Third Questionnaire of the OECD-NEA International Peer Review Team

1 Introduction

At the request of SSM, the OECD-NEA International Review Team (IRT) is examining the long-term safety aspects of the application by SKB for a construction license of a spent fuel repository in Sweden. It was anticipated that the written questions arising from IRT's review of the application would result in a total of three questionnaires. This is the third questionnaire.

This third set of questions is based on further study of SKB TR-11-01 Long-term safety for the final repository for spent nuclear fuel at Forsmark, main report of the SR-Site Project, Volumes I, II and III, and of supporting documentation prepared and provided by SKB. There are also some further questions that arose from the SKB's answers to IRT Questionnaire 2 (provided by SKB on September 6, 2011). These questions are identified as follow-up questions (QFU) to Questionnaire 2 in the present Questionnaire.

The questions in this third questionnaire are numbered as in Questionnaire 2 (but with (3) in the question number) and organized per IRT member in sections 2.1 through 2.9. Therefore, SKB may again find partial overlap in some of the questions, in which case the provision of one answer would suffice, providing that SKB indicates which questions are being answered in one response.

Note that the IRT would like to receive a number of reports (as specified by several of the reviewers in the following questions).

2 Questions from IRT Members

The IRT members encompass a diverse knowledge and experience set, and have reviewed the information in SKB TR-11-01 and supporting documentation from individual and unique view points. In order to reflect this diversity, the questions posed by each IRT member were not pooled together by subject but are presented as received from each individual IRT member. The questions were provided with a number and minor editing was applied.

2.1 Questions from IRT Member 1

2.1.1 Follow-up Questions to Questionnaire 2

QFU 2.1.1: Questions related to answer to Q 2.1.2
Is a 1 cm open slot between the canister and the bentonite blocks realistic for a feasible canister emplacement operation (especially under wet conditions)? Has this specific aspect of the canister emplacement operation already been demonstrated?

QFU 2.1.2: Question related to answer to Q 2.1.5
The referenced report (TR-06-30) seems to be focused on mineralogical properties of a set of different bentonites, with little emphasis on hydraulic and mechanical properties. Is there any other SKB report more focused on thermal, hydraulic and mechanical performance of the two bentonite materials considered in SR-Site?

QFU 2.1.3: Question related to answer to Q 2.1.8
Several laboratory tests performed on Febex bentonite (Ca-based bentonite) have shown that the final swelling strain (and hence the sealing capacity of the bentonite) decreases very significantly with increasing temperature. Question 2.1.8 was related to this aspect of bentonite performance. Has SKB analyzed the swelling strain evolution with time of the two selected materials for different temperatures and dry densities?

2.1.2 Questionnaire 3 Questions

No new questions for Questionnaire 3 from Reviewer 1

2.2 Questions from IRT Member 2

2.2.1 Follow-up Questions to Questionnaire 2

QFU 2.2.1: Questions related to answers to Q 2.2.7 and Q 2.2.12
There is no specification of further experiments given in the answers and/or the documents. What is the schedule and timetable of experiments and investigations to clarify the open questions referring to copper corrosion under repository conditions? The outlook by F. King at Eurocorr implies further actions but does not give any details.

QFU 2.2.2: Question related to answers to Q 2. 2.10 and Q 2.2.13
Due to the academic discussions about the effect of pure water on copper corrosion, the approach via calculations does not appear to be completely satisfying: How does SKB treat the experimental confirmation of the discussed effects? If hydrogen is produced: What might be the effect of hydrogen atoms and/or molecules to the surrounding barrier formed by bentonite? How does this affect the transport properties?

QFU 2.2.3: Question related to answers to Q 2.2.14
The answer does not cover the question of giving a maximum value for the mechanical properties (hardness, residual stresses,…). There should be a procedure for the manufacturing of the canisters paying attention to cold working, influence of hest by welding and the possible deformation by surrounding rock movements. How would such a cold working influence the susceptibility to SCC?

