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Summary

The objective of this report is to describe the radionuclide release and dose calculations for the SFR 1 repository within the SAFE study.

A number of calculation cases for quantitative analyses have been defined based on the expected development of the conditions in the repository, rock and biosphere for a base scenario and for other scenarios.

In this study three cases are analysed within the base scenario to illustrate the expected development in the near field, i.e. the vaults and Silo including the waste and technical barriers. The main case with intact barriers, a variation case with degraded technical barriers after 1000 years and a variation case with influence of gas. The variation case with influence of gas is presented in Moreno *et al.* (2001). The influence of the surrounding rock on the release of radionuclides is illustrated with two cases; included or neglected geosphere. Changes in discharge points and ecosystems in the biosphere are studied by calculation of human dose for a reasonable biosphere development, two variations of the development of the ecosystem (mire and well) as well as today's biosphere during the whole time period. The reasonable case assumes that the release of radionuclides from the time for repository closure until 5000 AD is to a coast recipient that corresponds to a part of the present Öregrundsgrepen. The ongoing land rise will decrease the size of Öregrundsgrepen with time. For the time period 4000 AD to 5000 AD the water volume and water turn over is thus assumed to be less than today. At 5000 AD the radionuclides are released to a lake that is developed in the area. This lake will remain as recipient until 8000 AD where after the radionuclides are assumed to be released to agricultural land until 12 000 AD.

In addition to the base scenario, calculations are performed for some other scenarios. The other scenarios include; initially degraded barriers, influence of chemicals, a combined effect of degraded barriers and influence of chemicals, permafrost and human intrusion.

The result for the base scenario with intact barriers and a reasonable biosphere development is an initial dose of about 10^{-8} Sv/yr determined by ^{137}Cs released from BLA. The maximum total dose for the whole SFR 1 repository is $4 \cdot 10^{-6}$ Sv/yr at 5000 AD totally dominated by organic ^{14}C from the Silo. The maximum dose if the release occurs to a mire area is $6 \cdot 10^{-6}$ Sv/yr. The dose is initially dominated by ^{239}Pu and ^{240}Pu from BLA and later by ^{79}Se. The maximum dose if the release occurs to a well with a recharge area from all vaults is $4 \cdot 10^{-4}$ Sv/yr. The dose is totally dominated by ^{239}Pu and ^{240}Pu from BLA. The alternative well with a recharge area from the Silo results in a maximum dose of $5 \cdot 10^{-5}$ Sv/yr, dominated by organic ^{14}C. In the case with release to today's biosphere the maximum dose is obtained directly after repository closure from release of ^{137}Cs from BLA at a level of 10^{-8} Sv/yr.

The case with degraded technical barriers results in a maximum dose for SFR 1 for all studied biospheres that is up to a factor three higher than that for intact barriers. The largest increase in dose is obtained for release from the Silo to mire.

Sammanfattning

Syftet med denna rapport är att beskriva radionuklidtransport- och dosberäkningarna för SFR 1 inom SAFE studien.

För den kvantitativa analysen har ett antal beräkningsfall definierats baserat på den förväntade utvecklingen av förhållandena i förvaret, omgivande berg och biosfären för ett basscenario och för övriga scenarier.

I denna studie analyseras tre fall inom basscenariot för att illustrera den förväntade utvecklingen i närzonen, bergsalarna och Silon inklusive avfall och tekniska barriärer. Huvudfallet med intakta barriärer, ett variationsfall med degraderade tekniska barriärer efter 1000 år och ett variationsfall med inverkan av gas. Variationsfallet med inverkan av gas presenteras i Moreno *et al.* (2001). Inverkan av det omgivande berget på radionuklidutsläppet illustreras i två beräkningsfall, inkluderad eller försummad geosfär. Förändringar i utsläppspunkt och ekosystem i biosfären studeras i beräkningarna av dos till människa för en rimlig biosfärsutveckling, två alternativa utvecklingar av ekosystemet (myr och brunn) liksom dagens biosfär för hela tidsperioden. I det rimliga fallet antas att utsläppet av radionuklider från förvarets förslutning till 5000 AD sker till en kustrecipient som motsvarar en del av den nuvarande Öregrunsgrepen. Den pågående landhöjningen medför att storleken på Öregrundsgrepen minskar med tiden. För tidsperioden 4000 AD till 5000 AD antas därför att vattenvolymen och vattenomsättningen är mindre än idag. Det antas vidare att en sjö har bildats i området och att denna sjö utgör recipient för utsläpp av radionuklider mellan 5000 ADoch 8000 AD. Från 8000 AD till och med 12 000 AD släpps nukliderna ut till ett jordbruksområde.

Beräkningar har förutom för basscenariot genomförts för ett antal övriga scenarier. Dessa scenarier omfattar initialt degraderade barriärer, inverkan av kemikalier, en kombinerad effekt av degraderade barriärer efter 1000 år och kemikalier, permafrost och slutligen ett intrångsscenario.

Resultatet för basscenariot med intakta barriärer och en rimlig biosfärsutveckling är en initial dos på ungefär 10^{-8} Sv/år som domineras av utsläpp av ^{137}Cs från BLA. Den totala maximaldosen för utsläpp från hela SFR 1 är $4 \cdot 10^{-6}$ Sv/år vilket erhålls år 5000 AD. Dosen domineras totalt av utsläppet av organiskt ^{14}C från Silon. Om utsläppet istället sker till ett myrområde erhålls en maximal dos på $6 \cdot 10^{-6}$ Sv/år. Dosen domineras till en början av ^{239}Pu och ^{240}Pu från BLA och senare av ^{79}Se. Utsläpp av radionuklider från de fyra bergsalarna till en brunn ger som mest en totaldos på $4 \cdot 10^{-4}$ Sv/år, vilken domineras helt och hållet av utsläpp av ^{239}Pu och ^{240}Pu från BLA. Motsvarande utsläpp från Silon ger en maximal totaldos på $5 \cdot 10^{-5}$ Sv/år dominerad av organiskt ^{14}C. Vid utsläpp till dagens biosfär erhålls den maximala dosen omedelbart efter förvarets förslutning. Den maximala dosen är ungefär 10^{-8} Sv/år och domineras av ^{137}Cs från BLA.

Beräkningsfallet med degraderade tekniska barriärer ger en maximal dos för hela SFR 1 för alla studerade biosfärer som är upp till tre gånger högre än för fallet med intakta barriärer. Den största ökningen i dos erhålls för utsläpp från Silon till en myr.

Contents

Appendices

1 Introduction

1.1 Background

Differences between this study and older studies of SFR 1 that influences the calculations and results of radionuclide release are:

The waste inventory has been updated, based on new detailed information of produced and planned waste (Riggare and Johansson, 2001). The total activity content is unchanged, 10^{16} Bq, but the distribution between different nuclides is different. The radionuclide inventory is given in detail, i.e. in each waste package instead of in each repository part only. This implies a possibility to describe the radionuclide release better.

New hydrogeological calculations (Holmén and Stigsson, 2001a) result in a more detailed description of the water flow inside the repository parts. The water flow rates inside the repository are lower in this study, since they were chosen very pessimistic in the older studies due to the lack of detailed information. Although the new near-field calculations are complex and many input parameters are changed the decrease in water flow is one of the main reasons to the lower near-field release rates for most calculation cases compared to the previous studies.

All input data (SKB, 2001a) have been thoroughly reviewed and many small changes were performed compared to older studies. Of major importance in the near field is decreased sorption capacity for nickel.

The near-field model set up to describe the release is made more complex, to be able to include the more detailed information on the inventory and water flow. This model may be seen as a somewhat simplified three-dimensional model. Older studies (Wiborgh *et al.*, 1987; Lindgren and Pers, 1991) were performed with a model describing different release path separately. The discretizations were finer in the transport direction in the older models. The performed changes imply a better description of influence between different release paths but a poorer description of the instationary diffusion.

In this study far-field calculations were performed for all cases. In older studies simplified calculations for selected nuclides have been performed (Neretnieks *et al.*, 1987).

For the biosphere calculations the most evident difference from earlier studies is the construction of a case where the ecosystems in the area changes with time as a consequence of the land rise (here called reasonable biosphere development). This approach also includes later releases of radionuclides accumulated in sediments. In the earlier study two separate cases – coast and inland – were modelled, without interaction

1.2 Objective

The objective of this report is to describe the radionuclide release and dose calculations for the SFR 1 repository within the SAFE study. The information used in the calculations is documented and the results are presented.

The aims of the radionuclide release calculations are to quantitatively describe the radionuclide transport and to analyse the effect of different scenarios on the environment during 10 000 years after repository closure, both in the near field and biosphere.

By performing several calculation cases for each repository part, enough knowledge and understanding are achieved to fulfil these aims.

1.3 Structure of report

The different calculation cases are described in Chapter 2 and the computer codes and the compartment models in Chapter 3. The input data used are summarised in Chapter 4. The results for the near field, far field and biosphere are presented in Chapter 5 for the base scenario and in Chapter 6 for the other scenarios. The base scenario comprises a main case and a case with degraded barriers. Other scenarios treat influence of chemicals, permafrost and human intrusion. A summary of the results is presented in Chapter 7.

2 Description of calculation cases

2.1 Choice of calculation case

A number of calculation cases for quantitative analyses have been defined based on the expected development of the conditions in the repository, rock and biosphere for the base scenario and for the other scenarios. The expected evolution of the repository system, the scenario analysis and the selection of calculation cases are given in the scenario report (SKB, 2001b). The aim is that the calculation cases will consider the expected development and the uncertainties connected to it, both concerning processes and events that influences the state of the system and quantitative data that describe these states. The uncertainties are illustrated by analysing different calculation cases for the base scenario in combination with pessimistic choice of the parameter values used in the calculations.

A schematic description of the calculation cases is shown in *Figure 2-1* and a short summary is given in Table 2-1. Three cases are analysed within the base scenario to illustrate the expected development in the near field, i.e. the vaults and Silo including the waste and technical barriers. The influence of the surrounding rock on the release of radionuclides is illustrated with two cases; included or neglected geosphere. Changes in discharge points and ecosystems in the biosphere are studied by calculation of human dose for a reasonable biosphere development, two variations of the development of the ecosystem as well as today's biosphere during the whole time period.

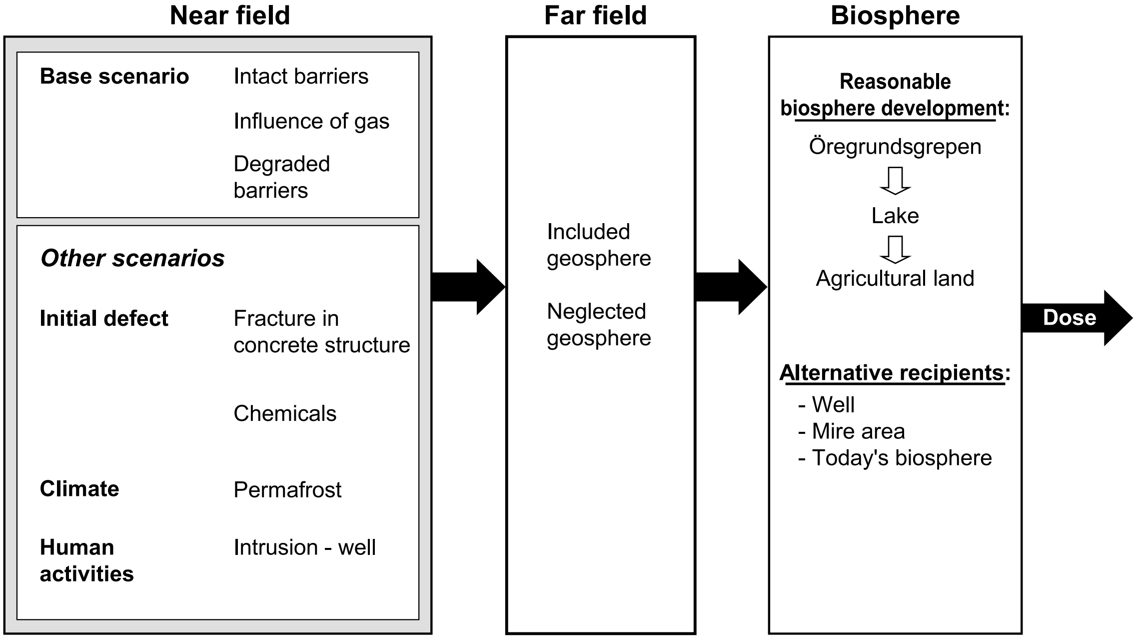

Figure 2-1. *Schematic description of the calculation cases.*

Table 2-1. Summary of the calculation cases.

Scenario/Calculation case	Description
Base scenario	
Main case (intact barriers)	All technical barriers fulfil the specifications of the construction at closure. Constant properties during the whole time period. Water flow in the near field influenced by the ongoing land rise. Dose to human for a reasonable biosphere development that imply release of radionuclides to Öregrundsgrepen during the time period 2000 AD to 5000 AD, release to a lake during the period 5000 AD to 8000 AD and release to agricultural land during the period 8000 AD to 12 000 AD. Dose consequence also for the alternatives with release of radionuclides to a well downstream the repository from 4000 AD to 12 000 AD, release of radionuclides to a mire area from 4000 AD to 12 000 AD and for release to Öregrundsgrepen with today's conditions during the whole time period.
Influence of gas	Expelled water containing radionuclides from the near field barriers due to gas produced in the near field. Other conditions as in the case "intact barriers". (not included in this report, see Moreno *et al*., 2001)
Degraded technical barriers	Conditions as in the case "intact barriers" during the time period 2000 AD to 3000 AD. Fractured/degraded barriers in the near field implies changed flow conditions in the near field from 3000 AD until 12 000 AD. Other conditions in the near field, geosphere and biosphere as in the case "intact barriers".
Other scenario: Initial defects	
Fracture in the concrete structure	Fracture(s) in the concrete barriers at repository closure that increase the water flow through the technical barriers in comparison to the case "intact barriers" in the Base scenario. Other conditions as in the case "intact barriers".
Fracture in the concrete structure and gas	Water containing radionuclides expelled through fracture(s) in the concrete barriers due to gas produced in the near field. Other conditions as in the case " Fracture in the concrete structure". (not included in this report, see Moreno *et al*., 2001)
Chemicals/complexing agents	Considerably poorer sorption in the technical barriers in the near field. Other conditions as in the case "intact barriers" in the Base scenario.
Chemicals/complexing agents and degraded barriers	Considerably poorer sorption in the technical barriers in the near field. Other conditions as in the case "degraded technical barriers" in the Base scenario.
Other scenario: Climate	
Permafrost	Frozen repository until 12 000 AD when radionuclide release occurs with the total flow through the different repository parts. Dose consequence with today's biosphere, Öregrundsgrepen.
Other scenario: Human activity	
Well in the repository	A well is sunk in the repository earliest when the shoreline passes by the repository area, i.e. earliest at 3000 AD. Immediate dose consequence from ingestion. The long term dose consequence caused by the well are changed flow conditions, but otherwise same conditions as in the case "intact barriers" in the Base scenario.

