfill and surrounding barriers.	Priority: Unchanged	3
REP 6.11b Capillary suction	The poresize distribution of the concrete backfill will affect the capillary suction of water into the concrete backfill and thus the degree of saturation of the concrete backfill, packagings, concrete backfill and vault backfill during the saturation phase.	Priority: Unchanged	4
REP 6.12a Degradation of organics	The type and amount of organic materials in the concrete backfill will affect the microbial and chemical degradation of these and thus the amount and composition of gas in the concrete backfill.	Priority: Unchanged Comment: Small amount of organics in concrete backfill and therefore negligible gas source compared to gas from degradation of organics in waste and corrosion of metals in the repository.	1
REP 6.12b Gas flow	Dimensions and physical properties of the concrete backfill will affect the magnitude, direction and distribution of gas flow in the backfill and in the other components of the repository system.	Priority: Unchanged	3
REP 6.13a Cement hydration	The hydration of cement in the concrete backfill will generate heat that can affect the temperature in the backfill, dependent on the extent of hydration after repository closure. The extent of hydration is in turn dependent on the type and amount of cement in the backfill and the time since the emplacement of the backfill.	Priority: Unchanged Comment: Time between construction of the concrete structures and repository closure is assessed to be long enough for total decay of heat generation due to cement hydration.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 6.13b Heat conduction	The thermal properties of the concrete backfill, i.e. heat capacity and heat conductivity, and dimensions will affect the heat conduction in the backfill and thereby the temperature in the concrete backfill and surrounding system components.	Priority: Unchanged	2
REP 6.14 Expansion/ contraction	Changes in geometry and dimensions of the concrete backfill, e.g. due to ettringite formation, will affect the stress conditions in the concrete backfill and adjacent system components.	Priority: Unchanged	3
REP 6.15 Microbial activity	Type and amount of organic materials and nutrients and energy sources in the concrete backfill and physical properties of the backfill will affect the microbial activity in the backfill and thus the type and amount of microbes in the backfill.	Priority: Unchanged	2
REP 6.16a Diffusion	The physical properties (porosity etc) of the concrete backfill affect the diffusive transport of dissolved radionuclides and toxicants through the backfill and thereby the concentration of radionuclides and toxicants in the water in the concrete backfill and surrounding system components.	Priority: Unchanged	3
REP 6.16b Sorption	The type and amount of materials in the concrete backfill will affect the sorption of radionuclides and toxicants and thereby the distribution between mobile and immobile radionuclides and toxicants in the concrete backfill. Saturation of sorption sites and non-linear sorption effects should be considered.	Priority: Unchanged	3
REP 6.16c Colloid filtering	The amount and size of the pores/fractures in the concrete backfill will affect the filtering of radioactive and toxic colloids/particles and thus the amount of radioactive and toxic colloids/particles in the water in the concrete backfill and in surrounding system components.	Priority: Unchanged	3
REP 6.17 None	No direct effect from the concrete backfill in the silo and the vaults on the tunnels and backfill since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 6.18 None	No direct effect from the concrete backfill in the silo and the vaults on the repository rock since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 7.1 None	The concrete structures are physically isolated from the cement conditioned waste. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 7.2 None	The concrete structures are physically isolated from the bitumen conditioned waste. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 7.3 None	The concrete structures are physically isolated from the non-solidified waste. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 7.4 None	No direct influence identified. Interacts via other diagonal elements.	Priority: Unchanged	0
REP 7.5 None	No direct influence identified. Interacts via other diagonal elements.	Priority: Unchanged	0

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 7.6 Expansion/ contraction	Changes in volume and dimensions of the concrete structures may affect the dimensions and volume of the concrete backfill.	Priority: Unchanged Comment: Change in volume and dimensions of the concrete structures will primarily affect the stress conditions, i.e. interaction 7.14, and not the volume and dimensions of the concrete backfill.	1
REP 7.7 Concrete structures	Concrete structures in the different repository parts in terms of bottom, lid and outer as well as inner walls in the Silo and BMA and concrete floor in BTF and BLA. It also includes shotcrete and rock bolts in the rock walls in all repository parts.		
REP 7.7a Recrystallisation	Recrystallisation of the hydration products in cement in the concrete structures may change the composition and internal physical structure of the concrete structures.	Priority: Unchanged	3
REP 7.8a Expansion/ contraction	Changes in volume and dimensions of the concrete structures in the Silo may affect the dimensions and volume of the bentonite barriers in the Silo and thereby also the density and swelling pressure of the bentonite barriers.	Priority: Unchanged	2
REP 7.8b Bentonite expansion	Bentonite may expand into fractures in the concrete structures. The extent of swelling will depend on the amount and apertures of these fractures and the expansion may affect the density and homogeneity of the bentonite.	Priority: Unchanged	2
REP 7.9 Expansion/ contraction	Changes in volume and dimensions of the concrete structures may affect the volume and dimensions of the repository vaults and the backfill in the vaults.	Priority: Unchanged	2
REP 7.10a Dissolution/ precipitation	The amount and composition of the concrete structures will affect the dissolution and precipitation of components in the structures and thus the water composition in the concrete structures. Includes also colloid formation.	Priority: Unchanged	3
REP 7.10b Corrosion	The type, amount and dimensions of reinforcements in the concrete structures and of rock bolts and reinforcement in shotcrete will affect corrosion of these and thus the water composition in the concrete structures. Includes also colloid formation.	Priority: Unchanged	3
REP 7.10c Degradation of organics	The type and amount of organic materials in the concrete structures will affect the chemical and microbial degradation of organics and thus the water composition in the concrete structures. Includes also colloid formation.	Priority: Unchanged	3
REP 7.10d Diffusion	The physical properties (porosity etc) of the concrete structures affect the diffusive transport of dissolved components through the structures and thereby the composition of the water in the concrete structures and in the components of the repository system.	Priority: Unchanged	3
REP 7.10e Sorption	The amount and composition of the concrete structures will affect the sorption of dissolved components and colloids and thereby the composition of the water in the concrete structures.	Priority: Unchanged	3
REP 7.10f Colloid filtering	The amount and size of pores/fractures in the concrete structures will affect the filtering of colloids/ particles and thus the amount of colloids/particles in the water in the concrete structures and in the other repository system components.	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 7.10g Erosion	The chemical and physical properties of the concrete structures affects its ability to withstand mechanical erosion and thus the amount of colloids/particles in the water in contact with the concrete structures.	Priority: Unchanged	2
REP 7.11a Water flow	The dimensions and physical properties of the concrete structures will affect the magnitude, direction and distribution of the water flow in the concrete structures and surrounding barriers.	Priority: Unchanged	3
REP 7.11b Capillary suction	The poresize distribution of the concrete structures will affect the capillary suction of water into the concrete structures and thus the degree of saturation of the concrete structures, concrete backfill and vault backfill during the saturation phase.	Priority: Unchanged	4
REP 7.12a Corrosion	Type, amount and dimensions of reinforcement in the concrete structures and of rock bolts and reinforcement in shotcrete will affect the mechanism and rate of corrosion and thus the amount and composition of gas in the concrete structures.	Priority: Unchanged	3
REP 7.12b Degradation of organics	The type and amount of organic materials in the concrete structures will affect the microbial and chemical degradation of these and thus the amount and composition of gas in the concrete structures.	Priority: Unchanged Comment: Small amount of organics in concrete structures and therefore negligible gas source compared to gas from corrosion of reinforcements.	1
REP 7.12c Gas flow	Dimensions and physical properties of the concrete structures will affect the magnitude, direction and distribution of gas flow in the structures and in the other repository system components.	Priority: Unchanged	3
REP 7.13a Cement hydration	The hydration of cement in the concrete structures will generate heat that can affect the temperature in the structures, dependent on the extent of hydration after repository closure. The extent of hydration is in turn dependent on the type and amount of cement in the concrete structures and the time since the construction of the concrete structures.	Priority: Unchanged Comment: Time between construction of the concrete structures and repository closure is assessed to be long enough for total decay of heat generation due to cement hydration.	1
REP 7.13b Heat conduction	The thermal properties of the concrete structures, i.e. heat capacity and heat conductivity, and dimensions will affect the heat conduction in the structures and thereby the temperature in the concrete structures and other repository system components.	Priority: Unchanged	2
REP 7.14 Expansion/contraction	Changes in geometry and dimensions of the concrete structures, e.g. due to corrosion of reinforcement and ettringite formation, will affect the stress conditions in the concrete structures and adjacent system components.	Priority: Unchanged	3
REP 7.15 Microbial activity	Type and amount of organic materials and nutrients and energy sources in the concrete structures and physical properties of the structures will affect the microbial activity in the structures and thus the type and amount of microbes in the structures.	Priority: Unchanged	2
REP 7.16a Diffusion	The physical properties (porosity etc) of the concrete structures affect the diffusive transport of dissolved radionuclides and toxicants through the structures and thereby the concentration of radionuclides and toxicants in the water in the concrete structures and surrounding repository system components.	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 7.16b Sorption	The type and amount of materials in the concrete structures will affect the sorption of radionuclides and toxicants and thereby the distribution between mobile and immobile radionuclides and toxicants in the concrete structures. Saturation of sorption sites and non-linear sorption effects should be considered.	Priority: Unchanged	3
REP 7.16c Colloid filtering	The amount and size of pores/fractures in the concrete structures will affect the filtering of radioactive and toxic colloids/particles and thus the amount of radioactive and toxic colloids/particles in the water in the concrete packaging and in surrounding repository system components.	Priority: Unchanged	3
REP 7.17 None	No direct effect from the concrete structures in the silo and the vaults on the tunnels and backfill since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 7.18 None	No direct effect from the concrete structures in the silo and the vaults on the repository rock since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 8.1 None	The bentonite barriers are physically isolated from the cement conditioned waste. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 8.2 None	The bentonite barries are physically isolated from the bitumen conditioned waste. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 8.3 None	The bentonite barriers are physically isolated from the non-solidified waste. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 8.4 None	No direct influence identified. Physically isolated. Interacts via other diagonal elements.	Priority: Unchanged	0
REP 8.5 None	No direct influence identified. Physically isolated. Interacts via other diagonal elements.	Priority: Unchanged	0
REP 8.6 None	The bentonite barriers are physically isolated from the concrete backfill. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 8.7 Bentonite expansion	Intrusion of bentonite into fractures in the concrete structures in the Silo. Includes also the potential sedimentation of liberated bentonite particles in the fractures.	Priority: Unchanged Comment: Probably small and positive effect.	1
REP 8.8 Bentonite barriers	Sand/bentonite in the bottom and top of the Silo and the bentonite surrounding the cylindrical concrete walls.		
REP 8.9 Bentonite expansion	Intrusion of bentonite into sand layer between concrete roof and bentonite top in silo and into backfill above bentonite top. Includes also the potential sedimentation of liberated bentonite particles in the voids.	Priority: Unchanged	2
REP 8.10a Dissolution/ precipitation	The amount and composition of the bentonite barriers in the Silo affects the dissolution/precipitation of non-clay minerals and other impurities in the bentonite barriers as well as the transformation of montmorillonite in the barriers. This will affect the water composition in the bentonite barriers. Includes also colloid formation	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 8.10b Degradation of organics	The type and amount of organic materials in the bentonite barriers in the Silo will affect the chemical and microbial degradation of these and thus the water composition in the bentonite barriers. Includes also colloid formation.	Priority: Unchanged	3
REP 8.10c Diffusion	The physical properties (porosity etc) of the bentonite barriers in the Silo will affect the diffusive transport of dissolved components through the bentonite barriers and thereby the composition of the water in the bentonite barriers and in other repository system components.	Priority: Unchanged	3
REP 8.10d Sorption/ion-exchange	The amount and composition of the bentonite barriers in the Silo will affect the sorption/ion-exchange of dissolved components and thereby the composition of the water in the bentonite barriers.	Priority: Unchanged	3
REP 8.10e Colloid filtering	The amount and size of pores/fractures in the bentonite barriers in the Silo will affect the filtering of colloids/particles and thus the amount of colloids/particles in the water in the bentonite barriers and in other repository system components.	Priority: Unchanged	3
REP 8.10f Colloid formation	The chemical and physical properties of the bentonite barriers affects its ability to withstand mechanical erosion and dispersion of clay particles and thus the amount of colloids/particles in the water in contact with the bentonite barriers in the Silo.	Priority: Unchanged	2
REP 8.11a Water flow	The dimensions and physical properties of the bentonite barriers will affect the magnitude, direction and distribution of the water flow in the bentonite barriers and surrounding barriers.	Priority: Unchanged	3
REP 8.11b Capillary suction	The poresize distribution of the bentonite barriers will affect the capillary suction of water into the bentonite barriers and thus the degree of saturation of the bentonite barriers, concrete structures, and vault backfill during the saturation phase.	Priority: Unchanged	4
REP 8.12a Degradation of organics	The type and amount of organic materials in the bentonite barriers in the Silo will affect the microbial and chemical degradation of these and thus the amount and composition of gas in the bentonite barriers.	Priority: Unchanged Comment: Too small amount of organics in the bentonite barriers to contribute to the gas in the barriers compared to the amount of gas generated in the interior of the Silo and subsequently flowing through the bentonite barriers.	1
REP 8.12b Gas flow	The dimensions and physical properties (e.g. permeability, porosity, poresize distribution, homogeneity) of the bentonite barriers in the Silo will affect the gas pressure as well as the magnitude, direction and distribution of gas flow in the bentonite barriers and in adjacent components of the repository system.	Priority: Unchanged	3
REP 8.13a Heat conduction	The thermal properties of the bentonite and sand/bentonite barriers in the Silo, i.e. heat capacity and heat conductivity, and dimensions will affect the heat conduction in the barriers and thereby the temperature in the bentonite barriers and other repository system components.	Priority: Unchanged	2
REP 8.13b Exothermic reactions	Amount and composition of the bentonite barriers in the Silo will affect the type of potential exothermic reactions that may take place and thus the temperature in the bentonite barriers in the Silo.	Priority: Unchanged	2

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 8.14 Expansion/ contraction	Changes in geometry and dimensions of the bentonite barriers will affect the swelling pressure of the bentonite barriers and the stress conditions in adjacent system components.	Priority: Unchanged	3
REP 8.15 Microbial activity	Type and amount of organic materials and nutrients and energy sources in the bentonite barriers and physical properties of the bentonite barriers will affect the microbial activity in the barriers and thus the type and amount of microbes in the barriers.	Priority: Unchanged	3
REP 8.16a Diffusion	The physical properties (porosity etc) of the bentonite barriers in the Silo will affect the diffusive transport of dissolved radionuclides and toxicants through the packaging and thereby the concentration of radionuclides and toxicants in the water in the bentonite barriers and surrounding system components.	Priority: Unchanged	3
REP 8.16b Sorption/ion-exchange	The amount and composition of the bentonite barriers in the Silo will affect the sorption of radionuclides and toxicants and thereby the distribution between mobile and immobile radionuclides and toxicants in the bentonite barriers. Saturation of sorption sites and non-linear sorption effects should be considered.	Priority: Unchanged	3
REP 8.16c Colloid filtering	The amount and size of pores/fractures in the bentonite barriers in the Silo will affect the filtering of radioactive and toxic colloids/particles and thus the amount of radioactive and toxic colloids/ particles in the water in the bentonite barriers and in surrounding system components.	Priority: Unchanged	3
REP 8.17 None	No direct effect from the silo barriers on tunnels and backfill. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
REP 8.18a Bentonite expansion	Bentonite expansion into fractures in the surrounding rock affecting the permeability of these fractures. Includes also the potential sedimentation of liberated bentonite particles in the fractures. (GEO 1.8)	Priority: Unchanged Comment: Probably small and positive effect.	1
REP 8.18b Erosion	Erosion of the external surfaces of the bentonite barriers in the silo may liberate particles to the water in the repository rock. (GEO 1.10b)	Priority: Unchanged	3
REP 9.1 None	The vaults and backfill are physically isolated from the cement conditioned waste. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 9.2 None	The vaults and backfill are physically isolated from the bitumen conditioned waste. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 9.3 None	The backfill in vaults are physically isolated from the non-solidified waste. Interacts via other diagonal elements in the matrix.	Priority: Unchanged	0
REP 9.4 Expansion/ contraction	Changes in volume and dimensions of the backfill material and voids in the vault may cause expansion/contraction of the materials and voids in the concrete packaging thereby affecting the volume and dimensions of the materials and voids in the concrete packaging.	Priority: Unchanged Comment: No such volume changes of the backfill material are expected.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 9.5 Expansion/ contraction	Changes in volume and dimensions of the backfill material and voids in the vault may cause expansion/contraction of the materials and voids in the steel packaging thereby affecting the volume and dimensions of the materials and voids in the steel packaging.	Priority: Unchanged Comment: No such volume changes of the backfill material are expected.	1
REP 9.6 Expansion/ contraction	Changes in dimensions and volume of vaults and backfill in BTF may affect the dimension and volume of the concrete backfill in BTF.	Priority: Unchanged Comment: No such volume changes of the backfill material are expected.	1
REP 9.7 Expansion/ contraction	Changes in volume and dimensions of the repository vaults and the backfill in the vaults may affect the volume and dimensions of the concrete structures.	Priority: Unchanged Comment: No such volume changes of the backfill material are expected.	1
REP 9.8a Expansion/ contraction	Changes in volume and dimensions of the vault and sand layers and backfill at the top of the Silo may affect the volume and dimensions and thereby the density and swelling pressure of the bentonite barriers.	Priority: Unchanged Comment: No such volume changes of the backfill material are expected.	1
REP 9.8b Bentonite expansion	Bentonite may expand into the sand layers and backfill at the top of the Silo. The extent of swelling will depend on the porosity of the sand layers and backfill and the expansion may affect the density and homogeneity of the bentonite.	Priority: Unchanged	3
REP 9.9 Vaults and backfill	Voids and backfill in the Silo cupola, outside the concrete structures in BMA and outside the waste packages in 1BTF, 2BTF and BLA. It also includes the sand layer above the concrete lid and the gas release devices in the Silo.		
REP 9.10a Dissolution/ precipitation	The amount and composition of the backfill in vaults will affect the dissolution and precipitation of components in the backfill and thus the water composition in the backfill and voids in the vaults. Includes also colloid formation	Priority: Unchanged	3
REP 9.10b Degradation of organics	The type and amount of organic materials in the backfill in the vaults will affect the chemical and microbial degradation of these and thus the water composition in the backfill and voids in the vaults. Includes also colloid formation.	Priority: Unchanged	3
REP 9.10c Diffusion	The physical properties (porosity etc) of the backfill and voids in the vaults will affect the diffusive transport of dissolved components in the vaults and thereby the composition of the water in the backfill and voids in the vaults and in other repository system components.	Priority: Unchanged	3
REP 9.10d Sorption	The amount and composition of backfill in the vaults will affect the sorption of dissolved components and colloids and thereby the composition of the water in the the backfill and voids in the vaults.	Priority: Unchanged Comment: Of no importance for the main constituents in the water. Since colloids could enhance migration of contaminants, sorption of colloids would give a positive effect which here is disregarded.	1
REP 9.10e Colloid filtering	The amount and size of pores/fractures in the backfill in the vaults will affect the filtering of colloids/particles and thus the amount of colloids/ particles in the water in the backfill and voids in the vaults and in other repository system components.	Priority: Unchanged Comment: Too large voids/pores in the tunnel backfill to give any filtering effects.	1
REP 9.10f Erosion	The chemical and physical properties of the backfill in the vaults affects its ability to withstand mechanical erosion and thus the amount of colloids/particles in the water in contact with the backfill in the vaults.	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 9.11a Water flow	The dimensions of the vault and backfill and physical properties of the backfill will affect the magnitude, direction and distribution of the water flow in the vault backfill and surrounding barriers.	Priority: Unchanged	3
REP 9.11b Capillary suction	The poresize distribution of the backfill in the vaults will affect the capillary suction of water into the vault backfill and thus the degree of saturation of the vault backfill, concrete structures, and bentonite barriers during the saturation phase.	Priority: Unchanged	4
REP 9.12a Degradation of organics	The type and amount of organic materials in the backfill in the vaults will affect the microbial and chemical degradation of these and thus the amount and composition of gas in the backfill in the vaults.	Priority: Unchanged Comment: Negligible contribution to gas generation from organic material in the backfill compared to organic material in the waste and gas from corrosion.	1
REP 9.12b Gas flow	Dimensions of the backfill and the vaults and physical properties of the backfill will affect the magnitude, direction and distribution of gas flow in the backfill and voids in the vaults and in other repository system components.	Priority: Unchanged	3
REP 9.13a Heat conduction	The thermal properties of the backfill in vaults and in the Silo, i.e. heat capacity and heat conductivity, and dimensions will affect the heat transport and thereby the temperature in the backfill and other repository system components.	Priority: Unchanged	2
REP 9.13b Exothermic reactions	Amount and composition of the backfill in the vaults and in the Silo will affect the type of potential exothermic reactions that may take place and thus the temperature in the backfill in vaults and Silo.	Priority: Unchanged	2
REP 9.14 Expansion/ contraction	Geometry and dimensions of the vaults and backfill in vaults will affect the stress conditions in the vaults and adjacent repository system components.	Priority: Unchanged Comment: Too small changes in volume and dimensions expected for this to be of importance for the stress conditions in the repository vaults and barriers.	1
REP 9.15 Microbial activity	Type and amount of organic materials and nutrients and energy sources in the backfill in the vaults and sand/gravel layers in the Silo and physical properties of these will affect the microbial activity in the backfill and sand/gravel layers and thus the type and amount of microbes in the backfill and sand/gravel layers.	Priority: Unchanged	2
REP 9.16a Diffusion	The physical properties (porosity etc) of the backfill and voids in the vaults affect the diffusive transport of dissolved radionuclides and toxicants through the backfill and voids and thereby the concentration of radionuclides and toxicants in the water in the backfill and voids in the vaults and in surrounding system components.	Priority: Unchanged	3
REP 9.16b Sorption	The amount and composition of the backfill in the vaults will affect the sorption of radionuclides and toxicants and thereby the distribution between mobile and immobile radionuclides and toxicants in the concrete packaging. Saturation of sorption sites and non-linear sorption effects should be considered.	Priority: Unchanged	3
REP 9.16c Colloid filtering	The amount and size of pores/fractures in the backfill and voids in the vaults will affect the filtering of radioactive and toxic colloids/particles and thus the amount of radioactive and toxic colloids/particles in the water in the backfill and voids in the vaults and in surrounding system components.	Priority: Unchanged Comment: Too large voids/pores in the tunnel backfill to give any filtering effects.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 9.17 None	No direct effect from the repository vaults and backfill on tunnels and backfill. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences. (GEO 2.5, GEO 3.5, GEO 4.5)	Priority: Unchanged	0
REP 9.18 None	No direct effect from the repository vaults and backfill on the surrounding repository rock. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences. (GEO 2.7, GEO 3.7, GEO 4.7, GEO 2.8, GEO 3.8, GEO 4.8)	Priority: Unchanged	0
REP 10.1a Dissolution/ precipitation	The water composition in the waste and cement matrix affects the dissolution/precipitation of waste and matrix components and thus the amount, composition, dimensions and porosity of the waste and cement matrix.	Priority: Unchanged	3
REP 10.1b Corrosion	The water composition in the waste and cement matrix affects the mode and rate of corrosion of metals in the waste and thus the amount, composition, dimensions and porosity of the waste and cement matrix. Induces volume changes due to formation of corrosion products.	Priority: Unchanged	3
REP 10.1c Degradation of organics	The water composition in the waste and cement matrix affects the chemical and microbial degradation of organics in the waste and matrix and thus the amount, composition, dimensions and porosity of the waste and cement matrix.	Priority: Unchanged	2
REP 10.1d Water uptake	The gradient in ionic strength in the ion-exchange resin-cement matrix affects the uptake of water and thus the geometry, structure and volume of the waste/cement matrix.	Priority: Unchanged	3
REP 10.2a Dissolution/ precipitation	The water composition in the waste/bitumen matrix affects the dissolution/precipitation of waste and matrix components and thus the amount, composition, dimensions and porosity of the waste and bitumen matrix.	Priority: Unchanged Comment: The composition of water inside the bitumen matrix will affect the dissolution of the waste. The effect of waste dissolution on the properties of the waste and waste matrix is, however, most likely much less important than the effect of the preeceding water uptake, see 10.2c.	1
REP 10.2b Degradation of organics	The water composition in the waste and bitumen matrix affects the chemical and microbial degradation of organics in the waste and matrix and thus the amount, composition, dimensions and porosity of the waste and bitumen matrix.	Priority: Unchanged Comment: Microbes can degrade organic waste and the bitumen matrix, but the effect is assessed to be small compared to the effect of water uptake.	1
REP 10.2d Water uptake	The gradient in ionic strength in the waste and bitumen matrix affects the uptake of water and thus the geometry, structure and volume of the waste/bitumen matrix.	Priority: Unchanged	3
REP 10.3a Dissolution/ precipitation	The water composition in the waste affects the dissolution/precipitation of waste components and thus the amount, composition, dimensions and porosity of the waste.	Priority: Unchanged Comment: Dissolution/precipitation of waste components may lead to volume and geometry changes of the waste, but these changes are probably of negligible importance for the function of the waste packages. The initial void in the packages with unconditioned waste is probably large enough.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 10.3b Corrosion	The water composition in the waste affects the mode and rate of corrosion of metals in the waste and thus the amount, composition, dimensions and porosity of the waste. Induces volume changes due to formation of corrosion products.	Priority: Unchanged	2
REP 10.3c Degradation of organics	The water composition in the waste affects the chemical and microbial degradation of organics in the waste and thus the amount, composition, dimensions and porosity of the waste.	Priority: Unchanged Comment: Degradation of organic waste components may lead to volume and geometry changes of the waste, but these changes are probably of negligible importance for the function of the waste packages. The initial void in the packages with unconditioned waste is probably large enough.	1
REP 10.3d Water uptake	The gradient in ionic strength in the waste (ion-exchange resins) affects the uptake of water and thus the geometry, structure and volume of the waste.	Priority: Unchanged Comment: The ion-exchange resins are not dried, only dewatered, and the expansion will therefore be small. Furthermore, there is an expansion volume inside the package.	1
REP 10.4a Dissolution/ precipitation	The water composition in the concrete packaging affects the dissolution/precipitation of components in the concrete packaging and thus the composition, dimensions and porosity of the concrete packaging.	Priority: Unchanged	3
REP 10.4b Corrosion	The water composition in the concrete packaging affects the mode and rate of corrosion of metal reinforcements in the packaging and thus the composition, dimensions and porosity of the concrete packaging. Induces volume changes due to formation of corrosion products.	Priority: Unchanged	3
REP 10.4c Degradation of organics	The water composition in the concrete packaging affects the chemical and microbial degradation of organics in the concrete packaging and thus the composition, dimensions and porosity of the concrete packaging.	Priority: Unchanged Comment: Too small amounts of organics for degradation of these to have any affect on concrete properties.	1
REP 10.5a Dissolution/ precipitation	The water composition in the steel packaging affects the dissolution/precipitation of components in the packaging and thus the composition, dimensions and porosity of the steel packaging.	Priority: Unchanged Comment: Corrosion products are the only components that are identified as being exposed to dissolution/precipitation. This should be treated as a part of corrosion, see 10.5.b.	1
REP 10.5b Corrosion	The water composition in the steel packaging affects the mode and rate of corrosion of the packaging and thus the composition, dimensions and porosity of the steel packaging. Induces volume changes due to formation of corrosion products. Localised corrosion should be considered.	Priority: Unchanged	3
REP 10.5c Degradation of organics	The water composition in the steel packaging affects the chemical and microbial degradation of organics in the steel packaging (e.g. surface coating) and thus the composition, dimensions and porosity of the steel packaging.	Priority: Unchanged Comment: Effects on packaging properties of negligible importance in comparison to other processes, e.g. corrosion.	1
REP 10.6a Dissolution/ precipitation	The water composition in the concrete backfill affects the dissolution/precipitation of components in the backfill and thus the composition, dimensions and porosity of the concrete backfill.	Priority: Unchanged	3
REP 10.6b Degradation of organics	The water composition in the concrete backfill affects the chemical and microbial degradation of organics in the backfill and thus the composition, dimensions and porosity of the concrete backfill.	Priority: Unchanged Comment: Too small amounts of organics in the backfill for degradation of these to affect the properties of the backfill.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 10.7a Dissolution/ precipitation	The water composition in the concrete structures affects the dissolution/precipitation of components in the concrete structures and thus the composition, dimensions and porosity of the concrete structures.	Priority: Unchanged	3
REP 10.7b Corrosion	The water composition in the concrete structures affects the mode and rate of corrosion of metal reinforcements in the structures and thus the composition, dimensions and porosity of the concrete structures. Induces volume changes due to formation of corrosion products.	Priority: Unchanged	3
REP 10.7c Degradation of organics	The water composition in the concrete structures affects the chemical and microbial degradation of organics in the concrete structures and thus the composition, dimensions and porosity of the concrete structures.	Priority: Unchanged Comment: Too small amounts of organics for degradation of these to have any effect on the overall properties of the concrete.	1
REP 10.8a Dissolution/ precipitation	The water composition in the bentonite barriers in the Silo affects the dissolution/precipitation of non-clay minerals and other impurities in the bentonite barriers and thus the composition, porosity, homogeneity and expandability of the bentonite barriers. This could also mean an uneven swelling of the bentonite.	Priority: Unchanged	3
REP 10.8b Degradation of organics	The water composition in the bentonite barriers in the Silo affects the chemical and microbial degradation of organics in the bentonite barriers and thus the composition and porosity of the bentonite barriers.	Priority: Unchanged Comment: Small amount of organics and degradation of these is not expected to affect the properties of the bentonite barriers.	1
REP 10.8c Ion-exchange	The composition of the water in the bentonite barriers in the Silo can change the type of adsorbed cation through ion-exchange (sorption) by which the physical properties of the adsorbed (interlamellar) water and the ability to form intergranular clay gels are altered. This causes changes in homogeneity, expandability and hydraulic and gas conductivities of the bentonite barriers.	Priority: Unchanged	3
REP 10.8d Water uptake	The gradient in ionic strength in the bentonite barriers in the Silo affects the uptake of water and thus the geometry, structure, volume, swelling pressure, expandability and self-healing ability of the bentonite barriers.	Priority: Unchanged	4
REP 10.8e Expansion/ dispersion	Clay particles in the bentonite may be dispersed through swelling, i.e. uptake of water in between the particles. Bentonite expansion and dispersion of clay particles requires a low ionic strength of the water and a free expansion volume such as fractures in the rock in contact with the bentonite. Expansion and dispersion of bentonite particles could affect the geometry, homogeneity, density and swelling pressure of the bentonite.	Priority: Unchanged	3
REP 10.8f Montmorillonite transformation	The presence of different species in the water may lead to transformation of the montmorillonite in the bentonite barriers. For example, the presence of potassium may lead to formation of illite and high pH may lead to alkaline hydrolysis of montmorillonite and/or dissolution of the montmorillonite and precipitation of secondary phases.	Priority: Unchanged	3
REP 10.9a Dissolution/ precipitation	The water composition in the backfill in the vaults (including sand backfill in the Silo) affects the dissolution/precipitation of components in the backfill in the vaults and thus the composition and porosity of the backfill in the vaults.	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 10.9b Degradation of organics	The water composition in the backfill in the vaults (including sand backfill in the Silo) affects the chemical and microbial degradation of organics in the backfill and thus the composition and porosity of the backfill in the vaults.	Priority: Unchanged Comment: Too small amounts of organics to result in any changes in backfill properties if consumed.	1
REP 10.10 Water composition	Water composition, including colloids/particles and dissolved gas, in waste and barriers in the Silo, BMA, 1BTF, 2BTF and BLA.		
REP 10.10a Colloid formation/stability	The formation and stability of colloids/particles depends on the composition of the water, e.g. ionic strength.	Priority: Unchanged	3
REP 10.11a Water flow	The water composition in the different components of the system will affect the density and viscosity of the water and thus the magnitude of the water flow in the different components of the repository system.	Priority: Unchanged Comment: Too small variations in water composition to be of importance compared to uncertainties in hydraulic properties of the near-field barriers.	1
REP 10.11b Convection	The salinity of the water will affect the density of the water and gradients in density will affect the magnitude, direction and distribution of water flow in the different components of the repository system. The water density is also affected by changes in temperature, see 13.10b.	Priority: Unchanged Comment: Too small gradients in salinity in the repository scale. However, could be of importance in a larger scale since gradients in salinity are expected as a consequence of land rise, see GEO 10.11a.	1
REP 10.11c Osmosis	Gradients in concentration in the different components of the system may cause osmotic potentials that affect the magnitude, direction and distribution of water flow in the different repository system components.	Priority: Unchanged	4
REP 10.11d Phase Changes Not defined in SAFE		Priority: Set to 2. Description: The water composition (salinity) affects the freezing point of water and may thus affect its aggregate state. Comment: Even a small change in freezing point may under specific conditions be of some importance.	2
REP 10.12a Gas dissolution/degassing	The water composition, e.g. concentration of dissolved species and amount and composition of dissolved gas, affects the dissolution of gas and degassing. This will influence the amount and composition of gas in gas phase in the different parts of the repository system.	Priority: Unchanged Comment: Small effect of water composition on gas solubilities and thus negligible effect on the amount and composition of gas.	1
REP 10.12b Chemical reactions	Changes in water composition that causes gas generation or consumption of gas, e.g. changes in pH that affects the amount of CO_2.	Priority: Unchanged Comment: The amount of gas consumed or generated by this mechanism is expected to be small compared to the amount of gas generated in the repository by degradation of organics and by corrosion.	1
REP 10.12c Corrosion	The composition of the water in the different components of the repository system will affect the mechanism and rate of corrosion and thus the amount and composition of gas in the repository.	Priority: Unchanged	3
REP 10.12d Degradation of organics	Water composition in the different components of the repository system will affect the microbial and chemical degradation of these, e.g. degradation of cellulose, and thus the amount and composition of gas.	Priority: Unchanged	3
REP 10.13 Heat transport	The water composition in the different components of the repository system will affect the thermal properties of the water and thus the heat transport by conduction and advection in the water phase and the temperature in the different parts of the repository system.	Priority: Unchanged Comment: The effect of water composition on thermal properties is negligibly small and thus also on heat transport and temperature.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 10.14 None	No direct interactions identified. Impact from water composition goes via interactions 10.1–10.9 and 1.14–9.14.	Priority: Unchanged	0
REP 10.15 Microbial activity	Type and amount of dissolved organic materials and nutrients in the water in the different components of the system will affect the microbial activity and thus the type and amount of microbes in the different components of the repository system.	Priority: Unchanged	3
REP 10.16a Dissolution/ precipitation	The water composition in the different components of the repository system affects the speciation and the dissolution/precipitation of radionuclides and toxicants and thus the distribution of mobile and immobile radionuclides and toxicants in the different components of the system. The concentration of stabile isotopes can also have an impact via isotopic dilution. In addition, the water composition affects the extent of precipitation of cementitious components like calcite/aragonite and corrosion products with which coprecipitation of radionuclides and toxicants may take place.	Priority: Unchanged	3
REP 10.16b Corrosion	The composition of the water in contact with metal waste affects the corrosion and the liberation of induced activity from metal waste and toxic metal elements and thus the distribution of mobile and immobile radionuclides and toxicants in the waste.	Priority: Unchanged Comment: The amount of induced activity in SFR is very small. Furthermore, conservative to neglect limitations in release of induced activity.	1
REP 10.16c Degradation of organics	The composition of the water in contact with organic waste materials affects the chemical and microbial degradation of this waste and the liberation of radionuclides and toxicants from this waste and thus the distribution of mobile and immobile radionuclides and toxicants in the waste.	Priority: Unchanged	3
REP 10.16d Diffusion	The water composition in the different components of the system, e.g. ionic strength that gives anion exclusion, affects the rate of diffusion and thus the concentration of radionuclides and toxicants in the water in different parts of the repository system.	Priority: Unchanged	3
REP 10.16e Sorption	The water composition (including type and amount of colloids/particles) in the different parts of the repository system affects the speciation and sorption of radionuclides and toxicants and thus also the distribution between mobile and immobile radionuclides and toxicants in the different parts of the repository system. The concentration of stabile isotopes can also have an impact via isotopic dilution in case of a non-linear sorption isoterm. In addition, the water composition may affect the competition about available sorption sites.	Priority: Unchanged	3
REP 10.16f Colloid transport	The type and amount of colloids/particles in the water in the different components of the repository system may affect the mobility of radionuclides and toxicants by acting as carriers for these. This in turn may have an impact on the concentration of radionuclides and toxicants in the water in different components of the repository system.	Priority: Unchanged	3
REP 10.17 Mass flow	Transport of components in the water in the silo, in the BMA, in the BTF and in BLA will affect the composition of the water in the tunnels. (GEO 1.10, GEO 2.10, GEO 3.10, GEO 4.10)	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 10.18 Mass flow	Transport of components in the water in the silo, in the BMA, in the BTF and in BLA will affect the composition of the water in the repository rock. (GEO 1.10, GEO 2.10, GEO 3.10, GEO 4.10)	Priority: Unchanged	3
REP 11.1a Dissolution/ precipitation	The amount of water (degree of saturation) in the waste and cement matrix affects the dissolution/ precipitation of waste and matrix components and thus the amount, composition, dimensions and porosity of the waste and cement matrix.	Priority: Unchanged Comment: Gas inside the waste matrix, e.g. from corrosion of metal waste, could delay the dissolution. However, difficult to quantify and conservative to neglect.	1
REP 11.1b Corrosion	The amount of water (degree of saturation) in the waste and cement matrix affects the corrosion of metals in the waste and thus the amount, composition, dimensions and porosity of the waste and cement matrix. Induces volume changes due to formation of corrosion products.	Priority: Unchanged Comment: Even if not fully water saturated there is probably enough water to maintain steel corrosion. Furthermore, conservative to neglect potential reduction in corrosion due to presence of gas.	1
REP 11.1c Degradation of organics	The amount of water (degree of saturation) in the waste and cement matrix affects the chemical and microbial degradation of organics in the waste and matrix and thus the amount, composition, dimensions and porosity of the waste and cement matrix.	Priority: Unchanged Comment: Gas inside the waste matrix, e.g. from corrosion of metal waste, could delay the degradation. However, difficult to quantify and conservative to neglect.	1
REP 11.1d Water uptake	The amount of water (degree of saturation) and water pressure in the waste/cement matrix and in surrounding components of the system affects the uptake of water in the waste and cement matrix and thus the geometry, structure and volume of the waste/cement matrix	Priority: Unchanged	3
REP 11.2a Dissolution/ precipitation	The amount of water (degree of saturation) in the waste/bitumen matrix affects the dissolution/ precipitation of waste and matrix components and thus the amount, composition, dimensions and porosity of the waste and bitumen matrix.	Priority: Unchanged Comment: The amount of water inside the bitumen matrix will affect the dissolution of the waste. The effect of waste dissolution on the properties of the waste and waste matrix is, however, most likely much less important than the effect of the preeceding water uptake, see 11.2c.	1
REP 11.2b Degradation of organics	The amount of water (degree of saturation) in the waste and bitumen matrix affects the chemical and microbial degradation of organics in the waste and matrix and thus the amount, composition, dimensions and porosity of the waste and bitumen matrix.	Priority: Unchanged Comment: Microbes can degrade organic waste and the bitumen matrix, but the effect is assessed to be small compared to the effect of water uptake.	1
REP 11.2c Water uptake	The amount of water (degree of saturation) and water pressure in the waste/bitumen matrix and in surrounding system components affects the uptake of water in the waste/bitumen matrix and thus the geometry, structure and volume of the waste/bitumen matrix	Priority: Unchanged	3
REP 11.3a Dissolution/ precipitation	The amount of water (degree of saturation) in the waste affects the dissolution/precipitation of waste components and thus the amount, composition, dimensions and porosity of the waste.	Priority: Unchanged Comment: Gas inside the waste packages, e.g. from corrosion of metal waste, could delay the dissolution. However, difficult to quantify and conservative to neglect.	1
REP 11.3b Corrosion	The amount of water (degree of saturation) in the waste affects the corrosion of metals in the waste and thus the amount, composition, dimensions and porosity of the waste. Induces volume changes due to formation of corrosion products.	Priority: Unchanged Comment: The supply of water should be enough to maintain corrosion.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 11.3c Degradation of organics	The amount of water (degree of saturation) in the waste affects the chemical and microbial degradation of organics in the waste and thus the amount, composition, dimensions and porosity of the waste.	Priority: Unchanged Comment: Corrosion gases can be present inside the waste packages, but the effect of unsaturated conditions on degradation of organics in the waste is probably small. Furthermore, conservative to neglect the potential presence of gas.	1
REP 11.3d Water uptake	The amount of water (degree of saturation) and water pressure in the waste and in surrounding system components affects the uptake of water in the waste and thus the geometry, structure and volume of the waste.	Priority: Unchanged Comment: The ion-exchange resins are not dried, only dewatered, and the expansion will therefore be small. Furthermore, there is an expansion volume inside the package.	1
REP 11.3e Redistribution	The magnitude, direction and distribution of water flow through the waste packages in BLA will affect the potential for redistribution of the waste material in these packages. Redistribution of the waste materials will affect the geometry of the waste materials and voids in the packages.	Priority: Unchanged Comment: Probably too small water flow rates to cause a redistribution of the waste materials inside the containers. Even if redistribution occurs, the resulting changes in geometries and voids inside the containers should be of negligible importance for the function of the repository.	1
REP 11.4a Dissolution/ precipitation	The amount of water (degree of saturation) in the concrete packaging affects the dissolution/ precipitation of components in the concrete packaging and thus the composition, dimensions and porosity of the concrete packaging.	Priority: Unchanged Comment: Unsaturated conditions in the concrete could delay the dissolution of cement components and concrete additives. However, the water content is probably quite high already at repository closure and the composition of the water is more important for the dissolution.	1
REP 11.4b Corrosion	The amount of water (degree of saturation) in the concrete packaging affects the corrosion of metal reinforcements in the packaging and thus the composition, dimensions and porosity of the concrete packaging. Induces volume changes due to formation of corrosion products.	Priority: Unchanged Comment: The supply of water is assessed to be enough to maintain corrosion.	1
REP 11.4c Degradation of organics	The amount of water (degree of saturation) in the concrete packaging affects the chemical and microbial degradation of organics in the concrete packaging and thus the composition, dimensions and porosity of the concrete packaging.	Priority: Unchanged Comment: Unsaturated conditions in the concrete could delay the degradation of organics. However, the water content is probably quite high already at repository closure and the composition of the water is more important.	1
REP 11.4d Erosion	Water flowing around and through concrete packaging not surrounded by concrete backfill may cause mechanical erosion of the packaging. This could affect the geometry and porosity of the packaging.	Priority: Unchanged Comment: Mechanical erosion due to water flow is insignificant compared to chemical erosion that is handled via REP 10.4a. Erosion by freezing goes through REP 14:4.	1
REP 11.5a Dissolution/ precipitation	The amount of water (degree of saturation) in the steel packaging affects the dissolution/precipitation of components in the packaging and thus the composition, dimensions and porosity of the steel packaging.	Priority: Unchanged Comment: Unsaturated conditions during the saturation phase (short time period) and potential small deviations from water saturated conditions in the long-term perspective are of negligible importance for dissolution/precipitation compared to the composition of the water.	1
REP 11.5b Corrosion	The amount of water (degree of saturation) in the steel packaging affects the corrosion of the packaging and thus the composition, dimensions and porosity of the steel packaging. Induces volume changes due to formation of corrosion products.	Priority: Unchanged Comment: Even during unsaturated conditions the supply of water should be enough to maintain corrosion.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 11.5c Degradation of organics	The amount of water (degree of saturation) in the steel packaging affects the chemical and microbial degradation of organics in the steel packaging (e.g. paint on surface) and thus the composition, dimensions and porosity of the steel packaging.	Priority: Unchanged	1
REP 11.5d Erosion	Water flowing around and through the steel packaging in BLA (not surrounded by concrete backfill) may cause mechanical erosion of the corrosion products on the packaging. This could affect the composition as well as the geometry and porosity of the packaging.	Priority: Unchanged Comment: Mechanical erosion due to water flow is insignificant compared to chemical erosion that is handled via REP 10.4a. Erosion by freezing goes through REP 14:4.	1
REP 11.6a Dissolution/ precipitation	The amount of water (degree of saturation) in the concrete backfill affects the dissolution/precipitation of components in the backfill and thus the composition, dimensions and porosity of the concrete backfill.	Priority: Unchanged Comment: Unsaturated conditions in the concrete could delay the dissolution of cement components and concrete additives. However, the water content is probably quite high already at repository closure and the composition of the water is more important for the dissolution.	1
REP 11.6b Degradation of organics	The amount of water (degree of saturation) in the concrete backfill affects the chemical and microbial degradation of organics in the backfill and thus the composition, dimensions and porosity of the concrete backfill.	Priority: Unchanged Comment: Unsaturated conditions in the concrete could delay the degradation of organics. However, the water content is probably quite high already at repository closure and the composition of the water is more important.	1
REP 11.6c Erosion	Water flow may cause mechanical erosion of the concrete backfill in 2BTF. This could affect the geometry and porosity of the backfill.	Priority: Unchanged Comment: Mechanical erosion due to water flow is insignificant compared to chemical erosion that is handled via REP 10.4a. Erosion by freezing goes through REP 14:4.	1
REP 11.7a Dissolution/ precipitation	The amount of water (degree of saturation) in the concrete structures affects the dissolution/ precipitation of components in the concrete structures and thus the composition, dimensions and porosity of the concrete packaging.	Priority: Unchanged Comment: Unsaturated conditions in the concrete could delay the dissolution of cement components and concrete additives. However, the water content is probably quite high already at repository closure and the composition of the water is more important for the dissolution. Furthermore, concrete dissolution is in itself a slow process.	1
REP 11.7b Corrosion	The amount of water (degree of saturation) in the concrete structures affects the corrosion of metal reinforcements in the structures and thus the composition, dimensions and porosity of the concrete structures. Induces volume changes due to formation of corrosion products.	Priority: Unchanged Comment: Even during unsaturated conditions the supply of water should be enough to maintain corrosion.	1
REP 11.7c Degradation of organics	The amount of water (degree of saturation) in the concrete structures affects the chemical and microbial degradation of organics in the concrete packaging and thus the composition, dimensions and porosity of the concrete packaging.	Priority: Unchanged Comment: Unsaturated conditions in the concrete could delay the degradation of organics. However, the water content is probably quite high already at repository closure or soon after and the composition of the water is more important.	1
REP 11.7d Erosion	Water flowing around the concrete structures in BMA and shotcrete in all vaults may cause mechanical erosion of these. This could affect the geometry and porosity of the concrete structures in BMA and chotcrete in all vaults.	Priority: Unchanged Comment: Mechanical erosion due to water flow is insignificant compared to chemical erosion that is handled via REP 10.4a. Erosion by freezing goes through REP 14:4.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 11.8a Dissolution/ precipitation	The amount of water (degree of saturation) in the bentonite barriers in the Silo affects the dissolution/precipitation of components in the bentonite barriers and thus the composition, porosity, homogeneity of the bentonite barriers.	Priority: Unchanged Comment: Unsaturated conditions in the bentonite barriers during the saturation phase could delay dissolution reactions. In a long-term perspective this potential delay is probably negligible. Gas produced in the repository and released through the bentonite barriers will only occupy a very small amount of the porosity and the effect should be negligible.	1
REP 11.8b Degradation of organics	The amount of water (degree of saturation) in the bentonite barriers in the Silo affects the chemical and microbial degradation of organics in the bentonite barriers and thus the composition and porosity of the bentonite barriers.	Priority: Unchanged Comment: Unsaturated conditions in the bentonite barriers during the saturation phase could delay degradation reactions. In a long-term perspective this potential delay is probably negligible. Gas produced in the repository and released through the bentonite barriers will only occupy a very small amount of the porosity and the effect should be negligible.	1
REP 11.8c Ion-exchange	The amount of water (degree of saturation) in the bentonite barriers in the Silo can change the type of adsorbed cation through ion exchange (sorption) by which the physical properties of the adsorbed (interlamellar) water and the ability to form intergranular clay gels are altered. This causes changes in homogeneity, expandability and hydraulic and gas conductivities of the bentonite barriers.	Priority: Unchanged Comment: Unsaturated conditions in the bentonite barriers during the saturation phase could delay ion-exchange reactions. In a long-term perspective this potential delay is probably negligible. Gas produced in the repository and released through the bentonite barriers will only occupy a very small amount of the porosity and the effect should be negligible.	1
REP 11.8d Water uptake	The amount of water (degree of saturation) and the water pressure in the bentonite barriers in the Silo and in adjacent components of the system affects the uptake of water in the bentonite barriers and thus the geometry, structure, volume, swelling pressure, expandability and self-healing ability of the bentonite barriers in the Silo.	Priority: Unchanged	4
REP 11.8e Erosion	Water flowing around and through the bentonite barriers in the Silo may cause mechanical erosion of these. This could affect the composition, geometry, density and porosity of the bentonite barriers in the Silo.	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Increased groundwater flow will affect bentonite erosion by way of transport of species and constituents to and from the bentonite barrier. Increased groundwater flow is e.g. expected as the ice sheet of a glacial period melts.	3
REP 11.9a Dissolution/ precipitation	The amount of water (degree of saturation) in the backfill in the vaults (including sand backfill in the Silo) affects the dissolution/precipitation of components in the backfill in the vaults and thus the composition and porosity of the backfill in the vaults.	Priority: Unchanged Comment: Unsaturated conditions during the saturation phase could delay dissolution reactions. In a long-term perspective this potential delay is negligible. Gas produced in the repository will only occupy a very small amount of the porosity and the effect should be negligible.	1
REP 11.9b Degradation of organics	The amount of water (degree of saturation) in the backfill in the vaults (including sand backfill in the Silo) affects the chemical and microbial degradation of organics in the backfill and thus the composition and porosity of the backfill in the vaults.	Priority: Unchanged Comment: Unsaturated conditions during the saturation phase could delay degradation reactions. In a long-term perspective this potential delay is negligible. Gas produced in the repository will only occupy a very small amount of the porosity and the effect should be negligible.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 11.9c Erosion	The water flow in the backfill in the vaults (including sand backfill in the Silo) affects the mechanical erosion of the backfill materials and thus the geometry, porosity and homogeneity of the backfill in the vaults.	Priority: Unchanged Comment: Expected water velocities too small to make effects of erosion significant compared to effects of chemical processes and mechanical impact.	1
REP 11.9d Redistribution (subsidence)	Under transient conditions, smaller particles may be transported by the water flowing in the backfill in the vaults. This may lead to a redistribution of the backfilled material. Comment: Interaction added by KS, 1999-09-03, compare GEO 11.5c.	Priority: Unchanged	4
REP 11.10a Advection and mixing	The magnitude, distribution and direction of water flow in the different components of the repository system will determine the advective and dispersive transport of species in the waters. This will cause mixing of different waters and affect the composition, including colloids/particles) of the water in the different components of the repository system.	Priority: Unchanged	3
REP 11.10b Chemical equilibria	The porewater pressure in the different components of the repository system affects the chemical equilibria and thus the water composition in the different components of the repository system.	Priority: Unchanged Comment: Too small pressure differences.	1
REP 11.10c Erosion	The magnitude of water flow (velocity) in the different components of the repository system will affect the extent of mechanical erosion of the barrier materials and thus the amount of colloids/particles in the water in the different components of the repository system.	Priority: Unchanged	2
REP 11.10d Concentration/ dilution Not defined in SAFE.		Priority: Set to 2 Description: Concentration and dilution of water occurring as result of change in water aggregate state. Comment: A common example is salt rejection giving rise to cryogenic brine.	2
REP 11.11 Hydrology	Water and water movement in waste and barriers in the Silo, BMA, 1BTF, 2BTF and BLA.	Comment: Includes change in aggregation state of water.	
REP 11.12a Saturation	The water pressure in the different components of the repository system affects the saturation process and thereby the degree of saturation in the different components of the repository system.	Priority: Unchanged	4
REP 11.12b Gas dissolution/ degassing	The water pressure in the different components of the repository system affects the gas solubility and thus the amount and composition of gas in gas phase in the different components of the repository system.	Priority: Unchanged Comment: Too small pressure differences.	1
REP 11.12c Two phase flow	The water pressure in the different components of the repository system will affect the magnitude, direction and distribution of gas flow in the repository system components.	Priority: Unchanged	3
REP 11.12d Expansion/ contraction	The water pressure in the different components of the repository system will affect the volume of the gas in the different repository system components.	Priority: Unchanged	3
REP 11.13 Heat advection	The magnitude, direction and distribution of water flow in the different components of the repository system will affect the heat transport by advection (forced convection) and thus the temperature in the different components of the repository system.	Priority: Unchanged Comment: Heat transport by advection negligibly small compared to heat transport by conduction in the solid. Positive effect to account for water flow. Reserve FEP.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 11.14 Water pressure interaction	The water pressure in the different components of the repository system, e.g. due to phase changes, affects the stress conditions in the components of the repository system.	Priority: Changed from 2 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Phase changes due to permafrost are expected in the different components of the repository system.	3
REP 11.15 Advection	The magnitude, direction and distribution of water flow in the different components of the repository system will affect the advective transport of microbes and bacteria (and other types of biomass) and thus the type and amount of these in the different parts of the repository system.	Priority: Unchanged	3
REP 11.16a Advection	The magnitude, direction and distribution of water flow in the different components of the repository system will affect the advective transport of radionuclides and toxicants and thereby the spatial and temporal distribution of radionuclides and toxicants in the water in the different components of the repository system.	Priority: Unchanged	3
REP 11.16b Dispersion	The distribution of the water flow in different flow paths in the components of the repository system will affect the dispersion of radionuclides and toxicants and thereby the temporal distribution of radionuclides and toxicants in the water in the components of the repository system.	Priority: Unchanged	3
REP 11.16c Gas dissolution/ degassing	The water pressure in the different components of the repository system will affect the solubility of radioactive and chemotoxic gases and thereby the distribution of radionuclides and toxicants between gas and water phase.	Priority: Unchanged Comment: Too small pressure differences in the repository components.	1
REP 11.17a Mass flow	Transport of components in the water in the silo, in the BMA, in the BTF and in BLA will affect the composition of the water in the tunnels. (GEO 1.10, GEO 2.10, GEO 3.10, GEO 4.10)	Priority: Unchanged	3
REP 11.17b Discharge/ recharge and pressure	The hydrological situation in the silo, BMA, BTF and BLA will affect the water exchange between the repository parts and the tunnels and thereby also the hydrology in the tunnels. (GEO 1.11, GEO 2.11, GEO 3.11, GEO 4.11)	Priority: Unchanged	3
REP 11.17c Biomass flow	Transport of biomass from the silo, BMA, BTF and BLA will affect the type and amount of biomass in the tunnels. (GEO 1.15, GEO 2.15, GEO 3.15, GEO 4.15)	Priority: Unchanged	2
REP 11.17d Contaminant transport	Transport of radionuclides and toxicants from the silo, BMA, BTF and BLA will affect the type and amount of radionuclides and toxicants in the tunnels. (GEO 1.16, GEO 2.16, GEO 3.16, GEO 4.16)	Priority: Unchanged	3
REP 11.18a Mass flow	Transport of components in the water in the silo, in the BMA, in the BTF and in BLA will affect the composition of the water in the repository rock. (GEO 1.10, GEO 2.10, GEO 3.10, GEO 4.10)	Priority: Unchanged	3
REP 11.18b Discharge/ recharge and pressure	The hydrological situation in the silo, BMA, BTF and BLA will affect the water exchange between the repository parts and the surrounding repository rock and thereby also the hydrology in the repository rock. (GEO 1.11, GEO 2.11, GEO 3.11, GEO 4.11)	Priority: Unchanged	3
REP 11.18c Biomass flow	Transport of biomass from the silo, BMA, BTF and BLA will affect the type and amount of biomass in the repository rock. (GEO 1.15, GEO 2.15, GEO 3.15, GEO 4.15)	Priority: Unchanged	2