2.2.2 Questionnaire 3 Questions

No new questions for Questionnaire 3 from Reviewer 2

2.3 Questions from IRT Member 3

2.3.1 Follow-up Questions to Questionnaire 2

No follow-up questions to answers in Questionnaire 2 from Reviewer 3

2.3.2 Questionnaire 3 Questions

New questions from Reviewer 3 are based on Reference Evolution (TR-11-01 Chapters 10.1 – 10.4): Thermal, mechanical and hydrogeological issues

Q 2.3.1 (3): p.296ff: The opening of the underground excavations will create a massive hydraulic sink with groundwater flow towards the excavations, a large scale change in hydraulic head fields, and a very significant reduction of pore pressures at the kilometer scale around the excavations. As shown in Zangerl et al. 2008a,b[1] such a pore pressure drawdown in fractured gneisses can cause significant surface deformations (in the order of 10 cm), shearing of pre-existing large scale fractures (indicated by surface displacements, but not definitely verified), and seismic activity (not yet published). Such scenarios could have an impact on the long term safety of the repository and possibly also on the nearby NNP (as long as the distance is a few kilometers only). Have such scenarios been considered?

Q 2.3.2 (3): p. 296: Figure 10-6a (left) shows anomalies cross-cutting the middle part of the tunnel. What is their origin?

Q 2.3.3 (3): p. 299: What is the assumed lifetime of the grout? Is grouting only relevant for the excavation and operational phase?

Q 2.3.4 (3): p. 300 & p. 302: The model predicts inflow mainly at the boundaries of the repository. When comparing inflow predictions with encountered inflows in underground excavations, not only the rates but also the locations normally differ very substantially. Why can you rely (so much) on these simplified modeling results?

Q 2.3.5 (3): p. 301: Systematic comparisons between modelled tunnel inflows and observed tunnel inflows[2] show that also the transient rates (not only the locations and steady state rates) deviate very significantly. Many real inflows show much more dramatic decreases in rate than the model predictions, mainly due to limited extent

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[1] Zangerl, C., Eberhardt, E., Evans, K. and Loew, S. (2008). "Consolidation settlements above deep tunnels in fractured crystalline rock: Part 1—Investigations above the Gotthard highway tunnel." *International Journal of Rock Mechanics and Mining Science* ***45***: 1195-1211.
Zangerl, C., Evans, K., Eberhardt, E. and Loew, S. (2008). "Consolidation settlements above deep tunnels in fractured crystalline rock: Part 2 –Numerical analysis of the Gotthard highway tunnel case study." *International Journal of Rock Mechanics and Mining Science* ***45***: 1211-1236.

[2] e.g. Masset, O. and Loew, S. (2010). "Hydraulic Conductivity Distributions Derived from Inflows to 136 km of Tunnels and Galleries in Crystalline Rocks (Central Alps, Switzerland) " *Hydrogeology Journal* ***18***: 863-891.

conductive fractures and possibly also some HM coupling. Has this been taken into account when the inflow rejection criterion was defined?

Q 2.3.6 (3): p. 319: In the Alps we observe a little ice age between 1250 and 1850 AD. Has such an event not also occurred in Fennoscandinavia?

Q 2.3.7 (3): p. 330ff, p. 460ff: It could be expected that normal-stress-transmissivity models are very uncertain, because the stress-aperture relationships vary a lot between different lab experiments[3] and the aperture-transmissivity relationship is also highly uncertain. The cubic laws normally employed in UDEC and 3DEC yield very uncertain results. Why do you trust these modeling results so much?

Q 2.3.8 (3): p. 330ff, p. 460ff: Which quantitative relationships have been used to assess transmissivity changes in relation to fracture shear deformation?

Q 2.3.9 (3): p. 341: The flow rates given here for operational stage A are low (one cannot call 1 L/s high). Do these values refer to a sealed repository and complete bentonite swelling? Does the given rate indeed correspond to the total flow rate at operational stage A?

Q 2.3.10 (3): p. 341: Why does the water that saturates the backfilled repository originates predominantly from the top of the model domain? In many deep tunnels in crystalline rocks, significant flow from below the tunnel can also be observed. This can be modeled with the assumption of a significant decrease of hydraulic conductivity with depth (which should also be the case for Fosmark?).

Q 2.3.11 (3): p. 459: a rock mass deformation module of 40-45 GPa seems still quite high when considering fracturing at Forsmark. How has this value been estimated in detail?

Q 2.3.12 (3): p. 459: what is meant by “residual pore pressure”?