2.2 Base scenario - Near field

The aim of the calculations for the base scenario is to show the ability of the repository to prevent radionuclide release from the waste, taking the future changes in barrier properties and other conditions into consideration. To fulfil this purpose a main case and two variation cases have been defined. The purpose of the variation cases is to illustrate the consequence of possible but more uncertain and not in detailed studied processes. One variation case show the consequence of water containing radionuclides expelled by gas formed in the repository. The other case shows the influence of an extensive degradation of the technical barriers with time. A general description of transport processes, barrier properties and other conditions taken into consideration in the different cases is given below. A more detailed description is given in the report describing the scenario and system analysis (SKB, 2001b).

2.2.1 Main case - intact barriers

One of the prerequisites of the base scenario is that the properties of all technical barriers fulfil the requirements at repository closure. This implies that concrete floor, walls and lid in the different repository parts do not contain large intersecting fractures. The same concerns the porous concrete or concrete grout surrounding the waste packages. Small fractures in the concrete may be formed due to stress in the material. Bentonite and sand/bentonite barriers in the Silo are assumed to be homogeneous.

The concrete moulds and concrete tanks are supposed to be almost intact at closure, i.e. they do not contain large intersecting fractures. Steel packagings may very well be tight at closure, but there might also be damages caused during the operational period, for example due to corrosion. Steel packagings are therefore not considered as barriers for water and dissolved radionuclides.

After closure groundwater will flow into the different repository parts from the surrounding rock and fill up pore volumes and empty space in the repository. The time from repository closure to a water filled repository is rather short, some few years for the vaults and some ten years for the Silo (Holmén and Stigsson, 2001a). In the calculations the time to fill the repository is neglected and a water filled repository is assumed to prevail immediately after repository closure.

When water flows into the different repository parts and come into contact with the waste the radionuclides in the waste dissolves in the water. Limitations in the solubility and availability in the waste will delay the dissolution and thereby influence the concentration of radionuclides in the water in contact with the waste. Dissolved radionuclides are thereafter transported through the waste matrix, walls of waste packages and surrounding concrete, bentonite and gravel barriers out from the different repository parts. The transport occurs by diffusion and with the water that flows in the different barriers but the release is delayed by sorption in the barrier materials. The quantity of the radionuclides that are released from the different repository parts is thus dependent on the concentration of radionuclides in the water in contact with the waste, on the diffusion and sorption properties of the barrier materials and on the size and distribution of the water flow in the barriers and how these change with time.

No limits in solubility or availability to dissolve in the water in contact with the waste are taken into account for the nuclides. However, the calculations take into account a certain time for the release of radionuclides in waste stabilised in bitumen. The release of radionuclides from a bitumen matrix is insignificant unless a network of pores or fractures is formed in the matrix. Such a network can be formed by several mechanisms (Pettersson and Elert, 2001). Once an opening to the surface of the matrix is established the radionuclides dissolve in the water filled pores or fractures and are released from the matrix by diffusion. This is a complicated course of events that is difficult to quantify, but a conservative estimate is that it will take at least 100 years before all nuclides in a bitumen matrix are dissolved. In the calculations it is therefore assumed that one percent of the initial radionuclide content in the waste is released from the bitumen matrix every year.

The resistance to diffusion and flow in the barriers depends on their porosity as well as the presence of fractures in the materials. Due to chemical reactions between the barrier material and components in the water these properties will change with time. Analysis performed indicate only small changes in the concrete barriers, even after long time (Höglund, 2001). In the calculations it is assumed that there are no changes of the fractures or porosity with time. Instead, values chosen on porosity, diffusion coefficient and hydraulic conductivity represent materials with the expected increase in porosity with time and small fractures in the concrete barriers already from repository closure.

The properties of the bentonite barriers will also change with time due to chemical reactions and the possibility exists that the concrete barriers may crack due to mechanical impact, from for example increased pressure from gas production. These mechanisms have not been studied in detailed within the SAFE project. Possible consequences of this type of degradation are difficult to define but are illustrated separately as a variation case, fractured/degraded barriers, to the main case.

Size and direction of the water that flows through the different repository parts and their barriers will change with time even if the hydrological properties are constant. This is due to the land rise and its influence on the groundwater flow in the surrounding rock. In the calculations this is simulated by stepwise changes of size and direction of the flow in accordance with the results from the hydrogeological calculations in the detailed model (Holmén and Stigsson, 2001a). Size and direction of the flow calculated for the time 2000 AD is assumed to be valid from repository closure to 3000 AD. At this time the size and direction of the flow are changed according to the hydrogeological calculations at 3000 AD. Stepwise changes are performed in the same way at 4000 and 5000 AD but since only small changes are expected for longer times stationary flow conditions is assumed to prevail from 5000 AD and ahead.

The transport of radionuclides in the near field will be delayed by sorption in cement and concrete as well as in bentonite barriers and gravel backfill. In cement and concrete barriers the penetrating water will quickly obtain a high pH, and the ion strength will be high since the penetrating water is salt and concrete contribute with dissolved salts. With time the leakage of cement components may result in some decrease in pH and ion strength in cement and concrete barriers, but alkaline conditions will be maintained during long time. The expected decrease in pH is not judged to influence the sorption in the cement and concrete barriers negatively but decreased ion strength will increase the sorption of elements like caesium and strontium that sorb by ion exchange. Therefore the sorption data is chosen to be representative for fresh cement and concrete with a high pH and high ion strength for the whole time period.

The water in the bentonite barriers and gravel backfill will at repository closure have pH and ion strength more in accordance with the penetrating groundwater. Leaching of concrete components will give rise to an increase in pH with time and also change the chemical composition of the solid materials. These processes have not been analysed, but they are not expected to decrease the sorption in comparison with the sorption in these materials at repository closure. The reason for that is that an increase in pH favours the sorption and that the secondary minerals formed in contact with alkaline water are mostly good sorbents. Therefore sorption data for gravel backfill and bentonite barriers representative for a saline groundwater are chosen and these are assumed to be valid for the whole studied time period. The future change from saline to non-saline groundwater is neglected since this only implies sorption of elements that sorb via ion exchange and thereby increase the sorption capacity for them.

Products from corrosion of iron and steel are not taken into account as sorption barrier despite that there is strong evidence that iron oxides and iron hydroxides bind many elements. Reported sorption data in the literature given as Kd-values are for many nuclides as high and in some cases higher than for sorption on cement and concrete (Savage *et al*., 2000). Sorption on corrosion products can thus be of importance for the release of radionuclides from the near field, especially from BLA that does not have concrete barriers.

The waste contains chemicals that may form complex with the radionuclides and thereby influence the sorption of the radionuclides. Cellulose in the waste and as additive in cement and concrete may through alkaline degradation form isosaccarinic acid (ISA) that is a strong complexing agent. Based on estimated amounts of chemicals and cellulose materials in different waste types in SFR 1 the concentrations of complexing agents inside the waste packages have been calculated (Fanger *et al.*, 2001). This shows that the concentration of complexing agents inside the waste packages for a few waste types can be so high that it can not be disregarded that sorption inside the packages can be influenced. The highest concentrations of ISA are obtained in the waste packages with bitumenised waste in steel packaging, but these are, however, not treated as a sorption barrier anyway.

Fanger and co-workers also show that there are a few waste types with cement stabilised waste where the concentration of ISA is of the same level as the threshold concentration ($1 \cdot 10^{-4}$ M) where ISA may lead to a small reduction in sorption of fourvalent and pentavalent elements in the cement matrix. Any influence on the sorption of these elements in mould walls or other concrete barriers outside the cement matrix at this low concentration of ISA seems not especially likely. The reason for this is that the ISA formed will to a large extent be kept inside the cement matrix since ISA itself sorb on cement. In addition there are experiments that indicate that lower concentrations of ISA do not influence sorption of elements in complexes with ISA.

There are also chemicals within the waste that may act as complexing agents. Two of these (EDTA and sodium capryliminodipropionat, NKP) give concentrations inside the waste packages of a few waste types that may imply a reduction of the sorption of Ni and chemically analogue divalent elements in the waste matrix with cement.

Regarding the expected small effects from complexing agents on the sorption and that the data representing the sorption in the system without complexing agents are already conservatively chosen, the possible effects from complexing agents are neglected in the base scenario. The presence of high concentrations of complexing agents may however be of importance for the safety of the repository. Thus this is illustrated as an initial defect scenario where the presence of complexing agents result in a considerable reduction of the sorption in the near field barriers. This case is further described in Section 2.5.1.

Despite complexing agents, colloids in water may reduce the delay of radionuclides in the near field barriers. Radionuclide transport with colloids in the near field is neglected due to the expected low concentrations of colloids in near-field water with such high concentrations of salt.

2.2.2 Fractured/degraded barriers

The performed analysis on the future chemical degradation of the concrete barriers in SFR 1 show only small changes even after long times (Höglund, 2001). There are, however, other processes that have not been studied in detail that may influence the barrier properties in the long term. Concerning cement and concrete barriers it is mainly mechanisms that can change the transport properties by causing fractures that need to be considered. Examples of such mechanisms are pressure build-up due to gas production, pressure from expanding corrosion products and stress in the materials caused by settlements and movements in the system. These types of changes can increase the hydraulic conductivity in cement and concrete barriers and also form preferential transport paths for the radionuclides.

The properties of bentonite barriers can also change, especially through chemical reactions with cement components. The performed analysis that has been made shows that rather fast ion exchange may occur in sand/bentonite. Chemical transformations of bentonite caused by high pH are also possible. This type of chemical transformations can imply reduced hydraulic properties in the bentonite barriers with time. The sorption properties are probably not negatively influenced since the minerals that can be formed, for example CSH phases, are as good sorbents as the original minerals.

The effect of deteriorating hydraulic properties with time in cement and concrete barriers as well as in bentonite barriers is illustrated in a variation case within the base scenario. Since the lapse of time for the degradation of the barriers is unknown it is assumed that the degeneration occur momentarily 1000 years after repository closure, i.e. at 3000 AD.

For the Silo the same conditions are assumed as in the base case despite other water flows through the Silo barriers from 3000 AD and further on. The size and direction of this water flow from 3000 AD and further on are given by the hydrogeological modelling in the detail scale with increased hydraulic conductivity in the barriers compared to the main case (Holmén and Stigsson, 2001a).

Also for BMA all conditions are assumed to be the same as in the main case except changed water flows from 3000 AD and further on. At this point the concrete walls in one room, room 12, closest to the fracture zone 6, are degraded. The size and direction of the water flow in different parts of BMA with degraded walls was calculated with the hydrogeological model in the detail scale and the results for year 3000 AD and further on are used in the calculations of the radionuclide release from the near field.

No calculations are performed for the radionuclide release from the BTF vaults in the case with degraded barriers after 1000 years. However an estimate is performed on possible changes based on calculated changes of the water flow.

2.3 Base scenario - Geosphere

Radionuclides transported out from the technical barriers in the different repository parts are transported further in the rock by the flowing water. The transport occurs mainly by advection in the open fractures in the rock. The ability of the rock to delay and thereby through decay reduce the release of radionuclides to the recipients in the biosphere compared to the release from the near field depend upon the so called transport resistance (see for example Andersson *et al.*, 1998). The transport resistance is determined by the size of the groundwater flow, the travel distance and the exchange of radionuclides between the flowing water and the rock matrix.

The ongoing land rise displaces the shoreline and thus both the travel distance and the groundwater flow change with time. The effect of that on the transport and delay of radionuclides are, however, relatively limited. Two simplified cases are illustrated.

In one case, it is assumed that the release occur directly from the near field to the recipient in the biosphere. This pessimistic case is based on the expected low transport resistance during the first 1000 to 2000 years after repository closure as well as uncertainties in parameters that quantifies transport and processes that may reduce travel times, for example transport with colloids and microbes.

In the other case the time dependence of the transport resistance is neglected and the influence of the rock on the release of radionuclides is illustrated with constant values on the migration parameters included in the model. The hydrogeological parameter values are chosen based on the results from the groundwater flow modelling and with the purpose that the chosen values as far as possible are valid for all repository parts during the whole time period.

2.4 Base scenario - Biosphere

To calculate the distribution of radionuclides in the biosphere and the dose to human four different cases have been defined. The reasonable development of the biosphere is based on the expected development of the biosphere and future changes of the discharge area for the groundwater passing the repository. In addition cases with a mire area and a well are studied to illustrate uncertainties in discharge areas and biosphere development. To show the influence of the repository independent of changes in the biosphere one case is where today's biosphere is assumed to prevail during the whole time period. A more detailed description of the calculations of the migration of radionuclides in the different ecosystems and the different exposure pathways to human that are included in the calculations of dose is given in Karlsson *et al.,* (2001).

2.4.1 Reasonable biosphere development

The reasonable case assumes that the release of radionuclides from the time for repository closure until 5000 AD is to a coast recipient that corresponds to a part of the present Öregrundsgrepen. In the calculations the same conditions as today is assumed to prevail until 4000 AD. The ongoing land rise will decrease the size of Öregrundsgrepen with time. For the time period 4000 AD to 5000 AD the water volume and water turn over is thus assumed to be less than today. At 5000 AD the radionuclides are released to a lake that is developed in the area. This lake will remain as recipient until 8000 AD. At that point the lake has grown into wet-land and mire areas has developed. After 8000 AD these areas are assumed to be drained and used as agricultural land until 12 000 AD. This reasonable biosphere development is schematically described in *Figure 2-2*.

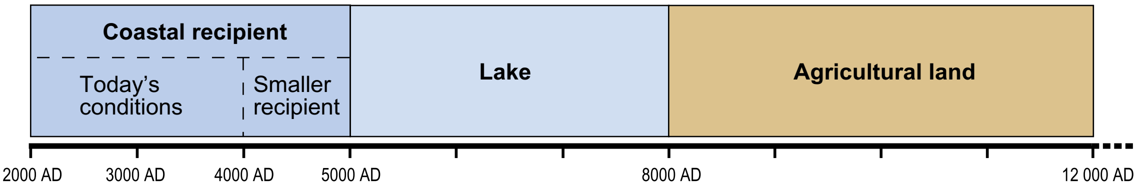

Figure 2-2. *Schematic description of the reasonable biosphere development.*

Radionuclides released to the Öregrundsgrepen are assumed to be distributed between the water phase and suspended material in the water. The water turnover in

Öregrundsgrepen imply that both dissolved radionuclides and radionuclides in suspended matter are spread over the whole water volume and further out in the Baltic Sea. The suspended matter with its content of radionuclides can settle as sediment and the nuclides can accumulate in deeper sediments but also move up to the water phase again. Vegetation in the water can take up radionuclides from the water while fish take up radionuclides both directly from the water and through contaminated food. Cattle that graze on the edge of the water can take up radionuclides by eating water vegetation and drink water. Humans are exposed for radionuclides by eating meat and drinking milk from cows that have been grazing at the shore and by eating fish from the area.

Radionuclides released to the lake can in the same way as in the coastal model be distributed between the water phase and suspended matter in the water. Dissolved radionuclides and radionuclides on suspended matter can also leave the system through discharge from the lake. Radionuclides on the suspended matter can settle on sediments and, if not resuspended to the water phase, become accumulated in deeper sediments as a consequence of burial of fresh sediment.