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 11.18d Contaminant transport	Transport of radionuclides and toxicants from the silo, BMA, BTF and BLA will affect the type and amount of radionuclides and toxicants in the repository rock. (GEO 1.15, GEO 2.15, GEO 3.15, GEO 4.15)	Priority: Unchanged	3
REP 12.1 None	No direct influence identified. Interacts via diagonal element 14.14 Stress conditions, i.e. interactions 12.14 and 14.1.	Priority: Unchanged	0
REP 12.2 None	No direct influence identified. Interacts via diagonal element 14.14 Stress conditions, i.e. interactions 12.14 and 14.2.	Priority: Unchanged	0
REP 12.3 None	No direct influence identified. Interacts via diagonal element 14.14 Stress conditions, i.e. interactions 12.14 and 14.3.	Priority: Unchanged	0
REP 12.4 None	No direct influence identified. Interacts via diagonal element 14.14 Stress conditions, i.e. interactions 12.14 and 14.4.	Priority: Unchanged	0
REP 12.5 None	No direct influence identified. Interacts via diagonal element 14.14 Stress conditions, i.e. interactions 12.14 and 14.5.	Priority: Unchanged	0
REP 12.6 None	No direct influence identified. Interacts via diagonal element 14.14 Stress conditions, i.e. interactions 12.14 and 14.6.	Priority: Unchanged	0
REP 12.7 None	No direct influence identified. Interacts via diagonal element 14.14 Stress conditions, i.e. interactions 12.14 and 14.7.	Priority: Unchanged	0
REP 12.8 None	No direct influence identified. Interacts via diagonal element 14.14 Stress conditions, i.e. interactions 12.14 and 14.8.	Priority: Unchanged	0
REP 12.9 None	No direct influence identified. Interacts via diagonal element 14.14 Stress conditions, i.e. interactions 12.14 and 14.9.	Priority: Unchanged	0
REP 12.10a Gas dissolution/ degassing	The water composition, e.g. concentration of dissolved species and amount and composition of dissolved gas, will be affected by the amount and composition of gas in gas phase in the different components of the repository system via gas dissolution or degassing.	Priority: Unchanged	3
REP 12.10b Colloid transport	Transport of colloids attached to the surface of gas bubbles could affect the amount of colloids in the different components of the repository system.	Priority: Unchanged	2
REP 12.11a Saturation	The gas pressure in the different components of the repository system affects the saturation process and thereby the degree of saturation in the different components of the repository system.	Priority: Unchanged	4
REP 12.11b Two phase flow	The gas pressure, gas flow and saturation degree in the different components of the repository system will affect the magnitude, direction and distribution of water flow in the system components.	Priority: Unchanged	3
REP 12.12 Gas	Gas and gas movement in waste and barriers in the Silo, BMA, 1BTF, 2BTF and BLA.		
REP 12.13a Heat advection	The magnitude, direction and distribution of gas flow in different components of the repository system may affect the heat transport by advection and thus the temperature in the different components of the repository system.	Priority: Unchanged Comment: Negligible compared to heat transport by conduction in the solid.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 12.13b Heat conduction	The degree of saturation in the different components of the repository system affects the heat transport by conduction and thus the temperature in the different components of the repository system.	Priority: Unchanged Comment: Negligible compared to heat transport by conduction in the solid.	1
REP 12.14 Gas pressure interaction	The gas pressure in the different components of the repository system affects the stress conditions in the components of the repository system.	Priority: Unchanged	3
REP 12.15a Microbial activity	The amount and composition of gas in gas phase in the different components of the repository system may affect the survival and activity of microbes and bacteria and thus also the type and amount of microbes and bacteria in the different components of the repository system.	Priority: Unchanged	3
REP 12.15b Advection-gas	Transport of microbes and bacteria by gas flowing in the different components of the repository system may affect the type and amount of microbes and bacteria in the different components of the repository system.	Priority: Unchanged Comment: Negligible transport mechanism for microbes compared to transport by advection.	1
REP 12.16a Advection-gas	The magnitude, direction and distribution of gas flow in the different components of the repository system will affect the transport of radionuclides and toxicants in gas phase and thereby the amount of radionuclides and toxicants in gas phase in different components of the repository system.	Priority: Unchanged	3
REP 12.16b Colloid transport	Transport of colloids attached to the surface of gas bubbles could affect the concentration of radionuclides and toxicants in the water in different parts of the repository system if the colloids act as carriers for the radionuclides and toxicants	Priority: Unchanged	2
REP 12.17 Gas transport	Release of gas from the silo, BMA, BTF and BLA will influence the amount and composition of gas in the tunnels. (GEO 1.12, GEO 2.12, GEO 3.12, GEO 4.12)	Priority: Unchanged	3
REP 12.18 Gas transport	Release of gas from the silo, BMA, BTF and BLA will influence the amount and composition of gas in the repository rock (GEO 1.12, GEO 2.12, GEO 3.12, GEO 4.12)	Priority: Unchanged	3
REP 13.1a Kinetics and equilibria	The temperature in the waste/cement matrix will affect the kinetics and equilibria of dissolution and precipitation reactions and thereby the amount and composition of the materials in the waste/cement matrix.	Priority: Unchanged Comment: Generally dissolution of the waste/cement matrix will proceed more slowly at lower temperatures. The effect on matrix composition is minor.	1
REP 13.1b Expansion/contraction	Changes in temperature may cause thermal expansion/contraction of the materials in the waste/cement matrix thereby affecting the dimensions and geometries of these materials.	Priority: Unchanged Comment: Too small difference in temperature is expected.	1
REP 13.2a Kinetics and equilibria	The temperature in the waste/bitumen matrix will affect the kinetics and equilibria of dissolution and precipitation reactions and thereby the amount and composition of the materials in the waste/bitumen matrix.	Priority: Unchanged Comment: Comment: Generally dissolution of the waste/bitumen matrix will proceed more slowly at lower temperatures. The effect on matrix composition is minor.	1
REP 13.2b Expansion/contraction	Changes in temperature may cause thermal expansion/contraction of the materials in the waste/bitumen matrix thereby affecting the dimensions and geometries of these materials.	Priority: Unchanged Comment: Too small difference in temperature is expected.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 13.3a Kinetics and equilibria	The temperature in the non-solidified waste will affect the kinetics and equilibria of dissolution and precipitation reactions and thereby the amount and composition of the materials in the waste.	Priority: Unchanged Comment: Generally reactions will proceed more slowly at lower temperatures. Equilibria are not expected to be altered to such magnitude that it affects safety assessment. Effects of equilibria on water composition, radionuclides and toxicants handled in REP 13.10 and REP 13.16.	1
REP 13.3b Expansion/ contraction	Changes in temperature may cause thermal expansion/contraction of the materials in the non-solidified waste thereby affecting the dimensions and geometries of these materials.	Priority: Unchanged Comment: Too small difference in temperature is expected.	1
REP 13.4a Kinetics and equilibria	The temperature in the concrete packaging will affect the kinetics and equilibria of dissolution and precipitation reactions and thereby the amount and composition of the materials in the concrete packaging.	Priority: Unchanged Comment: Generally dissolution of the concrete packaging will proceed more slowly at lower temperatures. The effect on concrete composition is minor.	1
REP 13.4b Expansion/ contraction	Changes in temperature may cause thermal expansion/contraction of the materials in the concrete packaging thereby affecting the dimensions and geometries of these materials.	Priority: Unchanged Comment: Too small difference in temperature is expected.	1
REP 13.5a Kinetics and equilibria	The temperature in the steel packaging will affect the kinetics and equilibria of dissolution and precipitation reactions and thereby the amount and composition of the steel packaging.	Priority: Unchanged Comment: Generally dissolution/corrosion of the steel packaging will proceed more slowly at lower temperatures.	1
REP 13.5b Expansion/ contraction	Changes in temperature may cause thermal expansion/contraction of the steel packaging thereby affecting the dimensions and geometries of the steel packaging.	Priority: Unchanged Comment: Too small differences in temperature are expected.	1
REP 13.6a Kinetics and equilibria	The temperature in the concrete backfill will affect the kinetics and equilibria of dissolution and precipitation reactions and thereby the amount and composition of the materials in the concrete backfill.	Priority: Unchanged Comment: Generally dissolution of the concrete backfill will proceed more slowly at lower temperatures. The effect on matrix composition is minor.	1
REP 13.6b Expansion/ contraction	Changes in temperature may cause thermal expansion/contraction of the materials in the concrete backfill thereby affecting the dimensions and geometries of these materials.	Priority: Unchanged Comment: Too small difference in temperature is expected.	1
REP 13.7a Kinetics and equilibria	The temperature in the concrete structures will affect the kinetics and equilibria of dissolution and precipitation reactions and thereby the amount and composition of the materials in the concrete structures.	Priority: Unchanged Comment: Generally dissolution of the concrete structures will proceed more slowly at lower temperatures. The effect on concrete composition is minor.	1
REP 13.7b Expansion/ contraction	Changes in temperature may cause thermal expansion/contraction of the materials in the concrete structures thereby affecting the dimensions and geometries of these materials.	Priority: Unchanged Comment: Too small difference in temperature is expected.	1
REP 13.8a Kinetics and equilibria	The temperature in the bentonite barriers in the Silo will affect the kinetics and equilibria of dissolution and precipitation reactions and thereby the amount and composition of the bentonite barriers in the Silo.	Priority: Unchanged Comment: Generally dissolution of the bentonite barriers will proceed more slowly at lower temperatures. The effect on barrier composition is minor.	1
REP 13.8b Expansion/ contraction	Changes in temperature may cause thermal expansion/contraction of the materials in the bentonite barriers in the Silo thereby affecting the dimensions and geometries of these materials.	Priority: Unchanged Comment: Too small difference in temperature is expected.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 13.9a Kinetics and equilibria	The temperature in the backfill in the vaults (including sand layers in the Silo) will affect the kinetics and equilibria of dissolution and precipitation reactions and thereby the amount and composition of the backfill in the vaults.	Priority: Unchanged Comment: Generally dissolution of the bentonite barriers will proceed more slowly at lower temperatures. The effect on backfill composition is minor.	1
REP 13.9b Expansion/ contraction	Changes in temperature may cause thermal expansion/contraction of the materials in the back-fill in the vaults (including sand layers in the Silo) thereby affecting the dimensions and geometries of these materials.	Priority: Unchanged Comment: Too small difference in temperature is expected.	1
REP 13.10a Kinetics and equilibria	The temperature in the different components of the repository system will affect the kinetics and equilibria of chemical reactions and gas solubili-ties and thereby the composition of the water in the different components of the repository system.	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glacia-tion. Comment: Changes in temperature by a number of degrees may cause precipita-tion, dissolution, changed reaction rates, and changes in speciation.	2
REP 13.10b Property changes	The temperature in the different components of the repository system will affect the density and viscosity of the water in the different components of the repository system.	Priority: Unchanged Comment: Too small differences in temperature are expected.	1
REP 13.10c Diffusion	The temperature in the different components of the repository system will affect the rate of diffu-sion of dissolved species and thereby the water composition in the different components of the repository system.	Priority: Unchanged Comment: Too small differences in temperature are expected.	1
REP 13.11 Phase changes	The temperature in the different components of the repository system affects the water pressure in the components. Extreme changes in temperature will lead to phase changes like freezing or evapo-ration. These extreme changes will affect both the water pressure and the amount of water.	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glacia-tion. Comment: Phase changes are expected due to permafrost at repository depth. Temperatures giving rise to freezing no longer considered as extreme.	3
REP 13.12a Expansion/ contraction	The temperature in the different components of the repository system will affect the volume and pressure of gas in the system components.	Priority: Unchanged Comment: In general low temperature will prevent gas formation. Existing gas volume will contract or expand perhaps 10%.	1
REP 13.12b Convection	The temperature in the different components of the repository system will affect the density of the gas and thus the magnitude, directions and distribution of gas flow in the different components of the repository system.	Priority: Unchanged Comment: Too small differences in temperature are expected.	1
REP 13.13 Temperature	Temperature in waste and barriers in the Silo, BMA, 1BTF, 2BTF and BLA.		
REP 13.14 Thermal stress interaction	Changes in temperature in the different compo-nents of the repository system will affect the stress conditions in components that cannot expand in volume. For components where volume expansion can take place, effects of temperature on stress conditions are considered via volume changes, e.g. by interactions 13.1b–13.9b and 1.14–9.14. Effects of temperature on water flow and thereby on stress go via 13.11 and 11.14.	Priority: Unchanged Comment: Too small difference in temperature is expected to affect solid material. Effects of temperature on water and water flow and thereby on stress go via 13.11 and 11.14.	1
REP 13.15 Microbial activity	The temperaure in the different parts of the repository system will affect the microbial activity and thereby the type and amount of microbes and bacteria in the different components of the repository system.	Priority: Unchanged Comment: Generally lower temperature will decrease microbial activities but they will start again when temperature increase to temperate conditions.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 13.16a Kinetics and equilibria	The temperature in the different components of the repository system will affect the kinetics and equilibria of sorption and dissolution/precipitation reactions and thereby the distribution between mobile and immobile radionuclides and toxicants in the different components of the repository system.	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glacia-tion. Comment: Changes in temperature may to some extent affect equilibria in waste packages and other parts of the repository affecting the speciation and mobility of radionuclides and toxicants.	2
REP 13.16b Diffusion	The temperature in the different components of the repository system will affect the rate of diffusion of dissolved species and thereby the concentration of radionuclides and toxicants in the water in the different components of the repository system.	Priority: Unchanged Comment: Too small differences in tem-perature are expected. Frozen conditions are not regarded in this FEP.	1
REP 13.16c Soret effect	Temperature gradients in the different com-ponents of the repository system may cause diffusion of dissolved species by the Soret mechanism and thereby affect the concentration of radionuclides and toxicants in the water in the different components of the repository system.	Priority: Unchanged Comment: Too small differences in temperature are expected.	1
REP 13.17 Heat transport	Heat transport from the silo, BMA, BTF and BLA will affect the temperature in the tunnels. (GEO 1.13, GEO 2.13, GEO 3.13, GEO 4.13)	Priority: Unchanged Comment: Heat production in the silo, BMA, BTF and BLA is negligible and thus the heat transport from these vaults.	1
REP 13.18 Heat transport	Heat transport from the silo, BMA, BTF and BLA will affect the temperature in the repository rock. (GEO 1.13, GEO 2.13, GEO 3.13, GEO 4.13)	Priority: Unchanged Comment: Heat production in the silo, BMA, BTF and BLA is negligible and thus the heat transport from these vaults.	1
REP 14.1 Cracking	Changes in stress conditions in the waste/cement matrix and surrounding barriers may cause crack-ing of the materials thereby affecting the geometry and porosity and amount and aperture of fractures in the materials.	Priority: Unchanged	3
REP 14.2 Cracking	Changes in stress conditions in the waste/bitumen matrix and surrounding barriers may cause crack-ing of the materials thereby affecting the geometry and porosity and amount and aperture of fractures in the materials.	Priority: Unchanged	3
REP 14.3 Redistribution	Changes in stress conditions in the non-solidified waste and voids inside the packaging and in sur-rounding barriers may cause a redistribution of the waste materials thereby affecting the geometry and size of voids and the porosity and homogene-ity of the waste materials.	Priority: Unchanged Comment: A redistribution of waste materi-als inside the waste packages may occur, but the effects of such redistribution are assessed to be negligible for the overall function of the repository.	1
REP 14.4 Cracking	Changes in stress conditions in the concrete packaging and/or in adjacent barriers may cause cracking of the materials thereby affecting the geometry and porosity and amount and aperture of fractures in the materials.	Priority: Unchanged	3
REP 14.5 Deformation	Changes in stress conditions in the steel packaging and adjacent barriers may cause a deformation of the packaging thereby affecting the dimension and geometry of the steel packaging	Priority: Unchanged	2
REP 14.6 Cracking	Changes in stress conditions in the concrete backfill and adjacent barriers may cause cracking of the materials thereby affecting the geometry and porosity and amount and aperture of fractures in the materials.	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 14.7a Cracking	Changes in stress conditions in the concrete structures and in adjacent barriers may cause cracking of the materials thereby affecting the geometry and porosity and amount and aperture of fractures in the materials.	Priority: Unchanged	3
REP 14.7b Redistribution	Changes in stress conditions in the shotcrete?? may cause fall out of shotcrete thereby affecting the amount of shotcrete left in place and the physical properties of the shotcrete.	Priority: Unchanged	2
REP 14.8 Redistribution (subsidence)	Changes in stress conditions in the bentonite barriers in the Silo and adjacent barriers may cause a redistribution of the materials in the bentonite barriers thereby affecting the geometry and size, porosity and homogeneity of the bentonite barriers. For example via subsidence.	Priority: Unchanged	2
REP 14.9 Redistribution (subsidence)	Changes in stress conditions in the backfill and voids in the vaults may cause a redistribution of the backfill materials thereby affecting the geometry and size of voids and the porosity and homogeneity of the backfill materials. For example via subsidence.	Priority: Unchanged Comment: No subsidence and/or material redistribution caused by changes in stress conditions is believed to give important changes in the properties of vaults and backfill. Effects of rock creep and volume changes of barriers are taken care of in other interactions, i.e. 4.9–8.9, and the subsidence that make take place during the water saturation phase is taken care of in interaction 11.9.	1
REP 14.10 None	Effects of stress on water composition goes via 14.11 and 11.10b.	Priority: Unchanged	0
REP 14.11 Water pressure interaction	The stress conditions in the different components of the repository system affect the porewater pressure in the system components.	Priority: Unchanged Comment: Expected changes in stress conditions not large enough.	1
REP 14.12 None	Effects of stress on gas goes via 14.11 and 11.12.	Priority: Unchanged	0
REP 14.13 None	No direct influence identified.	Priority: Unchanged	0
REP 14.14 Stress conditions	Stress and strain in waste and barriers in the Silo, BMA, 1BTF, 2BTF and BLA.	Comment: Includes stress and strain due to freezing.	
REP 14.15 None	No direct influence identified.	Priority: Unchanged	0
REP 14.16 None	No direct influence identified.	Priority: Unchanged	0
REP 14.17 Stress and strain changes	Changes in stress and strain at the boundary between the repository parts (silo, BMA, BTF and BLA) and the tunnels affects the stress conditions in the tunnels. (GEO 1.14, GEO 2.14, GEO 3.14, GEO 4.14)	Priority: Unchanged	3
REP 14.18 Stress and strain changes	Changes in stress and strain at the boundary between the repository parts (silo, BMA, BTF and BLA) and the surrounding repository rock affects the stress conditions in the rock. (GEO 1.14, GEO 2.14, GEO 3.14, GEO 4.14)	Priority: Unchanged	3
REP 15.1 Microbial growth	Microbes that utilises components in the waste/cement matrix as a source for energy and/or nutrients, can by this process affect the composition and porosity of the waste/cement matrix. Microbes may also affect the amount of surfaces of the materials that are accessible to chemical reactions such as dissolution and sorption by creating biofilms on the surfaces. They may also affect the porosity of the materials by clogging.	Priority: Unchanged	2

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 15.2 Microbial growth	Microbes that utilises components in the waste/bitumen matrix as a source for energy and/or nutrients, can by this process affect the composition and porosity of the waste/bitumen matrix. Microbes may also affect the amount of surfaces of the materials that are accessible to chemical reactions such as dissolution and sorption by creating biofilms on the surfaces. They may also affect the porosity of the materials by clogging.	Priority: Unchanged	2
REP 15.3 Microbial growth	Microbes that utilises components in the non-solidified waste as a source for energy and/or nutrients, can by this process affect the composition and porosity of the non-solidified waste. Microbes may also affect the amount of surfaces of the materials that are accessible to chemical reactions such as dissolution and sorption by creating biofilms on the surfaces. They may also affect the porosity of the materials by clogging.	Priority: Unchanged	2
REP 15.4 Microbial growth	Microbes that utilises components in the concrete packaging as a source for energy and/or nutrients, can by this process affect the composition and porosity of the concrete packaging. Microbes may also affect the amount of surfaces of the materials that are accessible to chemical reactions such as dissolution and sorption by creating biofilms on the surfaces. They may also affect the porosity of the materials by clogging.	Priority: Unchanged	2
REP 15.5 Microbial growth	Microbes that utilises components in the steel packaging as a source for energy and/or nutrients, can by this process affect the composition and porosity of the steel packaging. Microbes may also affect the amount of surfaces of the materials that are accessible to chemical reactions such as dissolution and sorption by creating biofilms on the surfaces. They may also affect the porosity of the materials by clogging.	Priority: Unchanged	2
REP 15.6 Microbial growth	Microbes that utilises components in the concrete backfill as a source for energy and/or nutrients, can by this process affect the composition and porosity of the concrete backfill. Microbes may also affect the amount of surfaces of the materials that are accessible to chemical reactions such as dissolution and sorption by creating biofilms on the surfaces. They may also affect the porosity of the materials by clogging.	Priority: Unchanged	2
REP 15.7 Microbial growth	Microbes that utilises components in the concrete structures as a source for energy and/or nutrients, can by this process affect the composition and porosity of the concrete structures. Microbes may also affect the amount of surfaces of the materials that are accessible to chemical reactions such as dissolution and sorption by creating biofilms on the surfaces. They may also affect the porosity of the materials by clogging.	Priority: Unchanged	2
REP 15.8 Microbial growth	Microbes that utilises components in the bentonite barriers in the Silo as a source for energy and/or nutrients, can by this process affect the composition and porosity of the bentonite barriers. Microbes may also affect the amount of surfaces of the materials that are accessible to chemical reactions such as dissolution and sorption by creating biofilms on the surfaces. They may also affect the porosity of the materials by clogging.	Priority: Unchanged	2

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 15.9 Microbial growth	Microbes that utilises components in the backfill in the vaults (including sand filling in the Silo) as a source for energy and/or nutrients, can by this process affect the composition and porosity of the backfill in the vaults. Microbes may also affect the amount of surfaces of the materials that are accessible to chemical reactions such as dissolution and sorption by creating biofilms on the surfaces. They may also affect the porosity of the materials by clogging.	Priority: Unchanged	2
REP 15.10 Microbial activity	The type and amount of microbes/bacteria will by their presence and growth affect the water composition in the different components of the repository system. Some examples are: production of dissolved CO_2 and CH_4 and organic complexing agents by degradation of organic materials, influence on pH by production of organic acids, generation of sulphide from sulphate and consumption of oxygen which affects the concentration of these species and the redox potential, consumption of hydrogen.	Priority: Unchanged	3
REP 15.11 None	No direct influence identified. Interactions goes via 15.1–15.9 and 1.11–9.11.	Priority: Unchanged	0
REP 15.12 Microbial activity	The type and amount of microbes/bacteria will affect the amount and composition of gas in the different components of the repository system via gas formation and consumption.	Priority: Unchanged	3
REP 15.13 Microbial activity	The type and amounts of microbes in the different parts of the repository system will affect the potential heat that is generated due to their presence and activity and thus also the temperature in the different parts of the repository system.	Priority: Unchanged	2
REP 15.14 None	No direct influence identified. Potential impact goes via interactions 15.1–15.9 and 1.14–9.14.	Priority: Unchanged	0
REP 15.15 Biological state	The biological state of waste and barriers in the Silo, BMA, 1BTF, 2BTF and BLA.		
REP 15.16a Microbial transport	Type and amount and mobility of microbes/bacteria may affect the transport of radionuclides and toxicants by acting as carriers for these.	Priority: Unchanged	3
REP 15.16b Methylation/ transformation	Microbes may change the chemical form of radionuclides and toxicants, e.g. methylation of metals and transformation of inorganic carbon (dissolved CO3) to organic carbon. Such transformations will change the migration properties, e.g. sorptivity, of metal species and carbon and thus also affect the distribution between immobile and mobile forms of these elements.	Priority: Unchanged	2
REP 15.17 Biomass flow	Growth and/or transport of biomass from the silo, BMA, BTF and BLA will affect the biological state in the tunnels. (GEO 1.15, GEO 2.15, GEO 3.15, GEO 4.15)	Priority: Unchanged	2
REP 15.18 Biomass flow	Growth and/or transport of biomass from the silo, BMA, BTF and BLA will affect the biological state in the surrounding repository rock. (GEO 1.15, GEO 2.15, GEO 3.15, GEO 4.15)	Priority: Unchanged	2
REP 16.1 Irradiation	Irradiation by decaying radionuclides affecting the chemical and physical properties of the waste and cement matrix.	Priority: Unchanged	2
REP 16.2 Irradiation	Irradiation by decaying radionuclides affecting the chemical and physical properties of the waste and bitumen matrix.	Priority: Unchanged	2

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 16.3 Irradiation	Irradiation by decaying radionuclides affecting the chemical and physical properties of the non-solidifies waste.	Priority: Unchanged	2
REP 16.4 Irradiation	Irradiation by decaying radionuclides affecting the chemical and physical properties of the concrete packaging.	Priority: Unchanged Comment: No influence on composition or structures of the concrete packaging expected because of small amounts of radionuclides and toxicants.	1
REP 16.5 Irradiation	Irradiation by decaying radionuclides affecting the chemical and physical properties of the steel packaging.	Priority: Unchanged Comment: No influence on composition or structures of the steel packaging expected because of small amounts of radionuclides and toxicants.	1
REP 16.6 Irradiation	Irradiation by decaying radionuclides affecting the chemical and physical properties of the concrete backfill.	Priority: Unchanged Comment: No influence on composition or structures of the concrete backfill expected because of small amounts of radionuclides and toxicants.	1
REP 16.7 Irradiation	Irradiation by decaying radionuclides affecting the chemical and physical properties of the concrete structures.	Priority: Unchanged Comment: No influence on composition or structures of the concrete structures expected because of small amounts of radionuclides and toxicants.	1
REP 16.8 Irradiation	Irradiation by decaying radionuclides affecting the chemical and physical properties of the bentonite barriers.	Priority: Unchanged Comment: No influence on composition or structures of the bentonite barriers expected because of small amounts of radionuclides and toxicants.	1
REP 16.9 Irradiation	Irradiation by decaying radionuclides affecting the chemical and physical properties of the backfill in vaults.	Priority: Unchanged Comment: No influence on composition or structures of the backfill in vaults expected because of small amounts of radionuclides and toxicants.	1
REP 16.10a Radiolysis	The type and amount of radionuclides in the different components of the repository system may affect the water composition in the components via radiolysis.	Priority: Unchanged Comment: Too low activity and large amounts of dissolved Fe(II) from steel corrosion and dissolution of corrosion products.	1
REP 16.10b Radionuclide decay	Decay of radionuclides to stable isotopes that affect the water composition in the different components of the repository system.	Priority: Unchanged Comment: Will most likely result in trace concentrations and not affect the major composition of the water.	1
REP 16.10c Degradation	Degradation of toxicants from the repository that affects the water composition in the different components of the repository system.	Priority: Unchanged Comment: Depends on type and amount of toxicant. Can be of importance if degradation results in complexing agents. However, the amount of toxicants is most likely small and organic toxicants and the degradation of these are included in interactions 1.10 to 9.10.	1
REP 16.11 None	No direct influence identified.	Priority: Unchanged	0
REP 16.12a Radiolysis	The type and amount of radionuclides affects the extent of radiolysis and thus the amounts of gas formed and the composition of the gas. (e.g. type of decay and energi levels)	Priority: Unchanged	2
REP 16.12b Degradation	The type and amount of organic toxicants from the repository affects the amount and composition of gas via degradation processes.	Priority: Unchanged Comment: Negligible compared to gas from steel corrosion.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 16.13 Heat from decay	Decay of radionuclides may generate heat and affect the temperature in different components of the repository system.	Priority: Unchanged	2
REP 16.14 None	No direct influence identified.	Priority: Unchanged	0
REP 16.15 Irradiation (mutation)	Effects on the biological state of irradiation by decaying radionuclides (mutation).	Priority: Unchanged Comment: The amount of radionuclides and other toxicants that originates from the repository is assessed to be too low to have any effect on the biological state in the repository.	1
REP 16.16 Radionuclides and toxicants	Radionuclides and toxicants in solid, aqueous and gas phase in waste and barriers in the Silo, BMA, 1BTF, 2BTF and BLA.		
REP 16.16a Radionuclide decay	Radioactive decay will affect the type and amount of radionuclides at different locations in the repository system. Decay may also affect the amount of radionuclides in gas phase, e.g. formation of Rn via decay.	Priority: Unchanged	3
REP 16.17 Contaminant transport	The release of radionuclides and toxicants in gas and water phase from the silo, BMA, BTF and BLA will affect the transport of radionuclides and toxicants in water and gas phase in the tunnels. (GEO 1.16, GEO 2.16, GEO 3.16, GEO 4.16)	Priority: Unchanged	3
REP 16.18 Contaminant transport	The release of radionuclides and toxicants in gas and water phase from the silo, BMA, BTF and BLA will affect the transport of radionuclides and toxicants in water and gas phase in the surrounding repository rock. (GEO 1.16, GEO 2.16, GEO 3.16, GEO 4.16)	Priority: Unchanged	3
REP 17.1 None	No direct effect from the tunnels and backfill on the waste matrix since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 17.2 None	No direct effect from the tunnels and backfill on the waste matrix since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 17.3 None	No direct effect from the tunnels and backfill on the waste since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 17.4 None	No direct effect from the tunnels and backfill on the packaging since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 17.5 None	No direct effect from the tunnels and backfill on the packaging since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 17.6 None	No direct effect from the tunnels and backfill on the concrete backfill in the silo and the vaults sine they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 17.7 None	No direct effect from the tunnels and backfill on the concrete structures in the silo and the vaults. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 17.8 None	No direct effect from the tunnels and backfill on the silo barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences. (GEO 5.1)	Priority: Unchanged	0
REP 17.9 None	No direct effect from the tunnels and backfill on the repository vaults and backfill. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences. (GEO 5.2, GEO 5.3, GEO 5.4)	Priority: Unchanged	0
REP 17.10 Mass flow	Transport of components in the water in the tunnels will affect the composition of the water in the silo, BMA, BTF and BLA. (GEO 10.1 GEO 10.2, GEO 10.3, GEO 10.4, GEO 11.1a, GEO 11.2a, GEO 11.3a, GEO 11.4a)	Priority: Unchanged	3
REP 17.11 Recharge/ discharge and pressure	The hydrological situation in the tunnels will affect the water exchange between the tunnels and the different repository parts and thereby also the hydrology in the silo, BMA, BTF and BLA. (GEO 11.1, GEO 11.2, GEO 11.3, GEO 11.4)	Priority: Unchanged	3
REP 17.12 Gas transport	Gas transport in the tunnels will influence the amount and composition of gas in the silo, BMA, BTF and BLA. (GEO 12.1, GEO 12.2, GEO 12.3, GEO 12.4)	Priority: Unchanged Comment: The gas transport capacity in rock and tunnels is sufficient and does not influence the amount and composition of gas in the repository parts.	1
REP 17.13 Heat transport	Heat transport in the tunnels will affect the temperature in the silo, BMA, BTF and BLA. (GEO 13.1, GEO 13.2, GEO 13.3, GEO 13.4)	Priority: Unchanged Comment: The temperature in the repository is set according to temperature in the geosphere.	1
REP 17.14 Stress and strain changes	Changes in stress and strain at the boundary between the tunnels and the silo, BMA, BTF or BLA affects the stress conditions in the silo, BMA, BTF and BMA. (GEO 14.1, GEO 14.2, GEO 14.3, GEO 14.4)	Priority: Unchanged	2
REP 17.15 Biomass flow	Growth and/or transport of biomass from the tunnels into the silo, BMA, BTF and BLA will affect the biological state in the silo, BMA, BTF and BLA. Root penetration and potential intrusion is judged to not propagate further into the repository. (GEO 15.1, GEO 15.2, GEO 15.3, GEO 15.4, GEO 11.1, GEO 11.2, GEO 11.3, GEO 11.4)	Priority: Unchanged	2
REP 17.16 Contaminant transport	Transport of radionuclides and toxicants in water and gas phase from the tunnels into the silo, BMA, BTF or BLA will affect the amount of these in the silo, BMA, BTF and BLA. The origin of these contaminants may be the waste and barrier materials in the other repository parts and contaminated water, gas and solids in the biosphere. (GEO 16.1, GEO 16.2, GEO 16.3, GEO 16.4, GEO 11.1, GEO 11.2, GEO 11.3, GEO 11.4)	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Toxicants (for example ISA) moving from one vault to another must be considered. Toxicants coming from the biosphere are judged to be negligible. It is a positive effect if the radionuclides return to the repository. ISA is formed in a very slow process. Thus, there is a risk of higher ISA-concentrations accumulating over longer time frames.	2
REP 17.17 Tunnels (B.C.)	The geometry of access tunnels and all physical components in tunnels, i.e. backfill, plugs and rock reinforcements (e.g. shotcrete, rock bolts etc). The definition also includes water and gas in the tunnels.		