2.4 Questions from IRT Member 4

2.4.1 Follow-up Questions to Questionnaire 2

QFU 2.4.1: Questions related to answer to Q 2.4.1
It is understood that the effects of different methodologies on estimating flow-dimensions and PSS data tend to result in lower flow-dimensionality. It is also understood that SKB principally used PFL data for transmissivity estimation for hydrogeological modeling because SKB considered that PFL results are more representative for the modeling. However, as expressed in the previous question (Q 2.4.1), if the flow dimension is set to be larger than the actual one, the obtained transmissivities should become smaller, and hence, it will result in less conservative values. Because the estimation of actual flow-

[3] Zangerl, C., Evans, K., Eberhardt, E. and Loew, S. (2008). "Normal stiffness of fractures in granitic rock: A compilation of laboratory and in-situ experiments." *International Journal of Rock Mechanics and Mining Science* ***45***: 1500-1508.

dimensions in fractures is very difficult, it is still desirable that SKB provides the IRT further explanation and/or opinion how the effects of possible smaller transmissivity estimation due to the assumption of radial flow are treated/evaluated.

QFU 2.4.2: Questions related to answer to Q 2.4.6
P. 289 on TR-08-05 was reviewed and the discussion in that section of the document was comprehended. However, subsequently another question arose. It is not clear how the hydrogeological situation in the deeper part, i.e., deeper than 200m, is evaluated. Groundwater chemistry data exist for the deeper part; however, pore pressures and/or hydraulic potentials seem not to be presented. Are there data on hydraulic potentials in the deeper part? Was the comparison between the measured hydraulic potential and numerically calculated results made? How does SKB consider the appropriateness of the hydrogeological model, especially in the deeper part?

2.4.2 Questionnaire 3 Questions

Q 2.4.1 (3): Flow paths can change due to climate changes and migration of ice sheets. It is stated that the steady state modeling results are used for particle tracking calculation and the estimation of F-values. Under the changing situation of climate condition, flow paths should change temporally according to the change of the external condition. How does SKB treat the possible effect of the changes of flow paths on the estimations of F-values and advective travel times? Also, are the calculated advective travel times presented in the report, and are the results evaluated to be reasonable? In relation to the previous question Q. 2.4.7, how does the possible remnant excess pore pressure during ice retreat affect the temporal changes of flow paths and the results of the particle tracking study?

Q 2.4.2 (3): Quality control and appropriate management of field data is considered to be crucial for the reliability of the results on the hydrogeological modeling and further discussion based on the model results. For the quality control, in addition to following protocols for field measurements, evaluation and checking of measured data themselves are necessary. How does SKB control and manage the quality of these data?

2.5 Questions from IRT Member 5

2.5.1 Follow-up Questions to Questionnaire 2

QFU 2.5.1: In General:
SKB states that some of the designs (e.g. for canister, plug) have not yet been finalized (see answers to Q.2.5.1. and Q 2.5.4). When does SKB plan to finalize these? Does SKB expect safety relevant changes?

QFU 2.5.2: Questions related to answer to Q 2.5.1
SKB states the quality control of the manufacturing process is not part of the licensing process for the final repository but will be supervised by an authorized body. Which

authorized body will supervise the manufacturing process including quality control? As the canister is the main barrier and essential for providing the safety, is there a cooperation/information exchange between this authorized body and the Swedish Radiation Safety Authority?

QFU 2.5.3: Questions related to answer to Q 2.5.2
SKB states that they are exploring the potential for revising the design premises from a deterministic rule of design premises to a probabilistic one, but the change will only be done if they can prove that safety is not affected. Is a possible revision of the design premises subject to a review/or a licensing process performed by the Swedish Radiation Safety Authority?

QFU 2.5.4: Questions related to answer to Q 2.5.3
According to SKB`s answer damage analysis have been done mostly for BWR inserts and for one PWR case. Is it correct to say that, on this basis, there is currently no valid safety assessment for the disposal of PWR-Spent Fuel at the planned repository? As SKB is carrying out complementary analysis for the PWR insert, what is the time schedule to close this gap in the licensing information?

QFU 2.5.5: Questions related to answer to Q 2.5.19 (and see also Q 2.7.3)
Taking into account the low denudation rates as discussed in the climate report, there is yet no or a very limited safety margin left in the 1 million-year perspective, regarding permafrost influence under extreme conditions. The answer to question 2.7.3 does not contribute much to the exclusion of a deeper repository. On p. 811, SKB states that "placing the repository some 100 m deeper would probably result in a risk contribution similar to the one obtained from the selected depth". If future analysis would reveal concerns about the interaction between permafrost depth and repository depth, would that be an option to strengthen the system's performance and robustness or is this ruled out?