In the same way as in the coastal model radionuclides can be taken up by fish and water vegetation. Cattle grazing on the shores may take up radionuclides by eating water vegetation and drinking water from the lake. In contrast to the coastal model it is assumed in the lake model that humans take water from the lake both as drinking water and to irrigate a garden plot where vegetables and root crops are grown. Radionuclides in the irrigation water are thus directly transferred to the upper soil layer in the garden plot but also to some extent directly to the crop surfaces through the water droplets that are maintained on the leaves and other vegetation parts above the ground. Vegetables and root crops growing in the garden may, through root uptake, take up the radionuclides in the upper soil layer but also bring back radionuclides to the upper soil by mouldering. At the same time an exchange between the upper and the deeper soil layers occur through processes like infiltration and bioturbation. Radionuclides in the deeper soil layers may also leak back to the lake and radionuclides in the upper soil layer may both return to the lake and leave the system through erosion.

Humans in the area can be exposed to radionuclides in the system by eating fish from the lake and by consumption of meat and milk from the cattle that grazes at the shores and drink water from the lake. In addition, exposure occurs through drinking water that is taken from the lake and through consumption of vegetables and root crops grown in the garden plot. Exposure via consumption of a small amount of soil, which is unintentionally eaten because of e.g. insufficiently washed vegetables, are also considered. Humans in the area can also be exposed by inhalation of contaminated soil particles in the air. In addition, it is assumed that working at the garden plot imply external exposure from the radionuclides in the soil.

The discharge area is changed to agricultural land at 8000 AD. The radionuclides are then supplied with the groundwater flowing in the saturated zone. These radionuclides can be transported up to the soil layer above through capillary forces, root uptake and through diffusion during dry periods while infiltration transports the radionuclide in the opposite direction during wet periods. Besides the radionuclides supplied with the groundwater the radionuclides accumulated in the sediments during the earlier coastal and lake periods are movable in the same way as the radionuclides in the groundwater. The concentration of radionuclides in the water phase is influenced by sorption on the solid materials. Radionuclides are transported out from the system with groundwater that leaves the system and due to erosion in the upper soil layer.

Radionuclides in the upper soil layer are available for root uptake and may be transferred to crops cultivated in the area in form of cereals, root crops and vegetables. Part of the area is also used as pasturage for cattle. Humans are exposed to these radionuclides by eating the crops and by eating meat and drinking milk from cattle fed with crops and grass grown in the area. In addition exposure by unintentional intake of contaminated soil particles left on vegetables are also considered. Inhalation of contaminated soil particles as well as external exposure when working on the field are also included.

2.4.2 Release to a mire area

This case is chosen to illustrate the uncertainty of discharge area for water and radionuclides and other uncertainties in future biosphere conditions. The reasonable biosphere development is based on a prognosis that shows that the discharge area will follow the shoreline. In this case it is instead assumed that the radionuclides are discharged into a mire area from year 4000 AD until 12 000 AD.

Radionuclides released into the mire area are distributed between the water phase and solid material. Out transport of radionuclides from the system occurs by water leaving the system from the layer close to the ground surface. It is assumed that peat from the mire area is used as soil improvement and as fuel in one household. The cultivated crops are taking up radionuclides from the peat and humans are exposed by consumption of the crops as well as meat and milk from cattle fed with the crops. In addition exposure is assumed to occur through inhalation of peat particles that are present in the air and through inhalation of the exhaust gas from peat combustion. External exposure from the mire area during outdoor staying in the area is also included.

2.4.3 Release to a well

The well case illustrates the consequences of release of radionuclides to a well that some time in the future is sunk downstream the repository area. The results of the calculation of the future hydrogeology in the area indicates that such a well can not exist before 4000 AD. In the well case the consequences of release of radionuclides from the repository to a well downstream the repository during the time period 4000 AD to 12 000 AD are analysed.

Based on the hydrogeological calculations (Holmén and Stigsson, 2001a) it is assumed that all radionuclides released from one repository part exit in this well with a water consumption of 2,37 m^3/day. Such a well can supply a small agricultural property with 5-10 cows and can also be used for irrigating a small garden plot where vegetables and root crops are grown. The turn-over of radionuclides that occurs by irrigation and the uptake through the food chains that this may cause is assumed to occur in the same way as in irrigation with lake water (see Section 2.4.1). One difference is that no nuclides may leave the system through erosion in the well case, so the well, crops and the upper and lower soil layers are in this respect a closed system.

Humans that take water from the well are supposed to be exposed by drinking water and by eating vegetables and root crops from the garden plot irrigated with water from the well. Uptake of radionuclides occurs also by consumption of meat and milk from cows that drink water from the well. Exposure also occurs by unintended intake of soil as well as through inhalation of contaminated soil particles in the air and through external exposure from radionuclides in the upper soil layer.

2.4.4 Release to today's biosphere

The model used is the same as that for the first 2000 years in the reasonable biosphere development (see Section 3.4.1), i.e. a coastal model describing the conditions in Öregrundsgrepen today. The exposure pathways considered are thus consumption of fish as well as consumption of milk and meat from cattle, which has been grazing at the shores.

2.5 Other scenarios

2.5.1 Initial defects

To illustrate the consequences of deviations from the expected properties of technical barriers and waste at repository closure three cases are studied:

- One or several large fractures in the concrete structure at repository closure
- Sorption in the technical barriers is considerably lower than in the base scenario due to considerable amounts of complexing agents that have been forgotten in the repository at closure
- The combined effect of a considerably lower sorption in the technical barriers and one or several large fractures in the concrete structure after 1000 years.

Fracture in the concrete structure

In this case it is assumed that, at closure of SFR 1, there are one or several large fractures in the concrete structures in BMA, 1BTF and 2BTF. These fractures are located in the vicinity of fracture zone 6 in the rock. Accordingly, this case is the same as the variation case in the base scenario with fractured/degraded barriers except for the point of time at which the fractures arise. Here it is assumed that fractures are already present at repository closure and the results from the hydrogeological modelling of the case with degraded barriers can therefore be used for the whole time period.

Chemicals/complexing agents

Two cases are studied to illustrate the effect of considerably deteriorated chemical barrier properties in the near field due to unexpected large amount of chemicals with complexing ability in for example the waste.

One case is identical to the main case in the base scenario except for that the sorption is considerably lower in all technical barriers in the Silo, BMA and BTF caverns for the elements influenced by complexing agents. The decreased sorption capacity is obtained by reducing the K_d-value in concrete/cement, bentonite, sand/bentonite and gravel backfill with a factor of 100 for tetravalent and pentavalent elements and with a factor of 10 for divalent and trivalent elements. In the other case, deteriorated sorption properties in the near field barriers described in the previous paragraph is combined with the variation case in the base scenario with degraded barriers after 1000 years.

2.5.2 Climate - Permafrost

Even though it is very unlikely that continuous permafrost down to the depth of the repository will be formed before 12 000 AD, the effects of such a scenario is illustrated. For the sake of simplicity it is assumed that the whole repository is frozen until 12 000 AD when it melts. At this point all barriers are assumed to be cracked and not sustain any resistance for flowing groundwater. The chemical barrier function in form of sorption on the barrier materials does, however, remain. Radionuclides are transported out through the near field barriers with the total flow of groundwater in the different repository parts. The size of the flow is obtained from the results of the calculation with the hydrogeological model on detail scale at 7000 AD, the end point of the calculations. The instant dose consequences at 12 000 AD are calculated for today's biosphere conditions.

2.5.3 Human activity - Well in the repository

As intrusion scenario the consequences of a well sunk into the different repository parts are studied. A well can be sunk at 3000 AD at the earliest, when parts of the repository are not below the sea any longer. Here it is assumed that a well is sunk into the different parts of the repository where the largest water turnover prevail, i.e. the gravel backfill in the upper parts of the Silo, BMA and BTF caverns and in BLA. The water in the well is assumed to be used only as drinking water since drinking water is the dominating exposure pathway initially.

The long-term consequences of wells sunk into the repository are that an open hole constitutes a fast transport path for radionuclides from the repository up to the ground surface and that the water flow rate through the repository is influenced. If a well is sunk into BLA and this hole is left open, the water flow rate through BLA is higher than the flow obtained for the base case. An increase of a factor three at 3000 AD and a factor seven at 5000 AD is obtained (Holmén and Stigsson, 2001a).

3 Models

3.1 Computer codes

3.1.1 Near-field code, NUCFLOW

The near-field code NUCFLOW is a compartment model developed from the NUCTRAN-code (Romero, 1995 and Romero *et al*., 1999). The major development in NUCFLOW is the possibility to use stepwise changes of the water flow with time.

NUCFLOW is a multiple path model that calculates the instationary nuclide transport in the near field of a repository as occurring through a network of resistances and capacitances coupled together in analogy with an electrical circuit network. The code takes into account diffusive and advective (water flow) transport, chain decay and sorption. It can simultaneously handle several sources, pathways and sinks to water flowing in fractures intersecting the repository.

To represent the barrier system, through which the species are transported, NUCFLOW makes use of the integrated finite difference method and of the concept of compartments. The barrier system is discretized into compartments. The material balance over a compartment connected to some other compartment for a dissolved single nuclide is described as:

$$V_i K_i \frac{dc_i}{dt} = \sum_{j \neq i} \left(\frac{AD_e}{d} \right)_{i,j} (c_j - c_i) + \sum_{j \neq i} \left(q_{j,i} c_j \right) - \sum_{j \neq i} \left(q_{i,j} c_i \right) - V_i K_i \lambda c_i$$

where
V_i is the volume of compartment i (m^3)
V_iK_i is the capacity of the compartment, $K = \varepsilon + (1-\varepsilon)K_d \rho_s$
ε is the porosity of the material in the compartment (-)
K_d is the distribution coefficient (m^3/kg)
ρ_s is the solid density (kg/m^3)
c_i, c_j is the concentration in compartment i and j respectively (mol/m^3)
t is time (s)
A is the diffusion area (m^2)
D_e is the effective diffusivity (m^2/s)
d is the diffusion length (m)
q is the water flow (m^3/s)
λ is the decay constant (s^{-1}).

The left-hand side of the equation accounts for the accumulation of nuclides in the water and the solid by sorption. The right hand side accounts for the diffusive transport from one compartment to the adjacent compartments, the advective transport from one compartment to the adjacent compartments and the radionuclide decay.

The compartments are defined by their volume, their diffusion length and cross sectional area used by the diffusion and by their material data, such as porosity, density and diffusivity.

The equivalent water flow rate, Q_{eq}, is used for representing the diffusive transport of radionuclides from the compartments in contact with the far field (host rock). This fictitious flow rate can be visualised as the flow rate that carries away dissolved species with the concentration at the compartment interface resulting in the release of radionuclides. It has been derived by solving equations for diffusive transport to the passing water by boundary layer theory. The value of Q_{eq} depends on the geometry of the contact area, the water flux, the flow porosity and the diffusivity as follows (Neretnieks *et al.*, 1987):

$$Q_{eq} = A_w \ \varepsilon_{rock} \sqrt{\frac{4\, D_w}{\pi \, t_{res}}}$$

where
A_w is the surface area between the compartment and rock (m^2)
ε_{rock} is the flow porosity (-)
D_w is the diffusivity of the nuclides in water (m^2/s)
t_{res} is the residence time of the water in contact with the compartment (s).

3.1.2 Far-field code, FARF31

The far-field code FARF31 used is the PROPER-version, Version 1.1.1. The PROPER-package is a complete program package developed by SKB for calculation of the radionuclide release from a spent fuel repository.

The code FARF31 (Norman and Kjellbert, 1990 and Eriksson *et al.*, 1999) calculates the transport of dissolved radionuclides through the fractured rock, the retention caused by interactions between the nuclides and the rock matrix, and the radioactive chain decay. The processes included are:
advection - transport of radionuclides by water flowing through fractures in the rock
dispersion - the spreading caused by velocity variations in different fractures or in different parts of a fracture
matrix diffusion and sorption - the diffusive transport of radionuclides from the water in the fracture into pores and microfissures of the rock matrix where the nuclides may sorb on the solid surfaces
radioactive chain decay - the decay and in-growth of radionuclides that are members of a decay chain.

FARF31 is based on the one-dimensional advection-dispersion equation with one-dimensional diffusion perpendicular to the flow into a matrix of finite depth. The equation is formulated in flux averaged quantities of concentration, water velocity, dispersivity and the exchange rate between flowing water and the pores of the rock matrix.

3.1.3 Biosphere model

The model system used is based on compartment models. Models are set up for each ecosystem studied, such as lake, agricultural land and coastal areas (Karlsson *et al.,* 2001). The concept of the models is a dynamic model for calculating the distribution of radionuclides between major physical components of the biosphere like soil, water and sediments, the result of which are used to predict biological uptake and radiation doses along multiple pathways. The turnover of radionuclides is described by first order differential equations, which are solved numerically with ACTIVI from the computer code BIOPATH (Bergström *et al.*, 1982 and 1995). The PRISM-system (Gardner et al, 1983) was used to generate randomly drawn values according to the statistical distribution, given for each parameter. The resulting transfers between different compartments of the models are all described by transfer coefficients or rate constants expressed as the turnover of elements per year.

The instationary phase of the important physical and geochemical processes such as erosion, sorption and radioactive decay are taken into account. Processes like bioaccumulation and root uptake are accounted for by steady state concentration ratios (bioconcentration factors).

The concentration of radionuclides in food stuff is calculated assuming equilibrium between plants/animals and their environment, an assumption that is justified by the time scale in question and that is usually used in this kind of modelling (e.g BIOMOVS, 1996, Davis *et al*., 1993). Uptake in aquatic biota is calculated using bioaccumulation factors whereas uptake in terrestrial vegetation is simulated using root-uptake factors and translocation factors (for radionuclides added to the vegetation surface). Specific transfer factors are used when calculating the transfer of radionuclides to milk and cattle meat. The internal exposure of humans is a combination of exposure from radionuclides that are eaten and those that are inhaled. Exposure from the former ones is calculated by combining the concentration in food stuff, consumption rates and nuclide specific dose coefficients for conversion from activity to dose (becquerel to sievert) for ingested radionuclides. By combining concentration in air with inhalation rates and nuclide specific dose coefficients for conversion from activity to dose for inhaled radionuclides exposure via inhalation is estimated. External exposure is estimated through consideration of exposure times, concentration of radionuclides in the air or on the ground and nuclide specific dose coefficients for conversion from concentration of radionuclides to dose (becquerel to sievert) for external exposure.

Probabilistic calculations have been performed for the biosphere. Thousand realisations have been performed for each case. The distribution functions used as input data are given in SKB (2001a). However, the results in this report are only presented as arithmetic mean values.

The total dose for each calculation case for the studied scenarios is calculated using TS01 and SUM41 within the PROPER-package.

3.2 Model descriptions

The model used for modelling the migration of radionuclides in each repository part is described in this section. A schematic layout of the compartments is given in Appendix B and an example of an input data file for NUCFLOW for each repository part compartments is given in Appendix C. Schematic layouts of the biosphere model systems are given in Appendix D and the models are described in Karlsson *et al.,* (2001).