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 17.18 None	Not relevant in the repository matrix since both elements are boundary elements. Interactions given in the geosphere matrix.	Priority: Unchanged	0
REP 18.1 None	No direct effect from the repository rock on the waste matrix since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 18.2 None	No direct effect from the repository rock on the waste matrix since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 18.3 None	No direct effect from the repository rock on the waste since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 18.4 None	No direct effect from the repository rock on the packaging since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix.	Priority: Unchanged	0
REP 18.5 Rock fall out	Changes in stress condition in the repository rock may cause rock fall out that damages the waste packages in BLA. (GEO 14.4)	Priority: Unchanged Comment: The containers are not considered as a barrier.	1
REP 18.6 None	No direct effect from the repository rock on the concrete backfill in the silo and the BMA vault since they are physically isolated. Interactions take place via other diagonal elements in the repository matrix. In BTF, the space between the waste packages and the rock walls is backfilled with concrete and stress changes in the rock (and rock creep) may affect the backfill. This is taken care of in interaction 18.14.	Priority: Unchanged	0
REP 18.7 Rock fallout	Changes in stress conditions in the repository rock may cause rock fallout that affects the dimensions, geometry and properties of the concrete structures in the BMA and BTF.	Priority: Unchanged	2
REP 18.8a Bentonite expansion	Bentonite expansion into fractures in the surrounding rock may affect the density of the bentonite barriers in the Silo. (GEO 8.1)	Priority: Unchanged	3
REP 18.8b Erosion	Erosion of the external surfaces of the bentonite barriers may affect the density of the barriers bay carrying away material. (GEO 11.1c)	Priority: Unchanged Comment: The amount that will be carried away is a fraction of the material that expands into fractures in adjacent rock and thus less important for the properties of the bentonite barriers than expansion into the fractures.	1
REP 18.8c Rock creep	Changes in stress conditions in the repository rock may cause rock creep that may affect the geometry, homogeneity, density etc of the bentonite barriers in the Silo. (GEO 14.1)	Priority: Unchanged Comment: Not a large-scale process at considered time.	1
REP 18.8d Rock fallout	Changes in stress conditions in the repository rock may cause rock creep that may affect the geometry, homogeneity, density etc of the bentonite barriers in the Silo. (GEO 14.1)	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Longer time frames and stress redistribution due to ice loading increase the risk of rock fallout.	2

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 18.9a Rock fall out	Changes in stress conditions in the repository rock may cause rock fall out that affects the dimensions of the silo and the vaults as well as geometry and homogeneity of the backfill in the vaults and in the silo. (GEO 14.1b, GEO 14.2b, GEO 14.3b, GEO 14.4b)	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glacia-tion. Comment: Longer time frames and stress redistribution due to ice loading increase the risk of rock fallout.	2
REP 18.9b Rock creep	Changes in stress conditions in the repository rock may cause rock creep that affects the dimensions and geometry of the vaults and homogeneity of the backfill in the vaults. (GEO 14.2c, GEO 14.3c, GEO 14.4c)	Priority: Unchanged Comment: Not a large-scale process at considered time. Only marginal effects are expected	1
REP 18.10 Mass flow	Transport of components in the water in the repository rock will affect the composition of the water in the silo, BMA, BTF and BLA. (GEO 10.1 GEO 10.2, GEO 10.3, GEO 10.4, GEO 11.1a, GEO 11.2a, GEO 11.3a, GEO 11.4a)	Priority: Unchanged	3
REP 18.11 Recharge/ discharge and pressure	The hydrological situation in the repository rock will affect the water exchange between the different repository parts and the surrounding repository rock and thereby the hydrology in the silo, BMA, BTF and BLA. (GEO 11.1, GEO 11.2, GEO 11.3, GEO 11.4)	Priority: Unchanged	3
REP 18.12 Gas transport	Gas transport in the repository rock will influence the amount and composition of gas in the silo, BMA, BTF and BLA. (GEO 12.1, GEO 12.2, GEO 12.3, GEO 12.4)	Priority: Unchanged Comment: The gas transport capacity in rock and tunnels is sufficient and does not influence the amount and composition of gas in the repository parts.	1
REP 18.13 Heat transport	Heat transport in the repository rock will affect the temperature in the silo, BMA, BTF and BLA. (GEO 13.1, GEO 13.2, GEO 13.3, GEO 13.4)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glacia-tion. Comment: Heat transport properties of the rock will affect the temperature and permafrost depth in the geosphere.	3
REP 18.14 Stress and strain changes	Changes in stress and strain at the boundary between the repository rock and the silo, BMA, BTF or BLA affects the stress conditions in the silo, BMA, BTF and BMA. (GEO 14.1, GEO 14.2, GEO 14.3, GEO 14.4)	Priority: Unchanged	2
REP 18.15 Biomass flow	Growth and/or transport of biomass from the repository rock into the silo, BMA, BTF and BLA will affect the biological state in the silo, BMA, BTF and BLA. Root penetration and potential intrusion is judged to not propagate further into the reposi-tory. (GEO 15.1, GEO 15.2, GEO 15.3, GEO 15.4, GEO 11.1, GEO 11.2, GEO 11.3, GEO 11.4)	Priority: Unchanged	2
REP 18.16 Contaminant transport	Transport of radionuclides and toxicants in water and gas phase from the repository rock into the silo, BMA, BTF or BLA will affect the amount of these in the silo, BMA, BTF and BLA. The origin of these contaminants may be the waste and barrier materials in the other repository parts and con-taminated water, gas and solids in the biosphere. (GEO 16.1, GEO 16.2, GEO 16.3, GEO 16.4, GEO 11.1, GEO 11.2, GEO 11.3, GEO 11.4)	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glacia-tion. Comment: Toxicants (for example ISA) moving from one vault to another must be considered. Toxicants coming from the biosphere are judged to be negligible. It is a positive effect if the radionuclides return to the repository. ISA is formed in a very slow process. Thus, there is a risk of higher ISA-concentrations accumulating over longer time frames.	2

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 priority
REP 18.17 None	Not relevant in the repository matrix since both elements are boundary elements. Interactions given in the geosphere matrix.	Priority: Unchanged	0
REP 18.18 Repository rock (B.C.)	Rock and fracture system in between as well as around the vaults and the Silo to a distance of about 20 to 30 m from the repository. The definition includes all solid phases as well as water and gas.		

Appendix A2

Geosphere interactions of SAR-08

Coloured fields indicate new interactions or interactions whose priority is updated in SAR-08 from that in SAFE. The SAR-08 geosphere interaction matrix is displayed in Appendix C. The SAFE descriptions have not been edited in this work.

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 1.1 SILO (B.C.)	The geometry of the Silo repository and the physical components in the Silo that via interactions can affect and be affected by properties and conditions in the physical components of the geosphere, i.e. bentonite barriers, sand/gravel, water and gas.		
GEO 1.2 None	Physically isolated. Interactions take place via other diagonal elements in this matrix and in the repository matrix.	Priority: Unchanged	0
GEO 1.3 None	Physically isolated. Interactions take place via other diagonal elements in this matrix and in the repository matrix.	Priority: Unchanged	0
GEO 1.4 None	Physically isolated. Interactions take place via other diagonal elements in this matrix and in the repository matrix.	Priority: Unchanged	0
GEO 1.5 None	No direct effect from the silo barriers on tunnels and backfill. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 1.6 None	No direct effect from the silo barriers on plugs in tunnels. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 1.7 None	No direct effect from the silo barriers on the matrix of the surrounding repository rock. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 1.8 Bentonite expansion	Bentonite expansion into fractures in the surrounding rock affecting the permeability of these fractures. Includes also the potential sedimentation of liberated bentonite particles in the fractures. (REP 8.18a)	Priority: Unchanged Comment: Probably small and positive effect.	1
GEO 1.9 None	No direct effect from the silo barriers on the rock outside the repository area (rock matrix and fractures). Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 1.10a Mass flow	Transport of components in the water in the silo will affect the composition of the water in the tunnels and in the repository rock. (REP 10.17, REP 10.18, REP 11.17, REP 11.18)	Priority: Unchanged	3
GEO 1.10b Erosion	Erosion of the external surfaces of the bentonite barriers in the silo may liberate particles to the water in the repository rock. (REP 8.18b)	Priority: Unchanged	3
GEO 1.11 Discharge/ recharge and pressure	The hydrological situation in the silo will affect the water exchange between the silo and the tunnels and repository rock and thereby the hydrology in the tunnels and in the repository rock. (REP 11.17, REP 11.18)	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 1.12 Gas transport	Transport and release of gas from the silo will influence the amount and composition of gas in the tunnels and repository rock. (REP 12.17, REP 12.18)	Priority: Unchanged	3
GEO 1.13 Heat transport	Heat transport from the silo will affect the temperature in the tunnels and in the repository rock. (REP 13.17, REP 13.18)	Priority: Unchanged Comment: Negligibly small temperature gradient between the Silo and its surroundings	1
GEO 1.14 Stress and strain changes	Changes in stress and strain at the boundary between the silo and the tunnels or repository rock affects the stress conditions in the tunnels and in the rock. (REP 14.17, REP 14.18)	Priority: Unchanged	3
GEO 1.15 Biomass flow	Growth and/or transport of biomass from the silo will affect the biological state in the tunnels and repository rock. (REP 15.17, REP 15.18, REP 11.17, REP 11.18)	Priority: Unchanged	2
GEO 1.16 Contaminant transport	The release of radionuclides and toxicants in water and gas phase from the silo will affect the transport of radionuclides and toxicants in water and gas phase in the tunnels and the surrounding repository rock. (REP 16.17, REP 16.18, REP 11.17, REP 11.18)	Priority: Unchanged	3
GEO 1.17 None	No direct impact on the biosphere from the silo as long as the silo is covered by rock. One exception could be the exposure to radiation in connection with human intrusion, but this is considered in a separate scenario.	Priority: Unchanged	0
GEO 1.18 None	The Silo is physically isolated from the system outside the disposal system. Interactions take place via other diagonal elements in the matrix.	Priority: Unchanged	0
GEO 2.1 None	Physically isolated. Interactions takes place via other diagonal elements in this matrix and in the repository matrix.	Priority: Unchanged	0
GEO 2.2 BMA (B.C.)	The geometry of the BMA vault and the physical components in the BMA that via interactions can affect and be affected by properties and conditions in the physical components of the geosphere.		
GEO 2.3 None	Physically isolated. Interactions take place via other diagonal elements in this matrix and in the repository matrix.	Priority: Unchanged	0
GEO 2.4 None	Physically isolated. Interactions take place via other diagonal elements in this matrix and in the repository matrix.	Priority: Unchanged	0
GEO 2.5 None	No direct effect from the BMA barriers on tunnels and backfill. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 2.6 None	No direct effect from the BMA barriers on plugs in the tunnels. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 2.7 None	No direct effect from the BMA barriers on the surrounding repository rock. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 2.8 None	No direct effect from the BMA barriers on fractures in the surrounding repository rock. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 2.9 None	No direct effect from the silo barriers on the rock outside the repository area (rock matrix and fractures). Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 2.10 Mass flow	Transport of components in the water in the BMA will affect the composition of the water in the tunnels and in the repository rock. (REP 10.17, REP 10.18, REP 11.17, REP 11.18)	Priority: Unchanged	3
GEO 2.11 Discharge/ recharge and pressure	The hydrological situation in the BMA will affect the water exchange between the BMA and the tunnels and repository rock and thereby the hydrology in the tunnels and in the repository rock. (REP 11.17, REP 11.18)	Priority: Unchanged	3
GEO 2.12 Gas transport	Transport and release of gas from the BMA will influence the amount and composition of gas in the tunnels and repository rock. (REP 12.17, REP 12.18)	Priority: Unchanged	3
GEO 2.13 Heat transport	Heat transport from the BMA will affect the temperature in the tunnels and in the repository rock. (REP 13.17, REP 13.18)	Priority: Unchanged Comment: Negligibly small temperature gradient between the BMA and its surroundings	1
GEO 2.14 Stress and strain changes	Changes in stress and strain at the boundary between the BMA and the tunnels or repository rock affects the stress conditions in the tunnels and in the rock. (REP 14.17, REP 14.18)	Priority: Unchanged	2
GEO 2.15 Biomass flow	Growth and/or transport of biomass from the BMA will affect the biological state in the tunnels and repository rock. (REP 15.17, REP 15.18, REP 11.17, REP 11.18)	Priority: Unchanged	2
GEO 2.16 Contaminant transport	The release of radionuclides and toxicants in water and gas phase from the BMA will affect the transport of radionuclides and toxicants in water and gas phase in the tunnels and the surrounding repository rock. (REP 16.17, REP 16.18, REP 11.17, REP 11.18)	Priority: Unchanged	3
GEO 2.17 None	No direct impact on the biosphere from the silo as long as the BMA is covered by rock. One exception could be the exposure to radiation in connection with human intrusion, but this is considered in a separate scenario.	Priority: Unchanged	0
GEO 2.18 None	The BMA is physically isolated from the system outside the disposal system. Interactions take place via other diagonal elements in the matrix.	Priority: Unchanged	0
GEO 3.1 None	Physically isolated. Interactions take place via other diagonal elements in this matrix and in the repository matrix.	Priority: Unchanged	0
GEO 3.2 None	Physically isolated. Interactions take place via other diagonal elements in this matrix and in the repository matrix.	Priority: Unchanged	0
GEO 3.3 BTF (B.C.)	The geometry of the BTF vaults and the physical components in 1BTF and 2BTF that via interactions can affect and be affected by properties and conditions in the physical components of the geosphere.		
GEO 3.4 None	Physically isolated. Interactions takes place via other diagonal elements in this matrix and in the repository matrix.	Priority: Unchanged	0
GEO 3.5 None	No direct effect from the BTF barriers on tunnels and backfill. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 3.6 None	No direct effect from the BTF barriers on plugs in the tunnels. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 3.7 None	No direct effect from the BTF barriers on the surrounding repository rock. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 3.8 None	No direct effect from the BTF barriers on fractures in the surrounding repository rock. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 3.9 None	No direct effect from the BTF barriers on the rock outside the repository area (rock matrix and fractures). Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 3.10 Mass flow	Transport of components in the water in the BTF will affect the composition of the water in the tunnels and in the repository rock. (REP 10.17, REP 10.18, REP 11.17, REP 11.18)	Priority: Unchanged	3
GEO 3.11 Discharge/ recharge and pressure	The hydrological situation in the BTF will affect the water exchange between the BTF and the tunnels and repository rock and thereby the hydrology in the tunnels and in the repository rock. (REP 11.17, REP 11.18)	Priority: Unchanged	3
GEO 3.12 Gas transport	Transport and release of gas from the BTF will influence the amount and composition of gas in the tunnels and repository rock. (REP 12.17, REP 12.18)	Priority: Unchanged	3
GEO 3.13 Heat transport	Heat transport from the BTF will affect the temperature in the tunnels and in the repository rock. (REP 13.17, REP 13.18)	Priority: Unchanged Comment: Negligibly small temperature gradient between the BTF and its surroundings	1
GEO 3.14 Stress and strain changes	Changes in stress and strain at the boundary between the BTF and the tunnels or repository rock affects the stress conditions in the tunnels and in the rock. (REP 14.17, REP 14.18)	Priority: Unchanged	2
GEO 3.15 Biomass flow	Growth and/or transport of biomass from the BTF will affect the biological state in the tunnels and repository rock. (REP 15.17, REP 15.18, REP 11.17, REP 11.18)	Priority: Unchanged	2
GEO 3.16 Contaminant transport	The release of radionuclides and toxicants in water and gas phase from the BTF will affect the transport of radionuclides and toxicants in water and gas phase in the tunnels and the surrounding repository rock. (REP 16.17, REP 16.18, REP 11.17, REP 11.18)	Priority: Unchanged	3
GEO 3.17 None	No direct impact on the biosphere from the BTF as long as the silo is covered by rock. One exception could be the exposure to radiation in connection with human intrusion, but this is considered in a separate scenario.	Priority: Unchanged	0
GEO 3.18 None	The BTF is physically isolated from the system outside the disposal system. Interactions take place via other diagonal elements in the matrix.	Priority: Unchanged	0
GEO 4.1 None	Physically isolated. Interactions take place via other diagonal elements in this matrix and in the repository matrix.	Priority: Unchanged	0

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 4.2 None	Physically isolated. Interactions take place via other diagonal elements in this matrix and in the repository matrix.	Priority: Unchanged	0
GEO 4.3 None	Physically isolated. Interactions take place via other diagonal elements in this matrix and in the repository matrix.	Priority: Unchanged	0
GEO 4.4 BLA (B.C.)	The geometry of the BLA vault and the physical components in the BLA that via interactions can affect and be affected by properties and conditions in the physical components of the geosphere.		
GEO 4.5 None	No direct effect from the BLA barriers on tunnels and backfill. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 4.6 None	No direct effect from the BLA barriers on plugs in the tunnels. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 4.7 None	No direct effect from the BLA barriers on the surrounding repository rock. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 4.8 None	No direct effect from the BLA barriers on fractures in the surrounding repository rock. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 4.9 None	No direct effect from the BLA barriers on the rock outside the repository area (rock matrix and fractures). Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 4.10 Mass flow	Transport of components in the water in the BLA will affect the composition of the water in the tunnels and in the repository rock. (REP 10.17, REP 10.18, REP 11.17, REP 11.18)	Priority: Unchanged	3
GEO 4.11 Discharge/ recharge and pressure	The hydrological situation in the BLA will affect the water exchange between the BLA and the tunnels and repository rock and thereby the hydrology in the tunnels and in the repository rock. (REP 11.17, REP 11.18)	Priority: Unchanged	3
GEO 4.12 Gas transport	Transport and release of gas from the BLA will influence the amount and composition of gas in the tunnels and repository rock. (REP 12.17, REP 12.18)	Priority: Unchanged	3
GEO 4.13 Heat transport	Heat transport from the BLA will affect the temperature in the tunnels and in the repository rock. (REP 13.17, REP 13.18)	Priority: Unchanged Comment: Negligibly small temperature gradient between the BLA and its surroundings	1
GEO 4.14 Stress and strain changes	Changes in stress and strain at the boundary between the BLA and the tunnels or repository rock affects the stress conditions in the tunnels and in the rock. (REP 14.17, REP 14.18)	Priority: Unchanged Comment: No backfill in BLA and thus no impact.	1
GEO 4.15 Biomass flow	Growth and/or transport of biomass from the BLA will affect the biological state in the tunnels and repository rock. (REP 15.17, REP 15.18, REP 11.17, REP 11.18)	Priority: Unchanged	2
GEO 4.16 Contaminant transport	The release of radionuclides and toxicants in water and gas phase from the BLA will affect the transport of radionuclides and toxicants in water and gas phase in the tunnels and the surrounding repository rock. (REP 16.17, REP 16.18, REP 11.17, REP 11.18)	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 4.17 None	No direct impact on the biosphere from the silo as long as the BLA is covered by rock. One exception could be the exposure to radiation in connection with human intrusion, but this is considered in a separate scenario.	Priority: Unchanged	0
GEO 4.18 None	The BLA is physically isolated from the system outside the disposal system. Interactions take place via other diagonal elements in the matrix.	Priority: Unchanged	0
GEO 5.1 None	No direct effect from the tunnels and backfill on the silo barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 5.2 None	No direct effect from the tunnels and backfill on the BMA barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 5.3 None	No direct effect from the tunnels and backfill on the BTF barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 5.4 None	No direct effect from the tunnels and backfill on the BLA barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 5.5 Tunnel/boreholes/backfill	The physical components included in this diagonal element are the access tunnels with their backfill (crushed rock) and rock reinforce-ments (shotcrete and rock bolts) and investigation boreholes and ventilation shafts and backfill in these.		
GEO 5.6 Bentonite expansion	If the concrete part of the plugs are degraded and lost the bentonite in the plugs may expand into adjacent voids in the tunnels/backfill in tunnels. The extent of expansion will depend on the amount and size of these voids and the expansion may affect the density and homogeneity of the bentonite in the plugs.	Priority: Unchanged	3
GEO 5.7 None	No direct effect from the tunnels and backfill on the matrix of the repository rock. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 5.8 Bentonite expansion	Expansion of bentonite used as backfill in investigation boreholes into fractures in the rock adjacent to the boreholes may affect the apertures and connectivity of these fractures. Includes also the potential sedimentation of liberated bentonite particles in the fractures.	Priority: Unchanged Comment: Probably small and positive effect.	1
GEO 5.9 Bentonite expansion	Expansion of bentonite used as backfill in investigation boreholes into fractures in the rock adjacent to the boreholes may affect the apertures and connectivity of these fractures. Includes also the potential sedimentation of liberated bentonite particles in the fractures.	Priority: Unchanged Comment: Probably small and positive effect.	1
GEO 5.10a Dissolution/precipitation	Dissolution and precipitation of components of the crushed rock backfilled in the tunnels and of shotcrete on the tunnel walls may affect the composition of the water in the tunnels. Includes also colloid formation. Includes also the effect of dissolution/precipitation of components in the backfill in investigation boreholes.	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 5.10b Corrosion	Corrosion of rock bolts and reinforcement in shotcrete on the tunnel walls may affect the composition of the water in the tunnels. Includes also colloid formation.	Priority: Unchanged Comment: Too small amounts to have any significant effects.	1
GEO 5.10c Diffusion	Geometry, homogeneity and porosity of the tunnel backfill affect the diffusive transport of dissolved components through the tunnels and thereby the composition of the water in the plugs, tunnels and repository rock. Includes also the effect of diffusion in backfill in investigation boreholes.	Priority: Unchanged	3
GEO 5.10d Sorption	The mineralogy and surface area of the tunnel backfill and shotcrete on tunnel walls affects the sorption of dissolved components and colloids and thereby the composition of the water in the tunnels.	Priority: Unchanged Comment: Of no importance for the main constituents in the water and of negligible effect on colloid amounts because of small surface area of tunnel walls and backfill (the tunnels will most likely be backfilled with large sized rock pieces/blocks). Since colloids could enhance migration of contaminants, sorption of colloids would give a positive effect, which here is disregarded.	1
GEO 5.10e Colloid filtering	The porosity of the tunnel backfill and backfill in investigation boreholes affects the filtering of colloids/ particles and thus the amount of these in the water in the plugs, tunnels and rock.	Priority: Unchanged Comment: Too large voids/pores in the tunnel backfill to give any filtering effects. The effect in the backfill in the investigation boreholes depends on the type of backfill material, but it is conservative to neglect any effects.	1
GEO 5.10f Erosion	The chemical and physical properties of the tunnel backfill and the backfill in investigation boreholes affects its ability to withstand mechanical erosion and thus the amount of colloids/particles in the water in the backfill.	Priority: Unchanged	3
GEO 5.10g Degradation of organics	The type and amount of organic materials in the backfill in the tunnels and in the backfill in investigation boreholes will affect the chemical and microbial degradation of these and thus the water composition in the backfill and voids in the tunnels. Includes also colloid formation.	Priority: Unchanged	3
GEO 5.11a Water flow	Geometries and hydraulic properties of the tunnels and backfill and of backfilled investigation boreholes affect the magnitude, direction and distribution of the water flow in the tunnels, plugs and rock.	Priority: Unchanged	3
GEO 5.11b Capillary suction	The poresize distribution of the backfill in the tunnels will affect the capillary suction of water into the backfill and thus the degree of saturation of the backfill during the saturation phase.	Priority: Unchanged	4
GEO 5.11b Flow in boreholes Not defined in SAFE		Priority: Set to 2. Description: Location, geometry and pump rate of open boreholes, for example water wells, and its effect on hydrology. Comment: Such boreholes are conceivable and may penetrate through the host rock affecting the local hydrology of part of the system.	2
GEO 5.12a Gas flow	Tunnel geometries and properties of the backfilled crushed rock will affect the magnitude, direction and distribution of gas flow in the tunnels, plugs and repository rock. Includes also the effect of borehole geometries and properties of backfill in boreholes.	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 5.12b Corrosion-gas generation	Corrosion of rock bolts and reinforcement in shotcrete on the tunnel walls may generate hydrogen gas and thereby affect the amount, composition and pressure of gas in the tunnels.	Priority: Unchanged Comment: Small amounts of iron and thus a negligible gas source compared to gas from the repository.	1
GEO 5.12c Microbial activity-gas generation	Microbial degradation of organic materials in the tunnels and in the boreholes may generate gas and thereby affect the amount, composition and pressure of gas in the tunnels and the boreholes.	Priority: Unchanged Comment: Negligible gas source compared to gas from the repository. Gas potentially generated in backfilled boreholes would be small enough to either dissolve in the water or escape through fractures in surrounding rock without creating any over-pressures.	1
GEO 5.13 Heat conduction	The thermal properties of the tunnels and backfilled rock (geometries and composition) affect the heat conduction in the materials and thereby the temperature in the tunnels as well as in plugs and rock. Includes also the effect of boreholes and backfill in boreholes.	Priority: Unchanged Comment: Negligible effect.	1
GEO 5.14 Stress and strain changes	Geometry and mechanical properties of the tunnel and backfilled rock and of investigation boreholes and backfill material in these will affect the stress conditions in the rock both inside and outside the repository area.	Priority: Unchanged	2
GEO 5.15 Microbial activity	The presence of organic materials, nutrients and energy sources in the tunnel, investigation boreholes and backfill will affect the population and activity of microbes and bacteria in the tunnels and boreholes.	Priority: Unchanged	2
GEO 5.16a Sorption	The amount and composition of backfilled rock and shotcrete on tunnel walls will affect the sorption of radionuclides and toxicants on these materials and thereby the concentration of mobile contaminants in the water in the tunnels. Saturation of sorption sites and non-linear sorption effects should be considered. If migration takes place through backfilled investigation boreholes sorption on the backfill will affect the concentration of mobile contaminants in the water in the boreholes.	Priority: Unchanged	3
GEO 5.16b Diffusion	The geometry and dimensions of the backfilled rock will affect the diffusive transport of radionuclides and toxicants in the tunnels and thereby the concentration of contaminants in the water in the tunnels, plugs and rock. Includes also the effect of physical properties of the backfill in investigation boreholes on the diffusive transport through the investigation boreholes.	Priority: Unchanged	3
GEO 5.17 None	No direct impact from tunnels and backfill or investigation boreholes on the biosphere components as long as the tunnel entrance and investigation boreholes are plugged at the surface. Interactions go via other diagonal elements in the geosphere matrix such as hydrology, groundwater chemistry, gas temperature, stress conditions and biological state.	Priority: Unchanged	0
GEO 5.18 None	The tunnels are physically isolated from the system outside the disposal system. Interactions take place via other diagonal elements in the matrix.	Priority: Unchanged	0
GEO 6.1 None	No direct effect from the plugs on the silo barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 6.2 None	No direct effect from the plugs on the BMA barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 6.3 None	No direct effect from the plugs on the BTF barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 6.4 None	No direct effect from the plugs on the BLA barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 6.5a Redistribution	Changes in the dimensions of plugs (e.g. due to degradation of the concrete part) may cause movements of the tunnel backfill which in turn may affect the geometry and physical properties of the backfill (porosity etc).	Priority: Unchanged Comment: The primary function of the plugs is not to act as a support for the backfill, and any movement of the backfill that can take place is of minor concern.	1
GEO 6.5b Bentonite expansion	If the concrete part of the plugs are degraded and lost the bentonite in the plugs may expand into the surrounding backfill and thereby affect the porosity of the backfill close to the plugs. Includes also the potential sedimentation of liberated bentonite particles in the backfill.	Priority: Unchanged Comment: Since this is a very local effect the overall effect on the backfill properties is negligible. Furthermore the result is an improvement of the backfill properties close to the plugs and thus conservative to neglect.	1
GEO 6.6 Plugs	Plugs at the entrance of the Silo and repository vaults and at the entrance of the access tunnels, made of concrete and bentonite.	Comment: No decision has been taken on the design of the repository plugs.	
GEO 6.6a Recrystallisation	Recrystallisation of the hydration products in cement in the concrete of the plugs may change the composition and internal physical structure of the concrete.	Priority: Unchanged	3
GEO 6.7 None	No direct effect from plugs on the matrix of the repository rock. Interactions take place via other diagonal elements in the matrix, e.g. via stress conditions.	Priority: Unchanged	0
GEO 6.8 Bentonite expansion	Expansion of bentonite in plugs into fractures in the rock adjacent to the plugs may affect the apertures and connectivity of these fractures. Includes also the potential sedimentation of liberated bentonite particles in the fractures.	Priority: Unchanged Comment: Probably small and positive effect	1
GEO 6.9 None	Physically isolated. Interactions take place via other diagonal elements in the matrix.	Priority: Unchanged	0
GEO 6.10a Dissolution/ precipitation, concrete	Dissolution/precipitation of concrete components of the plugs affects the water composition in the plugs. Includes also colloid formation.	Priority: Unchanged	3
GEO 6.10b Dissolution/ precipitation, bentonite	Dissolution/precipitation of components in the bentonite in the plugs affects the water composition in the plugs. Includes also colloid formation.	Priority: Unchanged	3
GEO 6.10c Diffusion	Geometry and pore and fracture characteristics of concrete and bentonite in plugs affect the diffusive transport of dissolved components through the plugs and thereby the composition of the water in the plugs, tunnels, repository rock and rock.	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 6.10d Sorption/ion exchange	The composition of concrete and bentonite in plugs affects the sorption/ion-exchange of dissolved components and colloids and thereby the composition of the water in the plugs.	Priority: Unchanged Comment: Small amounts of concrete and bentonite and will only affect trace components and not the main constituents in the water. Small amounts also mean small surface areas available for sorption/ion exchange and thereby negligible effect on sorption of colloids/particles.	1
GEO 6.10e Corrosion	Corrosion of steel reinforcement in plugs on may affect the composition of the water in the plugs. Includes also colloid formation.	Priority: Unchanged Comment: Negligible effect on water composition due to very small amounts of reinforcement in plugs.	1
GEO 6.10f Colloid filtering	The porosity and the fracture apertures in the plugs affects the filtering of colloids/particles and thus the amount of these in the water in the plugs, tunnels, repository rock and rock.	Priority: Unchanged	3
GEO 6.10g Colloid formation	The chemical and physical properties of the plugs affects its ability to withstand mechanical erosion and dispersion of clay particles and thus the amount of colloids/particles in the water in the backfill.	Priority: Unchanged Comment: The amount of material in the plugs is very small compared to the amount of other materials in the repository and its surroundings that can generate colloids.	1
GEO 6.11a Water flow	Geometries and pore and fracture characteristics of the plugs affect the magnitude, direction and distribution of the water flow in the tunnels, plugs and repository rock.	Priority: Unchanged	3
GEO 6.11b Capillary suction	The poresize distribution of the materials in the plugs will affect the capillary suction of water into the plugs and thus the degree of saturation of the plugs during the saturation phase.	Priority: Unchanged Comment: Of minor importance for the overall saturation process. Not meaningful to analyse at that level of detail before the exact design and location of plugs are finally decided.	1
GEO 6.12a Gas flow	Geometry and pore and fracture characteristics of the plugs will affect the magnitude, direction and distribution of gas flow in the tunnels, plugs and repository rock.	Priority: Unchanged	3
GEO 6.12b Corrosion-gas generation	Corrosion of reinforcement in plugs may generate hydrogen gas and thereby affect the amount, composition and pressure of gas in the plugs.	Priority: Unchanged Comment: Small amounts of iron and thus a negligible gas source compared to gas from the repository.	1
GEO 6.12c Microbial activity-gas generation	Microbial degradation of organic materials in the plugs may generate gas and thereby affect the amount, composition and pressure of gas in the plugs.	Priority: Unchanged Comment: Small amounts of organic materials and thus a negligible gas source compared to gas from the repository.	1
GEO 6.13 Heat conduction	The thermal properties of the plugs (geometries and composition) affect the heat conduction in the plugs and thereby the temperature in the plugs as well as in tunnels and rock.	Priority: Unchanged Comment: Negligible effect.	1
GEO 6.14a Bentonite expansion	The properties of the bentonite in plugs, e.g. composition and density, affect the swelling of the bentonite in the plugs and thus the swelling pressure and stress conditions in the plugs.	Priority: Unchanged	3
GEO 6.14b Stress and strain changes	The geometry and mechanical properties of the concrete in plugs affect the swelling pressure of the bentonite in the plugs as well as the stress conditions in the surrounding rock.	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 6.15 Microbial activity	The presence of organic materials, nutrients and energy sources in the plugs will affect the population and activity of microbes and bacteria in the plugs.	Priority: Unchanged Comment: Too small amounts from the plugs to give a significant contribution compared to the contribution from other sources.	1
GEO 6.16a Sorption	The amount and composition of bentonite and concrete in plugs will affect the sorption of radionuclides and toxicants on these materials and thereby the concentration of mobile contaminants in the water in the plugs. Saturation of sorption sites and non-linear sorption effects should be considered.	Priority: Unchanged Comment: Negligible sorption capacity in the plugs compared to the sorption capacity of other materials in the geosphere, e.g. tunnel backfill and rock.	1
GEO 6.16b Diffusion	The dimensions and porosity of the bentonite and concrete in plugs will affect the diffusive transport of radionuclides and toxicants in the plugs and thereby the concentration of contaminants in the water in the plugs, tunnels and rock.	Priority: Unchanged Comment: Too short diffusion lengths to have any effect on the overall migration in the geosphere.	1
GEO 6.17 None	No interaction between plugs in the tunnel system and the biosphere since they are physically isolated. Plugs at the entrance of the access tunnels might be an exeption, but this will have to be discussed when the actual location and design of the plugs are decided.	Priority: Unchanged Comment: No decision has been taken on the design of the repository plugs.	0
GEO 6.18 None	The plugs are physically isolated from the system outside the disposal system. Interactions take place via other diagonal elements in the matrix.	Priority: Unchanged	0
GEO 7.1 None	No direct effect from the matrix of the repository rock on the silo barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 7.2 None	No direct effect from the repository rock matrix on the BMA barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 7.3 None	No direct effect from the repository rock matrix on the BTF barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 7.4 None	No direct effect from the repository rock matrix on the BLA barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 7.5 None	No direct effect from the repository rock, rock matrix, on tunnels and backfill. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 7.6 None	No direct effect from the repository rock, rock matrix, on plugs. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 7.7 Repository rock matrix	The matrix of the rock in between as well as around the vaults and the Silo to a distance of about 20 to 30 m from the repository. The matrix of the rock in the disturbed zone around vaults and tunnels is also included.		