QFU 2.5.6: Questions related to answer to Q 2.5.20
SKB states that the collapse load of the canister is substantially higher than the design load. Has it been taken into consideration to revise the canister design load (currently 45 MPa) in order to better reflect the real properties of the canister (collapse load 100 MPa)? This would ensure that the real safety margin (or a relevant proportion of it) is preserved and that the properties of the canister are not revised in future, maybe for economic reasons, to better reflect the current design load.

QFU 2.5.7: Questions related to answer to Q 2.5.29
SKBs described the organization of funds which should allow SKB to maintain its organisation and personal resources as long as needed. What would happen in case of insolvency of SKB?

QFU 2.5.8: Questions related to answer to Q 2.5.32
SKB answered that sensitivity analyses are carried out at a late stage of the assessment, and the assessment led to no special "handling" afterwards. The identification of input variables should help to understand the impacts of variables in the calculations. After the

identification of sensitive variables, the results of the sensitivity analysis should be used to check whether they correspond to the input-data of the calculation performed before. If not, the calculation has to be repeated by varying the variable's values identified in the sensitivity analysis in order to understand the effects on the calculated dose/risk. One could say that the sensitivity analysis is used to re-check the correctness of the input variables and the validity of the calculated dose/risk.

According to SKB`s answer to Q 2.5.32 it remains unclear whether SKB has taken into account such considerations/calculations. Please explain.

QFU 2.5.9: Questions related to answer to Q 2.5.34
SKB describes in its answer the decisions for selection of certain techniques for BAT discussion. Can SKB provide a list of all techniques which were considered initially?

QFU 2.5.10: Questions related to answer to Q 2.5.36
SKB says it wants to continue the dialogue with municipalities concerned, other stakeholders and public in the future. What is planned in the near future?

2.5.2 Questionnaire 3 Questions

No new questions for Questionnaire 3 from Reviewer 5

2.6 Questions from IRT Member 6

IRT member 6 has no further questions at this point.

2.7 Questions from IRT Member 7

2.7.1 Follow-up Questions to Questionnaire 2

QFU 2.7.1: Questions related to answer to Q 2.7.1
In the answer to Q 2.7.1 SKB states that "When a deposition tunnel has been sealed the main barriers are in place and the bentonite is passively safe". In the answer to Q 2.5.4 SKB states that "The sealing ability of a tunnel plug is only needed during the operational period of the repository". A situation could be imagined where the sealing ability of tunnel plugs would be tested for more than the design lifetime in the case that, for whatever political or economic reason, the repository remains only partially filled. If there were unsealed main tunnels, the sealing ability of deposition tunnel plugs may have to last longer than planned. Should these plugs be designed for longer lives than just the planned operational stage of a repository?

QFU 2.7.2: Questions related to answer to Q 2.7.19
In the answer to question 2.7.19 SKB states that the bentonite will be delivered from the supplier at 17% moisture. This means that the bentonite will not be dried for as long as usual by the supplier, which seems to make economic sense. However, generally most bentonite is dried to a moisture content of about 10% and the microbial experiments with

bentonite at SKB appear to have been carried out with this drier material. This may have made a difference with respect to in situ viability of the microbes present. In uncompacted state at 17% water content, there likely will be more viable bacteria that at 10% water. Is SKB planning to repeat some of the microbial activity experiments with the 17% moisture material?

QFU 2.7.3: Questions related to answer to Q 2.7.26
In SKB's answer it is stated that "….the system can be considered as closed with respect to vapour so severe precipitation of salts cannot occur". However, depending on the temperature distribution, some bentonite shrinkage around the canister and some cracking radially outward from the canisters likely will occur due to water migration as a result of the almost 100^{o}C at the canister surface. Depending on how long this lasts, some cementing of these fractures could be possible due to mineral precipitation (anhydrite for instance). These cracks are expected to heal upon saturation when temperatures moderate and the water returns to the dried-out bentonite, but this may perhaps not occur fast enough or complete enough to prevent fresh, viable microbes to move with the incoming waterfront to the canister surface. This may be a temporary effect but it could conceivably bring viable bacteria, including perhaps SRB close to or at the canister surface (which is now cooler; the initially present microbes would have been inactivated or killed by the high temperature). If SRB produce sulphide at this location, this could have a direct effect on the canister. In TR-10-47 SKB states that migration of microorganisms through compacted bentonite is not well studied. What work is planned by SKB to shed some more light on this question, including transport through incomplete fractures? Some work was done in other countries on this topic (Canada, Japan).