3.2.1 Silo

A schematic figure of the model used for the radionuclide release calculations for the Silo is shown in *Figure 3-1*. The internal of the Silo has been divided into two sections in the radial direction and three in the vertical direction. The division in the radial direction is made to describe that the waste conditioned with bitumen is allocated to the inner part of the Silo surrounded by waste conditioned with cement. Approximately 20 % of the waste are embedded in bitumen, which means that the inner part with waste in the model is significantly smaller than the outer part. Three different waste types have been defined in the model; waste conditioned with cement in concrete moulds, waste conditioned with cement in steel packaging and waste conditioned with bitumen in steel packaging.

The division in three vertical sections is made to get a better representation of the transport. Each section is in turn divided into compartments representing different parts of the repository, e.g. waste, concrete backfill and concrete walls. In total the model consists of 94 compartments. A detailed figure of the discretization is given in Appendix B.

Radionuclides in waste conditioned with cement in concrete moulds and in steel packaging are transported out from the waste package both by diffusion and advection. The diffusivity used for the waste matrix is that in concrete grout. Water flowing through the walls of the moulds is assumed to flow in small fractures in the concrete material and hence, sorption in mould walls is not taken into account for the advective transport through the mould walls. The diffusivity in the walls of the moulds is that in construction concrete. Radionuclides in waste conditioned with bitumen are assumed to be dissolved from bitumen to the water filled pores in the bitumen matrix at a constant rate during 100 years. As soon as the nuclides are in solution, they are free to be transported out by diffusion through the waste matrix to the surrounding concrete grout using the diffusivity in water. No sorption in bitumen is accounted for.

The main part of the concrete walls inside the Silo, forming the shafts, is only accounted for as sorption capacity that is available when nuclides diffuse into them. However, walls separating waste embedded in bitumen in the inner part of the Silo from cement conditioned waste in the outer part represent both a sorption capacity and a diffusive resistance.

For each section, the diffusion length in the concrete grout surrounding the waste packages is assigned a thickness of 14 cm for bitumenised waste and 20 cm for cement conditioned waste. It is assumed that the diffusion length is the same for radial and axial transport. The retention of nuclides in the concrete grout is on average underestimated, since the majority of radionuclides have to be transported several meters through the concrete grout.

The water flow rate through the waste part of the Silo is very low due to the low hydraulic conductivity, particularly in the concrete structure and surrounding bentonite barriers. Water flowing through the waste part is predominantly directed in the vertical direction (Holmén and Stigsson, 2001a), and is directed upward during the first thousand years from repository closure and thereafter downward. In the model, the advective transport in the horizontal plane through the waste part and surrounding concrete and bentonite barriers is neglected but the diffusive transport is accounted for. The boundary condition outside the bentonite is a so-called equivalent flow rate, Q_{eq}. In the bottom and the top of the Silo diffusion and advection in vertical as well as in horizontal direction is accounted for. There is a diffusive transport through the concrete lid of the Silo, but the water is assumed to flow in the gas vents only. Sorption is accounted for in all barriers within the Silo.

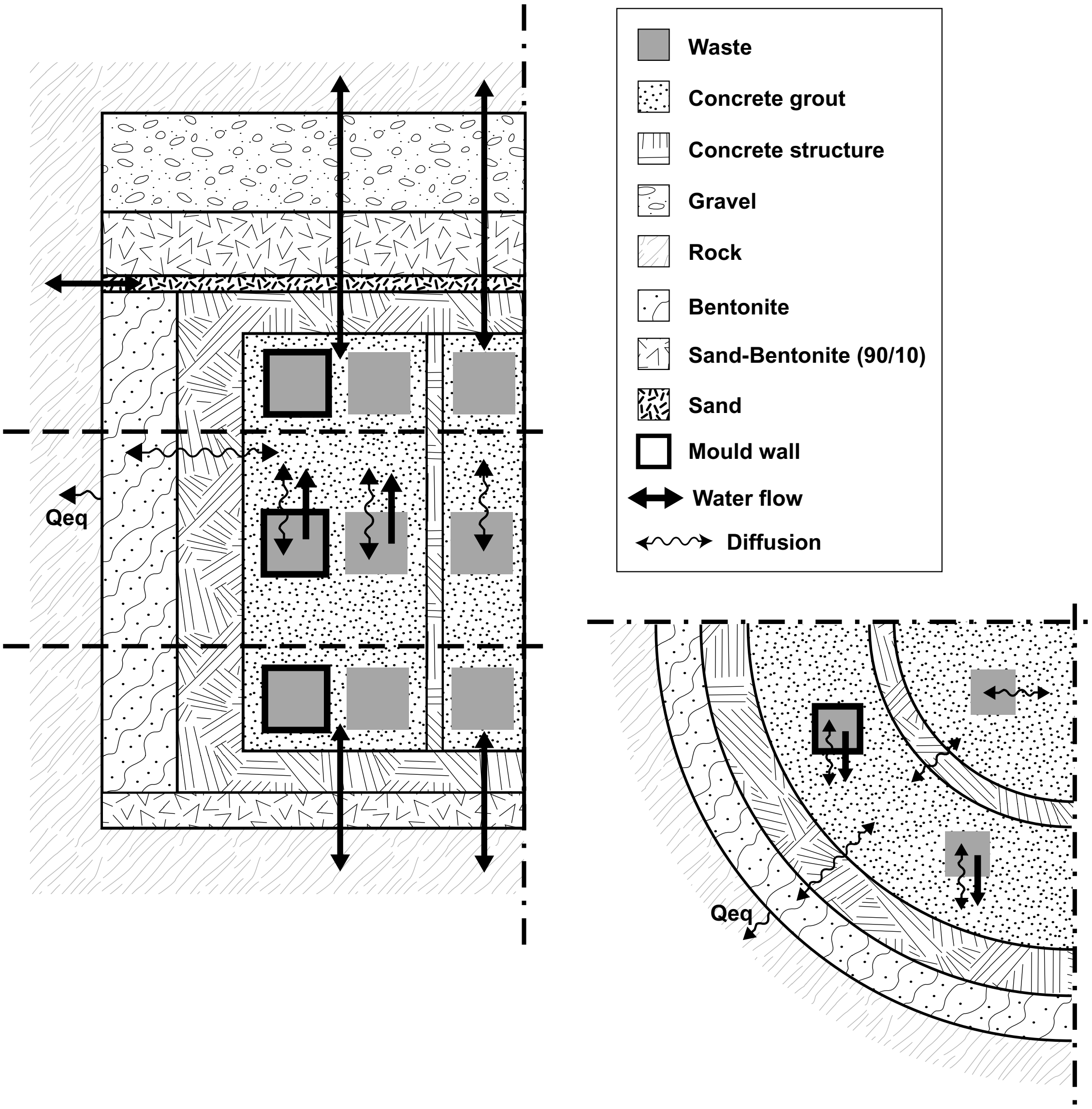

Figure 3-1. *Transport paths for radionuclides in the Silo. View from side and above.*

3.2.2 BMA

A schematic figure of the model used for the radionuclide release calculations for BMA is shown in *Figure 3-2*. To describe the transport from BMA the repository is divided into five sections plus two parts representing gravel backfill in both ends of the vault. The division is made to get a better representation of the transport along the vault. The size of each section is chosen to comprise a certain number of rooms of the encapsulation. The first section represents room 1-4, the second represents room 5-9, the third represents room 10-11, the fourth represents room 12 and the fifth represents room 13-15. Each section is in turn divided into compartments representing different parts of the repository, e.g. waste, mould walls and encapsulation. In total the model consists of 161 compartments. A more detailed figure of the discretization is given in Appendix B.

In the model the waste have been sorted into five different waste types; concrete moulds with waste conditioned with cement, steel containers with waste conditioned with cement, steel drums with waste conditioned with cement, steel containers with waste conditioned with bitumen and steel drums with waste conditioned with bitumen. It is foreseen that various metallic wastes will be deposited in BMA (“Other waste”). How this waste will be packaged is at present not specified, but in this study the waste is modelled as cement conditioned waste in steel containers. Each of the five sections of the model has a unique combination of the different waste types according to the present and planned allocation of the waste (Riggare and Johansson, 2001). This implies that the inventory of individual radionuclides is different in the five sections of the model.

In this study it is assumed that the space inside the encapsulation not occupied by waste is not backfilled. The high contrast in hydraulic conductivity between the space around the waste packages and the waste packages implies that the water flow through the waste packages will be limited. In the model it is assumed that no water is flowing through the packages. Radionuclides in waste conditioned with cement are transported out from the waste matrix by diffusion using the same diffusivity as in concrete grout. Radionuclides in concrete moulds also have to diffuse through the walls of the concrete moulds using a diffusivity of construction concrete. Radionuclides in waste conditioned with bitumen are assumed to be dissolved from bitumen to the water filled pores in the bitumen matrix at a constant rate during 100 years. As soon as the nuclides are in solution, they are free to be transported out by diffusion through the waste matrix using the diffusivity in water. Sorption is accounted for in waste conditioned with cement, but not for waste embedded in bitumen.

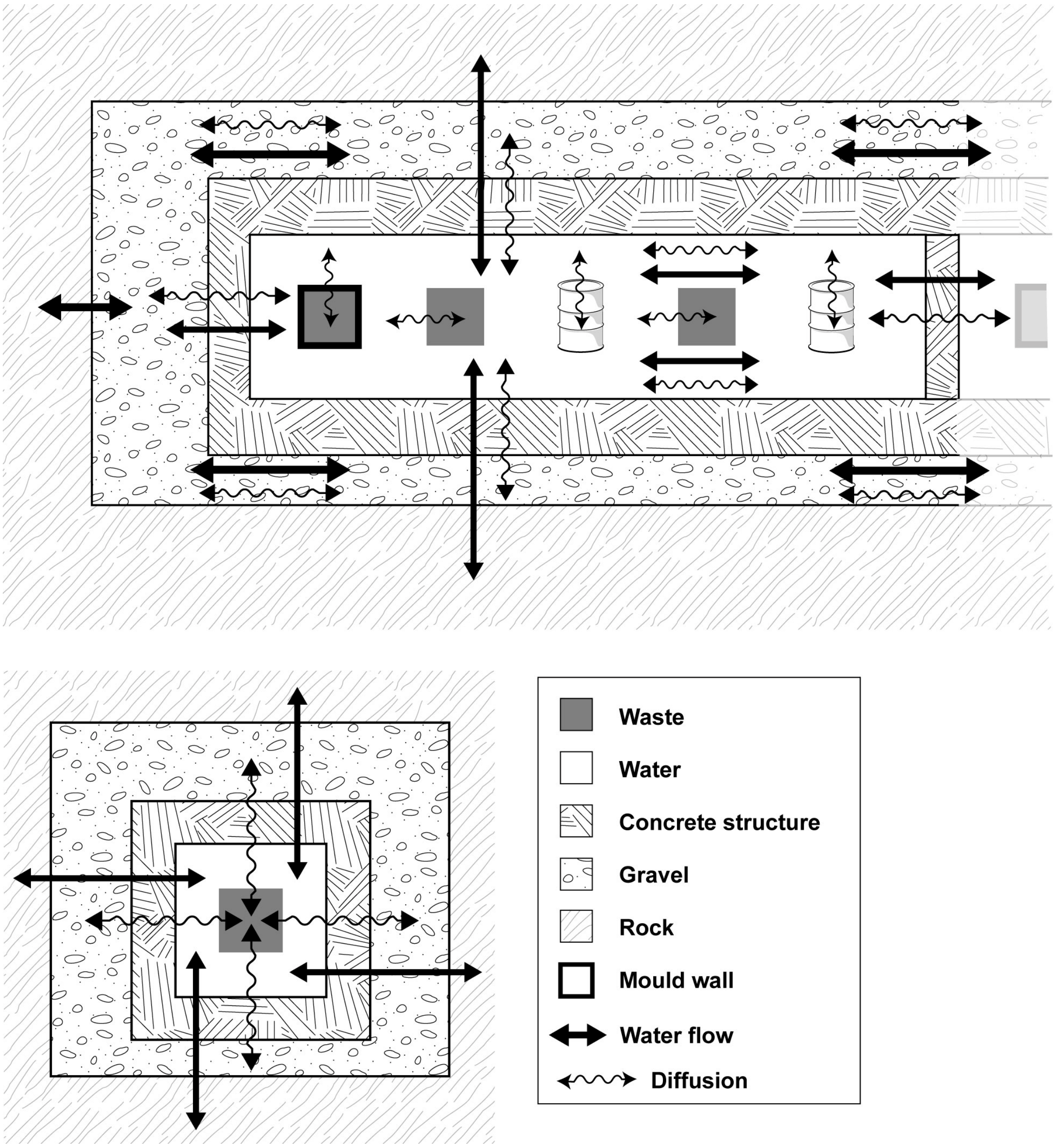

Figure 3-2. *Transport paths for radionuclides in BMA. View from long side and short side.*

3.2.3 1BTF

In the vault 1BTF, concrete tanks are stacked two high around the walls of the vault, see *Figure 3-3*. Concrete moulds are used to make “compartments” where drums with ashes can be stacked. To make a separating “wall” the moulds are stacked four moulds high and nine moulds wide. A total of six compartments are needed to make room for 6 479 steel drums. Five of the compartments will be completely filled, containing 1 110 drums each, and the last compartment will hold 929 drums. When a compartment is filled with drums, it is sealed using concrete grout. The rest of the vault is used for concrete tanks, steel boxes and various metallic waste.

A schematic figure of the model used for the radionuclide release calculations for 1BTF is shown in *Figure 3-4*. To describe the transport from 1BTF the repository is divided into five sections plus two parts representing gravel backfill in both ends of the vault. The division is made to get a better representation of the transport along the vault. The first section contains steel drums with ashes, plus surrounding concrete tanks and concrete moulds. The concrete tanks and moulds are used as walls to facilitate the emplacement of the steel drums. However, in the model this is simplified and the three waste types are assumed to be in parallel with each other and surrounded by concrete grout. In the four remaining sections of 1BTF an equal distribution of concrete tanks and "Berglöfslöfslådor" has been assumed. Various metallic wastes foreseen to be deposited in 1BTF are modelled as concrete tanks. Each section is in turn divided into compartments representing different parts of the repository, e.g. waste, tank walls and gravel backfill. In total the model consists of 195 compartments. A more detailed figure of the discretization is given in Appendix B.

The main part of the water flows in the gravel in the top, and the part that flows through the waste and surrounding concrete grout is rather small. The contrast in hydraulic conductivity between the waste packages and the concrete grout is small, and water flow through the waste packages can not be disregarded. In the calculations the water flow that passes through the concrete grout is also assumed to pass through the waste packages.

The steel drums are 200 l drums in which a smaller drum with waste is deposited and the space between the two drums is filled with concrete. In the model, it is assumed that the whole volume between the two drums is filled with concrete. The sorption capacity in this concrete is used as the radionuclides diffuse and flow into the concrete. The concrete moulds used as internal walls for the drums are of the same type as in BMA, but only moulds with low activity are allocated to 1BTF. In the calculations activity in moulds in 1BTF is neglected, but the sorption capacity in the moulds is used as radionuclides from the drums diffuse and flow into them.