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 7.8 None	No primary interactions identified since they are components of the same physical system. The separation into two diagonal elements is only due to their different functions what regards the transport of radionuclides and toxicants.	Priority: Unchanged	0
GEO 7.9 None	No primary interactions identified since they are components of the same physical system and the boundary is fictiv.	Priority: Unchanged	0
GEO 7.10a Dissolution/ precipitation	Dissolution/precipitation of rock minerals will affect the composition of the water in the repository rock. Includes also colloid formation.	Priority: Unchanged	3
GEO 7.10b Diffusion	The porosity of the repository rock matrix will affect the diffusion of dissolved species and thereby the composition of the water in the repository rock.	Priority: Unchanged	3
GEO 7.10c Sorption	The composition of the repository rock matrix and internal pore surfaces will affect the sorption of dissolved species and colloids and thereby the composition of the water in the repository rock.	Priority: Unchanged Comment: Will have negligible effect on the main composition of the water. Could have some effect on the sorption of colloids if colloids can move in pores in the matrix. This effect probably small compared to the sorption of colloids on fracture surfaces and anyhow conservative to neglect.	1
GEO 7.11 Capillary suction	The pore-size distribution of the rock matrix in the repository rock will affect the capillary suction of water into the rock matrix and thus the degree of saturation of the rock matrix during the saturation phase.	Priority: Unchanged Comment: Should have a marginal effect only on the time for resaturation and the flow paths during the resaturation phase.	1
GEO 7.12a Microbial activity	Microbial degradation of organic materials in the rock matrix in the repository rock may generate gas and thereby affect the amount, composition and pressure of gas in the rock matrix.	Priority: Unchanged Comment: Negligible gas source compared to gas released from the repository.	1
GEO 7.12b Radon generation	Radon generation in the matrix of the repository rock due to decay of naturally occurring radionuclides in the rock minerals.	Priority: Unchanged Comment: Negligible gas source compared to gas release from the repository. In addition radon gas is a natural radionuclide and in the analysis only radionuclides from the repository are included.	1
GEO 7.13 Heat conduction	The mineralogy of the rock matrix in the repository rock affects the heat conduction in the rock and thereby the temperature in the repository rock, tunnels and rock outside the repository area.	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The heat transport properties of the rock will affect the repository temperature and permafrost depth.	3
GEO 7.14 Deformation	Rock type, mineralogy and microstructure in the repository rock will affect the deformation of the rock and thus the stress conditions.	Priority: Unchanged	3
GEO 7.15 Microbial activity	The presence of organic materials, nutrients and energy sources in the rock matrix in the repository rock will affect the population and activity of microbes and bacteria in the repository rock.	Priority: Unchanged Comment: Microbial activity in the rock matrix is assessed to be negligibly small compared to microbial activity on fracture surfaces, because of small space and limited supply of organics, nutrients and energy sources.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 7.16a Matrix diffusion	The porosity of the rock matrix in the repository rock will affect the diffusion of radionuclides and toxicants into the rock matrix and thereby the concentration of these in the water in the rock matrix and in the fractures in the repository rock.	Priority: Unchanged	3
GEO 7.16b Sorption	The mineralogy of the rock matrix in the repository rock will affect the sorption of radionuclides and toxicants in the rock matrix and thereby the concentration of these in the water in the rock matrix. Saturation of sorption sites and non-linear sorption effects should be considered.	Priority: Unchanged	3
GEO 7.17 None	No direct impact from repository rock on the biosphere as long as they are physically separated by the rock outside the repository area.	Priority: Unchanged	0
GEO 7.18 None	By definition, the repository rock is physically isolated from the system outside the disposal system. Interactions take place via other diagonal elements in the matrix.	Priority: Unchanged	0
GEO 8.1 Bentonite expansion	Bentonite expansion into fractures in the surrounding rock may affect the density of the bentonite barriers in the Silo. (REP18.8)	Priority: Unchanged	3
GEO 8.2 None	No direct effect from the fractures in the repository rock on the BMA barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 8.3 None	No direct effect from the fractures in the repository rock on the BTF barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 8.4 None	No direct effect from the fractures in the repository rock on the BLA barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 8.5 Bentonite expansion	Bentonite used as backfill in investigation boreholes may expand into fractures in the rock adjacent to the holes. The extent of swelling will depend on the amount and apertures of these fractures and the expansion may affect the density and homogeneity of the bentonite in the boreholes.	Priority: Unchanged Comment: Most likely only small, local effects that do not influence the overall function of the backfill in the investigation boreholes.	1
GEO 8.6 Bentonite expansion	Bentonite in plugs may expand into fractures in the rock adjacent to the plugs. The extent of swelling will depend on the amount and apertures of these fractures and the expansion may affect the density and homogeneity of the bentonite in the plugs.	Priority: Unchanged	3
GEO 8.7 None	No primary interactions identified since they are components of the same physical system. The separation into two diagonal elements is only due to their different functions what regards the transport of radionuclides and toxicants.	Priority: Unchanged	0
GEO 8.8 Repository rock – fracture system	The fracture systems, including fracture coatings, in the rock in between as well as around the vaults and the Silo to a distance of about 20 to 30 m from the repository. The fractures in the disturbed zone around vaults and tunnels are also included.		
GEO 8.9 None	No primary interactions identified since they are components of the same physical system and the boundary is fictiv.	Priority: Unchanged	0

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 8.10a Dissolution/ precipitation	Dissolution/precipitation of fracture minerals will affect the composition of the water in the repository rock. Includes also colloid formation.	Priority: Unchanged	3
GEO 8.10b Diffusion	The amount and apertures of fractures in the repository rock will affect the diffusion of dissolved species in the fractures and thereby the composition of the water in the repository rock.	Priority: Unchanged	3
GEO 8.10c Sorption	The composition of the fracture minerals in the repository rock will affect the sorption of dissolved species and colloids and thereby the composition of the water in the repository rock.	Priority: Unchanged Comment: Will have negligible effect on the main composition of the water. Could have some effect on the sorption of colloids and thus on the amount of colloids in the water, but this effect is conservative to neglect.	1
GEO 8.10d Colloid filtering	The porosity and the fracture apertures in the repository rock fracture system affects the filtering of colloids/particles and thus the amount of these in the water.	Priority: Unchanged Comment: Most of the colloids will be transported in the larger fractures where there are no filtering effects. Moreover, filtering of colloids is a positive effect and thus conservative to neglect.	1
GEO 8.10e Erosion	The chemical and physical properties of the fractures in the repository rock affects its ability to withstand mechanical erosion and thus the amount of colloids/ particles in the water in the backfill.	Priority: Unchanged Comment: The expected flow rates are low and liberation of colloids/ particles by erosion should therefore be small compared to chemical formation of colloids/particles (e.g. natural organic colloids in the water).	1
GEO 8.11a Water flow	Frequency, apertures and connectivity of fractures in the repository rock will affect the magnitude, direction and distribution of water flow in the repository rock, the rock outside the repository area and in tunnels.	Priority: Unchanged	3
GEO 8.11b Capillary suction	The apertures of fractures in the repository rock will affect the capillary suction of water into the fractures and thus the degree of saturation of the fractures during the saturation phase.	Priority: Unchanged Comment: Large fractures do not have any capillary suction. Small fractures have such small volume that they will not affect the hydrology. Pores in fracture minerals will not be drained during the pre-closure phase because even if the interior of the fractures is drained some water will flow on the surface of the fractures.	1
GEO 8.12a Gas flow	Frequency, apertures and connectivity of fractures in the repository rock will affect the magnitude, direction and distribution of gas flow and the gas pressure in the repository rock, the rock outside the repository area and in tunnels.	Priority: Unchanged	3
GEO 8.12b Microbial activity	Microbial degradation of organic materials on the fracture surfaces in the repository rock may generate gas and thereby affect the amount, composition and pressure of gas in the repository rock.	Priority: Unchanged Comment: Too small gas source to be of importance. Much more gas is generated in the repository and this gas has to escape through the geosphere.	1
GEO 8.12c Radon generation	Radon generation in the fractures of the repository rock due to decay of naturally occurring radionuclides in the minerals of fracture coatings.	Priority: Unchanged Comment: Negligible radon source compared to the rock matrix, which in turn generates small amounts of gas in relation to the gas released from the repository.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 8.13 Heat conduction	The mineralogy of fracture coatings as well as the frequency, apertures and connectivity of fractures in the repository rock affect the heat conduction in the fractures and thereby the temperature in the repository rock, tunnels and rock outside the repository area.	Priority: Unchanged Comment: Negligible compared to heat conduction in repository rock.	1
GEO 8.14 Deformation	The mineralogy of fracture coatings as well as the frequency and apertures of fractures in the repository rock will affect the stress conditions in the repository rock.	Priority: Unchanged	3
GEO 8.15 Microbial activity	The presence of organic materials, nutrients and energy sources in fractures in the repository rock will affect the population and activity of microbes and bacteria in the repository rock.	Priority: Unchanged	2
GEO 8.16a Matrix diffusion	The frequency, aperture and connectivity of fractures in the repository rock will affect the "wet surface" of the fractures. This together with the porosity of fracture coatings in the repository rock will affect the diffusion of radionuclides and toxicants into the fracture coatings and thereby the concentration of these in the fractures and in the rock matrix in the repository rock.	Priority: Unchanged	3
GEO 8.16b Sorption	The mineralogy of fracture coatings in the repository rock will affect the sorption of radionuclides and toxicants in the fracture coatings and thereby the concentration of these in the fractures. Saturation of sorption sites and non-linear sorption effects should be considered.	Priority: Unchanged	3
GEO 8.16c Diffusion	The frequency, aperture and connectivity of fractures in the repository rock will affect the diffusion of radionuclides and toxicants in these fractures and thereby the concentration of these in the water in the repository rock, in the rock outside the repository area and in the tunnels.	Priority: Unchanged	3
GEO 8.17 None	No direct impact from repository rock on the biosphere as long as they are physically separated by the rock outside the repository area.	Priority: Unchanged	0
GEO 8.18 None	By definition, the repository rock is physically isolated from the system outside the disposal system. Interactions take place via other diagonal elements in the matrix.	Priority: Unchanged	0
GEO 9.1 None	No direct effect from the rock (matrix and fractures) outside the repository area on the silo barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 9.2 None	No direct effect from the rock (matrix and fractures) outside the repository area on the BMA barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 9.3 None	No direct effect from the rock (matrix and fractures) outside the repository area on the BTF barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 9.4 None	No direct effect from the rock (matrix and fractures) outside the repository area on the BLA barriers. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 9.5 Bentonite expansion	Bentonite used as backfill in investigation boreholes may expand into fractures in the rock adjacent to the holes. The extent of swelling will depend on the amount and apertures of these fractures and the expansion may affect the density and homogeneity of the bentonite in the boreholes.	Priority: Unchanged Comment: Most likely only small, local effects that do not influence the overall function of the backfill in the investigation boreholes.	1
GEO 9.6 None	No direct effect from the rock outside the repository area on repository plugs because they are physically isolated. No direct influence from the rock on the concrete plug in the entrance tunnel is identified. Interactions take place via other diagonal elements in the matrix.	Priority: Unchanged	0
GEO 9.7 None	No primary interactions identified since they are components of the same physical system and the boundary is fictiv.	Priority: Unchanged	0
GEO 9.8 None	No primary interactions identified since they are components of the same physical system and the boundary is fictiv.	Priority: Unchanged	0
GEO 9.9 Rock	Rock matrix, fracture systems and coating materials on fracture surfaces in the rock outside the repository rock.		
GEO 9.10a Dissolution/precipitation	Dissolution/precipitation of rock and fracture minerals in the rock outside the repository area will affect the composition of the water in the rock outside the repository area. Includes also colloid formation.	Priority: Unchanged	3
GEO 9.10b Diffusion	The rock matrix porosity and the amount and apertures of fractures in the rock will affect the diffusion of dissolved species in the rock and thereby the composition of the water in the rock outside the repository area.	Priority: Unchanged	2
GEO 9.10c Sorption	The composition of the rock matrix and fracture minerals will affect the sorption of dissolved species and colloids and thereby the composition of the water in the rock outside the repository area.	Priority: Unchanged Comment: Will have negligible effect on the main composition of the water. Could have som effect on the sorption of colloids and thus on the amount of colloids in the water, but this effect is conservative to neglect.	1
GEO 9.10d Colloid filtering	The porosity and the fracture apertures in the rock outside the repository area affects the filtering of colloids/particles and thus the amount of these in the water.	Priority: Unchanged Comment: Most of the colloids will be transported in the larger fractures where there are no filtering effects. Moreover, filtering of colloids is a positive effect and thus conservative to neglect.	1
GEO 9.10e Erosion	The chemical and physical properties of the rock matrix and fractures affects its ability to withstand mechanical erosion and thus the amount of colloids/particles in the water in the rock outside the repository area.	Priority: Unchanged Comment: The expected flow rates are low and liberation of colloids/particles by erosion should therefore be small compared to chemical formation of colloids/particles (e.g. natural organic colloids in the water).	1
GEO 9.11 Water flow	Frequency, apertures and connectivity of fractures in the rock outside the repository area will affect the magnitude, direction and distribution of water flow in the rock outside the repository area, in the repository rock and in tunnels.	Priority: Unchanged	3
GEO 9.12a Gas flow	Frequency, apertures and connectivity of fractures in the rock outside the repository area will affect the magnitude, direction and distribution of gas flow and the gas pressure in the rock outside the repository area as well as in the repository rock and in tunnels.	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 9.12b Microbial activity	Microbial degradation of organic materials in the rock outside the repository area may generate gas and thereby affect the amount, composition and pressure of gas in the rock outside the repsority area.	Priority: Unchanged Comment: Too small gas source to be of importance. Much more gas is generated in the repository and this gas has to escape through the geosphere.	1
GEO 9.12c Radon generation	Radon generation in the rock outside the repository area due to decay of naturally occurring radionuclides in the rock minerals.	Priority: Unchanged Comment: Small amounts of gas in relation to the gas released from the repository, which has to escape through the geosphere.	1
GEO 9.13 Heat conduction	The mineralogy of fracture coatings and the rock matrix as well as the frequency, apertures and connectivity of fractures in the rock outside the repository area affect the heat conduction in the rock and thereby the temperature in the rock outside the repository area, in the repository rock and in the tunnels.	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The heat transport properties of the rock will affect the repository temperature and permafrost depth.	3
GEO 9.14 Deformation	The mineralogy of the rock and fracture coatings as well as the frequency and apertures of fractures in the rock outside the repository area will affect the stress conditions in the rock outside the repository area.	Priority: Unchanged	3
GEO 9.15 Microbial activity	The presence of organic materials, nutrients and energy sources in the rock outside the repository area will affect the population and activity of microbes and bacteria in the rock.	Priority: Unchanged	2
GEO 9.16a Matrix diffusion	The frequency, aperture and connectivity of fractures in the repository rock will affect the “wet surface” of the fractures. This together with the porosity of the rock matrix and fracture coatings in the rock outside the repository area will affect the diffusion of radionuclides and toxicants into the fracture coatings and rock matrix and thereby the concentration of these in the fractures and in the rock matrix in the repository rock.	Priority: Unchanged	3
GEO 9.16b Sorption	The mineralogy of the rock matrix and fracture coatings in the rock outside the repository area will affect the sorption of radionuclides and toxicants and thereby the concentration of these in the rock outside the repository area. Saturation of sorption sites and non-linear sorption effects should be considered.	Priority: Unchanged	3
GEO 9.16c Diffusion	The frequency, aperture and connectivity of fractures in the rock outside the repository area will affect the diffusion of radionuclides and toxicants in these fractures and thereby the concentration of these in the water in the rock outside the repository area.	Priority: Unchanged	3
GEO 9.17 Erosion/ weathering	Formation of Quaternary deposits by erosion/weathering. (BIO 1.2a)	Priority: Unchanged Comment: Erosion of the rock minor influence on the formation of sediments compared to other sediment formation processes e.g. average erosion rates for soil-materials app. 0.1.mm/y (see BIO 1.2a and BIO 1.9)	1
GEO 9.18 None	The rock outside the repository area is by definition in contact with the system outside the disposal system, but no direct effect identified. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 10.1 Mass flow	Transport of components in the water in the tunnels and the repository rock will affect the composition of the water in the silo. (REP 17.10, REP 18.10)	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 10.2 Mass flow	Transport of components in the water in the tunnels and the repository rock will affect the composition of the water in the BMA. (REP 17.10, REP 18.10)	Priority: Unchanged	3
GEO 10.3 Mass flow	Transport of components in the water in the tunnels and the repository rock will affect the composition of the water in the BTF. (REP 17.10, REP 18.10)	Priority: Unchanged	3
GEO 10.4 Mass flow	Transport of components in the water in the tunnels and the repository rock will affect the composition of the water in the BLA. (REP 17.10, REP 18.10)	Priority: Unchanged	3
GEO 10.5a Dissolution/ precipitation	The composition of the water in the tunnel will affect the dissolution of primary minerals in backfilled rock and shotcrete and the precipitation of secondary minerals. This will affect the composition, porosity and permeability of these materials. Includes also the effect of water composition on the dissolution/precipitation of backfill in investigation boreholes and thus on the properties of the backfill in the boreholes.	Priority: Unchanged	2
GEO 10.5b Corrosion	The composition of the water in the tunnel will affect the corrosion of rock bolts and reinforcement in shotcrete, which will change the composition and structure of these materials. Includes also volume changes due to formation of corrosion products.	Priority: Unchanged Comment: Water composition is of importance for corrosion rates and modes but corrosion of rock bolts and reinforcement in shotcrete in tunnels are assessed to be of minor importance for the overall function of the tunnels in the post-closure phase.	1
GEO 10.5c Ionic strength effects	Bentonite used as backfill in the investigation boreholes can be altered by ion exchange processes and by expansion and dispersion of clay particles into adjacent fractures in the rock, compare 10.6c and 10.6e. This could change the homogeneity, expandability and hydraulic and gas conductivities of the bentonite in the investigation boreholes.	Priority: Changed from 2 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The bentonite will dissolve under low ionic strength conditions such as during glacial melting.	3
GEO 10.6a Dissolution/ precipitation	The composition of the water in the plugs will affect the dissolution of primary minerals in bentonite and concrete in plugs and the precipitation of secondary minerals. This will affect the composition, pore and fracture characteristics of these materials.	Priority: Unchanged	3
GEO 10.6b Corrosion	The composition of the water in the plugs will affect the corrosion of reinforcement in plugs which will change the composition and pore and fracture characteristics of the plugs. Includes also volume changes due to formation of corrosion products.	Priority: Unchanged	3
GEO 10.6c Ion-exchange	The composition of the water in the bentonite plugs can change the type of adsorbed cation in bentonite through ion-exchange (sorption) by which the physical properties of the adsorbed (interlamellar) water and the ability to form intergranular clay gels are altered. This causes changes in homogeneity, expandability and hydraulic and gas conductivities of the bentonite in the plugs.	Priority: Unchanged	3
GEO 10.6d Water uptake	The gradient in ionic strength in the water in the bentonite plugs affects the uptake of water and thus the density, geometry, structure and volume of the bentonite plugs.	Priority: Unchanged	4

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 10.6e Expansion/dispersion	Clay particles in the bentonite in the plugs may be dispersed through swelling, i.e. uptake of water in between the particles. Bentonite expansion and dispersion of clay particles requires a low ionic strength of the water and a free expansion volume such as fractures in the rock in contact with the bentonite. Expansion and dispersion of bentonite particles could affect the geometry, homogeneity and density of the bentonite in the plugs.	Priority: Unchanged	3
GEO 10.7 Dissolution/precipitation	The composition of the water in the rock matrix of the repository rock will affect the dissolution and precipitation of minerals. This may change the porosity and composition of the rock matrix.	Priority: Unchanged	3
GEO 10.8 Dissolution/precipitation	The composition of the water in the fractures in the repository rock will affect the dissolution and precipitation of minerals on the fracture surfaces. This may change the apertures and connectivity of the fractures and the mineralogic composition of the fracture surfaces.	Priority: Unchanged	3
GEO 10.9 Dissolution/precipitation	The composition of the water in the rock outside the repository area will affect the dissolution and precipitation of minerals on the fracture surfaces and in the rock matrix. This may change the apertures and connectivity of the fractures and the porosity of the rock matrix as well as the composition of the fracture surfaces and rock matrix.	Priority: Unchanged	3
GEO 10.10 Water composition	Water composition, including colloids/particles and dissolved gas, in tunnels, plugs, and investigation boreholes and in rock matrix and fractures in all rock in the geosphere system.		
GEO 10.10a Colloid formation/stability	The formation and stability of colloids/particles depends on the composition of the water, e.g. ionic strength.	Priority: Unchanged	3
GEO 10.11a Convection	The salinity of the water will affect the density of the water and gradients in density will affect the magnitude, direction and distribution of water flow in the different components of the geosphere system. The water density is also affected by changes in temperature, see 13.10b.	Priority: Unchanged	3
GEO 10.11b Water flow	The water composition in the different parts of the geosphere system will affect the density and viscosity of the water and thus the magnitude of the water flow in the different parts of the geosphere system.	Priority: Unchanged Comment: The variability in rock properties is much more important for the water flow than potential variations in water viscosity due to changes in water composition. The effect on freezing goes through GEO 10.11d.	1
GEO 10.11c Osmosis	Gradients in concentration in the different components of the system, e.g. bentonite plugs and bentonite in investigation boreholes, may cause osmotic potentials that affect the magnitude, direction and distribution of water flow in the system components, e.g. bentonite plugs.	Priority: Unchanged Comment: Could somewhat affect the water flow through plugs during the resaturation phase, but this is assessed to be of negligible importance for the long-term function of the repository.	1
GEO 10.11d Phase Changes Not defined in SAFE		Priority: Set to 2. Description: The water composition (salinity) affects the freezing point of water and may thus affect its aggregate state. Comment: Even a small change in freezing point may under specific conditions be of some importance.	2

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 10.12a Gas dissolution/ degassing	The water composition, e.g. concentration of dissolved species and amount and composition of dissolved gas, affects the dissolution of gas and degassing. This will influence the amount and composition of gas in gas phase in the different parts of the geosphere system.	Priority: Unchanged Comment: Small effect of water composition on gas solubilities and thus negligible effect on the amount and composition of gas	1
GEO 10.12b Chemical reactions	Changes in water composition that causes gas generation or consumption of gas, e.g. changes in pH that affects the amount of CO_2.	Priority: Unchanged Comment: The amount of gas consumed or generated, e.g. degas-sing of dissolved carbon dioxide from the repository, is expected to be small compared to the amount of gas generated in the repository and that escapes through the geosphere.	1
GEO 10.13 Heat conduction	The water composition in the different parts of the geosphere system will affect the heat transfer by con-duction in the water phase and thus the temperature in the different parts of the geosphere system.	Priority: Unchanged Comment: The water composition has a negligible effect on the temperature compared to the heat conductions properties of the rock.	1
GEO 10.14 None	No direct interactions identified. Impact from water composition via corrosion of rock bolts goes via interactions 10.5 and 5.14.	Priority: Unchanged	0
GEO 10.15 Microbial activity	The water composition in the different parts of the geosphere system, e.g. dissolved organics, nutrients, energy sources, Eh, pH etc, will affect the microbial activity and thus the type and amount of microbes/ bacteria present in the different parts of the geosphere system.	Priority: Unchanged	3
GEO 10.16a Diffusion	The water composition in the different parts of the geosphere system, e.g. ionic strength that gives anion exclusion, affects the rate of diffusion and thus the concentration of radionuclides and toxicants in the water in different parts of the geosphere system.	Priority: Unchanged	3
GEO 10.16b Sorption	The water composition in the different parts of the geosphere system (e.g. pH, Eh, concentration of complexing agents, type and amont of colloids/ particles etc) affects the speciation and sorption of radionuclides and toxicants on solid phases (including colloids/particles) and thus also the distribution between mobile and immobile radionuclides and toxi-cants in the different parts of the geosphere system. The concentration of stabile isotopes can also have an impact via isotopic dilution in case of a non-linear sorption isoterm. The water composition may also affect the competition about available sorption sites.	Priority: Unchanged	3
GEO 10.16c Precipitation/ dissolution	The water composition in the different parts of the geosphere system (e.g. pH, Eh, concentration of complexing agents, etc) affects the speciation and solubility of radionuclides and toxicants and thus also the distribution between mobile and immobile radionuclides and toxicants in the different parts of the geosphere system. The concentration of stabile isotopes can also have an impact via isotopic dilution as well as coprecipitation with e.g. iron corrosion products.	Priority: Unchanged	3
GEO 10.16d Colloid transport	The type and amount of colloids/particles in the water in the different parts of the geosphere system may affect the mobility of radionuclides and toxicants by acting as carriers for these. This in turn may have an impact on the concentration of radionuclides and toxi-cants in the water in different parts of the geosphere system.	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 10.17 Mass flow	Transport of groundwater components will affect the composition of water in Quaternary deposits and surface waters. (BIO 1.12)	Priority: Unchanged	2
GEO 10.18 Mass exchange	Exchange of groundwater components between the geosphere in the disposal system and the geosphere outside the disposal system will affect the composition of water in the geosphere outside the disposal system.	Priority: Unchanged Comment: By definition, this interaction is of no interest in the present analysis. The geosphere domain considered has been chosen so as to make this effect negligible.	1
GEO 11.1a Mass flow	Transport of components in the water in the tunnels and the repository rock will affect the composition of the water in the silo. (REP 17.10, REP 18.10)	Priority: Unchanged	3
GEO 11.1b Recharge/ discharge and pressure	The hydrological situation in the tunnels and the repository rock will affect the exchange of water between the silo and the tunnels and repository rock and thereby the hydrology in the silo. (REP 17.11, REP 18.11)	Priority: Unchanged	3
GEO 11.1c Erosion	Erosion of the external surfaces of the bentonite barriers may affect the density of the barriers by carrying away material. (REP 18.8)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Not enough is know concerning the magnitude of bentonite erosion. Therefore this process should not be overlooked when assessing repository safety.	3
GEO 11.1d Biomass flow	Transport of biomass in the water in the tunnels and the repository rock will affect the type and amount of biomass in the silo. (REP 17.15, REP 18.15)	Priority: Unchanged	2
GEO 11.1e Contaminant transport	Transport of radionuclides and toxicants in the water in the tunnels and the repository rock will affect the type and amount of radionuclides and toxicants in the Silo. (REP 17.16, REP 18.16)	Priority: Unchanged	3
GEO 11.2a Mass flow	Transport of components in the water in the tunnels and the repository rock will affect the composition of the water in the BMA. (REP 17.10, REP 18.10)	Priority: Unchanged	3
GEO 11.2b Recharge/ discharge and pressure	The hydrological situation in the tunnels and the repository rock will affect the water exchange between the BMA and the tunnels and repository rock and thereby the hydrology in the BMA. (REP 17.11, REP 18.11)	Priority: Unchanged	3
GEO 11.2c Biomass flow	Transport of biomass in the water in the tunnels and the repository rock will affect the type and amount of biomass in the BMA. (REP 17.15, REP 18.15)	Priority: Unchanged	2
GEO 11.2d Contaminant transport	Transport of radionuclides and toxicants in the water in the tunnels and the repository rock will affect the type and amount of radionuclides and toxicants in the BMA. (REP 17.16, REP 18.16)	Priority: Unchanged	3
GEO 11.3a Mass flow	Transport of components in the water in the tunnels and the repository rock will affect the composition of the water in the BTF. (REP 17.10, REP 18.10)	Priority: Unchanged	3
GEO 11.3b Recharge/ discharge and pressure	The hydrological situation in the tunnels and the repository rock will affect the water exchange between the BTF and the tunnels and repository rock and thereby the hydrology in the BTF. (REP 17.11, REP 18.11)	Priority: Unchanged	3
GEO 11.3c Biomass flow	Transport of biomass in the water in the tunnels and the repository rock will affect the type and amount of biomass in the BTF. (REP 17.15, REP 18.15)	Priority: Unchanged	2

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 11.3d Contaminant transport	Transport of radionuclides and toxicants in the water in the tunnels and the repository rock will affect the type and amount of radionuclides and toxicants in the BTF. (REP 17.16, REP 18.16)	Priority: Unchanged	3
GEO 11.4a Mass flow	Transport of components in the water in the tunnels and the repository rock will affect the composition of the water in the BLA. (REP 17.10, REP 18.10)	Priority: Unchanged	3
GEO 11.4b Recharge/ discharge and pressure	The hydrological situation in the tunnels and the repository rock will affect the water exchange between the BLA and the tunnels and repository rock and thereby the hydrology in the BLA. (REP 17.11, REP 18.11)	Priority: Unchanged	3
GEO 11.4c Biomass flow	Transport of biomass in the water in the tunnels and the repository rock will affect the type and amount of biomass in the BLA. (REP 17.15, REP 18.15)	Priority: Unchanged	2
GEO 11.4d Contaminant transport	Transport of radionuclides and toxicants in the water in the tunnels and the repository rock will affect the type and amount of radionuclides and toxicants in the BLA. (REP 17.16, REP 18.16)	Priority: Unchanged	3
GEO 11.5a Dissolution/ precipitation	The amount of water (degree of saturation) in the tunnel will affect the dissolution of primary minerals in backfilled rock and shotcrete and the precipitation of secondary minerals. This will affect the composition, porosity and permeability of these materials.	Priority: Unchanged Comment: Short duration of unsaturated conditions and any dissolution/ precipitation that will occur might give rise to small local changes in properties, but will most likely be of negligible importance for the long-term function of the repository.	1
GEO 11.5b Corrosion	The amount of water (degree of saturation) in the tunnel will affect the corrosion of rock bolts and reinforcement in shotcrete which will change the composition and structure of these materials.	Priority: Unchanged Comment: Short duration of the resaturation phase and probably anyhow enough water during the resaturation phase to maintain corrosion.	1
GEO 11.5c Redistribution	Under transient conditions, smaller particles may be transported by the water flowing in the tunnels. This may lead to a redistribution of the backfilled material. Under steady state conditions the water flow rate is expected to be too low for this process to occur.	Priority: Unchanged Comment: Mechanical damage due to freezing goes through GEO 11.14 and 14.5a. Flow rates may be increased even at steady state during glacial period.	3
GEO 11.6a Dissolution/ precipitation	The amount of water (degree of saturation) in the plugs will affect the dissolution of primary minerals in bentonite and concrete in plugs and the precipitation of secondary minerals. This will affect the composition, pore and fracture characteristics of these materials.	Priority: Unchanged Comment: The duration of the resaturation phase is expected to be short and any effects of dissolution/ precipitation during the resaturation phase are probably small.	1
GEO 11.6b Corrosion	The amount of water (degree of saturation) in the plugs will affect the corrosion of reinforcement in plugs which will change the composition and pore and fracture charactersitics of the plugs.	Priority: Unchanged Comment: Short duration of the resaturation phase and probably anyhow enough water during the resaturation phase to maintain corrosion.	1
GEO 11.6c Erosion	Water flowing in the tunnels and plugs and in the repository rock adjacent to the plugs may cause mechanical erosion of the plugs. This could affect the geometry and porosity of the plugs.	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The expected water velocities are too low for erosion to be of any importance for the properties of the concrete plugs. In case of bentonite plugs, erosion may be of importance. Especially at glacial period.	2

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 11.6d Water uptake	The amount of water (degree of saturation) and the water pressure in the bentonite plugs and in adjacent components of the system affects the uptake of water in the bentonite plugs and thus the density, geometry, structure and volume of the bentonite plugs.	Priority: Unchanged	4
GEO 11.7 Dissolution/ precipitation	The amount of water (degree of saturation) in the rock matrix of the repository rock will affect the dissolution and precipitation of minerals. This may change the porosity and composition of the rock matrix.	Priority: Unchanged Comment: Too short duration of the resaturation phase to be of any importance.	1
GEO 11.8a Dissolution/ precipitation	The amount of water (degree of saturation) in the fractures in the repository rock will affect the dissolution and precipitation of minerals on the fracture surfaces. This may change the apertures and connectivity of the fractures and the mineralogic composition of the fracture surfaces.	Priority: Unchanged Comment: Too short duartio of the resaturation phase to be of any importance.	1
GEO 11.8b Erosion	Water flowing in fractures in the repository rock may cause mechanical erosion of the fracture surfaces. This could affect the apertures of the fractures.	Priority: Unchanged Comment: The expected water velocity is too low for erosion to be of any importance for the properties of the rock. Erosion by freezing through 14.8	1
GEO 11.9a Dissolution/ precipitation	The amount of water (degree of saturation) in the rock outside the repository area will affect the dissolution and precipitation of minerals on the fracture surfaces and in the rock matrix. This may change the apertures and connectivity of the fractures and the porosity of the rock matrix as well as the composition of the fracture surfaces and rock matrix.	Priority: Unchanged Comment: Unsaturated conditions not expected in the rock outside the repository area.	1
GEO 11.9b Erosion	Water flowing in fractures in the rock outside the repository area may cause mechanical erosion of the fracture surfaces. This could affect the apertures of the fractures.	Priority: Unchanged Comment: The expected water velocity is too low for erosion to be of any importance for the properties of the rock. Erosion by freezing through 14.9	1
GEO 11.10a Advection and mixing	The magnitude, distribution and direction of water flow in the different parts of the geosphere system will determine the advective and dispersive transport of species in the waters. This will cause mixing of different waters and affect the composition of the water in the different parts of the geosphere system.	Priority: Unchanged	3
GEO 11.10b Chemical equilibria	The porewater pressure in the different parts of the geosphere system affects the chemical equilibria and thus the water composition in the different parts of the geosphere system.	Priority: Unchanged Comment: Too small pressure differences	1
GEO 11.10c Erosion	The magnitude of water flow (velocity) in the different parts of the geosphere system will affect the extent of mechanical erosion of the barrier materials and thus the amount of colloids/particles in the water in the different parts of the geosphere system.	Priority: Unchanged	2
GEO 11.10d Concentration/ dilution Not defined in SAFE.		Priority: Set to 2 Description: Concentration and dilution of water occurring as result of change in water aggregate state. Comment: A common example is salt rejection giving rise to cryogenic brine.	2
GEO 11.11 Hydrolgy	Water in all physical components of the geosphere system and water movement in plugs, tunnels boreholes, and fracture systems in the rock.	Comment: Includes change in aggregation state of water.	

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 11.12a Saturation	The water pressure in the different parts of the geosphere system affects the saturation process and thereby the degree of saturation in the different parts of the geosphere system.	Priority: Unchanged	4
GEO 11.12b Gas dissolution/ degassing	The water pressure in the different parts of the geosphere system affects the gas solubility and thus the amount and composition of gas in gas phase in the different parts of the geosphere system.	Priority: Unchanged	2
GEO 11.12c Two phase flow	The water pressure in the different parts of the geosphere system will affect the magnitude, direction and distribution of gas flow in the geosphere system components.	Priority: Unchanged	2
GEO 11.12d Expansion/ contraction	The water pressure in the different parts of the geosphere system will affect the volume of the gas in the different geosphere system components.	Priority: Unchanged	2
GEO 11.13 Heat advection	The magnitude, direction and distribution of water flow in the different components of the geosphere system will affect the heat transport by advection and thus the temperature in the different components of the geosphere system.	Priority: Unchanged Comment: Negligible effect compared to heat conduction in rock matrix.	1
GEO 11.14 Water pressure interaction	The water pressure in the different components of the geosphere system, e.g. due to phase changes, affects the stress conditions in the components of the geosphere system.	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Stress changes are expected due to phase changes during permafrost periods and glaciation.	3
GEO 11.15 Advection	The magnitude, direction and distribution of water flow in the different components of the geosphere system will affect the advective transport of microbes and bacteria (and other types of biomass) and thus the type and amount of these in the different parts of the geosphere system.	Priority: Unchanged	3
GEO 11.16a Advection	The magnitude, direction and distribution of water flow in the tunnels, repository rock and rock outside the repository area will affect the advective transport of radionuclides and toxicants and thereby the spatial and temporal distribution of radionuclides and toxicants in the water in the tunnels and rock.	Priority: Unchanged	3
GEO 11.16b Dispersion	The distribution of the water flow in different flow paths in the tunnel, repository rock and rock outside the repository area will affect the dispersion of radionuclides and toxicants and thereby the temporal distribution of radionuclides and toxicants in the water in the tunnel and rock.	Priority: Unchanged	3
GEO 11.16c Gas dissolution/ degassing	The water pressure in the different components of the geosphere system will affect the solubility of radioactive and chemotoxic gases and thereby the distribution of radionuclides and toxicants between gas and water phase.	Priority: Unchanged	2
GEO 11.17a Mass flow	Transport of groundwater components will affect the composition of water in Quaternary deposits and surface waters. (BIO 1.12)	Priority: Unchanged	2

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 11.17b Discharge/ recharge and pressure	The hydrology in the geosphere influences the discharge and recharge of groundwater and thereby the hydrology in the Quaternary deposits and the surface water hydrology. (BIO 1.10+BIO 1.11)	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The amount of water in Quaternary deposits could be determined by water in the geosphere if the biosphere freezes sporadically (see BIO 1.10). Precipitation and hydrology in Quaternary deposits is of more importance for surface water conditions under temperate conditions (see BIO 1.11)	2
GEO 11.17c Biomass flow	Transport of biomass from the geosphere will affect the type and amount of biomass in the biosphere.	Priority: Unchanged Comment: Negligible contribution.	1
GEO 11.17d Contaminant transport	Transport of radionuclides and toxicants from the geosphere will affect the type and amount of radionuclides and toxicants in the biosphere. (BIO 1.15)	Priority: Unchanged	3
GEO 11.18a Mass exchange	The magnitude and direction of groundwater flow in the geosphere will affect the exchange of groundwater components between the geosphere in the disposal system and the geosphere in the external system and thereby the water composition in the external system.	Priority: Unchanged Comment: By definition this interaction is of no interest in the present analysis.	1
GEO 11.18b Discharge/ recharge and pressure	Hydraulic situation in the geosphere affects recharge/ discharge of water from/to the external system and thereby the hydraulic situation in the external system.	Priority: Unchanged Comment: By definition this interaction is of no interest in the present analysis.	1
GEO 11.18c Biomass exchange	The magnitude and direction of groundwater flow in the geosphere will affect the exchange of biomass between the geosphere in the disposal system and the geosphere in the external system and thereby the type ad amount of biomass in the external system.	Priority: Unchanged Comment: By definition this interaction is of no interest in the present analysis.	1
GEO 12.1 Gas transport	Gas transport in the tunnels and repository rock will influence the amount and composition of gas in the silo. (REP 17.12, REP 18.12)	Priority: Unchanged Comment: The gas transport capacity in rock and tunnels is sufficient and does not influence the amount and composition of gas in the silo.	1
GEO 12.2 Gas transport	Gas transport in the tunnels and repository rock will influence the amount and composition of gas in the BMA. (REP 17.12, REP 18.12)	Priority: Unchanged Comment: The gas transport capacity in rock and tunnels is sufficient and does not influence the amount and composition of gas in the BMA.	1
GEO 12.3 Gas transport	Gas transport in the tunnels and repository rock will influence the amount and composition of gas in the BTF. (REP 17.12, REP 18.12)	Priority: Unchanged Comment: The gas transport capacity in rock and tunnels is sufficient and does not influence the amount and composition of gas in the BTF.	1
GEO 12.4 Gas transport	Gas transport in the tunnels and repository rock will influence the amount and composition of gas in the BLA. (REP 17.12, REP 18.12)	Priority: Unchanged Comment: The gas transport capacity in rock and tunnels is sufficient and does not influence the amount and composition of gas in the BLA.	1
GEO 12.5 None	No direct influence between gas and solid phase identified. Interacts via other diagonal elements in the matrix, e.g. chemical interactions go via 10.10 Groundwater composition and mechanical via 14.14 Stress conditions.	Priority: Unchanged	0