2.7.2 Questionnaire 3 Questions

These new questions are based on review of:

- TR-10-67: An update of the state-of-the-art report on the corrosion of copper under expected conditions in a deep geologic repository. Section 2.3 Microorganisms
- TR-10-58: SR-Site – hydrogeochemical evolution of the Forsmark site. Chapter 8 Evaluation of other geochemical parameters
- TR-10-54: Comparative analysis of safety related site characteristics.
- TR-10-48: Geosphere process report for the safety assessment SR-Site. Chapter 5 Chemical Processes
- TR-10-47: Buffer, backfill and closure report for the safety assessment SR-Site Section 3.5.14 Microbial Processes and Section 3.45.15 Cementation
- TR-10-39: SR-Site -Sulphide content in the groundwater at Forsmark.
- TR-10-19 Principal organic materials in a repository for spent nuclear fuel. Various sections
- R-08-47 Bedrock hydrogeochemistry Forsmark. Chapter 4 Bedrock hydrogeochemistry Forsmark

- Yang, C. et al. Modelling geochemical and microbial consumption of dissolved oxygen after backfilling a high level radioactive waste repository. J. Contaminant Hydrology 93 (2007) 130-148.

Q 2.7.1 (3): In TR-10-39, page 30 (section 3.2.3) SKB states that: "In contrast to the presented views in this report regarding the Forsmark data, the conclusion from the MICROBE experiment, concerning sulphide concentrations, was that the low concentrations generally found during flushing or pumping as well as from the CCC method during the site investigations are artefacts and that the high values represent a more accurate concentration in the ground waters."

This is clearly not the opinion of the authors of TR-10-39, who argue the opposite, i.e., that the low concentrations are the true in situ ones and that the high concentrations are due to SRB activity in borehole sections, lines etc., sustained by the materials placed in the borehole.

The sulphide concentrations are extremely important for the corrosion rate of the canister. Has SKB resolved this contradiction in the data and interpretation between the geochemists and microbiologists? Which conclusion is correct? It is acknowledged that SKB has partially answered this question in the answers to question Q 2.7.37 and Q 2.5.13. Can SKB make report P-10-18 available please?

Q 2.7.2 (3): It is mentioned in several SKB TR reports that the organics in the bentonite are largely unavailable for biological reactions (e.g., TR-10-19). This is at first glance a reasonable assumption considering that this material has been in the clay naturally for a long time and if available, would have been consumed in microbial reactions a long time ago. However, the production of bentonite includes a heating (drying) step and this may make any complex organic matter naturally present more available for microbiological reactions. In addition, the effects of the initial heating phase on the bentonite surrounding the canisters may further break down this complex organic matter such that it becomes more bio-available.

It was shown in studies in Canada* that organic matter from bentonite-based buffer materials can be released increasingly upon heat treatment and that this organic matter appeared to stimulate microbial activity. In a repository setting organic matter from the bentonite could diffuse to interfaces. Microbial activity could, therefore, perhaps be stimulation at rock-bentonite interfaces where water comes in by diffusion and a gel layer is formed. Increased numbers of viable bacteria in bentonite (compared to clay matrix numbers) have been observed in other programs at such interfaces.

*References: Vilks et al. 1998. Radiochim. Acta 82, 385-391; Stroes-Gascoyne et al. 1997. Mat. Res. Soc. Symp. Proc. 465, 987-994.

Q 2.7.3 (3): TR-10-47 p. 165 (section 3.5.14): How serious is the possibility that microbial activity (i.e., Fe(III) reduction), will affect the swelling capacity of the

bentonite? A Japanese paper* suggests it would be minimal. What is SKB's opinion on this?

*Reference: Nakano, M., and K. Kawamura. 2010. Applied Clay Science 47, 43-50.

Q 2.7.4 (3): R-08-47 page 124 (section 4.10.4) indicates lower confidence with respect to data on U-bearing minerals in fractures. In Canada at the URL drawdown caused increased U in the groundwater, to the point that the pumped out-water in the holding pond had to be treated before it could be released to the environment. Is anything like this expected at Forsmark? Has anything like this been seen at Äspö? What measures would be taken at Forsmark to avoid high U concentrations due to drawdown?