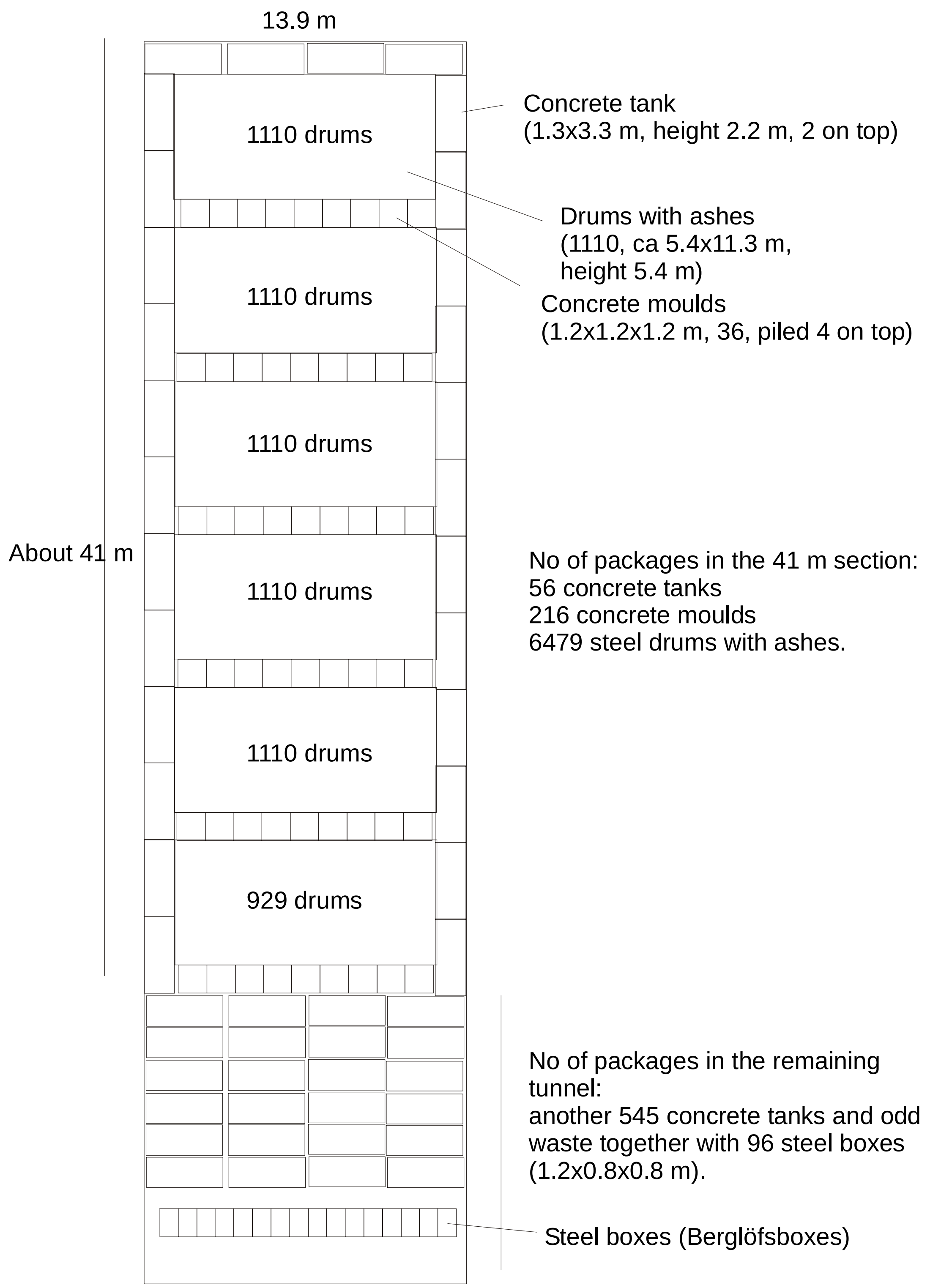

Figure 3-3. *Schematic view of the allocation of waste in 1BTF.*

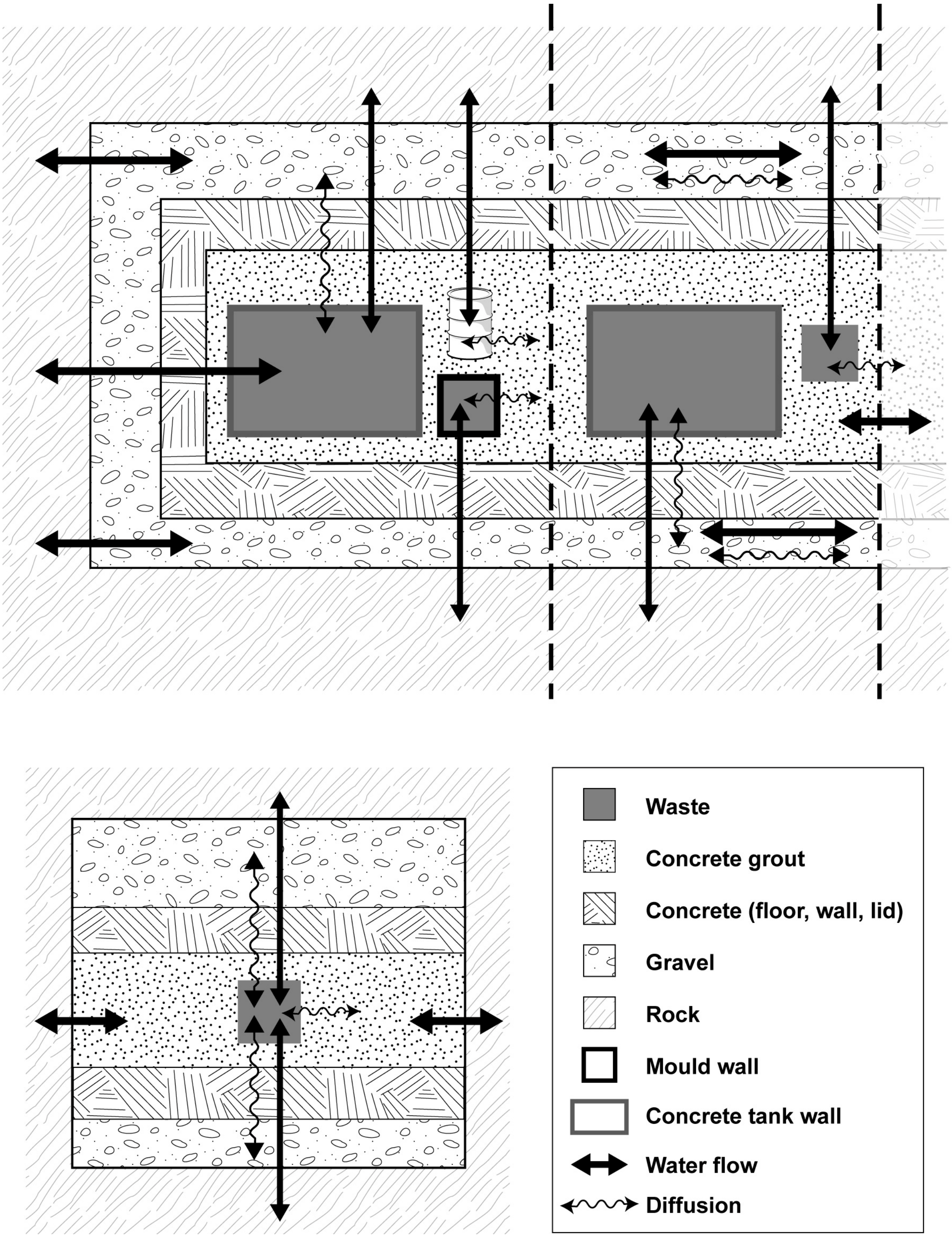

Figure 3-4. *Transport paths for radionuclides in 1BTF. View from long side and short side.*

3.2.4 2BTF

A schematic figure of the model used for the radionuclide release calculations for 2BTF is shown in *Figure 3-5*. To describe the transport from 2BTF the repository is divided into five sections plus two parts representing gravel backfill in both ends of the vault. The division is made to get a better representation of the transport along the vault. Since all the waste consists of ion exchange resins in concrete tanks, a homogeneous distribution of activity and waste packages is assumed. The model for 2BTF comprises

191 compartments totally. A more detailed figure of the discretization is given in Appendix B.

The water flows mainly in the gravel in the top of 2BTF and only a small part flow through the waste and surrounding concrete grout. The contrast in hydraulic conductivity between the waste packages and surrounding concrete grout is small and hence water flow through the waste packages may not be disregarded. In the calculations the water flow that passes through the concrete grout is also assumed to pass through the waste packages.

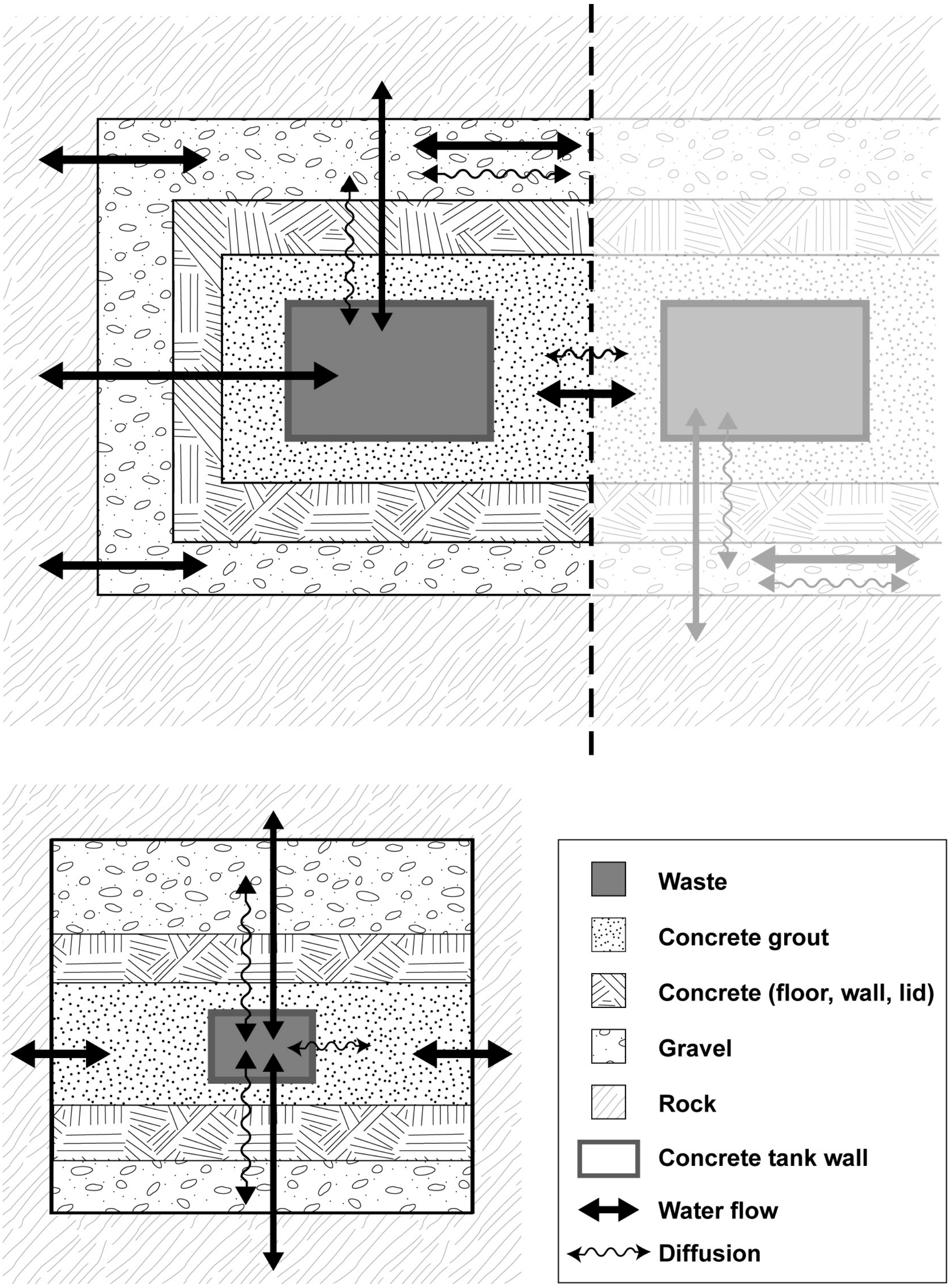

Figure 3-5. *Transport paths for radionuclides in 2BTF. View from long side and short side.*

3.2.5 BLA

A schematic figure of the model used for the radionuclide release calculations is shown in *Figure 3-6*. The model used for BLA is divided into five waste sections surrounded by a section with only water in each short side. The barriers in BLA are limited. In the model no barriers are taken into account. The nuclides are initially free to be transported with the water flow to the surrounding rock. The division into seven parts is probably of minor importance and the model may be seen as a stirred tank. This implies a high initial radionuclide release rate.

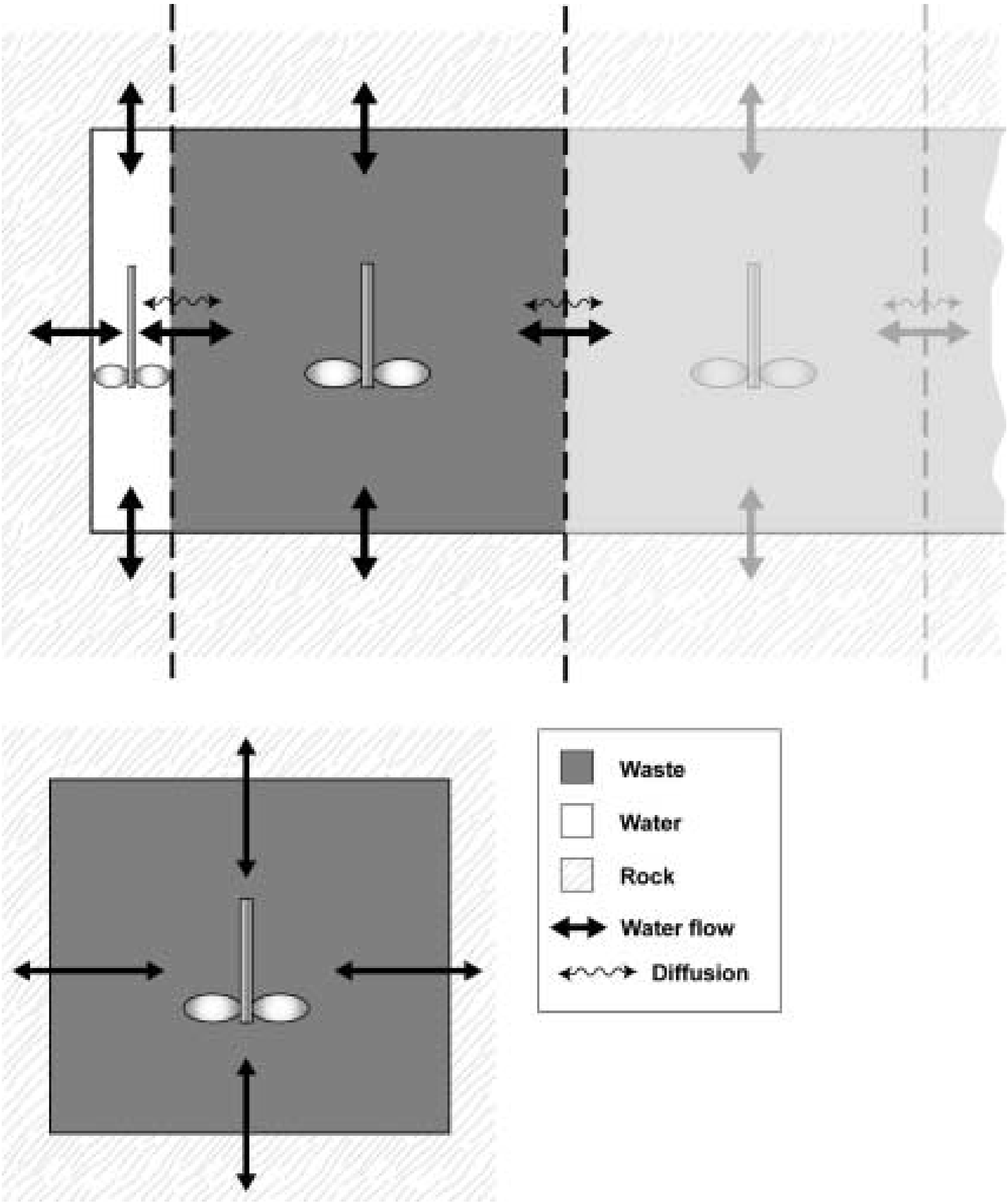

Figure 3-6. *Transport paths for radionuclides in BLA. View from long side and short side.*

4 Basic assumptions

This chapter summarises the premises on which this analysis is based upon. Also, the input data used for modelling the migration of radionuclides in the near field and the far field are compiled here. Motivations and a discussion of the selection of data is given elsewhere (SKB, 2001a).