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 12.6 None	No direct influence between gas and solid phase identified. Interacts via other diagonal elements in the matrix, e.g. chemical interactions go via 10.10 Groundwater composition and mechanical via 14.14 Stress conditions.	Priority: Unchanged	0
GEO 12.7 None	No direct influence between gas and solid phase identified. Interacts via other diagonal elements in the matrix, e.g. chemical interactions go via 10.10 Groundwater composition and mechanical via 14.14 Stress conditions.	Priority: Unchanged	0
GEO 12.8 None	No direct influence between gas and solid phase identified. Interacts via other diagonal elements in the matrix, e.g. chemical interactions go via 10.10 Groundwater composition and mechanical via 14.14 Stress conditions.	Priority: Unchanged	0
GEO 12.9 None	No direct influence between gas and solid phase identified. Interacts via other diagonal elements in the matrix, e.g. chemical interactions go via 10.10 Groundwater composition and mechanical via 14.14 Stress conditions.	Priority: Unchanged	0
GEO 12.10a Gas dissolution/ degassing	The water composition, e.g. concentration of dissolved species and amount and composition of dissolved gas, will be affected by the amount and composition of gas in gas phase in the different parts of the geosphere system via gas dissolution or degassing.	Priority: Unchanged	3
GEO 12.10b Colloid transport	Transport of colloids attached to the surface of gas bubbles could affect the amount of colloids in different parts of the geosphere system.	Priority: Unchanged	2
GEO 12.11a Saturation	The gas pressure in the different components affects the saturation process and thereby the degree of saturation in the tunnels, plugs and repository rock.	Priority: Unchanged	4
GEO 12.11b Two phase flow	The gas pressure, gas flow and saturation degree in the different components of the geosphere system will affect the magnitude, direction and distribution of water flow in the geosphere system components.	Priority: Unchanged Comment: Minor influence due to small amounts of gas.	1
GEO 12.12 Gas	Gas and movement of gas in tunnels, plugs, investigation boreholes and in the matrix and fractures in rock. Naturally occurring radionuclides in gaseous phase are also included here.		
GEO 12.13a Heat advection	The magnitude, direction and distribution of gas flow in different parts of the geosphere system may affect the heat transport by advection and thus the temperature in the different parts of the geosphere system.	Priority: Unchanged Comment: Gas flow is of negligible importance to the heat advection compared to heat conduction in the rock.	1
GEO 12.13b Heat conduction	The degree of saturation in different parts of the geosphere system affects the heat transport by conduction and thus the temperature in the different parts of the geosphere system.	Priority: Unchanged Comment: Gas content is of negligible importance to the heat conduction properties.	1
GEO 12.14 Gas pressure interaction	The gas pressure in the different parts of the geosphere system affects the stress conditions in the geosphere system components.	Priority: Unchanged Comment: The gas transport capacity is sufficient and no gas pressure will build up.	1
GEO 12.15a Biological activity	The amount and composition of gas in the different parts of the geosphere system may affect the survival and activity of organisms in the different parts of the geosphere system.	Priority: Unchanged	3
GEO 12.15b Advection-gas	Transport of organisms by gas flowing in the different parts of the geosphere system may affect the type and amount of organisms in different parts of the geosphere system.	Priority: Unchanged Comment: Negligible compared to advection	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 12.16a Advection-gas	The magnitude, direction and distribution of gas flow in different parts of the geosphere system will affect the transport of radionuclides and toxicants in gas phase and thereby the amount of radionuclides and toxicants in gas phase in different parts of the geosphere system.	Priority: Unchanged	3
GEO 12.16b Colloid transport	Transport of colloids attached to the surface of gas bubbles could affect the concentration of radionuclides and toxicants in the water in different parts of the geosphere system if the colloids act as carriers for the radionuclides and toxicants.	Priority: Unchanged	2
GEO 12.17 Gas transport	Transport and release of gas from the geosphere will influence the amount and composition of gas in the biosphere. (BIO 1.13)	Priority: Unchanged	3
GEO 12.18 Gas exchange	Exchange of gas between the geosphere in the disposal system and the geosphere in the system outside the disposal system (external system).	Priority: Unchanged Comment: By definition this interaction is of no interest in the present analysis.	1
GEO 13.1 Heat transport	Heat transport in the tunnels and repository rock will affect the temperature in the silo. (REP 17.13, REP 18.13)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Heat transport properties of the rock will affect the temperature and permafrost depth. Heat transport in the tunnels is judged to be negligible.	3
GEO 13.2 Heat transport	Heat transport in the tunnels and repository rock will affect the temperature in the BMA. (REP 17.13, REP 18.13)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Heat transport properties of the rock will affect the temperature and permafrost depth. Heat transport in the tunnels is judged to be negligible.	3
GEO 13.3 Heat transport	Heat transport in the tunnels and repository rock will affect the temperature in the BTF. (REP 17.13, REP 18.13)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Heat transport properties of the rock will affect the temperature and permafrost depth. Heat transport in the tunnels is judged to be negligible.	3
GEO 13.4 Heat transport	Heat transport in the tunnels and repository rock will affect the temperature in the BLA. (REP 17.13, REP 18.13)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Heat transport properties of the rock will affect the temperature and permafrost depth. Heat transport in the tunnels is judged to be negligible.	3
GEO 13.5a Kinetics and equilibria	The temperature in the tunnels and investigation boreholes will affect the kinetics and equilibria of dissolution and precipitation reactions and thereby the amount and composition of the materials in the tunnels and boreholes.	Priority: Unchanged Comment: Diminishing of backfill material through dissolution is slower at lower temperatures.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 13.5b Expansion/ contraction	Changes in temperature may cause thermal expansion/contraction of the materials in the tunnels and in the boreholes thereby affecting the dimensions and geometries of these materials.	Priority: Unchanged Comment: Too small temperature gradients.	1
GEO 13.6a Kinetics and equilibria	The temperature in the plugs will affect the kinetics and equilibria of dissolution and precipitation reactions and thereby the amount and composition of the materials in the plugs as well as the porosity of the plugs.	Priority: Unchanged Comment: Diminishing of plug material through dissolution is slower at lower temperatures.	1
GEO 13.6b Expansion/ contraction	Changes in temperature may cause thermal expansion/contraction of the materials in the plugs thereby affecting the dimensions and geometries of these materials.	Priority: Unchanged Comment: Too small temperature gradients.	1
GEO 13.7a Kinetics and equilibria	The temperature in the repository rock will affect the kinetics and equilibria of dissolution and precipitation reactions and thereby the mineralogy and porosity of the matrix of the repository rock.	Priority: Unchanged Comment: Diminishing of rock matrix through dissolution is slower at lower temperatures.	1
GEO 13.7b Expansion/ contraction	Changes in temperature may cause thermal expansion/contraction of the rock minerals thereby affecting the porosity of the rock matrix in the repository rock.	Priority: Unchanged Comment: Too small temperature changes to affect the rock.	1
GEO 13.8a Kinetics and equilibria	The temperature in the repository rock will affect the kinetics and equilibria of dissolution and precipitation reactions and thereby the mineralogy and porosity of the fracture coatings and the aperture and connectivity of fractures in the repository rock.	Priority: Unchanged Comment: Changes in temperature by a few degrees may cause fracture coatings to precipitate or dissolve. Co-precipitation of radionuclides and toxicants handled in GEO 13.16.	1
GEO 13.8b Expansion/ contraction	Changes in temperature may cause thermal expansion/contraction of the rock minerals thereby affecting the apertures of the fractures in the repository rock.	Priority: Unchanged Comment: Too small temperature changes to affect the rock.	1
GEO 13.9a Kinetics and equilibria	The temperature in the rock outside the repository area will affect the kinetics and equilibria of dissolution and precipitation reactions and thereby the mineralogy and porosity of the rock matrix and fracture coatings and the aperture and connectivity of fractures in the rock.	Priority: Unchanged Comment: Changes in temperature by a few degrees may cause fracture coatings to precipitate or dissolve. Co-precipitation of radionuclides and toxicants handled in GEO 13.16.	1
GEO 13.9b Expansion/ contraction	Changes in temperature may cause thermal expansion/contraction of the rock minerals thereby affecting the porosity of the rock matrix and the apertures of the fractures in the rock outside the repository area.	Priority: Unchanged Comment: Too small temperature changes to affect the rock.	1
GEO 13.10a Kinetics and equilibria	The temperature in the tunnels, plugs, repository rock and rock outside the repository area will affect the kinetics and equilibria of chemical reactions and gas solubilities and thereby the composition of the water in the tunnels, plugs, repository rock and rock outside the repository area.	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Changes in temperature may cause precipitation, dissolution, changed reaction rates, and changes in speciation.	2
GEO 13.10b Property changes	The temperature in the tunnels, plugs, repository rock and rock outside the repository area will affect the density and viscosity of the water in the tunnels, plugs, repository rock and rock outside the repository area.	Priority: Unchanged Comment: Due to temperature difference viscosity is affected less than a factor of two. Density is affected even less. Freezing of water is considered in FEP 13.11.	1
GEO 13.10c Diffusion	The temperature in the different components of the geosphere system will affect the rate of diffusion of dissolved species and thereby the water composition in the different components of the geosphere system.	Priority: Unchanged Comment: Temperature difference too small.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 13.11 Phase changes	The temperature in the different components of the geosphere system affects the water pressure in the components. Extreme changes in temperature will lead to phase changes like freezing or evaporation. These extreme changes will affect both the water pressure and the amount of water.	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Phase change in the form of freezing due to permafrost and glaciation must be considered. In SAR-08 temperatures causing freezing are not considered as extreme.	3
GEO 13.12a Expansion/ contraction	The temperature in the different components of the geosphere system will affect the volume and pressure of gas in the system components.	Priority: Unchanged Comment: In general low temperature will prevent gas formation. Existing gas volume will contract or expand perhaps 10%.	1
GEO 13.12b Convection	The temperature in the different components of the geosphere system will affect the density of the gas and thus the magnitude, directions and distribution of gas flow in the different components of the geosphere system.	Priority: Unchanged Comment: Temperature difference too small.	1
GEO 13.13 Temperature	Temperature in plugs, tunnels, investigation boreholes, rock and fracture systems.		
GEO 13.14 Thermal stress interaction	Changes in temperature in the different components of the geosphere system will affect the stress conditions in components that cannot expand in volume. For components where volume expansion can take place, effects of temperature on stress conditions are considered via volume changes, e.g. by interactions 13.5b–13.9b and 5.14–9.14. Effects of temperature on water flow and thereby on stress go via 13.11 and 11.14.	Priority: Unchanged Comment: Too small temperature changes except for the upper few meters, where unimportant increase in stress may occur. Phase changes are considered through FEP 13.11.	1
GEO 13.15 Microbial activity	The temperaure in the different parts of the geosphere system will affect the microbial activity and thereby the type and amount of microbes and bacteria in the different geosphere system components.	Priority: Unchanged Comment: The effect on repository safety from changes in microbial activity induced by temperature changes is insignificant.	1
GEO 13.16a Kinetics and equilibria	The temperature in the different components of the geosphere system will affect the kinetics and equilibria of sorption and dissolution/precipitation reactions and thereby the distribution between mobile and immobile radionuclides and toxicants in the different components of the geosphere system.	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Changes in temperature by a few degrees may cause fracture coatings to precipitate or dissolve. Radionuclides and toxicants may co-precipitate.	2
GEO 13.16b Diffusion	The temperature in the different components of the geosphere system will affect the rate of diffusion of dissolved species and thereby the concentration of radionuclides and toxicants in the water in the different components of the geosphere system.	Priority: Unchanged Comment: Too small differences in temperature are expected. Frozen conditions are not regarded in this FEP.	1
GEO 13.16c Soret effect	Temperature gradients in the different components of the geosphere system may cause diffusion of dissolved species by the Soret mechanism and thereby affect the concentration of radionuclides and toxicants in the water in the different components of the geosphere system.	Priority: Unchanged Comment: Too small temperature changes during the temperate period to affect the mass transfer.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 13.17 Heat transport	The heat exchange between geosphere and biosphere will affect the temperature in the biosphere. (BIO 1.14)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Surface temperature determines mainly the temperature in Quaternary deposits and surface waters. Is of importance during permafrost conditions. (see BIO 1.14)	3
GEO 13.18 Heat exchange	The heat exchange between the geosphere in the disposal system and the geosphere in the external system will affect the temperature in the external system.	Priority: Unchanged Comment: By definition this interaction is of no interest in the present analysis. The geosphere domain considered has been chosen so as to make this effect negligible.	1
GEO 14.1a Stress and strain changes	Changes in stress and strain at the boundary between the tunnels or repository rock and the silo affects the stress conditions in the silo. (REP 17.14, REP 18.14)	Priority: Changed from 2 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Stress and strain changes are expected due to redistribution due to ice loading	3
GEO 14.1b Rock fallout	Changes in stress conditions in the repository rock may cause rock fallout that affects the dimensions, geometry and homogeneity of the backfill in the silo. (REP 18.9)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Longer time frames and stress redistribution due to ice loading increase the risk of rock fallout.	3
GEO 14.1c Rock creep	Changes in stress conditions in the repository rock may cause rock creep that may affect the geometry, homogeneity, density etc of the bentonite barriers in the Silo. (REP 18.8)	Priority: Unchanged Comment: Not a large-scale process at considered time scales.	1
GEO 14.2a Stress and strain changes	Changes in stress and strain at the boundary between the tunnels or repository rock and the BMA affects the stress conditions in the BMA. (REP 17.14, REP 18.14)	Priority: Changed from 2 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Stress and strain changes are expected as a result of redistribution due to ice loading	3
GEO 14.2b Rock fallout	Changes in stress conditions in the repository rock may cause rock fallout that affects the dimensions and geometry of the vault and backfill and concrete structures as well as homogeneity of the backfill and pore and fracture characteristics of the structures in the BMA. (REP 18.7, REP 18.9)	Priority: Changed from 2 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Longer time frames and stress redistribution due to ice loading increase the risk of rock fallout.	3
GEO 14.2c Rock creep	Changes in stress conditions in the repository rock may cause rock creep that affects the dimensions and geometry of the BMA vault and the homogeneity of the backfill in the BMA. (REP 18.9)	Priority: Unchanged Comment: Not a large-scale process at considered time scales.	1
GEO 14.3a Stress and strain changes	Changes in stress and strain at the boundary between the tunnels or repository rock and the BTF affects the stress conditions in the BTF. (REP 17.14, REP 18.14)	Priority: Changed from 2 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Stress and strain changes are expected as a result of redistribution due to ice loading	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 14.3b Rock fallout	Changes in stress conditions in the repository rock may cause rock fallout that affects the vault dimensions as well as dimensions, geometry and properties of backfill and concrete structures in the BTF. (REP 18.7, REP 18.9)	Priority: Changed from 2 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Longer time frames and stress redistribution due to ice loading increase the risk of rock fallout.	3
GEO 14.3c Rock creep	Changes in stress conditions in the repository rock may cause rock creep that affects the dimensions and geometry of the BTF vaults and homogeneity of any backfill in the BTF. (REP 18.9)	Priority: Unchanged Comment: Not a large-scale process at considered time scales.	1
GEO 14.4a Stress and strain changes	Changes in stress and strain at the boundary between the tunnels or repository rock and the BLA affects the stress conditions in the BLA. (REP 17.14, REP 18.14)	Priority: Unchanged Comment: No backfill in BLA.	1
GEO 14.4b Rock fallout	Changes in stress conditions in the repository rock may cause rock fallout that affects the dimensions and geometry of the BLA vault and damages the waste containers in BLA. (REP 18.9, REP 18.5)	Priority: Unchanged Comment: The containers are not considered as a barrier.	1
GEO 14.4c Rock creep	Changes in stress conditions in the repository rock may cause rock creep that affects the dimensions and geometry of the BLA vault. (REP 18.9)	Priority: Unchanged Comment: Not a large-scale process at considered time scales.	1
GEO 14.5a Stress redistribution, backfill	Redistribution of stress inside the tunnel and borehole backfill may change the geometry and porosity and homogeneity of the backfill.	Priority: Unchanged Comment: Little relevance of mechanical changes on backfill.	1
GEO 14.5b Rock fallout	Changes in stress conditions in the repository rock may cause rock fall out that affects the dimensions, geometry and distribution of the tunnel backfill.	Priority: Unchanged Comment: Will not change the relative permeability in the tunnels, which already have high permeability.	1
GEO 14.5c Rock creep	Rock creep due to stress changes in the repository rock may change the geometry of the tunnel and the backfill. Rock creep may also change the geometry of the investigation boreholes and backfill in boreholes.	Priority: Unchanged Comment: Not a large-scale process at considered time scales.	1
GEO 14.6a Cracking	Cracking/damaging of the concrete in plugs caused by the swelling pressure of the bentonite in the plugs.	Priority: Unchanged Comment: Includes stress induces damage both on concrete and bentonite plugs. Includes stress induced by freezing.	3
GEO 14.6b Rock creep	Rock creep due to stress changes in the repository rock may change the dimensions and pore and fracture characteristics of the plugs.	Priority: Unchanged Comment: Not a large-scale process at considered time scales.	1
GEO 14.7 Stress redistribution	Redistribution of stress in the repository rock may change the porosity of the rock matrix.	Priority: Unchanged	2
GEO 14.8 Stress redistribution	Redistribution of the stress in the repository rock may change the fracture frequency, apertures and the location of fractures in the repository rock.	Priority: Changed from 2 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Stress redistribution due to ice loading must be considered in safety assessment.	3
GEO 14.9 Stress redistribution	Redistribution of the stress in the rock may change the porosity of the rock matrix and the fracture frequency, apertures and the location of fractures in the rock outside the repository area.	Priority: Changed from 2 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Stress redistribution due to ice loading must be considered in safety assessment.	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 14.10 None	Effects of stress on water composition goes via 14.11 and 11.10b.	Priority: Unchanged	0
GEO 14.11 Water pressure interaction	The stress conditions in the different components of the geosphere system affects the porewater pressure in the system components.	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Includes water pressure effects on freezing point that may affect water aggregation state.	2
GEO 14.12 None	Effects of stress on gas goes via 14.11 and 11.12.	Priority: Unchanged	0
GEO 14.13 None	No direct influence identified.	Priority: Unchanged	0
GEO 14.14 Stress conditions	Stress and strain in tunnels, plugs, investigation boreholes, rock and fracture systems.	Comment: Includes stress and strain due to freezing.	
GEO 14.15 None	No direct influence identified.	Priority: Unchanged	0
GEO 14.16 None	No direct influence identified.	Priority: Unchanged	0
GEO 14.17 Changes in rock surface location	Repository induced changes in rock surface location (eg collapse of caverns). The initiating event is eg cavern collapse that affects the stress conditions in the surrounding rock. These changes in stress may result in cave in of surrounding rock (subsidence). (BIO 1.9b)	Priority: Unchanged Comment: The thickness of Quaternary deposits is between 4–14 m /Sigurdsson 1987/. If caverns collapse or neotektonics occur the impact has to be in the order of several meters to influence the surface location. Therefore other processes affecting relocation of Quaternary deposits are more important for the topography (see BIO 1.9b).	1
GEO 14.18 Stress and strain changes	Changes in stress and strain at the boundary between the rock in the disposal system and the external system affects the stress conditions in the external system.	Priority: Unchanged Comment: By definition this interaction is of no interest in the present analysis. The geosphere domain considered has been chosen so as to make this effect negligible.	1
GEO 15.1 Biomass flow	Growth and/or transport of biomass from the tunnels and the repository rock into the silo will affect the biological state in the silo. Root penetration and potential intrusion is judged to not propagate further into the repository. (REP 17.15, REP 18.15)	Priority: Unchanged	2
GEO 15.2 Biomass flow	Growth and/or transport of biomass from the tunnels and the repository rock into the BMA will affect the biological state in the BMA. Root penetration and potential intrusion is judged to not propagate further into the repository. (REP 17.15, REP 18.15)	Priority: Unchanged	2
GEO 15.3 Biomass flow	Growth and/or transport of biomass from the tunnels and the repository rock into the BTF will affect the biological state in the BTF. Root penetration and potential intrusion is judged to not propagate further into the repository. (REP 17.15, REP 18.15)	Priority: Unchanged	2
GEO 15.4 Biomass flow	Growth and/or transport of biomass from the tunnels and the repository rock into the BLA will affect the biological state in the BLA. Root penetration and potential intrusion is judged to not propagate further into the repository. (REP 17.15, REP 18.15)	Priority: Unchanged	2

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 15.5 Microbial growth	Microbes that consume components of the backfill and shotcrete in tunnels, can by this process affect the composition and porosity of the materials. Microbes may also affect the amount of surfaces of the materials that are accessible to chemical reactions such as dissolution and sorption and they may also affect the porosity of the materials by clogging. Includes the same effects in the backfill in boreholes.	Priority: Unchanged	2
GEO 15.6 Microbial growth	Microbes that consume components of the plugs, e.g.sulphate, can by this process affect the composition and porosity of the plugs. Microbes may also affect the amount of surfaces of the materials that are accessible to chemical reactions such as dissolution and sorption and they may also affect the porosity of the materials by clogging.	Priority: Unchanged	2
GEO 15.7 Microbial growth	Microbial growth on repository rock surfaces may change the chemical properties of these surfaces thereby affecting chemical processes like mineral dissolution and sorption. The microbes may also cause clogging of pores.	Priority: Unchanged	2
GEO 15.8 Microbial growth	Microbial growth in the repository rock fracture system may affect the amount of surfaces that are accessible to chemical reactions such as dissolution and sorption. They may also affect the apertures and connectivity of fractures by clogging.	Priority: Unchanged	2
GEO 15.9 Microbial growth	Microbial growth in the rock will preferable take place in the fracture system and may change the chemical properties of the fracture surfaces thereby affecting chemical processes like mineral dissolution and sorption. They may also affect the porosity of the fracture system by clogging.	Priority: Unchanged	2
GEO 15.10 Microbial activity	The type and amount of microbes/bacteria will by their presence and growth affect the water composition in the different components of the geosphere system. Some examples are: production of dissolved CO_2 and CH_4 and organic complexing agents by degradation of organic materials, influence on pH by production of organic acids, generation of sulphide from sulphate and consumption of oxygen which affects the concentration of these species and the redox potential, consumption of hydrogen.	Priority: Unchanged	3
GEO 15.11 None	No direct influence identified. Interactions goes via 15.5 to 15.9 and via 5.11 to 9.11.	Priority: Unchanged	0
GEO 15.12 Microbial activity	The type and amount of microbes/bacteria will affect the amount and composition of gas in the different components of the geosphere system via gas formation and consumption.	Priority: Unchanged	3
GEO 15.13 Microbial activity	The type and amounts of microbes in the different parts of the geosphere system will, due to their presence and activity, generate heat. This may affect the temperature in the different parts of the repository system.	Priority: Unchanged Comment: Small amount of heat generated due to expected low activity and together with effective heat transport the effect on temperature is expected to be negligible.	1
GEO 15.14 None	No direct influence identified.	Priority: Unchanged	0
GEO 15.15 Biological state	The biological state of plugs, tunnels, investigation boreholes, rock and fracture systems		
GEO 15.16a Microbial transport	Type and amount and mobility of microbes/bacteria may affect the transport of radionuclides and toxicants by acting as carrier for these.	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 15.16b Methylation/ transformation	Microbes may change the chemical form of radionuclides and toxicants, e.g. methylation of metals and transformation of inorganic carbon (dissolved CO3) to organic carbon. Such transformations will change the migration properties, e.g. sorptivity, of metal species and carbon and thus also affect the distribution between immobile and mobile forms of these elements.	Priority: Unchanged	2
GEO 15.17 Biomass exchange	Exchange of biomass between the rock in the disposal system and the biosphere will affect the type and amount of biomass in the biosphere.	Priority: Unchanged Comment: Negligible contribution.	1
GEO 15.18 Biomass exchange	Exchange of biomass between the rock in the disposal system and the external system will affect the biological state in the external system.	Priority: Unchanged Comment: By definition this interaction is of no interest in the present analysis. The geosphere domain considered has been chosen so as to make this effect negligible.	1
GEO 16.1 Contaminant transport	Transport of radionuclides and toxicants in water and gas phase from the tunnels and repository rock into the silo will affect the amount of these in the silo. The origin of these contaminants may be the waste and barrier materials in the other repository parts and contaminated water, gas and solids in the biosphere. (REP 17.16, REP 18.16)	Priority: Unchanged Comment: It is a positive effect if the radionuclides and toxicants return to repository (the expected transport pathways are treated elsewhere).	1
GEO 16.2 Contaminant transport	Transport of radionuclides and toxicants in water and gas phase from the tunnels and repository rock into the BMA will affect the amount of these in the BMA. The origin of these contaminants may be the waste and barrier materials in the other repository parts and contaminated water, gas and solids in the biosphere. (REP 17.16, REP 18.16)	Priority: Unchanged Comment: It is a positive effect if the radionuclides and toxicants return to repository (the expected transport pathways are treated elsewhere).	1
GEO 16.3 Contaminant transport	Transport of radionuclides and toxicants in water and gas phase from the tunnels and repository rock into the BTF will affect the amount of these in the BTF. The origin of these contaminants may be the waste and barrier materials in the other repository parts and contaminated water, gas and solids in the biosphere. (REP 17.16, REP 18.16)	Priority: Unchanged Comment: It is a positive effect if the radionuclides and toxicants return to repository (the expected transport pathways are treated elsewhere).	1
GEO 16.4 Contaminant transport	Transport of radionuclides and toxicants in water and gas phase from the tunnels and repository rock into the BLA will affect the amount of these in the BLA. The origin of these contaminants may be the waste and barrier materials in the other repository parts and contaminated water, gas and solids in the biosphere. (REP 17.16, REP 18.16)	Priority: Unchanged Comment: It is a positive effect if the radionuclides and toxicants return to repository (the expected transport pathways are treated elsewhere).	1
GEO 16.5 Irradiation	Irradiation by decaying radionuclides affecting the chemical and physical properties of the backfill in tunnels and boreholes.	Priority: Unchanged Comment: No influence on tunnel backfill geometry and mineralogy because of small amounts of radionuclides.	1
GEO 16.6 Irradiation	Irradiation by decaying radionuclides affecting the chemical and physical properties of the plugs.	Priority: Unchanged Comment: No influence on plug geometry and mineralogy because of small amounts of radionuclides.	1
GEO 16.7 Irradiation	Irradiation by decaying radionuclides affecting the chemical and physical properties of the rock matrix in the repository rock.	Priority: Unchanged Comment: No influence on “Repository rock – rock matrix” geometry and mineralogy because of small amounts of radionuclides.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 16.8a Irradiation	Irradiation by decaying radionuclides affecting the chemical and physical properties of the fractures in the repository rock.	Priority: Unchanged Comment: No influence on “Repository rock – fracture system” geometry and mineralogy because of small amounts of radionuclides.	1
GEO 16.8b Precipitation	Precipitation of RN and toxicants in fractures affecting fracture properties.	Priority: Unchanged Comment: Small amounts compared to other potential sources for precipitation	1
GEO 16.9 Irradiation	Irradiation by decaying radionuclides affecting the chemical and physical properties of the fractures and rock matrix in the rock outside the repository.	Priority: Unchanged Comment: No influence on “Rock – rock matrix and fracture system” geometry and mineralogy because of small amounts of radionuclides and toxicants.	1
GEO 16.10a Radiolysis	The type and amount of radionuclides may affect the water composition via radiolysis.	Priority: Unchanged Comment: Low concentration of radionuclides. Negligible effects.	1
GEO 16.10b Radionuclide decay	Decay of radionuclides to stable isotopes that affect the water composition in the different components of the geosphere system.	Priority: Unchanged Comment: Low concentration of radionuclides. Negligible effects.	1
GEO 16.10c Degradation	Degradation of toxicants from the repository that affects the water composition in the different components of the geosphere system.	Priority: Unchanged Comment: No effects on large scale water chemistry.	1
GEO 16.11 None	No direct influence identified.	Priority: Unchanged	0
GEO 16.12a Radiolysis	The type and amount of radionuclides affects the extent of radiolysis and thus the amounts of gas formed and the composition of the gas. (e.g. type of decay and energi levels)	Priority: Unchanged Comment: Low concentration of radionuclides. Negligible effects.	1
GEO 16.12b Degradation	The type and amount of organic toxicants from the repository affects the amount and composition of gas via degradation processes.	Priority: Unchanged Comment: Small amounts of organic toxicants from the repository. Negligible effects.	1
GEO 16.13 Heat from decay	Decay of radionuclides may generate heat and affect the temperature in different parts of the geosphere system.	Priority: Unchanged Comment: Low concentration of radionuclides. Negligible effects.	1
GEO 16.14 None	No direct influence identified.	Priority: Unchanged	0
GEO 16.15 Irradiation (mutation)	Effects on the biological state of irradiation by decaying radionuclides (mutation).	Priority: Unchanged Comment: The amount of radionuclides and toxicants that originates from the repository is assesed to be too low to have any effect on the biological state in the geosphere.	1
GEO 16.16 Radionuclides and toxicants	Radionuclides and toxicants, originating from the repository, in solid, aqueous and gas phase in plugs, tunnels, investigation boreholes, rock and fracture systems.		
GEO 16.16 Radionuclide decay	Radioactive decay will affect the type and amount of radionuclides at different locations in the geosphere system. Decay may also affect the amount of radionuclides in gas phase, e.g. formation of Rn via decay.	Priority: Unchanged	3
GEO 16.17 Contaminant transport	The transport and release of radionuclides and toxicants in water and gas phase from the geosphere affects the transport of radionuclides in aqueous and gaseous form in the biospere. (BIO 1.15)	Priority: Unchanged	3

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 16.18 None	All radionuclides and toxicants from SFR should by definition belong to the disposal system.	Priority: Unchanged	0
GEO 17.1 None	No direct impact from the biosphere on the silo barriers as long as the silo is covered by rock. One exception could be human intrusion, but this is considered in a separate scenario.	Priority: Unchanged	0
GEO 17.2 None	No direct impact from the biosphere on the BMA barriers as long as the BMA is covered by rock. One exception could be human intrusion, but this is considered in a separate scenario.	Priority: Unchanged	0
GEO 17.3 None	No direct impact from the biosphere on the BTF barriers as long as the BTF is covered by rock. One exception could be human intrusion, but this is considered in a separate scenario.	Priority: Unchanged	0
GEO 17.4 None	No direct impact from the biosphere on the BLA barriers as long as the BLA is covered by rock. One exception could be human intrusion, but this is considered in a separate scenario.	Priority: Unchanged	0
GEO 17.5a Root penetration (Tunnels)	The penetration of roots into the plugged and backfilled access tunnels and investigation boreholes. (BIO 3.1b)	Priority: Unchanged Comment: It is unlikely that roots will penetrate significantly down in the rock. Especially during temperate climate conditions, because water will be available much shallower. But could be possible during arid condition which however not is considered to occur at the Forsmark area.	1
GEO 17.5b Borehole penetration Not defined in SAFE		Priority: Set to 3 Description: The penetration of future open boreholes used as water wells, adding to the inventory of boreholes in the geosphere. Comment: Such wells are conceivable.	3
GEO 17.6 Root penetration (Tunnels)	The penetration of roots into the plugged and backfilled access tunnels. (BIO 3.1b)	Priority: Unchanged Comment: It is unlikely that roots will penetrate significantly down in the rock. Especially during temperate climate conditions, because water will be available much shallower. But could be possible during arid condition which however not is considered to occur at the Forsmark area.	1
GEO 17.7 None	No direct influence identified. The repository rock is physically isolated from the biosphere.	Priority: Unchanged	0
GEO 17.8 None	No direct influence identified. The repository rock is physically isolated from the biosphere.	Priority: Unchanged	0
GEO 17.9a Consolidation	The slow transformation of Quaternary deposits to solid rock. The time is important for the extent of consolidation. (BIO 2.1b)	Priority: Unchanged Comment: Too slow processs in the time-scale of interest.	1
GEO 17.9b Root penetration (Rock)	The penetration of roots into fractures in the solid rock. (BIO 3.1a)	Priority: Unchanged Comment: It is unlikely that roots will penetrate significantly down in the rock. Especially during temperate climate conditions, because water will be available much shallower. But could be possible during arid condition which however not is considered to occur at the Forsmark area.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 17.9c Erosion/ weathering	Wind, running water at the surface and the composition of this water will affect the erosion/weathering of rock (outcrops). Moving ice blocks during the winter season and during glacial periods may also cause erosion of rock (outcrops). (BIO 10.1d, BIO 11.1d, BIO 12.1b, BIO 14.1c)	Priority: Unchanged Comment: The erosion and weathering of the rock is assumed too low for this type of rock and time perspective. Erosion of surface rock included in the biosphere matrix.	1
GEO 17.10 Mass flow	The composition and transport of water in Quaternary deposits and surface waters infiltrating the geoshere will influence the composition of the groundwater. (BIO 12.1+BIO 11.1+BIO 10.1)	Priority: Unchanged Comment: Also includes glacial melt water infiltrating from ice sheet.	3
GEO 17.11a Recharge/ discharge and wells	The hydrology in the Quaternary deposits and the surface water hydrology influence the hydrology in the geosphere. Includes also the effects of high demanding wells. (BIO 10.1a+BIO 11.1a)	Priority: Unchanged Comment: Also includes hydraulic condition imposed by the ice sheet.	3
GEO 17.11b Pressure change	The water pressure in the biosphere components will affect the water pressure in the rock. (BIO 10.1b+BIO 11.1b)	Priority: Unchanged Comment: Also includes water pressure imposed by the ice sheet.	3
GEO 17.12 Gas transport	Air intrusion can take place via human activities and can also be a consequence of landrise and climatic changes leading to unsaturated conditions. (BIO 13.1)	Priority: Unchanged Comment: (even for longer timeframe) Influence only the upper few meters. Negligible effect.	1
GEO 17.13 Heat transport	The heat exchange between geosphere and biosphere will affect the temperature in the geosphere. (BIO 14.1a)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The temperature in the biosphere, set by the climate, will affect the temperature in the shallow geosphere. This must be considered as a result of considered climate changes.	3
GEO 17.14a Mechanical load	Changes in mechanical load and thereby stress conditions in the geosphere due to changes in geometry and composition of Quaternary deposits. (BIO 2.1a)	Priority: Unchanged Comment: Normal variations. Negligible effects.	1
GEO 17.14b Ice load	Changes in thickness of the ice sheet due to seasonal variations and during periods of glaciation and deglaciation will affect the mechanical stress in the rock. (BIO 11.1e) (glaciation treated as a scenario)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Ice load effects must be considered due to expected glaciation.	3
GEO 17.15a Root penetration (biological)	The penetration of roots via fractures in the rock and via the plugged and backfilled tunnels (and ventilation shafts??) will affect the biological mass in the geosphere. (BIO 3.1c)	Priority: Unchanged Comment: It is unlikely that roots will penetrate down into the rock. Especially during climates conditions considered here, beacuse water will be available much shallower.	1
GEO 17.15b Intrusion	Potential intrusion of decomposers, filter feeders, herbivores and carnivores through degraded plugs at the surface. BIO 4.1+BIO 5.1+BIO 6.1+BIO 7.1)	Priority: Unchanged Comment: The surface effect is considered in the biosphere matrix. There is no significant effect in the geosphere.	1
GEO 17.15c Biomass exchange	Exchange of biomass between the geosphere and the biosphere by recharging/discharging water will affect the type and amount of microorganisms in the geosphere. (BIO???, BIO 10.1a, BIO 11.1a)	Priority: Unchanged	2

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 17.16 Contaminant transport	The transport of radionuclides and toxicants from the biosphere to the geosphere. The source of these nuclides can be radionuclides released from SFR or radionuclides from other sources. (BIO 15.1, BIO 10.1a, BIO 11.1a)	Priority: Unchanged Comment: Negligible effects.	1
GEO 17.17 Biosphere (B.C.)	Physical and biological components in the biosphere that via interactions can affect and be affected by properties and conditions in the physical components of the geosphere.		
GEO 17.18 None	Of no relevance in this matrix.	Priority: Unchanged	0
GEO 18.1 None	The Silo is physically isolated from the system outside the disposal system. Interactions take place via other diagonal elements in the matrix.	Priority: Unchanged	0
GEO 18.2 None	The BMA is physically isolated from the system outside the disposal system. Interactions take place via other diagonal elements in the matrix.	Priority: Unchanged	0
GEO 18.3 None	The BTF is physically isolated from the system outside the disposal system. Interactions take place via other diagonal elements in the matrix.	Priority: Unchanged	0
GEO 18.4 None	The BLA is physically isolated from the system outside the disposal system. Interactions take place via other diagonal elements in the matrix.	Priority: Unchanged	0
GEO 18.5 None	The tunnels and investigation holes are per definition physically isolated from the system outside the disposal system. Interactions take place via other diagonal elements in the matrix.	Priority: Unchanged	0
GEO 18.6 None	The plugs are physically isolated from the system outside the disposal system. Interactions take place via other diagonal elements in the matrix.	Priority: Unchanged	0
GEO 18.7 None	By definition, the repository rock is physically isolated from the system outside the disposal system. Interactions take place via other diagonal elements in the matrix.	Priority: Unchanged	0
GEO 18.8 None	By definition, the repository rock is physically isolated from the system outside the disposal system. Interactions take place via other diagonal elements in the matrix.	Priority: Unchanged	0
GEO 18.9 None	The rock outside the repository area is by definition in contact with the system outside the disposal system, but no direct effect identified. Interactions take place via other diagonal elements in the matrix in terms of thermal, hydrological, mechanical, chemical and biological influences.	Priority: Unchanged	0
GEO 18.10 Mass exchange	Import and export of groundwater components from or to the system outside the disposal system will affect the composition of water in the geosphere components.	Priority: Unchanged	3
GEO 18.11 Recharge/ discharge and pressure	The magnitude and direction of the groundwater flow in the external system affects the magnitude and direction of groundwater flow in the rock in the geosphere system e.g. density driven flow.	Priority: Unchanged	2
GEO 18.12 Gas exchange	The amount and composition of gas and the magnitude and direction of gas flow in the external system affects the amount, composition, magnitude and direction of gas flow in the rock in the geosphere.	Priority: Unchanged Comment: Judged to be negligible.	1
GEO 18.13 Heat exchange	The exchange of heat between the rock in the geosphere and the external system will affect the temperature in the rock in the geosphere.	Priority: Unchanged Comment: Judged to be negligible.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
GEO 18.14 Stress and strain changes	Changes in stress and strain at the boundary between the rock in the disposal system and the external system affects the stress conditions in the rock in the geosphere.	Priority: Unchanged Comment: Judged to be negligible.	1
GEO 18.15 Biomass exchange	Exchange of biomass between the rock in the disposal system and the external system will affect the biological state in the rock in the geosphere (disposal system).	Priority: Unchanged Comment: Judged to be negligible.	1
GEO 18.16 None	All radionuclides and toxicants from SFR should by definition belong to the disposal system.	Priority: Unchanged	0
GEO 18.17 None	Of no relevance in this matrix.	Priority: Unchanged	0
GEO 18.18 External rock (B.C.)	Rock beneath and around the rock included in the geosphere system.		

Appendix A3

Biosphere interactions with priority examined in SAR-08

Coloured fields indicate new interactions or interactions whose priority is updated in SAR-08 from that in SAFE. The SAR-08 biosphere interaction matrix is displayed in Appendix C. The SAFE descriptions have not been edited in this work.

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 1.2a Erosion/ weathering	Formation of Quaternary deposits and changes in topography by erosion/weathering. (GEO 9.17)	Priority: Unchanged Comment: Erosion of the rock has minor influence on the formation of sediments compared to other sediment formation processes e.g. average erosion rates for soil-materials approximately 0.1 mm/y No effect on topography expected compared to the land rise.	1
BIO 1.2b Changes in rock surface location	Repository induced changes in rock surface location (e.g. collapse of caverns). The initiating event is e.g. cavern collapse that affects the stress conditions in the surrounding rock. These changes in stress may result in cave in of surrounding rock. (GEO 14.17). Other examples could be neotectonic movements.	Priority: Unchanged Comment: The thickness of Quaternary deposits is between 4–14 m /Sigurdsson 1987/. If caverns collapse or neotektonics occur the impact has to be in the order of several meters to influence the surface location. Therefore other processes affecting relocation of Quaternary deposits are more important for the topography.	1
BIO 1.8a Material supply	Mineral resources and supply of water influence the location of human settlements. The sources for supply of water will also have an influence on the use of water e.g. showering and/or bathing.	Priority: Unchanged Comment: In this area there are no mineral resources of importance. Water usage is determined also by the supply and quality of water from other sources such as Quaternary deposits and surface waters. The area will be protected for some hundred years. Human activities caused by the existence of the repository are treated as separate scenarios.	1
BIO 1.8b Settlement – Living and building	Mineral resources and supply of water influence the location of human settlements as well as a stable ground. The sources for supply of water will also have an influence on the use of water e.g. showering and/or bathing.	Priority: Unchanged Comment: In this area there are no resources of importance. Water usage is determined also by the supply and quality of water from other sources such as Quaternary deposits and surface waters. The area will be protected for some hundred years. Human activities caused by the existence of the repository are treated as separate scenarios.	1
BIO 1.10 Discharge/ recharge	The hydrology in the geosphere influences the discharge and recharges of groundwater and thereby the hydrology in the Quaternary deposits. (GEO 11.17b)	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The amount of water in Quaternary deposits could be determined by water in the geosphere if the biosphere freezes sporadically.	2
BIO 1.11 Discharge/ recharge	The hydrology in the geosphere influences the discharge and recharge of groundwater and thereby the surface water hydrology. (GEO 11.17)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Precipitation and hydrology in Quaternary deposits are of more importance for surface water conditions during temperate conditions. During permafrost conditions talik formation can affect surface waters.	3
BIO 1.12 Mass flux	Transport of groundwater components will affect the composition of water in Quaternary deposits and surface waters. (GEO 10.17a+GEO 11.17a)	Priority: Unchanged	2