Q 2.7.5 (3): TR-10-39 P. 17 (section 3.1.1). Why would heavy pumping reduce microbial activity? If dilution with water from fractures that contain less active bacteria is the argument, the counter argument could be made, i.e., that heavy pumping could also increase sulphate reduction if water from very active fractures was pulled it. Could dislodging of biofilm material, as a result of heavy pumping, provide nutrients that would subsequently increase microbial activity in stagnant borehole water?

Q 2.7.6 (3): RE: Biofilms in fractures: Has SKB carried out any work to look at naturally occurring biofilms on fracture surfaces in recovered core? What is the percentage sessile versus planktonic microbial biomass in the crystalline system? A common opinion is that most microbes in oligotrophic systems such as crystalline rock are expected to form biofilms but that is not always seen*. There are not many data sets available in which core and water are analyzed from the same source. What is SKB's opinion on this? Does SKB think it has a good idea of the in situ populations by just sampling the water?

*Reference: Lehman, R.M., "Understanding of aquifer microbiology is tightly linked to sampling approaches", *Geomicrobiology Journal*, Vol. 24, 2007, pp. 331-341.

Q 2.7.7 (3): In TR-10-48 (P. 178 section 5.7.6) SKB states that after closure [of the repository] microbial activity will continue at a high rate, correlated with temperature. Where is the location of this activity? It is agreed that the activity will not occur much in the bentonite because of its high compaction (high SW. P., low a_w). Is the activity in the backfill and in the groundwater in the fractures? Why would SKB expect to always have higher microbial activity due to higher temperatures? Isn't it the case that most microbes in situ (in the groundwater) would probably be borderline psychrophilic and would first have to adapt to the higher temperatures? There are certainly optimum temperatures for most bacteria but with a canister output temperature of close to 100°C it is conceivable that in certain locations in a repository the temperature would be higher than the optimum temperature, certainly for the mostly psychrophilic population in the groundwater? Has SKB looked into the temperature sensitivity of the bacteria in groundwater samples and in sealing materials?

Q 2.7.8 (3): In TR-10-48 page 221 (section 5.13.9) SKB states that "Information on grouting materials is difficult to extract and there may be more information available." Is

SKB actively looking? Would information from nuclear reactors and containment be of use here?

2.8 Questions from IRT Member 8

IRT member 8 has no further questions at this point.

2.9 Questions from IRT Member 9

2.9.1 Follow-up Questions to Questionnaire 2

QFU 2.9.1: Questions related to answers to Q 2.2.2 and Q 2.5.1
TR-10-14 chapter 5 and TR-10-12 Section 5.3 for copper canister QC were reviewed. The answer to Q 2.5.1 implies SKB has not yet worked out all the details on inspecting the canister and the canister inserts. If this is correct, what are the technical bases SKB used to determine the probability that a "defective" canister or insert would not be detected by the yet-to-be-selected NDE methods? Was human error (for example, human error in NDE inspection) also considered when developing the probabilities? (Apparently neither SKB document 1175208 nor 1179633 are published and it is, therefore, not possible to check these. Can these documents be made available?).

In Section 5.2.10 of TR-10-14, SKB states that 47 BWR inserts and 8 PWR inserts were manufactured for the testing program "prior to 2008". Furthermore, this section states that only five BWR inserts and three PWR inserts were used to test for conformance to the required specifications. Are these, then, the total number of inserts upon which projections of insert failure probabilities are made?

QFU 2.9.2: Question related to answer to Q 2.5.13
It is unclear from SKB's response whether the "anomalous sulphide production" remains a concern even with adjusted groundwater monitoring procedures. Please clarify.

QFU 2.9.3: Question related to answer to Q 2.5.22
SKB's response provides a seismic probability value of less than one percent for the first 1000 years. What is the probability over the one million-year assessment period?

QFU 2.9.4: Question related to answer to Q 2.5.23
What is the "higher number … for the shear load scenario"?

QFU 2.9.5: Question related to answers to Q 2.9.1
It was not possible to check SKB's response because TR-09-22 could not be obtained from the SKB web site. The argument for the minimal effect of 600g of residual water on the cast iron insert was understood. Are there other impacts of the residual water on the UO_2 pellets themselves?

QFU 2.9.6: Question related to answer to Q 2.9.4
Where can it be found how SKB "converts" the probability of detection of flaws into the

probability that a canister will have particular degraded characteristics for the performance assessment?