4.1 Premises

The radionuclide transport calculations are based on the following assumptions for the near field:

- The time it takes to refill the repository with groundwater after closure is neglected and all repository sections are saturated with water in year 2030.
- The construction of all technical barriers in the Silo and the vaults are in accordance with specifications for the existing facility and present plans for repository closure. For BMA it is assumed that the space between the waste packages is not backfilled.
- Waste packagings of steel are already fully permeable to water at repository closure.
- Radionuclides in bitumenised waste are released from bitumen to the water filled pores in the bitumen matrix with a constant rate during 100 years without being limited by solubility. The nuclide can diffuse to surrounding barriers as soon as it is in solution. Sorption on bitumen is not accounted for.
- All other radionuclides, i.e. unconditioned or conditioned/stabilised in cement, are assumed to be instantaneously dissolved in water in contact with the waste without being limited by solubility. The nuclides are transported to surrounding barriers through diffusion and, in some repository parts, by advection. Sorption is accounted for in cement conditioned or stabilised waste.
- The advective transport through the barriers is given by the magnitude and the direction of a water flow through them that is changing with time due to land rise. The results from the detailed hydrogeology modelling (Holmén and Stigsson, 2001a) have been adjusted to be in accordance with the discretization used in the migration model (Holmén and Stigsson, 2001b). The magnitude and direction of the water flow in three dimensions is then transferred as input data to the migration model. The water flow is changed stepwise at 3000 AD, 4000 AD and 5000 AD.
- Diffusion and sorption properties of the barriers are assumed to be constant in time. The conditions determining the sorption properties of the different barriers are the initial composition of the material, a high ion-strength in water and, for cement and concrete barriers, high pH.
- Waste packages in BLA are not surrounded by any barriers. The small amount of bitumen and concrete used for conditioning part of the waste in BLA is not accounted for. Neither is the bottom plate made of concrete or shotcrete covering walls and ceiling of vault.

- For the cases where the barriers are assumed to be intact, the hydraulic properties of all barriers are assumed to be constant in time. The hydraulic conductivity assigned to intact concrete barriers corresponds to concrete with small, intersecting fractures.
- For the cases where barriers are assumed to be degraded, the degraded barriers are given the same hydraulic properties as gravel.

4.2 Near-field data

4.2.1 Radionuclide inventory

The estimated inventory of radionuclides in SFR 1 at repository closure (Riggare and Johansson, 2001) includes 59 radionuclides, but only 42 of these are considered to be of importance for the safety assessment (SKB, 2001a). The initial inventory of these 42 nuclides is compiled in Table 4-1. Note that 14C has been divided into organic and inorganic carbon. However, in order to reduce the time needed for calculating the migration of radionuclides in near field and far field as well as estimating the corresponding doses, the number of nuclides included in the calculations has been limited to 29. This is discussed in more detail in Appendix A. As indicated in Table 4-1, ^{241}Pu is omitted in the calculations. However, the initial inventory (in mole) of ^{241}Pu is added to the initial inventory of the next nuclide in chain 4N+1, ^{241}Am. Chain decay is not taken into account with one exception, the formation of ^{93m}Nb from decay of ^{93}Mo.

Table 4-1. Radionuclide inventory (Bq) in SFR 1 at repository closure (2030) (Riggare and Johansson, 2001a).

Nuclide	Half-life [years] a)	Silo	BMA	1BTF	2BTF	BLA
^{3}H	12.3	$5.8 \cdot 10^{11}$	$3.3 \cdot 10^{10}$	$3.3 \cdot 10^{9}$	$5.3 \cdot 10^{9}$	$6.6 \cdot 10^{8}$
^{14}C inorg	5730	$2.0 \cdot 10^{13}$	$1.9 \cdot 10^{12}$	$2.3 \cdot 10^{12}$	$2.7 \cdot 10^{11}$	$3.9 \cdot 10^{10}$
^{14}C org	5730	$1.8 \cdot 10^{12}$	$1.7 \cdot 10^{11}$	$1.8 \cdot 10^{11}$	$3.0 \cdot 10^{10}$	$3.3 \cdot 10^{7}$
^{36}Cl	301 000	$4.7 \cdot 10^{10}$	$3.4 \cdot 10^{9}$	$3.0 \cdot 10^{8}$	$5.4 \cdot 10^{8}$	$8.2 \cdot 10^{7}$
^{60}Co	5.27	$1.8 \cdot 10^{15}$	$7.1 \cdot 10^{13}$	$5.4 \cdot 10^{12}$	$9.1 \cdot 10^{12}$	$1.0 \cdot 10^{12}$
^{59}Ni	76 000	$2.1 \cdot 10^{13}$	$2.1 \cdot 10^{12}$	$1.8 \cdot 10^{11}$	$3.0 \cdot 10^{11}$	$3.9 \cdot 10^{10}$
^{63}Ni	100.1	$3.6 \cdot 10^{15}$	$3.2 \cdot 10^{14}$	$2.9 \cdot 10^{13}$	$4.7 \cdot 10^{13}$	$6.2 \cdot 10^{12}$
^{79}Se	1 130 000	$1.9 \cdot 10^{10}$	$1.4 \cdot 10^{9}$	$1.2 \cdot 10^{8}$	$2.2 \cdot 10^{8}$	$3.3 \cdot 10^{7}$
^{90}Sr	28.8	$2.4 \cdot 10^{14}$	$1.4 \cdot 10^{13}$	$1.3 \cdot 10^{12}$	$2.3 \cdot 10^{12}$	$3.6 \cdot 10^{11}$
^{93}Zr	1 530 000	$2.1 \cdot 10^{10}$	$2.1 \cdot 10^{9}$	$1.8 \cdot 10^{8}$	$3.0 \cdot 10^{8}$	$3.9 \cdot 10^{7}$
^{93m}Nb	16.1	$7.6 \cdot 10^{12}$	$4.9 \cdot 10^{11}$	$4.7 \cdot 10^{10}$	$7.6 \cdot 10^{10}$	$9.7 \cdot 10^{9}$
^{94}Nb	20 300	$2.1 \cdot 10^{11}$	$2.1 \cdot 10^{10}$	$1.8 \cdot 10^{9}$	$3.0 \cdot 10^{9}$	$3.9 \cdot 10^{8}$
^{93}Mo	4000	$1.1 \cdot 10^{11}$	$1.0 \cdot 10^{10}$	$9.1 \cdot 10^{8}$	$1.5 \cdot 10^{9}$	$1.9 \cdot 10^{8}$
^{99}Tc	211 000	$2.4 \cdot 10^{13}$	$1.7 \cdot 10^{12}$	$1.5 \cdot 10^{11}$	$2.7 \cdot 10^{11}$	$4.1 \cdot 10^{10}$
^{107}Pd	6 500 000	$4.7 \cdot 10^{9}$	$3.4 \cdot 10^{8}$	$3.0 \cdot 10^{7}$	$5.4 \cdot 10^{7}$	$8.2 \cdot 10^{6}$
^{108m}Ag	418	$1.2 \cdot 10^{12}$	$1.2 \cdot 10^{11}$	$1.0 \cdot 10^{10}$	$1.7 \cdot 10^{10}$	$2.2 \cdot 10^{9}$
^{113m}Cd	14.1	$8.2 \cdot 10^{11}$	$3.6 \cdot 10^{10}$	$3.6 \cdot 10^{9}$	$6.4 \cdot 10^{9}$	$1.0 \cdot 10^{9}$
^{126}Sn	100 000	$2.4 \cdot 10^{9}$	$1.7 \cdot 10^{8}$	$1.5 \cdot 10^{7}$	$2.7 \cdot 10^{7}$	$4.1 \cdot 10^{6}$
^{129}I	$1.6 \cdot 10^{7}$	$1.4 \cdot 10^{9}$	$1.0 \cdot 10^{8}$	$9.1 \cdot 10^{6}$	$1.6 \cdot 10^{7}$	$2.5 \cdot 10^{6}$
^{135}Cs	2 300 000	$2.4 \cdot 10^{10}$	$1.7 \cdot 10^{9}$	$1.5 \cdot 10^{8}$	$2.7 \cdot 10^{8}$	$4.1 \cdot 10^{7}$
^{137}Cs	30.1	$2.5 \cdot 10^{15}$	$1.4 \cdot 10^{14}$	$1.4 \cdot 10^{13}$	$2.4 \cdot 10^{13}$	$3.7 \cdot 10^{12}$
^{151}Sm	90	$1.1 \cdot 10^{13}$	$7.5 \cdot 10^{11}$	$6.9 \cdot 10^{10}$	$1.2 \cdot 10^{11}$	$1.9 \cdot 10^{10}$
^{152}Eu	13.5	$9.2 \cdot 10^{10}$	$4.0 \cdot 10^{9}$	$4.4 \cdot 10^{11}$	$7.1 \cdot 10^{8}$	$1.1 \cdot 10^{8}$
^{154}Eu	8.59	$7.9 \cdot 10^{13}$	$2.7 \cdot 10^{12}$	$2.8 \cdot 10^{11}$	$4.8 \cdot 10^{11}$	$7.6 \cdot 10^{10}$
^{166m}Ho	1200	$8.4 \cdot 10^{10}$	$8.2 \cdot 10^{9}$	$7.2 \cdot 10^{8}$	$1.2 \cdot 10^{9}$	$1.5 \cdot 10^{8}$
^{232}U b)	68.9	$2.0 \cdot 10^{7}$	$1.1 \cdot 10^{6}$	$8.1 \cdot 10^{4}$	$6.3 \cdot 10^{4}$	$6.1 \cdot 10^{4}$
^{234}U b)	246 000	$8.4 \cdot 10^{8}$	$4.5 \cdot 10^{7}$	$3.5 \cdot 10^{6}$	$2.7 \cdot 10^{6}$	$2.5 \cdot 10^{6}$
^{235}U b)	$7.0 \cdot 10^{8}$	$1.7 \cdot 10^{7}$	$8.9 \cdot 10^{5}$	$7.1 \cdot 10^{4}$	$5.4 \cdot 10^{4}$	$5.1 \cdot 10^{4}$
^{236}U b)	$2.3 \cdot 10^{7}$	$2.5 \cdot 10^{8}$	$1.3 \cdot 10^{7}$	$1.1 \cdot 10^{6}$	$8.2 \cdot 10^{5}$	$7.6 \cdot 10^{5}$
^{238}U b)	$4.5 \cdot 10^{9}$	$3.3 \cdot 10^{8}$	$1.8 \cdot 10^{7}$	$1.4 \cdot 10^{6}$	$1.1 \cdot 10^{6}$	$1.0 \cdot 10^{6}$
^{237}Np b)	2 140 000	$3.3 \cdot 10^{8}$	$1.8 \cdot 10^{7}$	$1.4 \cdot 10^{6}$	$1.1 \cdot 10^{6}$	$1.0 \cdot 10^{6}$
^{238}Pu	87.7	$2.8 \cdot 10^{12}$	$1.5 \cdot 10^{11}$	$1.1 \cdot 10^{10}$	$8.9 \cdot 10^{9}$	$8.5 \cdot 10^{9}$
^{239}Pu	24 100	$2.8 \cdot 10^{11}$	$1.5 \cdot 10^{10}$	$1.2 \cdot 10^{9}$	$9.1 \cdot 10^{8}$	$8.5 \cdot 10^{8}$
^{240}Pu	6560	$5.6 \cdot 10^{11}$	$3.0 \cdot 10^{10}$	$2.4 \cdot 10^{9}$	$1.8 \cdot 10^{9}$	$1.7 \cdot 10^{9}$
^{241}Pu b)	14.4	$3.1 \cdot 10^{13}$	$1.6 \cdot 10^{12}$	$1.0 \cdot 10^{11}$	$8.2 \cdot 10^{10}$	$8.8 \cdot 10^{10}$
^{242}Pu	373 000	$2.5 \cdot 10^{9}$	$1.3 \cdot 10^{8}$	$1.1 \cdot 10^{7}$	$8.2 \cdot 10^{6}$	$7.6 \cdot 10^{6}$
^{241}Am	432	$6.1 \cdot 10^{12}$	$4.3 \cdot 10^{10}$	$3.4 \cdot 10^{9}$	$2.6 \cdot 10^{9}$	$2.5 \cdot 10^{9}$
^{242m}Am b)	141	$7.5 \cdot 10^{9}$	$4.0 \cdot 10^{8}$	$3.1 \cdot 10^{7}$	$2.4 \cdot 10^{7}$	$2.3 \cdot 10^{7}$
^{243}Am b)	7370	$2.5 \cdot 10^{10}$	$1.3 \cdot 10^{9}$	$1.1 \cdot 10^{8}$	$8.1 \cdot 10^{7}$	$7.6 \cdot 10^{7}$
^{243}Cm b)	29.1	$1.0 \cdot 10^{10}$	$5.3 \cdot 10^{8}$	$3.8 \cdot 10^{7}$	$3.0 \cdot 10^{7}$	$3.0 \cdot 10^{7}$
^{244}Cm b)	18.1	$1.1 \cdot 10^{12}$	$5.9 \cdot 10^{10}$	$3.9 \cdot 10^{9}$	$3.1 \cdot 10^{9}$	$3.3 \cdot 10^{9}$
^{245}Cm b)	8500	$2.5 \cdot 10^{8}$	$1.3 \cdot 10^{7}$	$1.1 \cdot 10^{6}$	$8.1 \cdot 10^{5}$	$7.6 \cdot 10^{5}$
^{246}Cm b)	4730	$6.7 \cdot 10^{7}$	$3.6 \cdot 10^{6}$	$2.8 \cdot 10^{5}$	$2.2 \cdot 10^{5}$	$2.0 \cdot 10^{5}$

a) *Firestone (1998)*

b) *Nuclides not included in the final calculations.*

4.2.2 Physical and chemical data

Values on density, porosity and effective diffusivity for the materials modelled in SFR 1 are given in Table 4-2. Sorption coefficients used are compiled in Table 4-3 and Table 4-4. The latter table is valid for cases when the influence of chemicals, e.g. ISA, are accounted for. Note that the sorption coefficient is uninfluenced by chemicals for some elements. No sorption in bitumen has been accounted for.