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 1.14 Heat transport	The heat exchange between geosphere and biosphere will affect the temperature in the biosphere. (GEO 13.17)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The surface temperature determines mainly the temperature in Quaternary deposits and surface waters, and is of importance during permafrost conditions.	3
BIO 2.1a Mechanical load	Changes in mechanical load. (GEO 17.14)	Priority: Unchanged Comment: Normal variations. Negligible effects.	1
BIO 2.1b Consolidation	The slow transformation of Quaternary deposits to solid rock. The time is important for the extent of consolidation. (GEO 17.9)	Priority: Unchanged Comment: Too slow process in the time-scale of interest.	1
BIO 2.3b Deposition in water	Deposition of sediments on e.g. algae and other macrophytes will influence their location. The degree of deposition on primary producers is influenced by the location and the properties of Quaternary deposits. Examples are shading, high sediment load on the primary producers or changes in spore growth.	Priority: Unchanged Comment: In water of limited importance because effects occur locally and the primary producers will recolonisate in a relatively short term. The continuous sediment load on surface of algae is determined by water turnover and particle content in water. Not considered explicitly because it is assumed to be reflected by species composition.	1
BIO 2.3c Deposition on land	Deposition of sediments on e.g. plants and trees will influence their location. The degree of deposition on primary producers is influenced by the location and the properties of Quaternary deposits. Examples are shading or putting high load on the primary producers.	Priority: Unchanged Comment: This effect is of larger importance on land than in water because of the longer times for recolonisation (>1 year). The probability of large relocation is however small. Humans can cause relocation on land e.g. by ploughing. This is assessed for annual plants and more treated as soil turnover and thus not treated in a normal scenario.	1
BIO 2.5b Consumption	Consumption of sediments accidentally with the food or by purpose.	Priority: Unchanged Comment: Filter feeders consume resuspended sediment particles. Thus they are not directly affected by Quaternary deposits, but through water composition.	1
BIO 2.7b Consumption	Consumption of solid material accidentally with the food or by purpose.	Priority: Unchanged Comment: For pure predators the ingestion of soils and sediments probably is negligible compared to the ingestion of prey. For mixed carnivores, decomposers, herbivores this is handled for the other feeding strategies.	1
BIO 2.8b Consumption	Consumption of solid material accidentally with the food or by purpose e.g. children.	Priority: Unchanged Comment: If there are high concentrations of RN the exposure is handled in other pathways e.g. consumption of food.	1
BIO 2.8c Material supply	The Quaternary deposits can be used as construction material (e.g. sand, gravel, stones, clay).	Priority: Unchanged Comment: It is assumed that the external radiation from this material is low since the concentration from the repository is low. Thus it is not regarded in the safety analysis.	1
BIO 2.10b Dehydration	Transformation of crystal water in minerals in Quaternary deposits to "free" water may affect the water content in the Quaternary deposits.	Priority: Unchanged Comment: Under prevailing climate conditions and expected future conditions the water content in the Quaternary are probably more affected by variations in percolation and groundwater level changes.	1
BIO 2.12b Dissolution	The location of and the chemical composition of the Quaternary deposits and the mineralogy of rock surfaces influence the chemical composition of the water.	Priority: Unchanged Comment: This affects the chemistry of fresh water but not brackish water.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 2.12c Sorption/desorption	The composition and grain size distribution (available surfaces for sorption) of the materials in the Quaternary deposits will affect the extent of sorption of dissolved species and particulates and thus the composition of the water in the Quaternary deposits.	Priority: Unchanged Comment: This affects the water chemistry. However, it is assumed that there is an equilibrium already established and that there will be no significant changes.	1
BIO 2.13b Non-biological decomposition	Physical or chemical degradation of Quaternary deposits leading to gas formation, e.g. sun irradiation and fire.	Priority: Unchanged Comment: Peat fire is considered but is judged to have no significant impact on the safety assessment.	1
BIO 2.13c Wind field changes	The topography results in increases and decreases in the wind low and influence thereby the distribution of the wind velocities and directions.	Priority: Unchanged Comment: The wind field is affected by topography, but the process is fast and therefore not relevant in the time-scale of interest in the assessment.	1
BIO 2.13d Air pressure	The topography determines the air pressure at the surface.	Priority: Unchanged Comment: The expected height distribution is too small for this to be of importance.	1
BIO 2.14a Radiation	The reflection properties of the Quaternary deposits and the rock surfaces influence the amount of sunlight absorbed and thereby the temperature. The topography affects the extent of radiation (e.g. the angle for radiation and sheltering effects) and thereby the temperature distribution in the system.	Priority: Unchanged Comment: This is an important process for soil and air temperatures. However, not considered as a process and might be described by temperature statistics or climate postulations.	1
BIO 2.14b Heat transport	The composition and the grain size distribution of the materials in the Quaternary deposits affects the heat transport in Quaternary deposits and thereby the temperature in the different parts of the biosphere system.	Priority: Unchanged Comment: This is an important process for soil temperatures. However, not considered as a process and might be described by temperature statistics and suitable vegetation substrates.	1
BIO 2.14c Heat storage	The density and heat properties determines the amount of heat that can be stored in a volume of Quaternary deposits.	Priority: Unchanged Comment: See BIO 2.14b.	1
BIO 2.15b Dissolution	Dissolution of natural radionuclides and toxicants included in minerals in Quaternary deposits.	Priority: Unchanged Comment: Not important compared to sorption/desorption.	1
BIO 2.16 Export	Transport of Quaternary deposits out from the system.	Priority: Unchanged Comment: The main export is through resuspended matter thus dependent on water/air composition exported during temperate conditions. During glaciation periods the deposits are exported by the ice.	1
BIO 3.1a Root penetration (Rock)	The penetration of roots into fractures in the solid rock. (GEO 17.9)	Priority: Unchanged Comment: It is unlikely that roots will penetrate significantly down in the rock. Especially during temperate climate conditions, because water will be available much shallower. But could be possible during arid condition which however not is considered to occur at the Forsmark area.	1
BIO 3.1b Root penetration (Tunnels)	The penetration of roots into the plugged and backfilled access tunnels. (GEO 17.5+17.6)	Priority: Unchanged Comment: It is unlikely that roots will penetrate 50 m down in the rock to the repository. During temperate climate conditions, because water will be available much shallower. But could be possible during arid condition which however not is considered to occur at the Forsmark area.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 3.1c Root penetration (biological)	The penetration of roots via fractures in the rock and via the plugged and backfilled tunnels will affect the biological mass in the geosphere. (GEO 17.15)	Priority: Unchanged Comment: It is unlikely that roots will penetrate 50 m down in the rock. Especially during climate conditions considered here, because water will be available much shallower (see, 3.1b).	1
BIO 3.2 Root growth	Type and way of growing influence the depth of root penetration and thereby the physical properties of the Quaternary deposits, e.g. porosity Dead primary producers can influence the composition of the Quaternary deposits but this interaction goes via "Decomposers".	Priority: Unchanged Comment: This is important for the Quaternary deposits. However, treated as a description of the soil profile and not as this mechanism.	1
BIO 3.3a Stimulation/ Inhibition	Competition about space and resources and reproduction.	Priority: Unchanged Comment: The composition of primary producers is assumed to be "optimal" for the ecosystem considered. Thus competition is considered to be established and the result is dependent on external factors, a disturbance (e.g. agriculture), or the system is at its natural "climax" (e.g. forest). This is then identified through the composition of species registered by surveys /e.g. Kautsky et al. 1999, Jerling et al. 2001/ or assumptions (e.g. cereal crops).	1
BIO 3.4a Stimulation/ Inhibition	Quality as food (+ nutrient, - toxins, -mechanical structure). Can also via temperature and water content affect microclimate.	Priority: Unchanged Comment: This is not treated as a mechanism, but through the description of the ecosystem.	1
BIO 3.5a Stimulation/ Inhibition	Space competition; food shadowing; + -substrate, -toxin, size. Primary producers can stimulate the living conditions for filter feeders by e.g. symbiotic effects and by increasing the surface area available for living. Primary producers can inhibit or restrain the living conditions by e.g. competition of place, shadowing effects, content of toxicants.	Priority: Unchanged Comment: This not treated as a mechanism, but through the description of the ecosystem and correlation between macrophytes and filter feeders.	1
BIO 3.5b Food supply	Amount of plankton algae and spores. Debris goes via particle content in water composition Type and amount of primary producers affects the type and amount of filter feeders by acting as food supply.	Priority: Unchanged Comment: This is important for the amount of matter in the water and thus treated by influencing the amount of POC, which then affects the food supply for filter feeders.	1
BIO 3.7a Stimulation/ Inhibition	-habitat; -physical barrier; (feeding carnivorous plants).	Priority: Unchanged Comment: The primary producers are important as a habitat structure for other species. But there is no reason to believe that this will change independent from species composition.	1
BIO 3.8a Stimulation/ Inhibition	Species diversity and composition, shelter, beauty, -aufwuchs.	Priority: Unchanged Comment: Humans select places to live which are pretty, easy to maintain or give some shelter or view which can be dependent on the amount of primary producers (e.g. forest). Thus the settlement of humans is not random. In the assessment we assume that humans settle anywhere where it is possible.	1
BIO 3.10 Root uptake	Transpiration driven root uptake of water by plants may affect the water content in the Quaternary deposits. Primary producers living in the water have less influence than primary producers on land. Uptake of water from the air affects the need of water uptake by roots, and could in some cases result in the supply of water through roots.	Priority: Unchanged Comment: In Sweden there is generally an excess of water and groundwater table varies little. At Forsmark area during dry summer condition the groundwater table is strongly effected by evapotranspiration /Johansson et al. 2005/.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 3.11a Interception	The available surface area of primary producers influence the amount of water from irrigation and precipitation that is retarded on the primary producers and influence thereby the amount of surface waters Remark: The droplets on primary producers are included in the definition of surface waters.	Priority: Unchanged Comment: The interceptions are only interesting when the plants are irrigated, because the source term will be a contaminated water body. This is treated in 11.3. Moreover the effect interception will have on surface water is that more stays on leaves and less on lower places. This delay effect is not considered since the effects on surface water probably are of minor importance.	1
BIO 3.11b Retardation/ Acceleration	The type and amount of primary producers in surface waters influences the movement of water. For example the overgrow of a narrow sound. Remark: Algae in particulate form are included in the water composition, the amount of ages influences the water viscosity.	Priority: Unchanged Comment: This is not considered explicitly. It is assumed that these effects are included in the uncertainty of water exchange and in the dynamics describing this.	1
BIO 3.11c Uptake/Excretion	Uptake of surface water by primary producers via roots and cells affects the amount and movement of surface waters. For example water hyacinths take water directly from surface waters.	Priority: Unchanged Comment: Surface waters are not significantly affected by plant taking water of the reservoir. This path goes through water in Quaternary deposits.	1
BIO 3.11d Covering	The amount of primary producers covering the contact area between surface waters and the atmosphere determines the amount of water that can evaporate and thereby the amount of surface waters.	Priority: Unchanged Comment: This is not addressed explicitly. It is assumed to be included in the measurements or statistics of runoff.	1
BIO 3.12b Particle production and trapping	The existence of primary producers in the surface waters is a source for particle production. The type and amount of primary producers will thus influence the water composition. Particle trapping compare 3.13.	Priority: Unchanged Comment: The particle production and trapping by primary producers are not explicitly treated in the assessment. It is assumed that this is included in the estimates of sedimentation rates. For the turbidity and particle content in water the measured values are used instead.	1
BIO 3.13a Gas uptake and release	Primary producers will by their respiration (uptake of CO_2, H_2O gas and N_2 and the release of O_2) influence the amount of gas and the gas composition. Here is also included the root uptake in the unsaturated zone.	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The gas is affected by primary producers, but due to the high exchanges of gas there are small concentration gradients. This is considered for ^{14}C in terrestrial ecosystems.	2
BIO 3.13b Particle trapping and production	Primary producers may affect the amount of particles in the gas, e.g. by the deposition of particles on leaves and pine needles, and by the release of pollen.	Priority: Unchanged Comment: The effect on gas of dust collection is more dependent on wind direction and strength than on the mechanical obstruction of e.g. vegetation.	1
BIO 3.13c Wind retardation	The type, amount and location of primary producers determine the degree of sheltering and influence thereby wind directions and velocities.	Priority: Unchanged Comment: The turbulence and changing wind direction is assumed to be more variable than the physical obstruction of vegetation.	1
BIO 3.14a Radiation	The type, amount and location of primary producers determine the degree of sheltering, absorption and reflection (albedo) of radiation and influence thereby the temperature in the biosphere.	Priority: Unchanged Comment: Due to the variation of albedo and absorption of vegetation it is assumed that the air temperature as well as wind is the mean of a larger area. In soil the temperature is affected by different vegetation. There is no obvious way how this might affect radionuclide turnover significantly.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 3.14b Exothermic/ Endothermic reactions	Biotic processes (e.g. photosynthesis) and abiotic processes (e.g. fires) influence the temperature in the biosphere.	Priority: Unchanged Comment: The metabolic heat of vegetation is limited compared to the heat generated due to absorption (95% of the energy) and thus disregarded. Forest fires are only occasional and the effects on temperature are negligible under long-term conditions.	1
BIO 3.14c Heat transport	Vegetation can work as an efficient insulator between atmosphere and underlying soil or water.	Priority: Unchanged Comment: It is not treated explicitly since there is a high variation in air temperature and slope is also affecting e.g. soil temperature.	1
BIO 3.15c Degradation	Degradation of toxicants by primary producers affects the type and concentration of toxicants in the different parts of the biosphere system.	Priority: Unchanged Comment: Only important for toxicants. Not considering this for toxicants is a conservative approach.	1
BIO 3.15d Growth	The rate of growth of primary producers affects the concentration of radionuclides and other toxicants in the primary producers.	Priority: Unchanged Comment: Presently there is a “growth” of primary producers both on land and in water. Growth can affect the dilution of concentration, if biomass growth is larger than uptake. Not considering this is a conservative approach.	1
BIO 4.1 Potential intrusion	Potential intrusion of decomposers through degraded plugs at the surface. (GEO 17.15)	Priority: Unchanged Comment: Decomposers can intrude if the passage is open to the repository. But under normal conditions the plugs will submerge below the groundwater surface. Thus it is unlikely that any macro decomposer will have a significant impact. Micro decomposers are assumed to be existent in the repository and are treated as microbial interactions.	1
BIO 4.2a Decomposition	The type and efficiency of decomposers affects the content of non-degraded organic material in the Quaternary deposits and also the content of non-organics, e.g. shells.	Priority: Unchanged Comment: The decomposers affect the content of organic matter in sediment and soil. The process is not explicitly considered. The net accumulation of organic matter is calculated from sediment profiles or terrestrial model or peat accumulation measurement from bog profiles.	1
BIO 4.3a Stimulation/ Inhibition	Mycorriza; – toxins, Mineralisation goes via water composition. Soil structure goes via Quaternary deposits.	Priority: Unchanged Comment: Decomposers as fungi in symbiosis are important in providing terrestrial plant with nutrients. Decomposers can also affect its environment with toxins. However, the mycorhiza is included in the assessment of plants and thus not treated explicitly.	1
BIO 4.4a Stimulation/ Inhibition	Competition about space and resources; + mating; physical disturbance.	Priority: Unchanged Comment: The competition is assumed to be optimal and thus no further changes are expected to affect the composition as was estimated from field surveys or assumptions.	1
BIO 4.4b Food supply	Eating each other. Decomposers e.g. eat microbes, or fungi can be a food source to e.g. worms.	Priority: Unchanged Comment: The supply of organic or “conditioned” matter by decomposers is not considered explicitly. Is assumed to be contained in amount of organic matter in water, soil or sediments.	1
BIO 4.4c Feeding	Eating each other. Decomposers as e.g. worm can eat microbes or fungi.	Priority: Unchanged Comment: The consumption of decomposers by decomposers is not considered explicitly. Is assumed to be contained in consumption of organic matter in water, soil or sediments.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 4.5a Stimulation/ Inhibition	Toxicants, size, mechanical properties (spines…) nutritional value.	Priority: Unchanged Comment: The characteristics that affect the filter feeders are not evaluated. The effects should limit the food intake. Thus it is considered to just limit food and radionuclide uptake in filter feeders. This is important for the amount of matter in the water and thus treated by influencing the amount of POCK, which then affects the food supply for filter feeders.	1
BIO 4.5b Food supply	Amount of food.	Priority: Unchanged Comment: The transfer of organic matter to filter feeders is not delimited by the food supply in this system. This is important for the amount of matter in the water and thus treated by influencing the amount of POC, which then affects the food supply for filter feeders.	1
BIO 4.6a Stimulation/ Inhibition	Food quality (toxins, mushrooms).	Priority: Unchanged Comment: The toxic effects of decomposers are assumed to be occasional and thus not affect the population of herbivores.	1
BIO 4.6b Food supply	Food supply (mushrooms).	Priority: Unchanged Comment: Decomposers as fungi (mushrooms), but also as conditioners of plant material are food supply for herbivores. They are however not considered as limiting and thus the supply doesn't affect the herbivore population.	1
BIO 4.7a Stimulation/ Inhibition	Quality as food (+ nutrient, (– toxins), – mechanical structure e.g. shells).	Priority: Unchanged Comment: The food quality is assumed to be regarded in the species composition. Thus the species composition estimated from surveys or assumptions reflect the food quality.	1
BIO 4.8a Stimulation/ Inhibition	Quality as food (+ nutrient, (– toxins), – mechanical structure e.g. shells).	Priority: Unchanged Comment: The quality and taste of food certainly affects humans as well as toxic decomposers (mushrooms). However, this is assumed to be treated implicitly in food selection by humans based on available sources.	1
BIO 4.8b Food supply	Amount and production rate, mushrooms etc.	Priority: Changed from 1 to 2 Motivated by: Review comments on Project SAFE documents by authorities. Comment: Priority 1 was questioned in /SKI and SSI 2004/ as neglecting it "means that an important exposure pathway to man can be overlooked".	2
BIO 4.8d Material supply	Material supply Penicillin, yeast.	Priority: Unchanged Comment: Some decomposers could be regarded as material supply for e.g. medicine. When they are used for this purpose it is assumed that also a quality check will ensure that it is non-contaminated matter.	1
BIO 4.10 Decomposition	During decomposition of material the decomposers will release water from pores and cells which can influence the water content in the Quaternary deposits.	Priority: Unchanged Comment: For normal Swedish climate conditions this is assumed to be of limited importance compared to precipitation. Could be of importance during hot and humid climate when the decomposition processes are higher. However, still judged to be of negligible importance.	1
BIO 4.11a Decomposition	The decomposition of organic material produces water by releasing crystal water and by the production of the degradation products CO_2 and H_2O.	Priority: Unchanged Comment: The contribution from this release will be minor compared to the wet climate conditions in Sweden. Moreover it will not form surface waters, it will then evaporate in dry conditions.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 4.11b Retardation/ Acceleration	The type and amount of decomposers attached to surfaces in contact with surface waters influence the properties of the surfaces and thereby water movement.	Priority: Unchanged Comment: The viscosity of surface waters is affected by the amount of e.g. microbes. The variation in movement of surface waters and occasional occurrence of the viscosity effect assumes that this effect is already encompassed in the variance.	1
BIO 4.11c Uptake/Excretion	Uptake of surface water by decomposers affects the amount and movement of surface waters.	Priority: Unchanged Comment: The uptake or excretion of water will normally not affect the amount of surface water where there sustainable surface water. It could however cause ephemeral waterbodies (urine pits), but there lifelength and random placement is disregarded in timescales longer than a day.	1
BIO 4.11d Movement	The existence and movement of decomposers in surface waters may have an influence on the surface water movement.	Priority: Unchanged Comment: The decomposers are generally small (microbes, fungi, worms, snails) and will probably not affect waterbodies larger than some m3 with their movement. This size of waterbodies is assumed anyhow to be homogeneously mixed.	1
BIO 4.13a Gas uptake and release	Decomposers will for example by uptake of O_2 and release of CO_2 influence the gas composition. In addition, the decomposition of organic material lead to the production of different kinds of gases (e.g. production of CO_2, H_20 (g), H_2, CH_4, H_2S, S_2) that influences the amount of gas and the gas composition.	Priority: Unchanged Comment: The release and uptake of gas by decomposers will have limited local effect on gas composition, due to high exchange rates of gas in the air by wind and turbulence and is thus regarded as constants in the time perspective of an assessment.	1
BIO 4.13b Particle trapping and production	Decomposers may affect the amount of particles in the gas, e.g. by trapping on slimy surfaces and by the production and release of spores.	Priority: Unchanged Comment: The release and uptake of particles by decomposers will have a limited local effect on gas composition, due to high exchange rates of gas in the air by wind and turbulence and is thus regarded as constants in the time perspective of an assessment.	1
BIO 4.14a Radiation	The colour and structure of decomposers can affect the radiation balance.	Priority: Unchanged Comment: Most decomposers are small or in fauna (e.g. worms) and thus not exposed to the surface which can affect radiation balance. If they were at surface they should be out competed or in symbiosis with primary producers. Thus there is no or limited effect on radiation balance by decomposers.	1
BIO 4.14b Exothermic/ Endothermic reactions	The metabolic heat due to decomposition can increase temperature.	Priority: Unchanged Comment: The metabolic heat (e.g. compost) due to decomposition is normally a local effect. Normally air temperature and radiation is the dominating factors affecting the temperature. Thus this process is disregarded in the spatial and temporal time frame of assessment.	1
BIO 4.14c Heat transport	The isolation of decomposers or movement can affect heat transport.	Priority: Unchanged Comment: The density of decomposers is small compared to the decomposed matter and structure of it. Thus the heat transport properties of the Quaternary deposits are more important.	1
BIO 4.16 Export	Export of decomposers is mainly through outflow of e.g. microbes with water. Also hatching of e.g. insect larvae is an export of decomposers when the larvae change from decomposers to an herbivore or predator. Migration by animals is another type of export.	Priority: Unchanged Comment: The major loss of decomposers is planktonic decomposers, which follow the surface water. Most decomposers (e.g. worms and snails) are limited in migration distance and thus disregarded.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 5.1 Potential intrusion	Potential intrusion of filter feeders through degraded plugs at the surface. (GEO 17.15).	Priority: Unchanged Comment: Filter feeders penetrate a few dm through a sediment surface or e.g. wooden constructions in marine conditions. Filter feeders can have a substantial effect in open tunnels with flowing water. However, that condition itself is more serious than the effect of filter feeders.	2
BIO 5.2 Bioturbation	The type and amount of filter feeders in the waters affects the physical properties and the chemical composition of the Quaternary deposits e.g. by homogenisation of the upper layers. Dead filter feeders can influence the composition of the Quaternary deposits, but this interaction goes via "Decomposers".	Priority: Unchanged Comment: Filter feeders (e.g. mussels, clams) penetrate the sediment the first dm and cause bioturbation. Is not considered explicitly but regarded through sediment stratification.	2
BIO 5.3a Stimulation/ Inhibition	– space competition ; shadowing; + substrate, reproduction vector ; water transparency and mineralisation via watercomposition The type, amount and location of filter feeders can influence the living conditions for primary producers, e.g. stimulation by symbiotic effects, algae only living on clams that are acting as substrates. And inhibition by competition of place. Remark: The effect of remineralisation and filtering of particles water transparency goes via the water chemistry.	Priority: Unchanged Comment: The competition of space is important, but it is assumed that the species composition is estimated when the competition is in steady state. Thus the process itself is expressed in the estimate of species composition.	1
BIO 5.4a Stimulation/ Inhibition	Quality as food (+ nutrient, (– toxins), – mechanical structure e.g. shells). Can also with bioturbation and via water composition, water current and Quaternary deposits affect oxygen content and mechanical structure of sediment.	Priority: Unchanged Comment: Filter feeders can affect the species composition, which is assumed to be estimated by surveys.	1
BIO 5.4b Food supply	Mortality rate gives the supply amount of dead mater, sedimentation, debris production (faeces, pseudofaeces).	Priority: Unchanged Comment: The production of faeces and pseudofeaces is substantial for filter feeders and important food sources for decomposers. In this area the filter feeders are scarce and thus insignificant contribution. Is however affected by a more saline environment.	1
BIO 5.5a Stimulation/ Inhibition	Competition about space and resources;+ mating; physical disturbance.	Priority: Unchanged Comment: The competition is assumed to be optimal and thus no further changes are expected to affect the composition as estimated from field surveys or assumptions.	1
BIO 5.5b Food supply	Eating each other larvae.	Priority: Unchanged Comment: The process affecting composition and dominance is assumed to be covered by estimates of species composition.	1
BIO 5.5c Feeding	Eating each other larvae.	Priority: Unchanged Comment: The process affecting composition and dominance is assumed to be covered by estimates of species composition.	1
BIO 5.6a Stimulation/ Inhibition	Space competition (e.g. Mytilus –. Patella).	Priority: Unchanged Comment: Competition about space is assumed to be reflected by species composition.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 5.6c Feeding	Feeding on zoo plankton, larvae.	Priority: Unchanged Comment: Feeding is assumed to be low due to the low abundance in today's situation around SFR. Can be affected by higher salinity, but need also higher abundance of rock surfaces. Zoo plankton and larvae are assumed to be contributors to POM in water composition and treated there.	1
BIO 5.7a Stimulation/ Inhibition	Quality as food (+ nutrient, – mechanical structure e.g. shells). Can also with +– bioturbation and via water composition, water current and Quaternary deposits affect oxygen content and mechanical structure of sediment. + Mechanical degradation of other food items.	Priority: Unchanged Comment: The digestibility can affect the carnivore's food selection. However, carnivores seem not to be limited by filter feeder availability.	1
BIO 5.7c Feeding	Feeding on larvae, zoo plankton.	Priority: Unchanged Comment: The feeding on larvae and zoo plankton is assumed to go over the POM content in water composition.	1
BIO 5.8a Stimulation/ Inhibition	Aufwuchs; beauty; toxin.	Priority: Unchanged Comment: The change in human behaviour due to this is assumed to be included in the overall uncertainties of human consumption.	1
BIO 5.8d Material supply	Pearls; shells; corals.	Priority: Unchanged Comment: The supply of filter feeder is usually not a limiting factor for humans, and it is assumed that the external radiation from these objects is limited.	1
BIO 5.11a Water pumping	The filter feeders influence actively the water flow by filtrating/pumping the water.	Priority: Unchanged Comment: Compared to the turnover of water due to other water movement the effects of filter feeders are negligible.	1
BIO 5.11b Retardation/ Acceleration	The type and amount of filter feeders attached to surfaces in contact with surface waters influence the properties of the surfaces and thereby water movement.	Priority: Unchanged Comment: Usually of minor importance compared with other factors affecting water flow.	1
BIO 5.11c Uptake/Excretion	Uptake of surface water by filter feeders affects the amount and movement of surface waters.	Priority: Unchanged Comment: The exchange of water is small compared to the turbulence.	1
BIO 5.12a Uptake/Excretion	Uptake and excretion by filter feeders will have an influence on the water composition. For example the uptake of O_2 and the excretion of CO_2 and dissolved organic species.	Priority: Unchanged Comment: The process is important affecting the $C0_2$ and O_2 content as well as the nutrient level in the water. Here not explicitly treated as a process, but derived from actual water composition measured.	1
BIO 5.12b Particle production and trapping	The filtering of surface waters by filter feeders will decrease the amount of small particles in the water. However, by excretion they can be a source for production of larger particles. The type and amount of filter feeders will thus influence the water composition.	Priority: Unchanged Comment: The interaction is assumed to be expressed in water composition.	1
BIO 5.14a Radiation	The colour and texture of filter feeders could affect radiation.	Priority: Unchanged Comment: Of limited importance since radiation of water will be more important.	1
BIO 5.14b Exothermic/ Endothermic reactions	The metabolic heat will heat the water surrounding the filter feeders.	Priority: Unchanged Comment: Of limited importance since metabolic heat is very small.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 5.14c Heat transport	A layer of filter feeders could change isolation.	Priority: Unchanged Comment: Of limited importance since properties of water will be more important.	1
BIO 5.15c Degradation	Degradation of toxicants by filter feeders affects the type and concentration of toxicants in the different parts of the biosphere system.	Priority: Unchanged Comment: Only important for toxicants. If not used probably a conservative estimate.	1
BIO 5.15d Growth	The rate of growth of filter feeders affects the concentration of radionuclides and other toxicants in filter feeders.	Priority: Unchanged Comment: Could be of importance, but should normally give a dilution in organisms. If it is not treated it is probably a conservative approach.	1
BIO 5.16 Export	Export of filter feeders is detachment and sinking to deeper parts, detachment of macro algae with filter feeders, spawn.	Priority: Unchanged Comment: Because filter feeders are normally sessile, the main rout of export could be through spawn. Probably quantitatively of minor importance. Usually treated as export of POM.	1
BIO 6.1 Potential intrusion	Potential intrusion of herbivores through degraded plugs at the surface. (GEO 17.15)	Priority: Unchanged Comment: Normally it is unlikely that herbivores would be able to enter repository due to the level of the ground water. But could be possible during arid condition which however not is considered to occur at the Forsmark area.	1
BIO 6.2 Bioturbation	The type and amount of herbivores affects the physical properties and the chemical composition of the Quaternary deposits e.g. by homogenisation of the upper layers. Dead herbivores can influence the composition of the Quaternary deposits, but this interaction goes via "Decomposers".	Priority: Unchanged Comment: Even larger herbivores (e.g. cattle) have a local and limited direct effect on Quaternary deposits.	1
BIO 6.3a Stimulation/ Inhibition	Selection > competition e.g. feeding of epiphytes; +seed dispersal, pollination; trampling. Remark: Mineralisation and soil structure via water composition and deposits.	Priority: Unchanged Comment: The competition is assumed to be in steady state and reflected by the surveys of species composition and abundance.	1
BIO 6.3c Feeding	Feeding grazing, fruit, nectar consumption.	Priority: Unchanged Comment: The grazing is assumed to be in steady state and reflected by the surveys of species composition and abundance.	1
BIO 6.4a Stimulation/ Inhibition	Quality as food (+ nutrient, – mechanical structure e.g. shells). Can also with +– bioturbation and via water composition, water current and Quaternary deposits affect oxygen content and mechanical structure of sediment +Mechanical degradation of other food items, +– trampling, + storage (squirrels etc).	Priority: Unchanged Comment: The effect of nutritional value of decomposers for herbivores is assumed to be reflected in species composition of decomposers.	1
BIO 6.5a Stimulation/ Inhibition	Competition space food (plankton), – toxins.	Priority: Unchanged Comment: Populations are assumed to be in steady state, thus the species composition reflects the competition.	1
BIO 6.5b Food supply	Amount of herbivorous zoo plankton, gametes. Particle production goes via water composition.	Priority: Unchanged Comment: Reflected by species composition.	1
BIO 6.6a Stimulation/ Inhibition	Competition about space and resources; + mating.	Priority: Unchanged Comment: Populations assumed to be in steady state. That means that competition is expressed in species composition.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 6.7a Stimulation/ Inhibition	Quality as food (+ nutrient, – mechanical structure e.g. shells), +– trampling.	Priority: Unchanged Comment: The food quality is assumed to be included in feeding rates.	1
BIO 6.8a Stimulation/ Inhibition	Beauty; toxin; pleasure horse.	Priority: Unchanged Comment: The preference is assumed to be included in the variability of human behaviour.	1
BIO 6.11a Movement	The movement of herbivores in surface waters may have an influence on the surface water movement.	Priority: Unchanged Comment: Normally there are no hippos in the Swedish climate. The water movements induced by herbivores is assumed to be less than normal turnover by e.g. wind stress.	1
BIO 6.11b Retardation/ Acceleration	The type and amount of herbivores can by their existence influence the properties of the surface waters and thereby water movement.	Priority: Unchanged Comment: No known cases of this interaction in Sweden. Beavers could affect the water movements by binding dams. However, this is not considered.	1
BIO 6.11c Uptake/Excretion	Consumption of surface water by herbivores affects the amount of surface waters.	Priority: Unchanged Comment: Small waterbodies can be affected by consumption by e.g. cows as well as excretion by herbivores. These waterbodies are ephemeral anyhow due to desiccation/flooding and regarded to have statistical minor frequency compared to larger waterbodies.	1
BIO 6.12a Uptake/Excretion	Uptake and excretion by herbivores will have an influence on the water composition. For example the uptake of O_2 and the excretion of CO_2 and dissolved organic species.	Priority: Unchanged Comment: In water where the O_2 and CO_2 dynamics is important, herbivores are situated nearby the producers of O_2 and consumer of CO_2 and thus the effect by herbivores is regarded as insignificant. Excretion of nutrients and other substances in water affect the nutrient turnover. On land the excretion of nutrients can affect small water volumes.	1
BIO 6.12b Particle production and trapping	The eventual filtering of surface waters by herbivores will decrease the amount of small particles in the water. However, by excretion they can be a source for production of larger particles. The type and amount of herbivores will thus influence the water composition.	Priority: Unchanged Comment: This interaction affects the particle content in water, but it is reflected in estimates and measurements of particle content.	1
BIO 6.13a Gas uptake and release	Herbivores will for example by respiration (uptake of O_2 and release of CO_2) influence the gas composition.	Priority: Unchanged Comment: The effect is local and due to high turn over of atmosphere regarded as insignificant.	1
BIO 6.13b Particle trapping and production	Herbivores may affect the amount of particles in the gas, e.g. by trapping on slimy surfaces or furs and by the release of e.g. hair.	Priority: Unchanged Comment: The effect is local and due to high turn over of atmosphere regarded as insignificant.	1
BIO 6.14a Radiation	The colour and structure of herbivores can affect the radiation balance.	Priority: Unchanged Comment: Most herbivores are mobile and some are small and thus have specific effect on radiation.	1
BIO 6.14b Exothermic/ Endothermic reactions	The metabolic heat due to metabolism can increase temperature.	Priority: Unchanged Comment: The metabolic heat is normally a local effect. Normally air temperature and radiation is the dominating factor affecting the temperature. Thus this process is disregarded in the spatial and temporal time frame of the assessment.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 6.14c Heat transport	The isolation of herbivores or movement can affect heat transport.	Priority: Unchanged Comment: The density of herbivores is small compared to e.g. Quaternary deposits. Moreover herbivores are mobile and have little effect on isolation.	1
BIO 6.16 Export	Export of herbivores is migration, hunting and e.g. sinking out with detached algae.	Priority: Unchanged Comment: This will give a dilution of radionuclides in the system. Is normally quantitatively of minor importance. Not addressing the effect gives an overestimate of exposure within the system.	1
BIO 7.1 Potential intrusion	Potential intrusion of predators through degraded plugs at the surface. (GEO 17.15)	Priority: Unchanged Comment: Normally it is unlikely that carnivores would be able to enter repository due to the depth of water. But could be possible during arid condition which however not is considered to occur at the Forsmark area.	1
BIO 7.2 Bioturbation	The type and amount of predators affects the physical properties and the chemical composition of the Quaternary deposits e.g. by homogenisation of the upper layers. Remark: Dead predators can influence the composition of the Quaternary deposits but this interaction goes via "Decomposers".	Priority: Unchanged Comment: Even larger carnivores (e.g. fox) have a local and limited direct effect on Quaternary deposits, since the deposits are over the hard rock.	1
BIO 7.3a Stimulation/ Inhibition	Trampling; mechanical by nesting wood pecking etc; Remark: mineralisation via water composition; feeding on herbivores via herbivores.	Priority: Unchanged Comment: The effect is limited and random over a large area and thus not regarded.	1
BIO 7.4a Stimulation/ Inhibition	Quality as food (+ nutrient, – mechanical structure e.g. shells). Can also with +– bioturbation and via water composition, water current and Quaternary deposits affect oxygen content and mechanical structure of sediment +Mechanical degradation of other food items, +– trampling, + storage (bobcats).	Priority: Unchanged Comment: This interaction is assumed to already be established and reflected by species composition.	1
BIO 7.4b Food supply	Mortality rate gives the supply amount of dead mater, sedimentation, debris production (faeces, mechanical fragmentation, horns, fur, feathers).	Priority: Unchanged	2
BIO 7.4c Feeding	Feeding of worms, larvae.	Priority: Unchanged Comment: The feeding by carnivores on decomposers, (e.g. worms) can affect the population, but is assumed to be expressed in species composition.	1
BIO 7.5a Stimulation/ Inhibition	Competition space ; negative selection affects competition between filter feeders.	Priority: Unchanged Comment: This interaction is assumed to already be established and is reflected by species composition.	1
BIO 7.5b Food supply	Amount of gametes.	Priority: Unchanged Comment: Gametes; particle production goes via water composition as particulate matter.	1
BIO 7.5c Feeding	Predation e.g. Flounders, eider.	Priority: Unchanged Comment: The feeding by carnivores on filter feeders can affect the population of filter feeders, but is assumed to be expressed in species composition.	1
BIO 7.6a Stimulation/ Inhibition	Selection affects competition between herbivores.	Priority: Unchanged Comment: The interaction is assumed to be reflected by species composition.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 7.6c Feeding	Predation Carnivores eating herbivores...	Priority: Unchanged Comment: The interaction is assumed to be reflected by species composition.	1
BIO 7.7a Stimulation/ Inhibition	Competition about space and resources;+ mating; physical disturbance.	Priority: Unchanged Comment: The competition is assumed to be estimated by species composition and it is assumed that the interactions show up in species dominance.	1
BIO 7.8a Stimulation/ Inhibition	Food competition: hunting, gaming, disturbance.	Priority: Unchanged Comment: Not a significant interaction in today's human world.	1
BIO 7.8c Feeding	Bears, wolf, crows, gulls, fish on corpses.	Priority: Unchanged Comment: The consumption of humans by carnivores is unusual.	1
BIO 7.8d Resource	Resource souvenirs, bone, zoo, dog, cat.	Priority: Unchanged Comment: The effect as external radiation from these things is of minor importance.	1
BIO 7.11a Movement	The existence and movement of carnivores in surface waters may have an influence on the surface water movement.	Priority: Unchanged Comment: Crocodiles and shark are not assumed to belong to the Swedish fauna today.	1
BIO 7.11b Retardation/ Acceleration	The type and amount of carnivores attached to surfaces in contact with surface waters influence the properties of the surfaces and thereby water movement.	Priority: Unchanged Comment: No example found that shows this problem.	1
BIO 7.11c Uptake/Excretion	Uptake of surface water by carnivores affects the amount and movement of surface waters.	Priority: Unchanged Comment: The water consumption and release by terrestrial carnivores is small compared to their prey.	1
BIO 7.12a Uptake/Excretion	Uptake and excretion by carnivores will have an influence on the water composition. For example the uptake of O_2 and the excretion of CO_2 and dissolved organic species.	Priority: Unchanged Comment: In water where the O_2 and CO_2 dynamics is important. However, carnivores contribute far less than decomposers. Excretion of nutrients and other substances in water affect the nutrient turnover. On land the excretion of nutrients can affect small water volumes.	1
BIO 7.12b Particle production and trapping	The eventual filtering of surface waters by carnivores will decrease the amount of small particles in the water. However, by excretion they can be a source for production of larger particles. The type and amount of carnivores will thus influence the water composition.	Priority: Unchanged Comment: This is interaction affect the particle content in water, but is reflected in estimates and measurements.	1
BIO 7.13a Gas uptake and release	Carnivores will for example by respiration (uptake of O_2 and release of CO_2) influence the gas composition.	Priority: Unchanged Comment: The effect is local and due to high turn over of atmosphere regarded as insignificant.	1
BIO 7.13b Particle trapping and production	Carnivores may affect the amount of particles in the gas, e.g. by trapping on slimy surfaces or furs.	Priority: Unchanged Comment: The effect is local and due to high turn over of atmosphere regarded as insignificant.	1
BIO 7.14a Radiation	The colour and structure of carnivores can affect the radiation balance.	Priority: Unchanged Comment: Most carnivores are very mobile and thus have specific effect on radiation.	1
BIO 7.14b Exothermic/ Endothermic reactions	The metabolic heat due to metabolism can increase temperature.	Priority: Unchanged Comment: The metabolic heat is normally a local effect. Normally air temperature and radiation is the dominating factor affecting the temperature. Thus this process is disregarded in the spatial and temporal time frame of assessment.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 7.14c Heat transport	The isolation of carnivores or movement can affect heat transport.	Priority: Unchanged Comment: The density of carnivores is small compared to e.g. Quaternary deposits. Moreover carnivores are mobile and have little effect on isolation.	1
BIO 7.15c Degradation	Degradation of toxicants by carnivores affects the type and concentration of toxicants in the different parts of the biosphere system.	Priority: Unchanged Comment: Only important for toxicants.	1
BIO 7.16 Export	Export of carnivores by migration, hunting.	Priority: Unchanged Comment: This will give a dilution of radionuclides in the system. Is normally quantitatively of minor importance. Not addressing the effect gives an overestimate of exposure within the system.	1
BIO 8.1 Borehole intrusion Not defined in SAFE		Priority: Set to 3 Description: Future human action resulting in the penetration of open boreholes, such as water wells, into the geosphere. Comment: Such boreholes are conceivable.	3
BIO 8.2 Disturbance	Humans can by different activities e.g. dredging, digging, covering etc, change the composition and properties of the Quaternary deposits and the base line topography. Normal activities are thought to be included in the Base Scenario whereas other disruptive events are treated as separate scenarios. Dead humans can influence the composition of the Quaternary deposits, but this interaction goes via "Decomposers".	Priority: Unchanged Comment: Ploughing is affecting deposits. However it is assumed to be independent of human living in the area. During permafrost condition the assumption is that the soil is not used for agriculture purposes and thus not ploughed.	1
BIO 8.3c Feeding	Feeding of fruits, plants, seeds, roots, medicine, tobacco.	Priority: Unchanged Comment: Feeding is assumed to be including in habit of utilizing the nature and thus there is no interaction.	1
BIO 8.3d Dispersal/ Extermination	Dispersal of new populations by cultivation or by accident (e.g. farming planting), gengineering, – extermination of populations by negative selection, many other ways over chemical composition or toxicants.	Priority: Unchanged Comment: Dispersal is assumed to be including in habit of utilizing the nature and thus there is no interaction.	1
BIO 8.4a Stimulation/ Inhibition	Cultivation by supply of substrate or selection, storages in waste deposits, composts.	Priority: Unchanged Comment: Human have an impact in storing and producing garbage etc, but the amount is given by assumption and thus not treated as an interaction.	1
BIO 8.4b Food supply	Debris production (faeces, mechanical fragmentation). Mortality rate gives the supply amount of dead maters.	Priority: Unchanged Comment: The faeces production is assumed to have only local influence. For that spatial scale the time scale is very long for reutilizing faeces in large quantities.	1
BIO 8.4c Feeding	Feeding of mushrooms, worms and larvae.	Priority: Unchanged Comment: The human consumption of detrivores is assumed to be negligible as an impact on them. Moreover this is treated in species composition after impact.	1
BIO 8.4d Dispersal/ Extermination	Dispersal of new populations by cultivation or by accident (e.g. mushroom farms), gengineering, – extermination of populations by negative selection. Many other ways over chemical composition or toxicants.	Priority: Unchanged Comment: The human influence can be large, but this is not considered as an interaction because it is assumed to be given by the assessment context.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 8.5a Stimulation/ Inhibition	Cultivation, supply of substrate or opposite via over deposits, selection.	Priority: Unchanged Comment: The human influence is moderate and not used as an interaction because it is assumed to be given by the assessment context.	1
BIO 8.5c Feeding	Feeding on mussels, oysters etc.	Priority: Unchanged Comment: The human consumption of filter feeders is assumed to be negligible as impact on filter feeders. Moreover this is treated in species composition after impact.	1
BIO 8.5d Dispersal/ Extermination	Dispersal of new populations by cultivation (e.g. farming) or by accident (e.g. Dreissena spp), gengineering, – extermination of populations by negative selection (Anodonta), many other ways over chemical composition or toxicants.	Priority: Unchanged Comment: The human influence is moderate and not used as an interaction because it is assumed to be given by the assessment context.	1
BIO 8.6c Feeding	Feeding on animals.	Priority: Unchanged Comment: Feeding on animal has a large impact on population, but is assumed to be fixed by assumption.	1
BIO 8.6d Dispersal/ Extermination	Dispersal of new populations by cultivation (e.g. farming) or by accident (e.g. rabbits), gengineering, – extermination of populations by negative selection (e.g. Vincent).	Priority: Unchanged Comment: Included in stimulation.	1
BIO 8.7a Stimulation/ Inhibition	Game, – extermination programs, +– cultivation, sanctuaries, national parks.	Priority: Unchanged Comment: The humans have large impact on carnivores, but it is assumed that this is reflected by species composition and assessment context.	1
BIO 8.7b Food supply	Humans could be a food supply for carnivores e. g. bears.	Priority: Unchanged Comment: Normally the assumption is that humans not are a food supply for animals.	1
BIO 8.7c Feeding	Feeding of fish, birds, etc.	Priority: Unchanged Comment: Unusual that human feed on carnivorous mammals, but on fish and occasionally lizards. In Sweden fish belong to a normal diet. The impact on fish can be large, but is assumed to be covered by the species composition.	1
BIO 8.7d Dispersal/ Extermination	Dispersal of new populations by cultivation or by accident (e.g. mink, dog. cat), gengineering, – extermination of populations by negative selection e.g. wolf, falcon, many other ways over chemical composition or toxicants.	Priority: Unchanged Comment: The impact can be large, but is assumed to be covered by the species composition.	1
BIO 8.7e Material use	Horns, teeth, stuffed birds.	Priority: Unchanged Comment: Has an impact on population, but is assumed to be reflected in species composition.	1
BIO 8.8a Stimulation/ Inhibition	Competition about space and resources;+ mating fun.	Priority: Unchanged Comment: Human interacts in many ways, but for the future we assume that humans are responsible thinking beings respecting each other loving each other as much that the population is happy and the resources are exploited in a sustainable way.	1
BIO 8.10a Water extraction	Extraction of water by humans, e.g. from wells, may affect the water flow and water content in the Quaternary deposits.	Priority: Unchanged	2
BIO 8.10b Artificial infiltration	Infiltration of water caused by humans, e.g. leakage of municipal water, may affect the water flow and water content in the Quaternary deposits.	Priority: Unchanged Comment: The infiltration will normally lead to higher dilution than natural. Not taking this into account thus overestimates the exposure and therefore neglected.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
8.11a Movement	The movement of humans (e.g. swimming) in surface waters may have an influence on the surface water movement. In addition, other human activities e.g. large scale export, piping, wave generation etc will have an influence on amount and movement of surface waters. Treated as separate scenarios??	Priority: Unchanged	2
BIO 8.11b Retardation/ Acceleration	Human themselves don't change the retardation/acceleration of water, but through constructions e.g. houses, dams, boats and icebreakers that influence water movement.	Priority: Unchanged Comment: Humans mainly have small impact on water movement compared with natural sources.	1
BIO 8.11c Uptake/Excretion	Uptake of surface water by humans for consumption can influence the amount and movement of surface waters.	Priority: Unchanged	2
BIO 8.11d Covering	The use of icebreakers by humans influence the amount of surfaces covered with ice and the free water surfaces and influence thereby amount and surface water movement.	Priority: Unchanged Comment: Not regarded as important.	1
BIO 8.12a Excretion	Humans excrete nutrients and thus affects chemical composition of water.	Priority: Unchanged Comment: Assumed that this already is reflected in water composition.	1
BIO 8.12b Filtering	Humans may affect the composition of surface waters by filtering.	Priority: Unchanged Comment: Human filter water which will affect e.g. drinking water. This will, if anything, probably reduce the contaminants. Although the filter equipment needs to be taken care of. It is assumed that this is neglible.	1
BIO 8.12c Pollution	Humans may affect the water composition by releasing pollutants (chemical toxicants and radionuclides not included).	Priority: Unchanged Comment: Humans certainly affect the water composition by pollution, but it is assumed that this already is reflected in water composition.	1
BIO 8.13a Gas uptake and release	Humans can for example by respiration (uptake of O_2 and release of CO_2) influence the air composition.	Priority: Unchanged Comment: The release is assumed to be included already in atmosphere composition.	1
BIO 8.13b Particle trapping and production	Humans can for example by ploughing generate particles.	Priority: Unchanged	2
BIO 8.13c Wind	Humans can by their behaviour have an influence on wind velocities and fields, for example by the use of airplanes, helicopters, cars, fans, etc. In addition, man made structures such as buildings can redistribute wind velocities and field.	Priority: Unchanged Comment: The influence on mass transport is regarded as insignificant compared to natural causes for wind.	1
BIO 8.13d Pollution	Humans may affect the gas composition in the surrounding air and atmosphere by their behaviour and by industrial activities releasing pollutants (chemical toxicants and radionuclides not included).	Priority: Unchanged Comment: Assumed to already be taken into account by the composition of the air.	1
BIO 8.14a Radiation	Humans may affect the radiation balance.	Priority: Unchanged Comment: Humans are doing the best to change the radiation balance with their activities. However, this is dependent on the assessment context.	1
BIO 8.14b Exothermic/ Endothermic reactions	The metabolic heat.	Priority: Unchanged Comment: Metabolic heat is assumed to be negligible compared to other sources.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 8.14c Heat transport	Isolation, greenhouse influenced heat transport.	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: It is assumed that this already is given in the climate situation from assessment context. Greenhouse influence is considered.	2
BIO 8.14d Anthropogenic effects	Human activities such as industrial activities may have a direct influence on the temperature in the biosphere. Treated as an alternative scenario.	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: It is assumed that this already is given in the climate situation from assessment context. Greenhouse influence is considered.	2
BIO 8.15c Degradation	Degradation of toxicants by humans affects the type and concentration of toxicants in the different parts of the biosphere system.	Priority: Unchanged Comment: These types of contaminant are not considered.	1
BIO 8.15d Growth	The rate of growth of humans and their length of life affects the concentration of radionuclides and other toxicants in humans.	Priority: Unchanged Comment: Could be of importance, but is already accounted for in the establishment of dose coefficients and permitted doses.	1
BIO 8.15e Human activities	Human activities can affect the concentration of radionuclides and toxicants in the biosphere system e.g. pollution and the operation of nuclear facilities.	Priority: Unchanged Comment: Uncertain of the importance. Depends on the amount of radionuclides or toxicants released. In this assessment it is assumed that no other releases than from SFR are occurring.	1
BIO 8.16a Export of energy	Export of energy.	Priority: Unchanged Comment: Not relevant.	1
BIO 8.16b Emigration	Humans moving from site.	Priority: Unchanged Comment: Human moving from the area will get a lower exposure than people living at the site, thus it is conservative not to account for this.	1
BIO 8.5b Food supply	Debris production (faeces, mechanical fragmentation). However, this goes via water composition (particle content).	Priority: Unchanged Comment: The human influence can be large in debris production, but this is not used as an interaction because it is assumed to be included in water composition as particle content.	1
BIO 10.1d Erosion/ weathering	The water flow in the Quaternary deposits influences the erosion of rock. (GEO 17.9c)	Priority: Unchanged Comment: The erosion and weathering of the rock is expected to be low for this type of rock and time perspective. Erosion of surface rock included in the geosphere matrix.	1
BIO 10.2a Erosion	The magnitude and direction of the water flow influences the magnitude of erosion and thereby the structure and porosity of Quaternary deposits.	Priority: Unchanged Comment: The water in the deposits is assumed to be equilibrated with the erosion process in the assessment.	1
BIO 10.2c Pingo formation	Temperature changes leading to freezing of the water and expansion of the ice and/or freeze and thaw in Quaternary deposits may result in the formation of pingos thereby changing the topography, e.g. formation of hills in bog lands.	Priority: Unchanged Comment: Not relevant for the base scenario. Could possibly be important in case of permafrost, but it is not known if the conditions in the SFR area are such that pingos will develop. Furthermore it is assessed that formation of pingos is of negligible importance for the performance of SFR.	1
BIO 10.4a Settlement	The amount of water in Quaternary deposits affects the settlement of decomposers. Too little or too much water prevents settlement.	Priority: Unchanged Comment: Decomposers (esp. mushrooms) on land are affected by water content in deposits. The effects as loose or dry soil are assumed to be reflected in species composition.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 10.6a Settlement	The amount of water in Quaternary deposits affects the settlement of herbivores. Too little or too much water prevents settlement.	Priority: Unchanged Comment: The effects as loose or dry soil are assumed to be reflected in species composition and probably of minor importance.	1
BIO 10.6b Water uptake	The amount of water in Quaternary deposits affects the water uptake and living conditions for herbivores and thus the type, amount and life-time of herbivores in the area.	Priority: Unchanged Comment: Assumed to be reflected in species composition and of minor importance.	1
BIO 10.7a Settlement	The amount of water in Quaternary deposits affects the settlement of carnivores. Too little or too much water prevents settlement, e.g. worms entering the surface in case of to much water.	Priority: Unchanged Comment: The effects as loose or dry soil are assumed to be reflected in species composition and probably of minor importance.	1
BIO 10.7b Water uptake	The amount of water in Quaternary deposits affects the water uptake and living conditions for carnivores and thus the type, amount and life-time of carnivores in the area.	Priority: Unchanged Comment: Assumed to be reflected in species composition and of minor importance.	1
BIO 10.8a Settlement	The presence, location and amount of accessible water in Quaternary deposits affects the settlement of humans in the area.	Priority: Unchanged Comment: It is assumed that the availabily of water doesn't affect settlement of humans.	1
BIO 10.12a Erosion	The magnitude and direction of the water flow influence the extent of erosion of the Quaternary deposits and thereby the amount and type of particulates in the water.	Priority: Unchanged Comment: This interaction is assumed to be already in equilibrium. Thus the water composition is assumed to be represented by measured or estimated values.	1
BIO 10.12b Mixing	The magnitude, direction and distribution of the water flow in the Quaternary deposits will affect the mixing of the water and thereby also the composition of the water.	Priority: Unchanged Comment: The mixing especially with surface or deep groundwater in deposits is an important process. It is however assumed that it is represented by measured or estimated values.	1
BIO 10.12c Density effect	The water pressure affects the density of the water in the Quaternary deposits and thereby the water composition.	Priority: Unchanged Comment: Assumed to have a minor influence in the normally thin deposits in the SFR area.	1
BIO 10.13a Evaporation/ condensation	Transformation of water in liquid phase to gas phase by evaporation in the Quaternary deposits.	Priority: Unchanged Comment: This is transport of water, but it is assumed that contaminants are not directly related to this.	1
BIO 10.13b Sublimation	Transformation of water in solid phase (frost, ice) to gas phase by sublimation in the Quaternary deposits.	Priority: Unchanged Comment: This is transport of water, but it is assumed that contaminants are not directly related to this.	1
BIO 10.14a Heat transport	The water content as well as the magnitude, direction and distribution of water flow in the Quaternary deposits affect the heat transport in the biosphere system and thus the temperature in the system components.	Priority: Unchanged Comment: This can affect surface temperature especially in winter. However, assumed that these effects will be reflected in species composition and therefore not specifically taken into account.	1
BIO 10.14b Heat storage	The water content as well as the magnitude, direction and distribution of water flow in the Quaternary deposits affect the heat storage capacity and thus the temperature in the Quaternary deposits.	Priority: Unchanged Comment: This can affect surface temperature especially in winter. However, assumed that these effects will be reflected in species composition and therefore not specifically taken into account.	1
BIO 10.16 Export	The export is groundwater flow out of the system.	Priority: Unchanged Comment: The outflow is assumed to be minor because there are discharges in lakes or sea from where the export will go.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 11.1d Erosion/ weathering	The surface water hydrology influences the erosion of rock (GEO 17.9c) Remark: includes also the erosion caused by ice movement and snow movements e.g. avalanches.	Priority: Unchanged Comment: The erosion and weathering of the rock are expected to be low for this type of rock and time perspective. Even a glacial condition is not considered to erode the geosphere to any substantial extent. Erosion of surface rock included in the geosphere matrix.	1
BIO 11.1e Ice load	Changes in thickness of the ice sheet due to seasonal variations and during periods of glaciation and deglaciation will affect the mechanical stress in the rock. (GEO 17.14b)	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Must be accounted for during periods of glaciation, see GEO 17.14b.	3
BIO 11.3b Relocation	The magnitude and direction of surface water flow affects the extent of relocation of primary producers and thus the location. In addition, ice scraping can cause relocation.	Priority: Unchanged Comment: This is an important process along the shoreline above and under water. It is however reflected in species composition in this area.	1
BIO 11.4a Settlement	Decomposers on land live mainly in Quaternary deposit. In water they are everywhere mainly as bacteria Remark: Live mainly in Quaternary deposits.	Priority: Unchanged Comment: Decomposers on land are more dependent on water in Quaternary deposits and vegetation structure, which is affected by surface water. Thus they are correlated to vegetation. In water they are abundant everywhere and treated then as estimated species abundance.	1
BIO 11.4b Relocation	The flow of surface water cause detachment of decomposers and dispersal of decomposer to other places.	Priority: Unchanged Comment: Decomposers are either living in Quaternary deposit and not directly affected by this process or they live in water and are assumed to be reflected by species composition and a homogeneous distribution in water.	1
BIO 11.4c Water uptake	Decomposers on land and water need water to their metabolism.	Priority: Unchanged Comment: The assumption is that there is sufficient of water for metabolism and contaminants transported with water are addressed in radionuclide transport.	1
BIO 11.5b Relocation	Currents and water level changes detach filter feeders from their substrate.	Priority: Unchanged Comment: The estimated composition of species is assumed to reflect the variations in the water level and current conditions.	1
BIO 11.5c Water uptake	Filter feeders need water for metabolism and as a carrier of organic matter and oxygen.	Priority: Unchanged Comment: Assumed that there is sufficient of water for established filter feeders. Uptake of organic matter is derived from water composition.	1
BIO 11.6b Relocation	Currents and waterlevel changes can detach small herbivores.	Priority: Unchanged Comment: Assumed to be reflected in species composition.	1
BIO 11.7b Relocation	Surface waters could move carnivores.	Priority: Unchanged Comment: They are moving as plankton, but that is reflected in species composition for plankton. Detachment is of minor importance because most carnivores are mobile.	1
BIO 11.7c Water uptake	Carnivores need water for metabolism.	Priority: Unchanged Comment: Quantitatively not so high compared to their pre.	1
BIO 11.8b Relocation	The water level changes or current relocate humans.	Priority: Unchanged Comment: This process can be avoided by human behaviour.	1
BIO 11.12 Salt formation from freezing	Marine waters are separated to fresh waters and salt waters.	Priority: Unchanged Comment: During freezing conditions the dynamic for the ice is more important.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 11.12b Density effect	The water pressure affects the density of the water and thereby the water composition.	Priority: Unchanged Comment: Not regarded because the water is shallow (less than 80 m) in this area. Probably of minor importance due to the low compressibility of water.	1
BIO 11.13a Evaporation/ condensation	Transformation of water in surface waters to gas phase by evaporation.	Priority: Unchanged Comment: This is an important process for the water balance, but the effects on local atmosphere are assumed to be negligible compared to air exchange.	1
BIO 11.13b Sublimation	Transformation of water in solid phase (frost, ice) to gas phase by sublimation.	Priority: Unchanged Comment: The effects on local atmosphere are assumed to be negligible compared to air exchange.	1
BIO 11.13c Erosion	The release of water droplets by sea spray or snow by snowdrifts influences the composition of gas.	Priority: Unchanged Comment: The effects on local atmosphere are assumed to be negligible compared to air exchange.	1
BIO 11.14a Radiation	The size of the surface water area affects the extent of radiation and thereby the temperature in the surface waters.	Priority: Unchanged Comment: This is an important interaction for the temperature in different compartments. However, the interaction is assumed to be expressed in available data on temperatures.	1
BIO 11.14b Exothermic/ Endothermic reactions	Exothermic/endothermic reactions would impact temperature in surface waters.	Priority: Unchanged Comment: No exothermic or endothermic reactions of significance are identified.	1
BIO 11.14c Heat transport	The magnitude, direction and distribution of water flow in the surface waters affect the heat transport in the biosphere system and thus the temperature in the system components.	Priority: Unchanged Comment: The heat transport between compartments in surface waters is small compared to the heat transport through convection.	1
BIO 11.14e Light reflection	The wave form of the surface waters affects light reflection and thereby the temperature in the surface waters.	Priority: Unchanged Comment: The measured temperatures in water are a long term integrated of the high variation in waves and light reflection. Thus it is assumed that the water temperature reflects this process.	1
BIO 11.16 Export/import	The exchange of surface water with the surrounding surface water.	Priority: Unchanged Comment: The effect of a local surface water with its surrounding water is assumed to be negligible compared to the effect of the surrounding water on the local water.	1
BIO 12.1b Erosion/ weathering	The composition of water in Quaternary deposits and surface waters influences the erosion/weathering of rock. (GEO 17.9c)	Priority: Unchanged Comment: The erosion and weathering of the rock is expected to have low effect for this type of rock and time perspective.	1
BIO 12.2b Precipitation/ dissolution	The composition of the water in Quaternary deposits will affect precipitation/ dissolution reactions and thus the material composition, geometry and porosity of the Quaternary deposits.	Priority: Unchanged Comment: The physical structure of deposits is assumed to be a result of this interaction.	1
BIO 12.2c Erosion/ weathering	The composition of water in Quaternary deposits and surface waters influences the erosion/weathering of Quaternary deposits. For example the extent of blasting is influenced by the particle content in the waters.	Priority: Unchanged Comment: The composition will affect the deposits but the movement of water will be higher and it is assumed that the effect of composition is included in the interaction with water movement.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 12.4b Stimulation/ Inhibition	The water composition (e.g. trace elements, nutrients, toxicants, etc) in Quaternary deposits (and surface waters) will affect the stimulation/inhibition of production of decomposers.	Priority: Unchanged Comment: The stimulation and inhibition is assumed to be reflected in the species composition.	1
BIO 12.6b Stimulation/ Inhibition	The water composition (e.g. trace elements, toxicants, etc) in Quaternary deposits and surface waters will affect the stimulation/inhibition of production of herbivores and thereby affecting the amount of herbivores living both in water and on land.	Priority: Unchanged Comment: Herbivores get their major supply of nutrient elements through their food and thus the growth effects are assumed to be reflected by food and not in settlement	1
BIO 12.7b Stimulation/ Inhibition	The water composition (e.g. trace elements, toxicants, etc) in Quaternary deposits and surface waters will affect the stimulation/inhibition of production of carnivores and thereby affecting the amount of carnivores living both in water and on land.	Priority: Unchanged Comment: Carnivores get their major supply of nutrient elements through their food and thus the growth effects are assumed to be reflected by food and not in settlement.	1
BIO 12.8a Settlement	The water composition (e.g. salinity, trace elements, toxicants, etc) in Quaternary deposits and surface waters affects the settlement of humans.	Priority: Unchanged Comment: Humans are not in a very large extent affected by water composition.	1
BIO 12.13a Spray/Snowdrift	The composition of surface waters and snow will affect the composition of water droplets and snow particles that are part of the atmosphere.	Priority: Unchanged Comment: The interaction is important, but the local atmosphere is assumed to be affected more by exchange of wind.	1
BIO 12.13b Dissolution/ Degassing	The amount of dissolved gases in surface waters and waters in Quaternary deposits will affect the degree of dissolution/degassing and thereby the composition of gas and atmosphere.	Priority: Unchanged Comment: The gas exchange with the atmosphere is an important process. However, the local atmosphere will not be affected to a large extent because of the wind exchanges. The neglect ion of this will make a conservative estimate for contaminants (e.g. $^{14}CO_2$).	1
BIO 12.14a Exothermic/ Endothermic reactions	The reaction between substances in water in Quaternary deposits and surface waters can require heat or release heat	Priority: Unchanged Comment: This process is assumed to be negligible in the normal case since the substances are already dissolved in water. Other heat producing processes are of higher importance.	1
BIO 12.14c Light reflection/ scattering	The presence of snow or other particles at the surface will influence the degree of light reflection and the amount of particles in the waters will influence the degree of scattering and thus the temperature in surface waters.	Priority: Unchanged Comment: When this occurs the temperature of the water will anyhow be low and much lower is not possible due to convection of water.	1
BIO 12.14d Adiabatic compression	Water with higher density will by gravitational forces sink and the water will be compressed when the pressure increases. The compression leads to the release of heat and thus a temperature increase.	Priority: Unchanged Comment: This adiabatic compression occurs at high pressures not obtainable in this area.	1
BIO 12.15c Sedimentation	Aggregation of particles and sedimentation of these. Is influenced by the ionic strength and the particle size.	Priority: Unchanged Comment: An important process for sedimentation. However, the estimated sedimentation rates include these effects.	1
BIO 12.16 Export	The outflow of water composition to the surrounding.	Priority: Unchanged Comment: It has a minor effect to the surrounding due to the high volumes compared with the small flows.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 13.1 Gas transport	Air intrusion can take place via human activities and can also be a consequence of land rise and climatic changes leading to unsaturated conditions. (GEO 17.12)	Priority: Unchanged Comment: Influence only the upper few meters. Negligible effect.	1
BIO 13.2a Erosion	The strength of the wind determines the amount of particles that will get airborne and influence thereby by erosion the geometry and amount of Quaternary deposits. In addition, high wind velocities can demolish buildings and structures included in the definition of Quaternary deposits.	Priority: Unchanged Comment: In this area with wave-washed till there is a small amount of fine particles in deposits and thus the erosion is small. This condition is also assumed during coming interglacial periods based on the assumption of the glacial cycle.	1
BIO 13.2b Deposition	The amount of particles in the atmosphere and the wind velocity will affect the amount of deposited particles and thereby the amount, geometry and composition of Quaternary deposits.	Priority: Unchanged Comment: The transport of fine material is limited in this region and thus also the deposition.	1
BIO 13.2c Oxidation	The humidity of gas atmosphere and the content of oxidants, e.g. O_2, will affect the oxidation of minerals in Quaternary deposits and thereby the composition. In addition, fires will oxidise organic materi-als in Quaternary deposits and thereby change the composition.	Priority: Unchanged Comment: It is assumed that this process has already occurred.	1
BIO 13.3a Settlement	The deposition of spores, seeds and pollen is influenced by wind velocities and wind fields and affects thereby the settlement of primary producers.	Priority: Unchanged Comment: This is an important dispersal process, but it is assumed that the species composition is instantaneous and reflected by the estimated composition.	1
BIO 13.3b Stimulation/ Inhibition	The atmospheric conditions influence the living conditions and thus the productivity of primary producers, e.g. humidity, CO_2 and toxicants. In addition, the deposition of particles leading to shadowing and the shadowing effects by clouds is included here.	Priority: Unchanged Comment: It is assumed that this is reflected by species composition and that these processes vary largely over time.	1
BIO 13.3c Relocation	The magnitude of the wind velocities and the distribution of the wind field affect the extent of relocation of primary producers and thus the location.	Priority: Unchanged Comment: Likewise to settlement it is assumed that species composition reflects this condition. In the current climate it is not regarded as important in this area compared to the action of water.	1
BIO 13.3d Deposition/ Removal	The magnitude of the wind velocities and the distribution of the wind field determine the deposition or removal of particulates, but also the removal of parts of primary producers and thus the living conditions.	Priority: Unchanged Comment: See BIO 13.3c.	1
BIO 13.4a Settlement	Dispersal can be mediated by wind.	Priority: Unchanged Comment: The dispersal e.g. spores is assumed to be reflected by the species composition.	1
BIO 13.4b Stimulation/ Inhibition	The atmospheric conditions influence the living conditions and thus the productivity of “species” e.g. humidity, O_2 and toxicants.	Priority: Unchanged Comment: The atmospheric condition affects the organism, but it is assumed that this is already reflected by species composition.	1
BIO 13.4c Relocation	See 13.4a.	Priority: Unchanged Comment: See BIO 13.4a.	1
BIO 13.4d Deposition/ Removal	See 13.4a.	Priority: Unchanged Comment: See BIO 13.4a.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 13.6a Settlement	Herbivores could avoid sheltered areas (e.g. reindeers) or the opposite.	Priority: Unchanged Comment: The atmospheric changes have a short time constant and is assumed to vary randomly and thus the response is assumed to be random and with low quantitative importance.	1
BIO 13.6b Stimulation/ Inhibition	The atmospheric conditions influence the living conditions and thus the productivity of "species" e.g. humidity, O_2 and toxicants.	Priority: Unchanged Comment: See BIO 13.6a.	1
BIO 13.6c Relocation	See 13.6a.	Priority: Unchanged Comment: See BIO 13.6a.	1
BIO 13.6d Deposition/ Removal	See 13.6a.	Priority: Unchanged Comment: See BIO 13.6a.	1
BIO 13.7a Settlement	Carnivores select areas depending on e.g. wind.	Priority: Unchanged Comment: The atmospheric changes have a short time constant and is assumed to vary randomly and thus the response is assumed to be random and with low quantitative importance.	1
BIO 13.7b Stimulation/ Inhibition	The atmospheric conditions influence the living conditions and thus the productivity of "species" e.g. humidity, O_2 and toxicants.	Priority: Unchanged Comment: The atmospheric changes have a short time constant and is assumed to vary randomly and thus the response is assumed to be random and with low quantitative importance.	1
BIO 13.7c Relocation	See 13.7a.	Priority: Unchanged Comment: The atmospheric changes have a short time constant and is assumed to vary randomly and thus the response is assumed to be random and with low quantitative importance.	1
BIO 13.7d Deposition/ Removal	See 13.7a.	Priority: Unchanged Comment: The atmospheric changes have a short time constant and is assumed to vary randomly and thus the response is assumed to be random and with low quantitative importance.	1
BIO 13.8a Settlement	Humans might select place to settle depending on wind.	Priority: Unchanged Comment: Not assumed to be important in this assessment.	1
BIO 13.8b Stimulation/ Inhibition	The atmospheric conditions influence the living conditions and thus the productivity of "species" e.g. humidity, O_2 and toxicants.	Priority: Unchanged Comment: Not assumed to be important in this assessment.	1
BIO 13.8c Relocation	See 13.8a.	Priority: Unchanged Comment: Not assumed to be important in this assessment since humans are very mobile.	1
BIO 13.8d Deposition/ Removal	See 13.8a.	Priority: Unchanged Comment: Not assumed to be important in this assessment since humans are very mobile.	1
BIO 13.10c Sublimation	The transformation of water in solid phase (frost, ice) to gas phase by sublimation in the Quaternary deposits is influenced by the gas and atmospheric pressure.	Priority: Unchanged Comment: Not regarded as a quantitatively important process compared with the others.	1
BIO 13.11e Sublimation	The degree of transformation of water in solid phase (frost, ice) to gas phase by sublimation is influenced by the atmospheric pressure.	Priority: Unchanged Comment: Not regarded as quantitatively important compared with other processes.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 13.12a Precipitation	The precipitation of rain/snow will influence the water composition by dilution. Remark: only the amounts are included in this interaction.	Priority: Unchanged Comment: The amount of water is included in interaction with surface water. The primary source of contamination is assumed to be through the ground. Thus secondary deposition does not provide higher levels.	1
BIO 13.12b Deposition	Dry and wet deposition may affect the water composition.	Priority: Unchanged Comment: The primary source of contamination is assumed to be through the ground. Thus secondary deposition does not provide higher levels.	1
BIO 13.12c Evaporation/ Condensation	The degree of evaporation of water and the degree of condensation of humidity in the gas/atmosphere will by concentration and dilution, respectively, influence the water composition.	Priority: Unchanged Comment: The water balance is included in interaction with surface water. The primary source of contamination is assumed to be through the ground. Thus secondary deposition does not provide higher levels.	1
BIO 13.12d Dissolution/ Degassing	The chemical composition of gas and atmosphere will by dissolution of gas in waters influence the water composition. In addition, the degree of degassing is influenced by the gas and atmospheric pressure.	Priority: Unchanged Comment: The diffusion between water and atmosphere is regarded to be of quantitatively low importance. Neglecting it gives a conservative estimate.	1
BIO 13.14a Radiation	The composition of the atmosphere affects the absorption/scattering/reflection of radiation and thus the temperature.	Priority: Unchanged Comment: The atmosphere changes are rapid and it is assumed that the annual average temperature reflects the influence.	1
BIO 13.14b Exothermic/ Endothermic reactions	Change in temperature due to exothermic/ endothermic reactions.	Priority: Unchanged Comment: The heat contribution due to exothermic/endothermic reactions is assumed to be of quantitatively small importance for heat transport compared with e.g. change in heat transport due to wind.	1
BIO 13.14c Heat transport	Heat transport by gas/atmosphere.	Priority: Unchanged Comment: The heat transport with the atmosphere is rapid and assumed to be reflected by temperature measurements.	1
BIO 13.14d Heat storage	Heat storage in gas/atmosphere that affects temperature.	Priority: Unchanged Comment: The heat storage in gas is limited compared to heat storage in soil and water and thus neglected.	1
BIO 13.14e Adiabatic temperature change	Changes in gas pressure that affects temperature.	Priority: Unchanged Comment: The adiabatic temperature changes are assumed to be reflected by temperature measurements. The build up of mountains is unlikely in this time period with small changes in adiabatic processes.	1
BIO 13.14f Phase changes	Heat generation/consumption due to phase changes will affect the temperature. Of importance in transpiration of primary producers.	Priority: Unchanged Comment: The temperature changes due to phase transition is assumed to be reflected by temperature and not treated explicitly.	1
BIO 13.15a Mixing	The distribution, magnitude and direction of gas (including air) flow in the different components of the biosphere system affect the concentration of radionuclides and other toxicants in gas phase in the system components.	Priority: Unchanged Comment: Important for ^{14}C, Tritium, Iodine and Radon. It is assumed that the mixing is quick in the atmosphere and thus the concentrations are low.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 13.15b Sorption/ desorption	Sorption/desorption of radionuclides and other toxicants in gas phase on particles, pollen and water drops in the atmosphere that affects the distribution of radionuclides and other toxicants and thus the concentration in gas phase, on particles and in water drops.	Priority: Unchanged Comment: Of no importance for ^{14}C and Radon. Could be of importance for Iodine in the aspect of Iodine in water drops that deposits on the surface.	1
BIO 13.15c Photochemical reactions	Photochemical reaction can produce toxicants.	Priority: Unchanged Comment: There are no such toxicants identified and thus the process is neglected.	1
BIO 13.16 Export	The wind and exchange with the surrounding environment.	Priority: Unchanged Comment: The export is assumed to be of little importance and not driven by internal composition of gas.	1
BIO 14.1a Heat transport	The heat exchange between geosphere and biosphere will affect the temperature in the geosphere. (GEO 17.13)	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: Influence on the geosphere from temperature in the biosphere must be considered.	2
BIO 14.1b Erosion/ weathering	Erosion caused by temperature changes. (GEO 17.9)	Priority: Unchanged Comment: The erosion and weathering of the rock especially during frost conditions is considered in the Geosphere. Erosion of surface rock included in the geosphere matrix.	1
BIO 14.2a Weathering	The temperature will affect the volume of the materials and thus changes may cause physical weathering e.g. frost ice. In addition, the temperature will affect the kinetics of chemical reactions and thus the chemical weathering and the properties of the Quaternary deposits.	Priority: Unchanged Comment: Under normal condition (no climate changes) there is a seasonal change of this, which however is included in the annual average and thus assumed to be reflected by the actual estimates for the deposits.	1
BIO 14.2b Thermal expansion/ contraction	The change in geometry due to temperature and phase transitions e.g. water freezing.	Priority: Unchanged Comment: The changes of geometry are minor compared to other causes of changes in geometry e.g. erosion etc.	1
BIO 14.3a Settlement	The temperature will affect the settlement of plants.	Priority: Changed from 1 to 2 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: The estimated species distribution is assumed to reflect the temperature dependence on settlement during temperate conditions. During permafrost condition this must be considered explicitly or through water availability.	2
BIO 14.3b Stimulation/ Inhibition	The temperature affects the productivity and water turnover of plant and algae.	Priority: Unchanged Comment: The temperature is an important factor regulating the processes. However, when estimating the annual net primary production the summer temperature has less effect than light and respiration. The estimated species distribution is assumed to reflect the temperature dependence on settlement.	1
BIO 14.4a Settlement	The temperature will affect the settlement of decomposers.	Priority: Unchanged Comment: The estimated species distribution is assumed to reflect the temperature dependence on settlement The estimated species distribution is assumed to reflect the temperature dependence on settlement.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 14.5a Settlement	The temperature affects the settlement of filter feeders.	Priority: Unchanged Comment: The water temperature affects the settlement and spawning of e.g. blue mussels. However, it is assumed that this is reflected in the estimated species distribution The estimated species distribution is assumed to reflect the temperature dependence on settlement.	1
BIO 14.6a Settlement	The temperature affects the settlement of herbivores.	Priority: Unchanged Comment: The estimated species distribution is assumed to reflect the temperature dependence on settlement The estimated species distribution is assumed to reflect the temperature dependence on settlement.	1
BIO 14.7a Settlement	The temperature affect the settlement of Carnivores.	Priority: Unchanged Comment: The estimated species distribution is assumed to reflect the temperature dependence on settlement The estimated species distribution is assumed to reflect the temperature dependence on settlement.	1
BIO 14.8a Settlement	Humans settle, build houses or prefer to stay where temperatures are nice.	Priority: Unchanged Comment: It is assumed that humans do the worst to get exposed, thus even settle in hostile environments.	1
BIO 14.8b Stimulation/ Inhibition	Humans are stimulated/inhibited dependent on temperature.	Priority: Unchanged Comment: It is assumed that humans do the worst to get exposed, and they are able to alter its environment to make it more stimulating.	1
BIO 14.10 Phase transitions	Freezing of water, melting of snow and evaporation of water in Quaternary deposits as a result of changes in temperature will affect the water content, water pressure and water flow in the Quaternary deposits.	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: This is an important process, which however is included in most annual averages in normal climate scenario. In a cooler climate this interaction is important as it influences the groundwater movement.	3
BIO 14.11a Phase transitions	Freezing and evaporation of surface waters as a result of changes in temperature will affect water movement and amounts of water and ice. Temperature affects the aggregation state of water (gas, ice and water).	Priority: Changed from 1 to 3 Motivated by: Extended time frame of analysis including permafrost and glaciation. Comment: This is an important process, which however is included in most annual averages in the normal climate scenario. In a cooler climate this interaction is important and must be considered due to occurrence of permafrost.	3
BIO 14.12a Kinetics and chemical equilibra	The kinetics and chemical equilibra are affected by temperature, especially kinetics.	Priority: Unchanged Comment: Although the kinetics is largely affected, it is of minor importance compared to other processes.	1
BIO 14.12c Mixing	The temperature influences the diffusion.	Priority: Unchanged Comment: The mixing process due to water movement is assumed to be much larger than the molecular diffusion.	1
BIO 14.13a Pressure change	Changes in temperature gives pressure changes that affect gas and wind movements. Inversion effects are included in this interaction.	Priority: Unchanged Comment: The temperature effect on gas is an important driving mechanism for the turnover of the atmosphere. The external influences are assumed to be larger than the local effect of temperature differences.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 14.13b Phase transitions	Temperature affects the aggregation state of water (gas, ice and water) Remark: To get precipitation condensation kernels are required.	Priority: Unchanged Comment: The temperature effect on gas is an important driving mechanism for the phase transitions in the atmosphere. The external influences are assumed to be larger than the local effect.	1
BIO 14.15a Kinetics and chemical equilibra	The temperature affects kinetics and chemical equilibra and thus the concentration of radionuclides and toxicants in the system components.	Priority: Unchanged Comment: The seasonal temperature variation encompasses the natural extremes for kinetics and chemical equilibra of radionuclides. Thus it is assumed that the annual average includes this variation.	1
BIO 14.15b Phase transitions	The distribution of species between different phases (solid, liquid, gas) is influenced by the temperature.		2
BIO 14.16 Export of heat	Export of heat from the system.	Priority: Unchanged Comment: Not regarded as quantitatively important compared with the surroundings.	1
BIO 15.1 Contaminant transport	Transport of radionuclides and toxicants in water and gas phase from the biosphere into the geosphere will affect the amount of these in the geosphere. The origin of these contaminants may be the SPHERE itself as well as contaminants from other sources. (GEO 17.16)	Priority: Unchanged Comment: Negligible effects.	1
BIO 15.2a Surface deposition/uptake	Deposition or uptake of radionuclides and other toxicants on the surfaces of Quaternary deposits may change the physical and chemical properties (mineralogy) of the surfaces.	Priority: Unchanged Comment: Too small amounts of radionuclides to have any significant effect.	1
BIO 15.2b Irradiation	Irradiation of the materials in Quaternary deposits by radionuclides in the materials and in the water in Quaternary deposits may affect the mineralogical structure of the materials in Quaternary deposits.	Priority: Unchanged Comment: Too small amounts of radionuclides to have any significant effect.	1
BIO 15.12a Radiolysis	Radiation from decaying radionuclides causing radiolytic decomposition of the water and thereby affecting the water composition in the different components of the biosphere system.	Priority: Unchanged Comment: Too small amounts.	1
BIO 15.12b Formation of stabile isotopes	Decay of radionuclides to stabile isotopes that affect the composition of the water in the different components of the biosphere system.	Priority: Unchanged Comment: Probably too small amounts.	1
BIO 15.12c Chemical reactions	Chemical reactions, e.g. decomposition of organic toxicants, and all other reactions involving radionuclides and other toxicants in dissolved and in particulate form may affect the composition of the water in the different components of the biosphere system.	Priority: Unchanged Comment: Too small amounts of radionuclides to have any important effect.	1
BIO 15.13 Phase transition	Formation of elements in gas phase due to decay of radionuclides and/or decomposition of organic toxicants.	Priority: Unchanged Comment: Phase transition of Ra to Rn will not affect gas atmosphere.	1
BIO 15.14 Heat from decay	Decaying radionuclides will generate heat that may influence the temperature in the different components of the biosphere system.	Priority: Unchanged Comment: Too small amounts of radionuclides.	1