QFU 2.9.7: Question related to answer to Q 2.9.7
The SKB response still does not directly address how SKB took a limited set of inspection data and extrapolated to their estimates of the anticipated number of defects for the entire fleet of disposal canisters.

QFU 2.9.8: Question related to answer to Q 2.9.37
Potentially, the primary difference in fuel characteristics with newer spent fuel will be the burn-up. Does TR-10-13 take this evolution of burn-up values into account?

2.9.2 Questionnaire 3 Questions

Q 2.9.1 (3): RE Table 5-9 on P. 172: It is unclear how SKB arrives at the fraction of canisters with the specified canister thickness values shown in TR-11-01 Table 5-9 based on a relatively limited set of test values. For example, how does SKB arrive at the conclusion that "a few per thousand" have the stated thickness range based on the limited number of tests?

3 Editorial comments

While the overall quality of editing of TR-11-01 is excellent, a number of small grammatical or typing errors were noted while reviewing TR-11-01 Volumes I, II and III. Suggested corrections are shown *in italics*. These are provided for SKB's information only and do not require a reply from SKB.

P. 17 first line under S2.2: The Forsmark site is located in *the* northern part….

P. 22 fourth paragraph: …deposition holes are place*d*, not place

P. 205: Twice on this page the reader is referred to the previous section where monitoring is discussed. However, there is no discussion, just a referral to a report on monitoring.

P. 241 Table 7-8 not mentioned in text

P. 256 last line in paragraph named buffer freezing: thawing, not thawning

P. 276 second line under Data recommended for use in SR-Site modelling: ..often in *the* form of…

P. 303: 4th line from bottom: If the pellet*s* filling the seal…

P. 305: 2nd last line in paragraph above Erosion estimates in deposition holes:: However, measurements…. Add space before m

p. 356 Fig. 10-38 in legend black dots should be red dots

P. 361 3rd line below Fig. 10-42, should say "dissolved" sulphide content; one cannot access the precipitated sulphide. Last line on same page: sulphide should be sulphate

P. 362 second line in paragraph above Fig. 10-43: sulphide should be sulphate

P. 387: last line of second-last paragraph: section 10.3.10 is not about buffer erosion but about buffer and backfill chemical erosion; should be section 10.3.11.

P. 389: middle paragraph: Looks as if this paragraph has a different font, line spacing closer?

P. 396: Figure 10.68: add the word smectite to dissolution rate axis, such that figure can be understood without referring to text.

P. 413: decrease in instead of decreasein (space between words missing)

P. 417: Osmotic effects: first sentence have word(s) missing? According to what…?

P. 423: One but last paragraph: where is this subsection on SRB in B&B?

P. 424 Figure 10-88: Typo in legend of figure: the blue crosses represent (plural)

P. 432: Sub-heading near top of page: Should be: Geosphere (not rock) safety functions, as in Table 10-2.

P. 433: EDZ (if it exist*s*) last line first paragraph

P. 435: middle paragraph, 3rd last line: intersecting deposition tunnel*s*. Same on P. 436 last bullet: tunnel*s* or *a* tunnel.

P. 440: Figure 10-96: …result*s* in…..not result in: caption of Figure 10-96

P. 444: first paragraph: Use: "Very little is known…" and …"as is understood today"….. the "we" style does not occur in this report.

P. 446: 3rd last paragraph, first line: Talik*s*

P. 446: one but last line, add "the" last glacial cycle

P. 457: third line from above: *a*ffect instead of effect

P. 465 3rd line of 1st paragraph: ..should not exceed 5 cm (safety function R3b), and…. Add brackets (as in next line)

P. 468: 7th line from bottom one but last paragraph: ..endglacial earthquakes during *and* following

P. 492 first line of Performance measures: …are Darcy flux (*q*), advective travel time…. Add comma after (*q*)

P. 512: Middle of page: 2nd last line 4th paragraph *out in* instead of outin

P. 513: 3rd line 2nd paragraph: *calculate* instead of calculated

P. 525: Middle of Page: Birgesson et al *have*, not has

P. 531: 4th line 6th paragraph: *for about* instead of forabout

P. 538: last line 6th paragraph: *43.5* MPa, not 43 MPa.

P. 538 last line and 543 last line 3rd paragraph: *R3b*, not R3a.

P. 540: last line 5th paragraph: *for*, not for for

P. 541: 6th line 3rd paragraph: *does*, not do

P. 544: 7th line from bottom: ocean *water* (add water)

P. 570: Top of table: should FHA be in red? It is not different from the base case.

P. 571: 2nd line above 12.1.2: scenarios *are*, not is

P. 578: 3rd line 7th paragraph : ….of time during..., not of time *of* during... (remove *of*)

P. 596: third line from top: However, *no*..., rather than However, No... (remove capital). Two lines lower: *therefore* instead of thereby?