Table 4-2. Physical data for materials used in SFR 1 (SKB, 2001a).

Material	Solid density (kg/m^3)	Effective diffusivity (m^2/s)	Porosity (m^3/m^3)
Construction concrete	2529	$1{\cdot}10^{-11}$	0.15
Concrete grout in Silo	2429	$1{\cdot}10^{-10}$	0.30
Concrete grout in 1BTF/2BTF	2625	$1{\cdot}10^{-10}$	0.20
Gravel and sand	2700	$6{\cdot}10^{-10}$	0.30
Cement conditioning in packages	2250	$1{\cdot}10^{-10}$	0.20
Bentonite	2692	$1{\cdot}10^{-10}$	0.61
Sand/bentonite 90/10	2667	$1{\cdot}10^{-10}$	0.25
Bitumen	1030	–	0
Water	1000	$2{\cdot}10^{-9}$	1

Table 4-3. Sorption coefficients, K_d, (m^3/kg) (SKB, 2001a).

Element	Concrete and cement	Gravel and sand	Bentonite	Sand/bentonite 90/10
H	0	0	0	0
C (inorganic)	0.2	0.0005	0	0.0005
C (organic)	0	0	0	0
Cl	0.006	0	0	0
Co	0.04	0.01	0.02	0.01
Ni	0.04	0.01	0.02	0.01
Se	0.006	0.0005	0	0.0005
Sr	0.001	0.0001	0.001	0.0002
Zr	0.5	0.5	0.05	0.5
Nb	0.5	0.5	0	0.5
Mo	0.006	0	0	0
Tc	0.5	0.3	0.01	0.3
Pd	0.04	0.001	0	0.0009
Ag	0.001	0.01	0	0.009
Cd	0.04	0.01	0.02	0.01
Sn	0.5	0	0.01	0.001
I	0.003	0	0	0
Cs	0.001	0.01	0.005	0.01
Sm	5	1	0.2	0.9
Eu	5	1	0.2	0.9
Ho	5	1	0.2	0.9
U	5	1	0.01	0.9
Np	5	1	0.1	0.9
Pu	5	1	1	1
Am	1	1	1	1
Cm	1	1	1	1

Table 4-4. Sorption coefficients, K_d (m^3/kg), influenced by chemicals (SKB, 2001a).

Element	Concrete and cement	Gravel and sand	Bentonite	Sand/bentonite 90/10
H	0	0	0	0
C (inorganic)	0.2	0.0005	0	0.0005
C (organic)	0	0	0	0
Cl	0.006	0	0	0
Co	0.004	0.001	0.002	0.001
Ni	0.004	0.001	0.002	0.001
Se	0.006	0.0005	0	0.0005
Sr	0.001	0.0001	0.001	0.0002
Zr	0.005	0.005	0.0005	0.005
Nb	0.005	0.005	0	0.005
Mo	0.006	0	0	0
Tc	0.005	0.003	0.0001	0.003
Pd	0.004	0.0001	0	0.00009
Ag	0.001	0.01	0	0.009
Cd	0.004	0.001	0.002	0.001
Sn	0.005	0	0.0001	0.00001
I	0.003	0	0	0
Cs	0.001	0.01	0.005	0.01
Sm	0.5	0.1	0.02	0.09
Eu	0.5	0.1	0.02	0.09
Ho	0.5	0.1	0.02	0.09
U	0.05	0.01	0.0001	0.009
Np	0.05	0.01	0.001	0.009
Pu	0.05	0.01	0.01	0.01
Am	0.1	0.1	0.1	0.1
Cm	0.1	0.1	0.1	0.1

4.2.3 Hydrological data

The water flow rate through the different repository parts of SFR 1 has been estimated and is discussed in detail elsewhere (Holmén and Stigsson, 2001a). The total water flow rate through the different repository parts of SFR 1 as estimated in the detailed hydrogeology modelling is given in Table 4-5. The results from the detailed hydrogeology modelling have been adjusted to be in accordance with the discretization used in the migration model (Holmén and Stigsson, 2001b). The adjusted data on magnitude and direction of water flow in three dimensions is then transferred as input data to the migration model. Accordingly, a three-dimensional water flow is assigned to each compartment in the migration model.

Table 4-5. Total water flow rate through different repository parts (Holmén and Stigsson, 2001a).

Repository part	Total water flow rate (m^3/yr)			
	2000 AD	3000 AD	4000 AD	5000 AD
BTF1: Waste part	2.4	2.7	6.8	7.8
BTF1: Whole vault	7.5	19.4	26.4	30.7
BTF2: Waste part	2.4	3.0	6.0	6.8
BTF2: Whole vault	6.7	17.6	27.7	29.6
BLA: Waste part	9.6	19.4	35.0	38.4
BLA: Whole vault	13.6	33.1	50.2	54.2
BMA: Encapsulation	0.07	0.13	0.26	0.28
BMA: Whole vault	8.7	36.7	52.7	54.7
Silo: Encapsulation	0.23	0.22	0.16	0.23
Silo: Top filling	0.53	1.4	2.2	2.2

Tabell 4-6. Total water flow rate through different repository parts when these are degraded (Holmén and Stigsson, 2001a)

Repository part	Total water flow rate (m^3/yr)			
	2000 AD	**3000 AD**	**4000 AD**	**5000 AD**
BTF1: Waste part				
Intact part	1.2	1.9	4.0	4.7
Degraded part	12.0	15.1	30.7	33.9
BTF1: Whole vault	14.5	24.1	45.0	50.2
BTF2	Same data assumed as for 1BTF			
BMA: Encapsulation				
Intact part	0.04	0.16	0.29	0.30
Degraded part	2.4	3.7	9.2	10.1
BMA: Whole vault	8.7	36.6	52.6	54.6
Silo: Encapsulation	0.66	1.1	1.5	1.5
Silo: Top filling	0.81	1.8	2.6	2.5

The equivalent water flow rate, Q_{eq}, used for representing the diffusive transport of radionuclides from the bentonite wall of the Silo to the far field (host rock) is given in Table 4-7.

Table 4-7. Equivalent water flow rate (m^3/yr) for the Silo model.

	Q_{eq} (m^3/yr)			
Compartment*)	2000AD – 3000AD	3000AD – 4000AD	4000AD – 5000AD	5000AD –
40	0.004	0.023	0.026	0.028
41	0.019	0.021	0.024	0.026
42	0.020	0.004	0.004	0.005

*) The Silo model with the compartments is given in Appendix B.

4.3 Far-field data

The data needed for modelling the far-field transport using FARF31 is summarised in Table 4-8. Radionuclide specific effective diffusivities, D_e, and sorption coefficients, K_d, used within this work are compiled in Table 4-9.

Table 4-8. Compilation of data used for modelling the migration of radionuclides in the far field (SKB, 2001a).

Parameter	
Water travel time, t_w (yr)	50
Peclet number, Pe (–)	10
Flow-wetted surface area, a_w (m^2/m^3)	120
Matrix porosity, ε (m^3/m^3)	0.005
Maximum penetration depth, x_0 (m)	2

Table 4-9. Radionuclide specific effective diffusivites D_e (m^2/s) and sorption coefficients K_d (m^3/kg) (SKB, 2001a).

Element	D_e Saline	K_d Saline
H	$1.0 \cdot 10^{-13}$	0
$C_{inorganic}$	$5.0 \cdot 10^{-14}$	0.001
$C_{organic}$	$4.0 \cdot 10^{-14}$	0
Cl	$8.3 \cdot 10^{-14}$	0
Co	$2.9 \cdot 10^{-14}$	0.02
Ni	$2.8 \cdot 10^{-14}$	0.02
Se	$4.0 \cdot 10^{-14}$	0.001
Sr	$3.3 \cdot 10^{-14}$	0.0002
Zr	$4.0 \cdot 10^{-14}$	1
Nb	$4.0 \cdot 10^{-14}$	1
Mo	$4.0 \cdot 10^{-14}$	0
Tc(IV)	$4.0 \cdot 10^{-14}$	1
Pd	$4.0 \cdot 10^{-14}$	0.01
Ag	$7.1 \cdot 10^{-14}$	0.05
Cd	$3.0 \cdot 10^{-14}$	0.02
Sn	$4.0 \cdot 10^{-14}$	0.001
I	$8.3 \cdot 10^{-14}$	0
Cs	$8.8 \cdot 10^{-14}$	0.05
Sm	$4.0 \cdot 10^{-14}$	2
Eu	$4.0 \cdot 10^{-14}$	2
Ho	$4.0 \cdot 10^{-14}$	2
U(IV)	$4.0 \cdot 10^{-14}$	5
Np(IV)	$4.0 \cdot 10^{-14}$	5
Pu	$4.0 \cdot 10^{-14}$	5
Am	$4.0 \cdot 10^{-14}$	3
Cm	$4.0 \cdot 10^{-14}$	3

4.4 Biosphere data

The dose conversion factors for ingestion used for estimating the dose in the human intrusion scenario are summarised in Table 4-10. These factors are also used in the check of the screening of nuclides (Appendix A). The dose conversion factors for coast given in Table 4-10 are used for estimating the dose in the permafrost scenario. Other data used for modelling the transport of radionuclides in the biosphere and estimation of dose is presented and discussed in Karlsson *et al.* (2001) and is compiled in SKB (2001a).

Table 4-10. Dose conversion factors for ingestion (EU, 1996) and ecosystem specific dose conversion factors for coast (Karlsson *et al.,* 2001).

Nuclide	Ingestion dose factor [Sv/Bq]	Ecosystem specific dose conversion factor for coast [Sv/Bq]
^{3}H	$1.80 \cdot 10^{-11}$	$2.68 \cdot 10^{-21}$
^{14}C inorg	$5.80 \cdot 10^{-10}$	$1.28 \cdot 10^{-18}$
^{14}C org	$5.80 \cdot 10^{-10}$	$1.28 \cdot 10^{-18}$
^{36}Cl	$9.30 \cdot 10^{-10}$	$1.40 \cdot 10^{-19}$
^{60}Co	$3.40 \cdot 10^{-9}$	$5.86 \cdot 10^{-19}$
^{59}Ni	$6.30 \cdot 10^{-11}$	$1.72 \cdot 10^{-20}$
^{63}Ni	$1.50 \cdot 10^{-10}$	$4.09 \cdot 10^{-20}$
^{79}Se	$2.90 \cdot 10^{-9}$	$1.02 \cdot 10^{-17}$
^{90}Sr	$2.80 \cdot 10^{-8}$	$1.06 \cdot 10^{-18}$
^{93}Zr	$1.10 \cdot 10^{-9}$	$6.16 \cdot 10^{-20}$
^{93m}Nb	$1.20 \cdot 10^{-10}$	$1.05 \cdot 10^{-20}$
^{94}Nb	$1.70 \cdot 10^{-9}$	$1.51 \cdot 10^{-19}$
^{93}Mo	$3.10 \cdot 10^{-9}$	$1.00 \cdot 10^{-19}$
^{99}Tc	$6.40 \cdot 10^{-10}$	$1.22 \cdot 10^{-20}$
^{107}Pd	$3.70 \cdot 10^{-11}$	$9.27 \cdot 10^{-22}$
^{108m}Ag	$2.30 \cdot 10^{-9}$	$8.41 \cdot 10^{-19}$
^{113m}Cd	$2.30 \cdot 10^{-8}$	$5.79 \cdot 10^{-18}$
^{126}Sn	$4.70 \cdot 10^{-9}$	$5.92 \cdot 10^{-18}$
^{129}I	$1.10 \cdot 10^{-7}$	$1.49 \cdot 10^{-17}$
^{135}Cs	$2.00 \cdot 10^{-9}$	$5.79 \cdot 10^{-19}$
^{137}Cs	$1.30 \cdot 10^{-8}$	$3.73 \cdot 10^{-18}$
^{151}Sm	$9.80 \cdot 10^{-11}$	$4.61 \cdot 10^{-21}$
^{152}Eu	$1.40 \cdot 10^{-9}$	$1.94 \cdot 10^{-19}$
^{154}Eu	$2.00 \cdot 10^{-9}$	$2.76 \cdot 10^{-19}$
^{166m}Ho	$2.00 \cdot 10^{-9}$	$9.50 \cdot 10^{-20}$
^{238}Pu	$2.30 \cdot 10^{-7}$	$3.92 \cdot 10^{-18}$
^{239}Pu	$2.50 \cdot 10^{-7}$	$4.28 \cdot 10^{-18}$
^{240}Pu	$2.50 \cdot 10^{-7}$	$4.27 \cdot 10^{-18}$
^{242}Pu	$2.40 \cdot 10^{-7}$	$4.10 \cdot 10^{-18}$
^{241}Am	$2.00 \cdot 10^{-7}$	$1.16 \cdot 10^{-17}$

5 Results - Base scenario

In this chapter, the results for the base scenario are presented. Results for other scenarios, e.g. the influence of uncertainty in sorption data, are presented in Chapter 6. A main case has been defined within the base scenario where the near-field barriers are intact, the retention in the far-field rock is neglected and the doses from release of radionuclides are based on a reasonable biosphere development. The effect of near-field barriers being degraded after 1000 years is also highlighted, as well as the importance of the far-field rock as a barrier. In addition, three variations of ecosystems have been investigated.

This chapter is divided into five sections, each section focusing on one repository part. All sections have the same disposition. First the release from the near field is discussed. Since the far field is not accounted for in the main case, the dose in recipient is based on the near-field release rate. The near-field release rate is therefore followed by the dose obtained for the reasonable biosphere development. Next the effect of an accounted far field is shown. Finally, the dose corresponding to a near-field release, neglecting the far field, to today's biosphere, mire and well is discussed.

The reasonable development of the biosphere in the area is described elsewhere (Kautsky, 2001). This has been the base for the *reasonable biosphere development case* used in this study. It assumes that the release of radionuclides from the time for closure of the repository to year 5000 AD occurs to a coastal recipient corresponding to a part of Öregrundsgrepen. It is assumed that the conditions of today prevail until 4000 AD. The size of Öregrundsgrepen will decrease as a consequence of the land rise and therefore a smaller water volume and longer water retention times has been assumed for the time period 4000 AD to 5000 AD. After 5000 AD the release of radionuclides occurs to a lake which has been developed in the area. This lake is used as a recipient until 8000 AD. At that time the lake has grown into a mire area. After 8000 AD it is assumed that this area is drained and used for agricultural purposes until 12 000 AD.