Interaction name and number	SAFE description	Comment valid for SAR-08	SAR-08 Priority
BIO 16.2a Import	Import of different materials e.g. building materials, dredging materials, earth, coal, crushed rock and gravel will influence the composition, amount and type of Quaternary deposits.	Priority: Unchanged Comment: The import of matter during temperate conditions is assumed to be negligible except for human actions. Human actions are handled under human scenarios. During glacial condition there are large quantities.	1
BIO 16.3a Import	Import of plants and seeds by some natural way e.g. spreading of seeds with the wind and by humans by plantation.	Priority: Unchanged Comment: It is assumed to be reflected by the estimates of species distribution.	1
BIO 16.4 Import	Immigration of animals.	Priority: Unchanged Comment: It is assumed to be reflected by the estimates of species distribution.	1
BIO 16.5 Import	Immigration of animals.	Priority: Unchanged Comment: It is assumed to be reflected by the estimates of species distribution.	1
BIO 16.6 Import	Immigration of animals.	Priority: Unchanged Comment: It is assumed to be reflected in the estimates of species distribution.	1
BIO 16.8a Import of energy	Import of energy affects human behaviour and living conditions.	Priority: Unchanged Comment: It is assumed that human behaviour is predefined to give highest doses. Thus most imports of material that are uncontaminated will be disregarded because it will be a dilution of the contamination.	1
BIO 16.8b Immigration	The degree of immigration of humans to the studied area influences e.g. living conditions and human behaviour.	Priority: Unchanged Comment: It is assumed that human behaviour is predefined to give highest doses. Thus immigration will reduce the doses and is disregarded.	1
BIO 16.13b Photochemical reactions	Photochemical reactions close to the surface will affect the gas composition e.g. ozone formation, smog formation and reactions in exhaust gases.	Priority: Unchanged Comment: Assumed to be a non site-specific effect. If important then included in transfer factors.	1
BIO 16.14b Insolation	Insolation and other irradiation entering the system influence the temperature in the different part of the system. Remark: The true interaction goes via absorption in the different components.	Priority: Unchanged Comment: The Insolation for temperature change is assumed to be included in temperature statistics and climate postulations. The Insolation as a factor affecting photosynthesis is treated directly for primary producers.	1
BIO 16.15 External load of contaminants	Contaminated surrounding can give higher loads of contaminants than possible sources assessed.	Priority: Unchanged Comment: It is assumed that the only source of contaminants is internal.	1

Appendix B

Updated treatment of external FEPs for SAR-08

1. Climate changes

Unique number	NEA Project FEP	Comment valid for SAR-08	Priority
J 5.22	**Accumulation of gases under permafrost**	Gas production is estimated to be low at the time of permafrost. Even though the permafrost may act as a lid and prevent gas from escaping, the reaction rates, and thus gas production, decrease with lower temperatures.	B
A 3.002	**Alkali flats** accumulation of salts due to extreme and continuous dry weather	Such extreme climatic variation is not considered as likely at the site within 100,000 years after repository closure.	B
A 2.07 A 3.024 W 1.061 A 1.12 H 3.1.2	**Climate change** wetter, dryer, warmer, cooler, permafrost, glaciation	Must be considered in scenario selection as such event is part of a conceivable climatic evolution.	A
J 5.32	**Desert and unsaturation**	Extremely dry climate is not expected on site. A dry climate would lead to much less flow of water through the geosphere. Thus, it is conservative to neglect a dry climate.	B
A 2.19	**Drought**	Extremely dry climate is not expected on site. A dry climate would lead to much less flow of water through the geosphere. Thus, it is conservative to neglect a dry climate.	B
A 3.043	**Dust storms and desertification**	Extremely dry climate is not expected on site. A dry climate would lead to much less flow of water through the geosphere. Thus, it is conservative to neglect a dry climate.	B
N 1.7.9	**Ecological response to climate** (e.g. desert formation)	This EFEP is taken to concern desert formation only, and not ecological response to other climates. Extremely dry climate is not expected on site. A dry climate would lead to much less flow of water through the geosphere. Thus, it is conservative to neglect a dry climate.	B
H 3.1.3	**Exit from glacial/interglacial cycling** accumulation of surface waters	Must be considered in scenario selection as such event is part of a conceivable climatic evolution.	A
A 2.24 S 036 J 4.2.06 H 2.1.7	**Faulting**	Must be considered in scenario selection as such event is part of a conceivable climatic evolution.	A
A 2.25	**Flood** increase in meteoric precipitation	Increased precipitation will not increase the flow through the repository compared to the present situation. A flood, leaving the repository submerged, would be favourable since the recipient would render lower doses compared to other biospheres.	B
K 10.04	**Future climatic conditions** climate change – natural or human induced	Must be considered in scenario selection as climatic evolution, natural or anthropogenically induced, is a prerequisite of SAR-08.	A
H 2.4.1	**Generalised denudation** glacial, fluvial, aeolian erosion	Denudation, surface weathering, and erosion are judged as small within the next 100,000 years /SKB 2006b/ and to be of negligible consequence for repository safety.	B
K 10.06 A 3.057 A 1.38 A 2.30 J 5.42 N 1.3.6 S 047 W 1.062	**Glacial climate – Glaciation**	Must be considered in scenario selection as such event is part of a conceivable climatic evolution.	A

Unique number	NEA Project FEP	Comment valid for SAR-08	Priority
K 10.14 K 10.15	**Glacial-fluvial erosion/sedimentation** erosion/deposition by ice and meltwater	Denudation, surface weathering, and erosion are judged as small within the next 100,000 years /SKB 2006b/ and to be of negligible consequence for repository safety.	B
K 10.16	**Ice sheet effects** loading, melt water recharge	Must be considered in scenario selection as such event is part of a conceivable climatic evolution.	A
H 3.1.4	**Intensification of natural climate change** more frequent and intense glaciations	Must be considered in scenario selection as such events are part of a conceivable climatic evolution.	A
A 2.38	**Isostatic rebound** removal of ice load	Must be considered in scenario selection as such event is ongoing and part of the glacial cycle.	A
A 2.40 A 3.051	**Magnetic poles (reversal)** changes earth's ionization layer thus affecting climate	Reversal of magnetic poles is considered to be of minor importance for the climate system, and thus also for repository safety.	B
H 2.1.8	**Major incision** due to glacial erosion	Denudation, surface weathering, and erosion are judged as small within the next 100,000 years /SKB 2006b/ and to be of negligible consequence for repository safety.	B
J 6.10 N 1.3.7	**No ice age**	Must be considered in scenario selection as the absence of a glacial period with the next 100,000 years is conceivable (e.g. due to greenhouse effect).	A
J 5.17 S 059 K 10.13 W 1.063	**Permafrost**	Must be considered in scenario selection as such event is part of a conceivable climatic evolution.	A
K 10.05	**Tundra climate**	Must be considered in scenario selection as such event is part of a conceivable climatic evolution.	A
K 10.07	**Warmer climate – arid**	Extremely dry climate is not expected on site. A dry climate would lead to much less flow of water through the geosphere. Thus, it is conservative to neglect a dry climate.	B
K 10.09	**Warmer climate – equable humid**	Must be considered in scenario selection as such event is part of a conceivable climatic evolution.	A
K 10.08	**Warmer climate – seasonal humid**	Must be considered in scenario selection as such event is part of a conceivable climatic evolution.	A

2. Climate – Human actions

Unique number	NEA Project FEP	Comment valid for SAR-08	Priority
W 3.048 A 3.001	**Acid rain**	Acid rain is considered to be neutralised through buffering during infiltration.	B
K 8.02	**Future biosphere conditions**	Must be considered in scenario selection as climatic evolution, natural or anthropogenically induced, is a prerequisite of SAR-08.	A
A 1.39	**Global effects**	Must be considered in scenario selection as climatic evolution, natural or anthropogenically induced, is a prerequisite of SAR-08.	A
K 10.10 A 2.31 A 3.059 W 3.047	**Greenhouse effect**	Must be considered in scenario selection as such event is part of a conceivable climatic evolution.	A
K 11.09 N 2.4.9 H 3.1.1 J 6.08	**Human-induced climate change**	Must be considered in scenario selection as climatic evolution, natural or anthropogenically induced, is a prerequisite of SAR-08.	A
A 3.078 A 2.48 W 3.049	**Ozone layer failure**	It is unlikely that ozone layer failure to a reasonable degree will affect repository safety. Although a reduction of the ozone layer may affect the biosphere, which in turn may affect the amount of precipitation etc, the effects are likely to be small. A total ozone layer failure would lead to a collapse of the biosphere resulting in substantial decrease in population and also risk.	B

3. Initial defects

Unique number	NEA Project FEP	Comment valid for SAR-08	Priority
N 2.2.9	**Abandonment of unsealed repository**	An unclosed repository should be considered when setting up residual scenarios, in line with request in SKIFS 2002:1 /SKI 2002/.	A
J 3.2.11	**Backfill material deficiencies**	Must be considered in scenario selection as such initial defect is conceivable.	A
J 5.04	**Decontamination materials left**	Must be considered in scenario selection as such deviation from intended repository at closure is conceivable.	A
K 1.26	**Handling accidents**	Any apparent operational failures would be corrected before closure.	B
N 2.2.2	**Inadequate backfill or compaction, voidage**	Must be considered in scenario selection as such initial defect is conceivable.	A
N 2.2.4	**Inadvertent inclusion of undesirable materials**	Must be considered in scenario selection as such deviation from intended repository at closure is conceivable.	A
A 1.45	**Incomplete closure**	An unclosed repository should be considered when setting up residual scenarios, in line with request in SKIFS 2002:1 /SKI 2002/.	A
N 2.1.6	**Material defects**	Must be considered in scenario selection as such initial defect is conceivable.	A
J 5.02	**Non-sealed repository**	An unclosed repository should be considered when setting up residual scenarios, in line with request in SKIFS 2002:1 /SKI 2002/.	A
K 4.18	**Oil or organic fluid spill**	Any apparent operational failures would be corrected before closure.	B
A 2.47	**Open boreholes**	Part of unclosed repository. An unclosed repository should be considered when setting up residual scenarios, in line with request in SKIFS 2002:1 /SKI 2002/.	A
K 3.24	**Organics/contamination of bentonite**	Must be considered in scenario selection as such deviation from intended repository at closure is conceivable.	A
K 3.23	**Poor emplacement of buffer**	Must be considered in scenario selection as such initial defect is conceivable.	A
J 5.03	**Stray materials left**	Must be considered in scenario selection as such deviation from intended repository at closure is conceivable.	A
J 5.09	**Unsealed boreholes and/or shafts**	An unclosed repository should be considered when setting up residual scenarios, in line with request in SKIFS 2002:1 /SKI 2002/.	A
A 2.70	**Vault closure (incomplete)**	An unclosed repository should be considered when setting up residual scenarios, in line with request in SKIFS 2002:1 /SKI 2002/.	A