P. 598 1st line under Initial copper coverage: …was evaluated extensively (change order of words)

P. 599: 3rd line 4th paragraph: Brackets in wrong place? Hydrogen is not organic matter. Add bracket after biofilms and remove it at end of sentence.

P. 600: first line: data indicate, not indicates, data is plural

P. 621: 7th line from bottom: ..this does not reduce..., not reduce*d*

P. 629: 2nd last line 2nd paragraph: indicate*s*, not indicate

P. 630: 7th line 2nd paragraph: affect, not affect*s*; 3rd line from bottom of 3rd paragraph: contain*ed*, not contain (Holocene is past tense)

P. 631: 2nd line 2nd paragraph: reflect, not reflect*s*

P. 638: 8th line from bottom of page: However, for two radionuclides have… should be: However, two radionuclides have….; remove *for*

P. 645: 2nd line from bottom of 4th paragraph: *do* not; not does not; LDF's is plural

P. 655: 1st line, 2nd paragraph: occur; not occur*s*; failures is plural

P. 679: 6th line 2nd paragraph:: move slash (/) to after Geosphere Process report

P. 700: 1st line 3rd paragraph: None; the vast amount…. Change the comma to a semi-colon

P. 700: last line: *still not*… rather than not still

P. 705: 2nd line 2nd paragraph: offer*s*, not offer; pinhole is singular

P. 711: bullet A: *causing*…, instead of to cause.. the original sentence does not read well.

P. 713: 4th line from bottom: add *later in this section* after Fig 13-67.

P. 722: 7th line 5th paragraph:: Add gas *generated from corrosion* inside the container; sentence makes not enough sense otherwise.

P. 723: bullet 3: produce, not produce*s*

P. 725: 1st line 2nd paragraph: where no advective conditions occur in deposition holes; the sentence "as is" is colloquial.

P. 736: 2nd lat line above Candidate issues for the corrosion scenario: do not misunderstand issue on table for discussion, table here is Table 13-13; repeat Table 13-13 or say *this Table*

P. 740: top line of radiotoxic material…, not of *the* radiotoxic material

P. 740: 9th line from bottom: ongoing emissions… *have* no…, rather than has no…; emissions are plural

P. 743: 6th line 5th paragraph: site, not site*s*?

P. 756: 5th line 4th paragraph: to either the… rather than to either to the…; take "to" out:

P. 759: Figure 14-5, y-axis scale, is the unit correct? Should it be 10^{-6} etc., microSv?

P. 761: 1st line 2nd paragraph: fail*s*, not fail

P. 764: 5th line 1st paragraph: wa*t*er, not waer

P. 775: 3rd line 3rd paragraph: premise, not premise*s*?

P. 781: 4th line 2nd paragraph: details *are* neglected, not is neglected

P. 784: 3rd line 7th paragraph: studies reveal, not reveal*s*

P. 786:2nd line 4th paragraph: *the* same rather than same

P. 788: 5th line 2nd paragraph: occur*s* instead of occur

P. 788: 7th line from bottom: *uranium containing* or *uranium-containing* instead of uraniumcontaining

P. 798: 11th line from top: not, neither nor is a double negative… Better to say:… is not strongly affected by *either* societal changes *or*….

P. 809: 4th line 5th paragraph: *fewer* rather than less

P. 810: 3rd line from top in *the* above, or above; add *the* or remove *in*

P. 818: 4th line from top: design *basis value*, not design basisvalue

P. 824: 4th line from top: ...maintained reflect.., not …maintainedreflect…

P. 825: 9th line from top: remove *such*

P. 840: 12th line from bottom: values for input parameters, not values for input parameter values. Remove last *values*

Throughout the report (Vol I, II and III) there are several occurrences where the word "like" is used rather than "such as". Example: "This depends not only on the external conditions *like* the size of a future glacial load. It is better grammatically to use "such as" instead of "like".