4. Human actions

Unique number	NEA Project FEP	Comment valid for SAR-08	Priority
H 5.2.4 A 3.071	**Accidental intrusion – drilling and pumping**	Accidental intrusion concerning drilling of boreholes into the system followed by pumping, for various purposes. This is a conceivable future human action and must be considered in scenario selection.	A
	Accidental intrusion – tunnelling	Accidental intrusion concerning tunnelling into the system enabling intrusion of humans. This event should be considered when setting up residual scenarios, in line with request in SKIFS 2002:1 /SKI 2002/.	A
N 2.4.7	**Agricultural and fisheries practice changes**	Treatment according to SSI regulations. Thus, present human habits are considered.	B
N 2.3.9 W 3.017 J 5.37 W 3.006	**Archaeological investigation**	Accidental intrusion concerning tunnelling into the system enabling intrusion of humans. Should be considered when setting up residual scenarios, in line with request in SKIFS 2002:1 /SKI 2002/.	A
W 3.023	**Blowouts**	This is an event associated with drilling into the system. This is a conceivable future human action and must be considered in scenario selection.	A
W 2.085	**Cavings**	This is an event associated with drilling into the system. This is a conceivable future human action and must be considered in scenario selection.	A
W 3.038	**Changes in geochemistry due to mining**	This EFEP concerns effects on the repository system associated with mining. Mining is likely to be commenced after a programme of borehole investigations that would identify the repository. As a result the mine would be located elsewhere. This EFEP does not focus on human intrusion, which should be given extra attention /SKI 2002/, but on geochemistry. As the occurrence of such an event is considered as unlikely it need not to be considered in scenario selection.	B
W 3.039	**Changes in groundwater flow due to explosions**	This EFEP concerns effects on the repository system associated with mining or tunnelling. Mining and tunnelling are likely to be commenced after a programme of borehole investigations that would identify the repository. As a result the mine would be located elsewhere. This EFEP does not focus on human intrusion, which should be given extra attention /SKI 2002/, but on groundwater flow. As the occurrence of such an event is considered as unlikely it need not to be considered in scenario selection.	B
W 3.037	**Changes in groundwater flow due to mining**	This EFEP concerns effects on the repository system associated with mining. Mining is likely to be commenced after a programme of borehole investigations that would identify the repository. As a result the mine would be located elsewhere. This EFEP does not focus on human intrusion, which should be given extra attention /SKI 2002/, but on groundwater flow. As the occurrence of such an event is considered as unlikely it need not to be considered in scenario selection.	B
J 7.11	**City on the site**	Treatment according to SSI regulations. Thus, present human habits are considered.	B
A 3.025	**Collisions, explosions and impacts**	This EFEP concern major collisions, explosions, and impacts from meteorites and nuclear detonations. The probability of such an event at the SFR site is too little to be of consequence for SAR-08.	B

Unique number	NEA Project FEP	Comment valid for SAR-08	Priority
W 3.016 N 2.3.8 W 3.015 N 2.3.7 J 5.28	**Construction of underground facilities**	Accidental intrusion due to construction of underground facilities in the system, enabling intrusion of humans. Should be considered when setting up residual scenarios, in line with request in SKIFS 2002:1 /SKI 2002/.	A
J 5.06	**Co-storage of other waste**	This would be a deliberate action and such are not considered in SAR-08.	B
A 3.031	**Critical group – evolution** life-style and activities	Treatment according to SSI regulations. Thus, present human habits are considered.	B
A 3.038	**Cure for cancer** due to scientific and technological advances	Treatment according to SSI regulations. Thus, present human habits are considered.	B
W 2.084	**Cuttings**	This is an event associated with drilling into the system. This is a conceivable future human action and must be considered in scenario selection.	A
A 2.14 N 2.4.2 W 3.042 W 3.043	**Dams and reservoirs, built/drained**	Artificial surface water bodies would not induce higher hydraulic gradients than natural surface water bodies. Changing hydraulic gradients are part of site evolution due to shoreline displacement.	B
H 5.2.2 A 1.49 A 3.070 W 3.012 N 2.3.1	**Deliberate intrusion**	Deliberate actions are not considered in SAR-08.	B
W 3.056 N 2.4.8	**Demographic change and urban development** development of new communities and new activities	Treatment according to SSI regulations. Thus, present human habits are considered.	B
W 3.021 W 3.022 W 3.024	**Drilling fluid flow** **Drilling-induced geochemical changes**	This is an event associated with drilling into the system. This is a conceivable future human action and must be considered in scenario selection.	A
K 8.37 A 2.20 A 3.044 N 2.4.10	**Earthworks (human actions, dredging, etc)** quarrying, mining, earth moving actions	This EFEP concerns the removal of gravel and soil, the mining of crystalline rock as raw material in a quarry and similar activities. It is unlikely that the activities would be commenced at a large enough depth to affect repository safety, due to the topography of the site and its vicinity to the coast.	B
K 11.01 A 2.05 J 5.21 W 3.032	**Exploratory drilling**	Drilling into the system is a conceivable future human action and must be considered in scenario selection.	A
A 2.23 A 1.32 A 2.02 J 5.38 W 3.019	**Explosions**	This EFEP concerns minor explosions associated with construction. To be of consequence for SFR, such construction must be of underground facilities. Such construction is likely to be commenced after a programme of borehole investigations that would identify the repository. As a result the facility would be located elsewhere. This EFEP does not focus on human intrusion, which should be given extra attention /SKI 2002/, but on mechanical damages of the repository. As the occurrence of such an event is considered as unlikely it need not to be considered in scenario selection.	B
A 3.052	**Flooding**	Artificial or human induced surface water bodies would not induce higher hydraulic gradients than natural surface water bodies. A flooded recipient would render lower doses compared to other biospheres.	B
W 3.030	**Fluid injection-induced geochemical changes**	This is an event associated with boreholes drilled into the system. This is a conceivable future human action and must be considered in scenario selection.	A

Unique number	NEA Project FEP	Comment valid for SAR-08	Priority
J 5.34 W 3.007 N 2.3.5 K 11.03	**Geothermal energy production**	This is an event associated with boreholes drilled into the system. This is a conceivable future human action and must be considered in scenario selection.	A
A 3.061	**Heat storage in lakes or underground**	Heat storage in underground is associated with boreholes drilled into the system. This is a conceivable future human action and must be considered in scenario selection.	A
J 5.27	**Human induced actions on groundwater recharge**	Human induced changes of surface hydrology will not render larger changes in hydraulic situation at repository depth than naturally induced changes due to shoreline displacement and climatic evolution.	B
J 7.07	**Human induced changes in surface hydrology**	Human induced changes of surface hydrology will not render larger changes in hydraulic situation at repository depth than naturally induced changes due to shoreline displacement and climatic evolution.	B
K 8.41	**Hunter/gathering lifestyle** nomadic community	Treatment according to SSI regulations. Thus, present human habits are considered.	B
W 3.011 W 3.029	**Hydrocarbon storage**	Hydrocarbon storage would be preceded by a programme of borehole investigations to assure a suitable location. Upon the detection of the repository, which would present an unsuitable location, the hydrocarbon storage would be placed elsewhere. The same would apply for storage of other compounds, e.g. carbon dioxide.	B
A 3.068	**Industrial water use**	Human induced changes of surface hydrology will not render larger changes in hydraulic situation at repository depth than naturally induced changes due to shoreline displacement and climatic evolution.	B
A 2.37 W 3.018 A 2.46 K 11.02 J 5.33 N 2.3.6 A 2.61	**Intrusion (mines)**	Accidental intrusion due to mining into the system, enabling intrusion of humans. Should be considered when setting up residual scenarios, in line with request in SKIFS 2002:1 /SKI 2002/.	A
A 3.075	**Lake mixing (artificial)** aeration, wave makers, purifiers, heat storage	Human induced changes of surface hydrology will not render larger changes in hydraulic situation at repository depth than naturally induced changes due to shoreline displacement and climatic evolution.	B
N 2.4.6 W 3.040	**Land use changes** surface activities	Treatment according to SSI regulations. Thus, present human habits are considered.	B
W 3.010 W 3.027 K 11.04	**Liquid waste disposal**	Liquid waste disposal in underground is associated with boreholes drilled into the system. This is a conceivable future human action and must be considered in scenario selection.	A
K 11.10 J 7.09 N 2.4.1 W 3.057	**Loss of records**	A prerequisite for unconscious action. Therefore taken care of by the other EFEPs.	B
N 2.3.2 H 5.2.3	**Malicious intrusion**	No deliberate actions are considered	B
A 1.56	**Monitoring and remedial activities**	No intrusive post-closure monitoring or remediation is planned.	B

Unique number	NEA Project FEP	Comment valid for SAR-08	Priority
J 5.12	**Near storage of other waste**	This EFEP concern storage of other waste types in nearby repositories, and its implications on the groundwater chemistry. Construction of such a repository is likely to be commenced after a programme of borehole investigations that would identify SFR. As a result the facility would be located elsewhere. This EFEP does not focus on human intrusion, which should be given extra attention /SKI 2002/, but on geochemistry. As the occurrence of such an event is considered as unlikely it need not to be considered in scenario selection.	B
J 6.07	**Nuclear war**	If the location of the repository is known, a detonation at the site is a deliberate action that is not considered in SAR-08. If the location is not known the probability of a nuclear detonation at the SFR site is too little to be of consequence for SAR-08.	B
W 3.004 W 3.001 W 3.025	**Oil and gas exploitation**	Attempts to exploit oil or gas at the site would be preceded by exploratory drilling, which would show that the site is unsuitable for such activities.	B
J 5.35	**Other future uses of crystalline rock**	Accidental intrusion due to construction of mines in the system, enabling intrusion of humans. Should be considered when setting up residual scenarios, in line with request in SKIFS 2002:1 /SKI 2002/.	A
W 3.008 W 3.014	**Other resources**	Accidental intrusion due to construction of mines in the system, enabling intrusion of humans. Should be considered when setting up residual scenarios, in line with request in SKIFS 2002:1 /SKI 2002/.	A
J 5.39 W 2.011	**Postclosure monitoring**	No intrusive post-closure monitoring planned.	B
J 5.36 A 2.03	**Reuse of boreholes**	Reuse of boreholes is a conceivable future human action and must be considered in scenario selection.	A
A 1.70 A 2.56 N 2.2.7 J 5.05 A 1.44	**Sabotage and improper operation**	Deliberate actions are not considered in SAR-08.	B
W 3.041	**Surface disruptions** actions taking place at surface	This EFEP concerns various shallow surface disruptions such as archaeological investigation, sand and gravel quarrying, etc. It is unlikely that the activities would be commenced at a large enough depth to affect repository safety, due to the topography of the site and its vicinity to the coast.	B
A 3.109	**Toxicity of mined rock**	This EFEP concerns the toxicity of the rock excavated when constructing the SFR-1 repository. As repository already exists, it needs not to be considered.	B
W 3.020 N 2.3.12 J 5.30	**Underground nuclear device testing**	If the location of the repository is known, a detonation at the site is a deliberate action that is not considered in SAR-08. If the location is not known the probability of performing such testing at the SFR site is too little to be of consequence for SAR-08.	B
J 5.40	**Unsuccessful attempt of site improvement**	Deliberate actions are not considered in SAR-08.	B
A 3.112	**Urbanization on the discharge site** affects critical group characters	Treatment according to SSI regulations. Thus, present human habits are considered.	B
A 3.115	**Water management projects**	Human induced changes of surface hydrology will not render larger changes in hydraulic situation at repository depth than naturally induced changes due to shoreline displacement and climatic evolution.	B
K 11.06	**Water management schemes**	Human induced changes of surface hydrology will not render larger changes in hydraulic situation at repository depth than naturally induced changes due to shoreline displacement and climatic evolution.	B

5. Tectonics

Unique number	NEA Project FEP	Comment valid for SAR-08	Priority
A 1.29 A 2.21 A 3.045 J 5.15	**Earthquakes**	Must be considered in scenario selection as such events are part of a conceivable site evolution.	A
W 1.011 K 9.03 K 9.04 K 9.01 K 9.02	**Fault movement**	Must be considered in scenario selection as such events are part of a conceivable site evolution.	A
A 2.24 S 036 J 4.2.06 H 2.1.7 W 1.010	**Faulting**	Must be considered in scenario selection as such events are part of a conceivable site evolution.	A
W 1.031	**Hydrological response to earthquakes** e.g. change in surface water flow directions from fault movements	Must be considered in scenario selection as such events are part of a conceivable site evolution.	A
A 2.39 N 1.2.3 H 2.1.2 W 1.014 K 9.09 A 2.36	**Magmatic activity**	Such an event is considered unlikely at the site within 100,000 years after repository closure.	B
J 4.2.01	**Mechanical failure of repository** due to earthquakes, loading-unloading, plate motions	Must be considered in scenario selection as such events are part of a conceivable site evolution.	A
A 2.42 N 1.2.4 W 1.015	**Metamorphic activity**	Such an event is considered unlikely at the site within 100,000 years after repository closure.	B
H 2.1.1 W 1.004 J 6.14 W 1.003	**Regional tectonic activity**	Must be considered in scenario selection as such events are part of a conceivable site evolution.	A
K 9.05 W 1.012 N 1.2.8 H 2.1.6	**Seismic activity**	Must be considered in scenario selection as such events are part of a conceivable site evolution.	A
K 9.06	**Stress changes – hydrogeological effects** due to fault movements	Must be considered in scenario selection as such events are part of a conceivable site evolution.	A
W 1.013 A 2.72 J 5.13	**Volcanic activity**	Such an event is considered unlikely at the site within 100,000 years after repository closure.	B

6. Others

Unique number	NEA Project FEP	Comment valid for SAR-08	Priority
A 1.05	**Buffer additives** to enhance performance	The occurrence of such buffer additives is not in line with the initial state of the repository at closure.	B
N 1.2.2 J 5.20	**Changes in the Earth's magnetic field**	Changes in the Earth's magnetic field do not affect the function of the repository	B
K 1.27	**Deviant inventory flask** deviation in RN inventory	This EFEP is taken to concern remarkable deviations in the radionuclide inventory that is not in line with the intended initial state at repository closure. Such deviating inventory may be of concern when selecting residual scenarios. The EFEP is not taken to concern minor deviation in radionuclide amounts, compared to that intended.	A
K 9.11	**Extraterrestrial events**	Not considered as probable to affect the repository.	B
W 3.033	**Flow through undetected boreholes**	This EFEP concerns flow through undetected boreholes, which by definitions cannot be pumped. If not pumped, the borehole must penetrate the repository to be of consequence for repository safety. Therefore this EFEP is part of the category unclosed repository that should be considered when setting up residual scenarios, in line with request in SKIFS 2002:1 /SKI 2002/.	A
W 2.027 J 1.2.02 H 1.2.7	**Gas explosions** hydrogen, methane, air – early after closure	This event is probably not relevant for SFR, /SKI 1989/.	B
K 9.10	**Hydrothermal activity**	No hydrothermal activity exists presently on site and this condition is not expected to change.	B
A 1.48	**Intrusion (animal)**	This EFEP is included as a FEP in the biosphere interaction matrix, where it is judged to be irrelevant.	B
J 5.29 A 2.43 N 1.1.1 H 5.2.1 W 1.040	**Meteorite**	Such an event is not relevant for SFR, as motivated in SKB/SKI Joint scenario project /Andersson et al. 1989/.	B
A 1.87	**Unmodelled design features** differences between designed and constructed, unforeseen modifications in design, features required for operation but not considered part of the conceptual design	This EFEP is not relevant as the repository is already constructed.	B

Appendix C

SAR-08 interaction matrices for repository, geosphere and biosphere

The repository matrix

	1	2	3	4	5	6	7	8	9
1	**Waste/cement** a) Recrystallis.	NONE	NONE	Expans./contract.	Expans./contract.	NONE	NONE	NONE	NONE
2	NONE	**Waste/bitumen**	NONE	NONE	Expans./contract.	NONE	NONE	NONE	NONE
3	NONE	NONE	**Waste/non-solidified**	Expans./contract.	Expans./contract.	NONE	NONE	NONE	NONE
4	Expans./contract.	NONE	Expans./contract.	**Concrete packaging** a) Recrystallis.	NONE	Expans./contract.	NONE	NONE	Expans./contract.
5	Expans./contract.	Expans./contract.	Expans./contract.	NONE	**Steel packaging**	Expans./contract.	NONE	NONE	Expans./contract.
6	NONE	NONE	NONE	Expans./contract.	Expans./contract.	**Concrete backfill** a) Recrystallis.	Expans./contract.	NONE	Expans./contract.
7	NONE	NONE	NONE	NONE	NONE	Expans./contract.	**Concrete structures** a) Recrystallis.	a) Expans/ contraction b) Bentonite expansion	Expans./contract.
8	NONE	NONE	NONE	NONE	NONE	NONE	Bentonite expansion	Bentonite barriers	Bentonite expansion
9	NONE	NONE	NONE	Expans./contract.	Expans./contract.	Expans./contract.	Expans./contract.	a) Expans./ contraction b) Bentonite expansion	Vaults and backfill
10	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Water uptake	a) Dissol./precip. b) Degrad.organic c) Water uptake	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Water uptake	a) Dissol./precip. b) Corrosion c) Degrad.organic	a) Dissol./precip. b) Corrosion c) Degrad.organic	a) Dissol./precip. b) Degrad.organic	a) Dissol./precip. b) Corrosion c) Degrad.organic	a) Dissol./precip. b) Degrad.organic c) Ion-exchange d) Water uptake e) Expans/dispers f) Montmorillonite transformation	a) Dissol./precip. b) Degrad.organic
11	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Water uptake	a) Dissol./precip. b) Degrad.organic d) Water uptake	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Water uptake e) Redistribution	a) Dissol./precip. b) Corrosion c) Degrad.organic e) Erosion	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Erosion	a) Dissol./precip. b) Degrad.organic c) Erosion	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Erosion	a) Dissol./precip. b) Degrad.organic c) Ion-exchange d) Water uptake e) Erosion	a) Dissol./precip. b) Degrad.organic c) Erosion d) Redistribution (subsidence)
12	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
13	a) Kinetics and equlibria b) Expansion/ contraction	a) Kinetics and equlibria b) Expansion/ contraction	a) Kinetics and equlibria b) Expansion/ contraction	a) Kinetics and equlibria b) Expansion/ contraction	a) Kinetics and equlibria b) Expansion/ contraction	a) Kinetics and equlibria b) Expansion/ contraction	a) Kinetics and equlibria b) Expansion/ contraction	a) Kinetics and equlibria b) Expansion/ contraction	a) Kinetics and equlibria b) Expansion/ contraction
14	Cracking	Cracking	Redistribution	Cracking	Deformation	Cracking	a) Cracking b) Redistribution	Redistribution (subsidence)	Redistribution (subsidence)
15	Microbial growth	Microbial growth	Microbial growth	Microbial growth	Microbial growth	Microbial growth	Microbial growth	Microbial growth	Microbial growth
16	Irradiation	Irradiation	Irradiation	Irradiation	Irradiation	Irradiation	Irradiation	Irradiation	Irradiation
17	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
18	NONE	NONE	NONE	NONE	Rock fall out	NONE	Rock fallout	a) Bent. expans. b) Erosion c) Rock creep d) Rock fallout	a) Rock fallout b) Rock creep

	10	11	12	13	14	15	16	17	18
1	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Diffusion e) Sorption f) Colloid filtering	a) Water flow b) Capillary suct.	a) Corrosion b) Degrad.organic c) Gas flow	a) Cement hydration b) Heat conduction c) Exothermic reactions	Expans./contract.	Microbial activity	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Diffusion e) Sorption f) Colloid filtering	NONE	NONE
2	a) Dissol./precip. b) Degrad.organic c) Diffusion d) Sorption e) Colloid filtering	a) Water flow b) Capillary suct.	a) Degrad.organic b) Gas flow	a) Heat conduction b) Exothermic reactions	Expans./contract.	Microbial activity	a) Dissol./precip. b) Degrad.organic c) Diffusion d) Sorption e) Colloid filtering	NONE	NONE
3	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Diffusion e) Sorption f) Colloid filtering	a) Water flow b) Capillary suct.	a) Corrosion b) Degrad.organic c) Gas flow	a) Heat conduction b) Exothermic reactions	Expans./contract.	Microbial activity	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Diffusion e) Sorption f) Colloid filtering	NONE	NONE
4	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Diffusion e) Sorption f) Colloid filtering g) Erosion	a) Water flow b) Capillary suct.	a) Corrosion b) Degrad.organic c) Gas flow	a) Cement hydration b) Heat conduction	Expans./contract.	Microbial activity	a) Diffusion b) Sorption c) Colloid filtering	NONE	NONE
5	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Diffusion e) Sorption f) Colloid filtering g) Erosion	a) Water flow b) Capillary suct.	a) Corrosion b) Degrad.organic c) Gas flow	Heat conduction	Expans./contract.	Microbial activity	a) Diffusion b) Sorption c) Colloid filtering	NONE	NONE
6	a) Dissol./precip. b) Degrad.organic c) Diffusion d) Sorption e) Colloid filtering f) Erosion	a) Water flow b) Capillary suct.	a) Degrad.organic b) Gas flow	a) Cement hydration b) Heat conduction	Expans./contract.	Microbial activity	a) Diffusion b) Sorption c) Colloid filtering	NONE	NONE
7	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Diffusion e) Sorption f) Colloid filtering g) Erosion	a) Water flow b) Capillary suct.	a) Corrosion b) Degrad.organic c) Gas flow	a) Cement hydration b) Heat conduction	Expans./contract.	Microbial activity	a) Diffusion b) Sorption c) Colloid filtering	NONE	NONE
8	a) Dissol./precip. b) Degrad.organic c) Diffusion d) Sorpt/ion-exch. e) Colloid filtering f) Colloid formation	a) Water flow b) Capillary suct.	a) Degrad.organic b) Gas flow	a) Heat conduction b) Exothermic reactions	Expans./contract.	Microbial activity	a) Diffusion b) Sorption/ ion-exch. c) Colloid filtering	NONE	a) Bent. expans. b) Erosion
9	a) Dissol./precip. b) Degrad.organic c) Diffusion d) Sorption e) Colloid filtering f) Erosion	a) Water flow b) Capillary suct.	a) Degrad.organic b) Gas flow	a) Heat conduction b) Exothermic reactions	Expans./contract.	Microbial activity	a) Diffusion b) Sorption c) Colloid filtering	NONE	NONE
10	**Water composition** a) Colloid formation/stability	a) Water flow b) Convection c) Osmosis d) Phase changes	a) Gas dissol./ degassing b) Chem. react. c) Corrosion d) Degrad.organic	Heat transport	NONE	Microbial activity	a) Dissol./precip. b) Corrosion c) Degrad.organic d) Diffusion e) Sorption f) Colloid trsp	Mass flow	Mass flow
11	a) Advection and mixing b) Chem. equilibr. c) Erosion d) Conc./dilution	**Hydrology**	a) Saturation b) Diss./degass. c) Two phase flow d) Expansion/ contraction	Heat advection	Water pressure interaction	Advection	a) Advection b) Dispersion c) Gas dissol./ degassing	a) Mass flow b) Disch./rech and pressure c) Biomass flow d) Contamin.trsp	a) Mass flow b) Disch./rech and pressure c) Biomass flow d) Contamin.trsp
12	a) Gas dissolution/ degassing b) Colloid trsp	a) Saturation b) Two phase flow	**Gas**	a) Heat advection b) Heat conduction	Gas pressure interaction	a) Micr. activity b) Advection-gas	a) Advection-gas b) Colloid trsp	Gas transport	Gas transport
13	a) Kinetics and equlibria b) Prop. changes c) Diffusion	Phase changes	a) Exp./contract. b) Convection	**Temperature**	Thermal stress interaction	Microbial activity	a) Kinetics and equilibria b) Diffusion c) Soret effect	Heat transport	Heat transport
14	NONE	Water pressure interaction	NONE	NONE	**Stress conditions**	NONE	NONE	Stress and strain changes	Stress and strain changes
15	Microbial activity	NONE	Microbial activity	Microbial activity	NONE	**Biological state**	a) Microbial trsp b) Methylation/ transformation	Biomass flow	Biomass flow
16	a) Radiolysis b) Radionuclide decay c) Degradation	NONE	a) Radiolysis b) Degradation	Heat from decay	NONE	Irradiation (mutation)	**Radionuclides and toxicants** a) Radionuclide decay	Contaminant transport	Contaminant transport
17	Mass flow	Rech./disch. and pressure	Gas transport	Heat transport	Stress and strain changes	Biomass flow	Contaminant transport	**Tunnels (B.C.)**	NONE
18	Mass flow	Rech./disch. and pressure	Gas transport	Heat transport	Stress and strain changes	Biomass flow	Contaminant transport	NONE	**Repository rock (B.C.)**

The geosphere matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	**SILO (B.C.)**	NONE	NONE	NONE	NONE	NONE	NONE	Bentonite expansion	NONE	a) Mass flow b) Erosion	Disch/recharge and pressure	Gas transport	Heat transport	Stress and strain changes	Biomass flow	Contaminant transport	NONE	NONE
2	NONE	**BMA (B.C.)**	NONE	NONE	NONE	NONE	NONE	NONE	NONE	Mass flow	Disch/recharge and pressure	Gas transport	Heat transport	Stress and strain changes	Biomass flow	Contaminant transport	NONE	NONE
3	NONE	NONE	**BTF (B.C.)**	NONE	NONE	NONE	NONE	NONE	NONE	Mass flow	Disch/recharge and pressure	Gas transport	Heat transport	Stress and strain changes	Biomass flow	Contaminant transport	NONE	NONE
4	NONE	NONE	NONE	**BLA (B.C.)**	NONE	NONE	NONE	NONE	NONE	Mass flow	Disch/recharge and pressure	Gas transport	Heat transport	Stress and strain changes	Biomass flow	Contaminant transport	NONE	NONE
5	NONE	NONE	NONE	NONE	**Tunnel/borehole/ backfill**	Bentonite expansion	NONE	Bentonite expansion	Bentonite expansion	a) Dissol./precip. b) Corrosion c) Diffusion d) Sorption e) Colloid filtering f) Erosion g) Degr. of organics	a) Water flow b) Capillary suct. c) Flow in boreholes	a) Gas flow b) Corrosion c) Microbial activity	Heat conduction	Stress and strain changes	Microbial activity	a) Sorption b) Diffusion	NONE	NONE
6	NONE	NONE	NONE	NONE	a) Redistribution b) Bentonite exp.	**Plugs** a) Recrystallis.	NONE	Bentonite expansion	NONE	a) Diss/prec. Concr. b) Diss/prec. Bent. c) Diffusion d) Sorption/ ion-exch e) Corrosion f) Colloid filtering g) Colloid formation	a) Water flow b) Capillary suct.	a) Gas flow b) Corrosion c) Microbial activity	Heat conduction	a) Bentonite expansion b) Stress and strain changes	Microbial activity	a) Sorption b) Diffusion	NONE	NONE
7	NONE	NONE	NONE	NONE	NONE	NONE	**Repository rock – rock matrix**	NONE	NONE	a) Dissol./precip. b) Diffusion c) Sorption	Capillary suction	a) Microbial activity b) Radon gener.	Heat conduction	Deformation	Microbial activity	a) Matrix diffusion b) Sorption	NONE	NONE
8	Bentonite expansion	NONE	NONE	NONE	Bentonite expansion	Bentonite expansion	NONE	**Repository rock – fracture system**	NONE	a) Dissol./prec. b) Diffusion c) Sorption d) Colloid filtering e) Erosion	a) Water flow b) Capillary suct.	a) Gas flow b) Microbial activity c) Radon gener.	Heat conduction	Deformation	Microbial activity	a) Matrix diff. b) Sorption c) Diffusion	NONE	NONE
9	NONE	NONE	NONE	NONE	Bentonite expansion	NONE	NONE	NONE	**Rock – rock matrix and fracture systems**	a) Dissol./prec. b) Diffusion c) Sorption d) Colloid filtering e) Erosion	Water flow	a) Gas flow b) Microbial activity c) Radon gen.	Heat conduction	Deformation	Microbial activity	a) Matrix diff. b) Sorption c) Diffusion	Erosion/ weathering	NONE
10	Mass flow	Mass flow	Mass flow	Mass flow	a) Diss./precip. b) Corrosion c) Ionic strength effects	a) Diss./precip. b) Corrosion c) Ion-exchange d) Water uptake e) Expans/dispers	Dissolution/ precipitation	Dissolution/ precipitation	Dissolution/ precipitation	**Water composition** a) Colloid formation/stability	a) Convection b) Water flow c) Osmosis d) Phase changes	a) Gas dissol./ degassing b) Chemical reactions	Heat conduction	NONE	Microbial activity	a) Diffusion b) Sorption c) Prec./diss. d) Colloid trsp	Mass flow	Mass exchange
11	a) Mass flow b) Rech/disch and pressure c) Erosion d) Biomass flow e) Contamin.trsp	a) Mass flow b) Rech./disch and pressure c) Biomass flow d) Contamin.trsp	a) Mass flow b) Rech./disch and pressure c) Biomass flow d) Contamin.trsp	a) Mass flow b) Rech./disch and pressure c) Biomass flow d) Contamin.trsp	a) Diss./precip. b) Corrosion c) Redistribution	a) Diss./precip. b) Corrosion c) Erosion d) Water uptake	Diss./precip.	a) Diss./precip. b) Erosion	a) Diss./precip. b) Erosion	a) Advection and mixing b) Chemical equilibria c) Erosion d) Conc./dilution	**Hydrology**	a) Saturation b) Diss./degass. c) Two phase flow d) Expansion/ contraction	Heat advection	Water pressure interaction	Advection	a) Advection b) Dispersion c) Gas dissol./ degassing	a) Mass flow b) Disch./rech and pressure c) Biomass flow d) Contamin trsp	a) Mass exchange b) Disch./rech and pressure c) Biomass exch.
12	Gas transport	Gas transport	Gas transport	Gas transport	NONE	NONE	NONE	NONE	NONE	a) Gas dissol./ degassing b) Colloid trsp	a) Saturation b) Two phase flow	**Gas**	a) Heat adv. b) Heat cond.	Gas pressure interaction	a) Biological activity b) Advection-gas	a) Advection-gas b) Colloid trsp	Gas transport	Gas exchange
13	Heat transport	Heat transport	Heat transport	Heat transport	a) Kinetics and equilibria b) Expansion/ contraction	a) Kinetics and equilibria b) Expansion/ contraction	a) Kinetics and equilibria b) Expansion/ contraction	a) Kinetics and equilibria b) Expansion/ contraction	a) Kinetics and equilibria b) Expansion/ contraction	a) Kinetics and equilibria b) Property changes c) Diffusion	Phase changes	a) Expansion/ contraction b) Convection	**Temperature**	Thermal stress interaction	Microbial activity	a) Kinetics and equilibria b) Diffusion c) Soret effect	Heat transport	Heat exchange
14	a) Stress/strain changes b) Rock fallout c) Rock creep	a) Stress/strain changes b) Rock fallout c) Rock creep	a) Stress/strain changes b) Rock fallout c) Rock creep	a) Stress/strain changes b) Rock fallout c) Rock creep	a) Rock creep b) Stress redist. c) Rock fall out	a) Cracking b) Rock creep	Stress redistribution	Stress redistribution	Stress redistribution	NONE	Water pressure interaction	NONE	NONE	**Stress conditions**	NONE	NONE	Change in rock surface location	Stress and strain changes
15	Biomass flow	Biomass flow	Biomass flow	Biomass flow	Microbial growth	Microbial growth	Microbial growth	Microbial growth	Microbial growth	Microbial activity	NONE	Microbial activity	Microbial activity	NONE	**Biological state**	a) Microbial trsp b) Methylation/ transformation	Biomass exchange	Biomass exchange
16	Contaminant transport	Contaminant transport	Contaminant transport	Contaminant transport	Irradiation	Irradiation	Irradiation	a) Irradiation b) Precipitation	Irradiation	a) Radiolysis b) Radionuclide decay c) Degradation	NONE	a) Radiolysis b) Degradation	Heat from decay	NONE	Irradiation (mutation)	**Radionuclides and toxicants** a) Radionuclide decay	Contaminant transport	NONE
17	NONE	NONE	NONE	NONE	a) Root penetration b) Borehole penetration	Root penetration	NONE	NONE	a) Consolid. b) Root penetr. c) Erosion/ weath.	Mass flow	a) Rech./disch and wells b) Press. change	Gas transport	Heat transport	a) Mechan. load b) Ice load	a) Root penetr. b) Intrusion c) Biomass exchange	Contaminant transport	**Biosphere (B.C.)**	NONE
18	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	Mass exchange	Rech./disch and pressure	Gas exchange	Heat exchange	Stress and strain changes	Biomass exchange	NONE	NONE	**External rock (B.C.)**

The biosphere matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	**GEOSPHERE (B.C.)**	a) Erosion/weath. b) Change in rock surface location	NONE	NONE	NONE	NONE	NONE	a) Material supply b) Settlement		Discharge/ recharge	Discharge/ recharge	Mass flux	Gas transport	Heat transport	Contaminant transport	NONE
2	a) Mech. load b) Consolidation	**Quaternary deposits** a) Relocation	a) Settlement b) Deposition	a) Settlement b) Consumption	a) Settlement b) Consumption	a) Settlement b) Consumption	a) Settlement b) Consumption	a) Settlement b) Consumption c) Material supply		a) Water transport b) Dehydration	a) Water transport b) Wave formation	a) Resuspension b) Leaching c) Sorpt./desorpt.	a) Resuspension b) Non-biol decomp c) Wind field changes d) Air pressure	a) Radiation b) Heat transport c) Heat storage	a) Sorption/ desorpt. b) Dissolution	Export
3	Root penetration a) Rock b) Tunnels c) Biological	Root growth	**Primary producers** a) Stimul./Inhib.	a) Stimul./Inhib. b) Food supply	a) Stimul./Inhib. b) Food supply	a) Stimul./Inhib. b) Food supply	a) Stimul./Inhib.	a) Stimul./Inhib. b) Food supply d) Material supply		Root uptake	a) Interception b) Retard./Accel. c) Uptake/Excret. d) Covering	a) Uptake./Excret. b) Particle prod	a) Gas uptake/rel b) Part. trap/prod c) Wind retard.	a) Radiation b) Exo/Endo react. c) Heat transp.	a) Uptake/sorpt. b) Excretion c) Degradation d) Growth	Export *detached outflow of plankton*
4	Potential intrusion	a) Decomposition b) Bioturbation	a) Stimul./Inhib.	**Decomposers** a) Stimul/Inhib. b) Food supply c) Feeding	a) Stimul./Inhib. b) Food supply	a) Stimul./Inhib. b) Food supply	a) Stimul./Inhib. b) Food supply	a) Stimul./Inhib. b) Food supply d) Material supply		Decomposition	a) Decomposition b) Retard./Accel. c) Uptake/Excret. d) Movement	a) Uptake./Excret. b) Particle prod	a) Gas uptake/rel b) Part. trap/prod	a) Radiation b) Exo/Endo react. c) Heat transp.	a) Uptake/sorpt. b) Excretion c) Degradation d) Growth	Export
5	Potential intrusion	Bioturbation	a) Stimul/Inhib. c) Feeding	a) Stimul./Inhib. b) Food supply c) Feeding	**Filter feeders** a) Stimul/Inhib. b) Food supply c) Feeding	a) Stimul./Inhib. c) Feeding	a) Stimul./Inhib. b) Food supply c) Feeding	a) Stimul./Inhib. b) Food supply d) Material supply		NONE	a) Water-pumping b) Retard./Accel. c) Uptake/Excret.	a) Uptake./Excret. b) Particle prod	NONE	a) Radiation b) Exo/Endo react. c) Heat transp.	a) Uptake/sorpt. b) Excretion c) Degradation d) Growth	Export *detachment spawn*
6	Potential intrusion	Bioturbation	a) Stimul./Inhib. c) Feeding	a) Stimul./Inhib. b) Food supply c) Feeding	a) Stimul./Inhib. b) Food supply	**Herbivores** a) Stimul/Inhib.	a) Stimul./Inhib. b) Food supply	a) Stimul./Inhib. b) Food supply d) Resource		NONE	a) Movement b) Retard./Accel. c) Uptake/Excret.	a) Uptake./Excret. b) Particle prod	a) Gas uptake/rel b) Part. trap/prod	a) Radiation b) Exo/Endo react. c) Heat transp.	a) Uptake/sorpt. b) Excretion c) Degradation d) Growth	Export
7	Potential intrusion	Bioturbation	a) Stimul./Inhib.	a) Stimul./Inhib. b) Food supply c) Feeding	a) Stimul./Inhib. b) Food supply c) Feeding	a) Stimul./Inhib. c) Feeding	**Carnivores** a) Stimul/Inhib. b) Food supply c) Feeding	a) Stimul./Inhib. b) Food supply c) Feeding d) Resource		NONE	a) Movement b) Retard./Accel. c) Uptake/Excret.	a) Uptake./Excret. b) Particle prod	a) Gas uptake/rel b) Part. trap/prod	a) Radiation b) Exo/Endo react. c) Heat transp.	a) Uptake/sorpt. b) Excretion c) Degradation d) Growth	Export *swimming running*
8	Borehole intrusion	Disturbance *(dredging, digging)*	a) Stimul./Inhib. c) Feeding d) Dispersal/ Extermination	a) Stimul./Inhib. b) Food supply c) Feeding d) Dispersal/ Extermination	a) Stimul./Inhib. c) Feeding d) Dispersal/ Extermination	a) Stimul./Inhib. c) Feeding d) Dispersal/ Extermination	a) Stimul./Inhib. b) Food supply c) Feeding d) Dispersal/ Extermination e) Material use	**Humans** a) Stimul/Inhib.		a) Water extraction b) Artific.infiltr.	a) Movement b) Retard./Accel. c) Uptake/Excret. d) Covering	a) Excretion b) Filtering c) Pollution	a) Gas uptake/rel b) Part. trap/prod c) Pollution d) Wind retard/acc.	a) Radiation b) Exo/Endo react. c) Heat transp. d) Antropogen eff	a) Uptake/sorpt. b) Excretion c) Degradation d) Growth	a) Export of energy b) Emigration?
9									NONE (former topography)							
10	a) Rech./disch. b) Press. change c) Mass flux d) Erosion/weath.	a) Erosion b) Water content change	a) Settlement b) Water uptake	a) Settlement b) Water uptake	NONE	a) Settlement b) Water uptake	a) Settlement b) Water uptake	a) Settlement b) Water use		Water in Quaternary deposits	Discharge (recharge)	a) Erosion b) Mixing c) Dens. effects	a) Evapo./Cond. b) Sublimation	a) Heat transp. b) Heat storage	Mixing	Export
11	a) Rech./disch. b) Press. change c) Mass flux d) Erosion/weath. e) Ice-load	Erosion *(icescoring)*	a) Settlement b) Relocation c) Water uptake	a) Settlement b) Relocation c) Water uptake	a) Settlement b) Relocation c) Water uptake	a) Settlement b) Relocation c) Water uptake	a) Settlement b) Relocation c) Water uptake	a) Settlement b) Relocation c) Water use		Recharge (discharge)	**Surface water**	a) Mixing b) Dens. effects	a) Evapo./Cond. b) Sublimation c) Erosion *(seaspray/ snowdrift)*	a) Radiation b) Exo/Endo react. c) Heat transp. d) Heat storage e) Light reflection	Mixing	Export/import
12	a) Mass flux b) Erosion/weath.	a) Sedimentation b) Precip./dissol. c) Erosion/weath.	a) Settlement b) Stimul./Inhib. c) Light attenu.	a) Settlement b) Stimul./Inhib.	a) Settlement b) Stimul./Inhib.	a) Settlement b) Stimul./Inhib.	a) Settlement b) Stimul./Inhib.	a) Settlement b) Stimul./Inhib.		Water transport	Water transport	**Water composition**	a) Spray/Snowdrift b) Dissol./Degas.	a) Exo/Endo react. b) Light absorb. c) Light reflect./ scatt. d) Adiab. compr.	a) Sorpt./desorpt. b) Dissol./precip. c) Sedimentation	Export
13	Gas transport	a) Erosion b) Deposition c) Oxidation	a) Settlement b) Stimul./Inhib. c) Relocation d) Depos./Remov.	a) Settlement b) Stimul./Inhib. c) Relocation d) Depos./Remov.	NONE	a) Settlement b) Stimul./Inhib. c) Relocation d) Depos./Remov.	a) Settlement b) Stimul./Inhib. c) Relocation d) Depos./Remov.	a) Settlement b) Stimul./Inhib. c) Relocation d) Depos./Remov.		a) Water transport b) Evapo./cond. c) Sublimation	a) Water transport b) Evapo./Cond. c) Precipitation d) Wind stress e) Sublimation	a) Precipitation b) Deposition c) Evapo./Cond. d) Dissol./Degas.	Gas ------------- Atmosphere	a) Radiation b) Exo/Endo react. c) Heat transp. d) Heat storage e) Adiab.temp. change f) Phase changes	a) Mixing b) Sorpt./desorpt. c) Photochem. reactions	Export
14	a) Heat transport b) Erosion/weath.	a) Weathering b) Thermal expans/contr	a) Settlement b) Stimul./Inhib.	a) Settlement b) Stimul./Inhib.	a) Settlement b) Stimul./Inhib.	a) Settlement b) Stimul./Inhib.	a) Settlement b) Stimul./Inhib.	a) Settlement b) Stimul./Inhib.		Phase transitions	a) Phase transitions b) Convection	a) Kinetics & chem equil. b) Property changes c) Mixing	a) Pressure change b) Phase transitions	Temperature	a) Kinetics & chem equil. b) Phase transitions	Export of heat
15	Contaminant transport	a) Surface dep./uptake b) Irradiation	a) Int. exposure b) Ext. exposure	a) Int. exposure b) Ext. exposure	a) Int. exposure b) Ext. exposure	a) Int. exposure b) Ext. exposure	a) Int. exposure b) Ext. exposure	a) Int. exposure b) Ext. exposure		NONE	NONE	a) Radiolysis b) Stab. isotopes c) Chem. react.	Phase transition	Heat from decay	**Radionuclides and toxicants** a) Decay	Export
16	NONE	a) Import b) Land rise	a) Import b) Insolation	Import	Import	Import	Import	a) Import of energy b) Immigration		Import	a) Sea level changes b) Sea currents	Import	a) Import b) Photochem- reactions	a) Import of heat b) Insolation	External load of contaminants	**External conditions (B.C.)**