Two other recipients are also used in order to illustrate the uncertainties in where the groundwater from the repository will reach the biosphere after 4000 AD. The reasonable biosphere development case is based on the prediction that the release point will follow the shoreline. In the *mire recipient case* it is instead assumed that the radionuclides are released to a mire area during the time period 4000 AD to 12 000 AD. In the *well recipient case* the radionuclides are assumed to reach the biosphere within a well during the time period 4000 AD to 12 000 AD.

A forth case, the *today's biosphere case*, where the coastal recipient of today is assumed to prevail during the time period from the closure of the repository until 12 000 AD has also been used in accordance to the statements in the directions of SSI (SSI, 1998).

The results are presented in graphs where the release rate (Bq/yr) or the arithmetic mean dose (Sv/yr) is plotted as a function of time. As seen in for example *Figure 5-1*, there is a sudden increase, or sometimes a decrease, in near-field release rate, especially evident at 3000 AD. This is an artefact from the way a non-stationary water flow is taken into account in the near-field model (in the model a continuously changing water flow is represented by stepwise changes). This artefact propagates to the results on far-field release rate as well as dose in recipient. The figures on dose for the reasonable biosphere development shows a sudden increase in dose around 4000 AD and 5000 AD, as well as an increase or decrease at 8000 AD. These stepwise changes in dose is due to the fact the recipient to which the nuclides are assumed to be released changes from one recipient to another, as described above.

In general the doses increase as the recipient in the reasonable biosphere development case changes from Öregrundsgrepen to a coast with smaller water volume as well as when the coast changes to lake. This is mainly due to decreased dilution as water volumes decrease and retention times increase. Another important factor is that additional exposure pathways are considered in the lake model compared to the coastal models as freshwater is also used for consumption and irrigation. The model used for the time period 8000 AD to 12 000 AD (agricultural land model) is very different from the other used as the inflow of radionuclides occurs within a porous medium (soil) instead of to a water volume. In this model accumulation of radionuclides in soil is an important process for the calculation of the concentration of nuclides in the soil profile whereas dilution is the most important process in the coastal and lake models.

In the agricultural land model it is also assumed that radionuclides which have accumulated in sediments earlier during the coastal and lake stages are present within the soil and available for exposure to humans. This can be seen as a peak in the dose curves at 8000 AD. Processes like erosion of the uppermost soil layer and mixing between soil layers results in a decrease of the accumulated radionuclides with time leading to decreasing doses. For some radionuclides it can be seen that the dose curves increase again after a certain decrease. This is because “new” nuclides are supplied with the groundwater. The lines in the dose curves are interpolated between a number of points and because relatively few time steps has been used in the calculations for this later time period the curves do not describe the decrease in dose fully properly. For nuclides, which sorb to solid matter in soil this decrease is slower than for more mobile nuclides but this can, unfortunately, not be seen in the figures.

One radionuclide which deserves special attention here is ^{14}C for which the dose curves decrease drastically when the use of the agricultural land model starts. This is due to that no root uptake of carbon is considered in the model (carbon is fixed by the green parts above the ground). Instead humans intake ^{14}C only through unintended consumption of soil (e.g. via insufficiently washed vegetables) and through consumption of milk and meat from cattle which have consumed contaminated soil when grazing. This leads to a much lower exposure for ^{14} Cin the agricultural land model compared to other nuclides, which are also taken up by crops. ^{14}C is also one of the nuclides which give the highest doses in the lake model (the uptake in fish is very large) which fortifies the impression of a drastically decrease in the dose curves at 8000 AD.

5.1 Silo

5.1.1 Intact barriers

The modelling of the migration of radionuclides in the Silo gives a release from the near field that during the whole studied time period is dominated by organic ^{14}C (see *Figure 5-1*). In the beginning, ^{3}H gives the second highest release rate, but from about 2200 AD ^{108m}Ag is the second most dominating nuclide in terms of release rate. The maximum release rate of ^{108m}Ag is obtained at 3000 AD. The release of ^{36}Cl, ^{93}Mo and ^{135}Cs becomes more and more important from about 5000 AD. The release rate of these three nuclides is, however, some three orders of magnitude lower than for organic ^{14}C.

For a reasonable biosphere development the dose is dominated by organic ^{14}C up to about 8000 AD (*Figure 5-2*), when the recipient is changed from a lake to agricultural land and a significantly lower dose is obtained from organic ^{14}C. The dose is dominated by ^{129}I, ^{36}Cl, ^{79}Se and ^{93}Mo instead. The dose during the agricultural period is less than 10^{-8} Sv/yr. The maximum total dose obtained from release of radionuclides from the Silo is $3 \cdot 10^{-6}$ Sv/yr which is at 5000 AD.

The far-field barrier (the geosphere) delays the release of radionuclides. How effective the far field rock is as a barrier varies from nuclide to nuclide. The effect of the far-field barrier on the release of radionuclides in the Silo is shown in *Figure 5-3*. By comparing *Figure 5-1* and *Figure 5-3* it is seen that it to a large extent is the same nuclides that dominate the release rate from both the near field and the far field. The difference in release rate between the near field and the far field is insignificant for organic ^{14}C, ^{36}Cl, ^{93}Mo and ^{129}I. These nuclides do not sorb in the geosphere. For nuclides like inorganic ^{14}C, ^{59}Ni and ^{79}Se a reduction in maximum release rate of about a factor two is obtained at most. For other nuclides the far-field rock is a more effective barrier. The maximum far-field release rate of ^{90}Sr and ^{135}Cs is between three and six times lower than that from the near field. The corresponding reductions in release rate of ^{3}H and ^{108m}Ag is up to two orders of magnitude and of ^{137}Cs four orders of magnitude.

When the nuclides are released to today's biosphere the whole studied period the dose obtained from release of radionuclides in Silo is very low (*Figure 5-4*). The maximum dose is less than 10^{-10} Sv/yr and is dominated by the release of organic ^{14}C.

If the nuclides are released to a mire area after 4000 AD instead, higher doses are obtained (compare *Figure 5-5*). The dose dominating nuclide is organic ^{14}C between 4000 AD and 6000 AD and after that ^{79}Se. Other nuclides of importance for the total dose are ^{108m}Ag and ^{36}Cl. The maximum total dose ($2 \cdot 10^{-7}$ Sv/yr) is obtained at the end of the near-field calculations (12 000 AD).

An even higher total dose is obtained if the nuclides are released to a well located downstream the repository (*Figure 5-6*). The maximum total dose ($5 \cdot 10^{-5}$ Sv/yr) is obtained when the well is sunk (4000 AD), and is dominated by organic ^{14}C. The second most important nuclide is ^{129}I but its dose is between one and two orders of magnitude lower than that for the dominating nuclide.

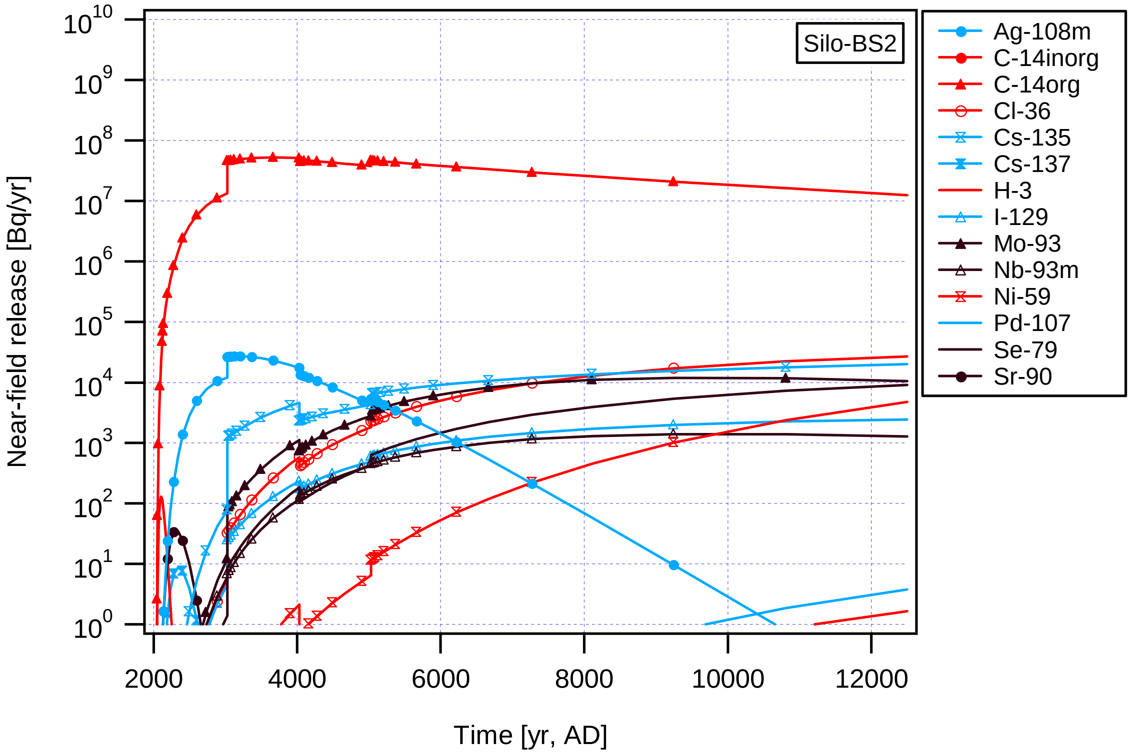

Figure 5-1. *Near-field release rate from Silo.(The nuclides in the bottom right corner are* ^{107}*Pd and inorganic* ^{14}*C.)*

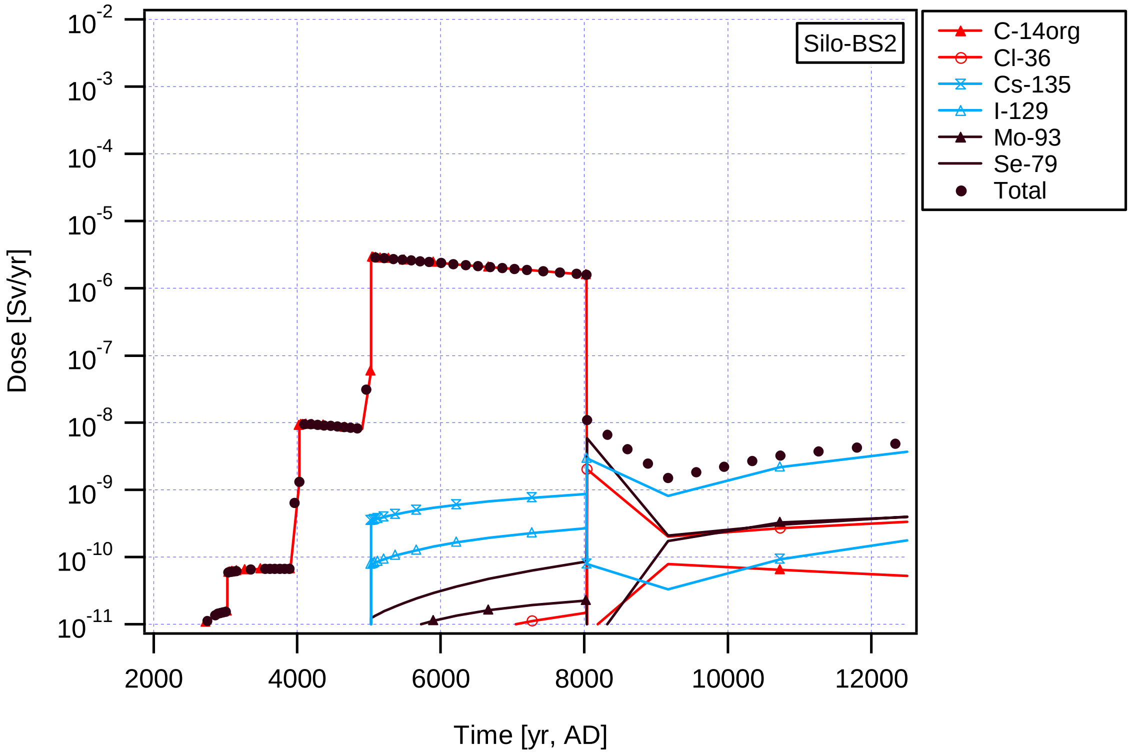

Figure 5-2. *Dose from release of radionuclides from Silo to the reasonable biosphere.*

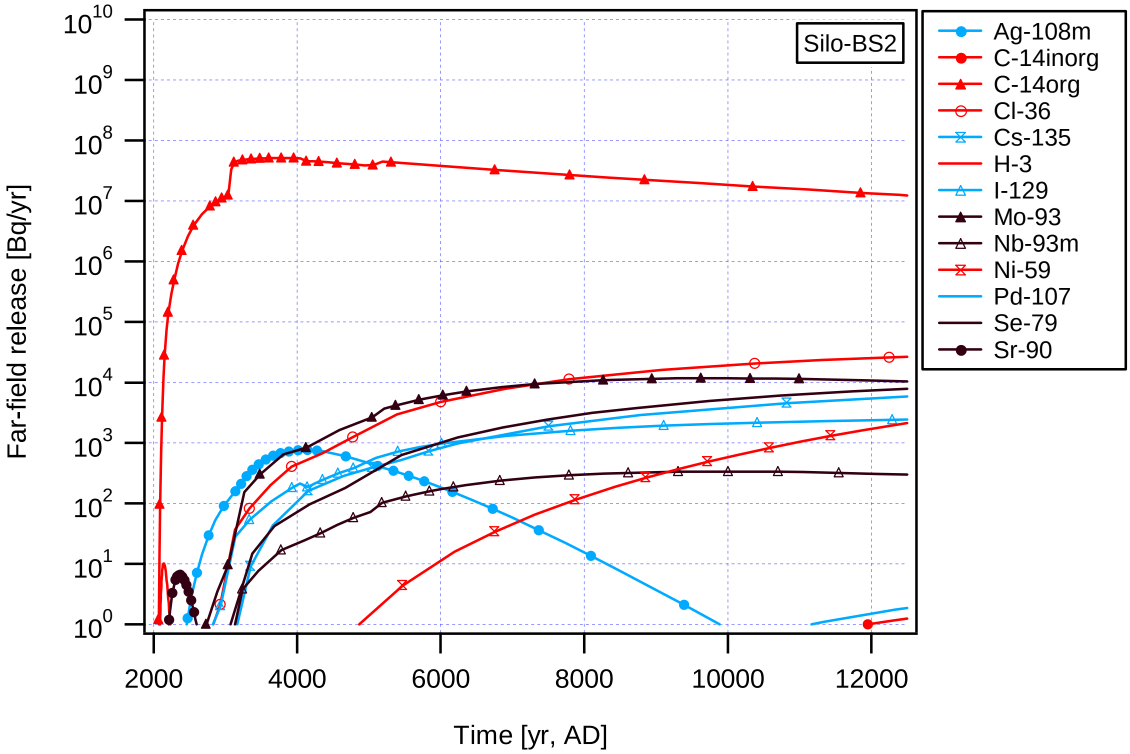

Figure 5-3. Far-field release rate from Silo.

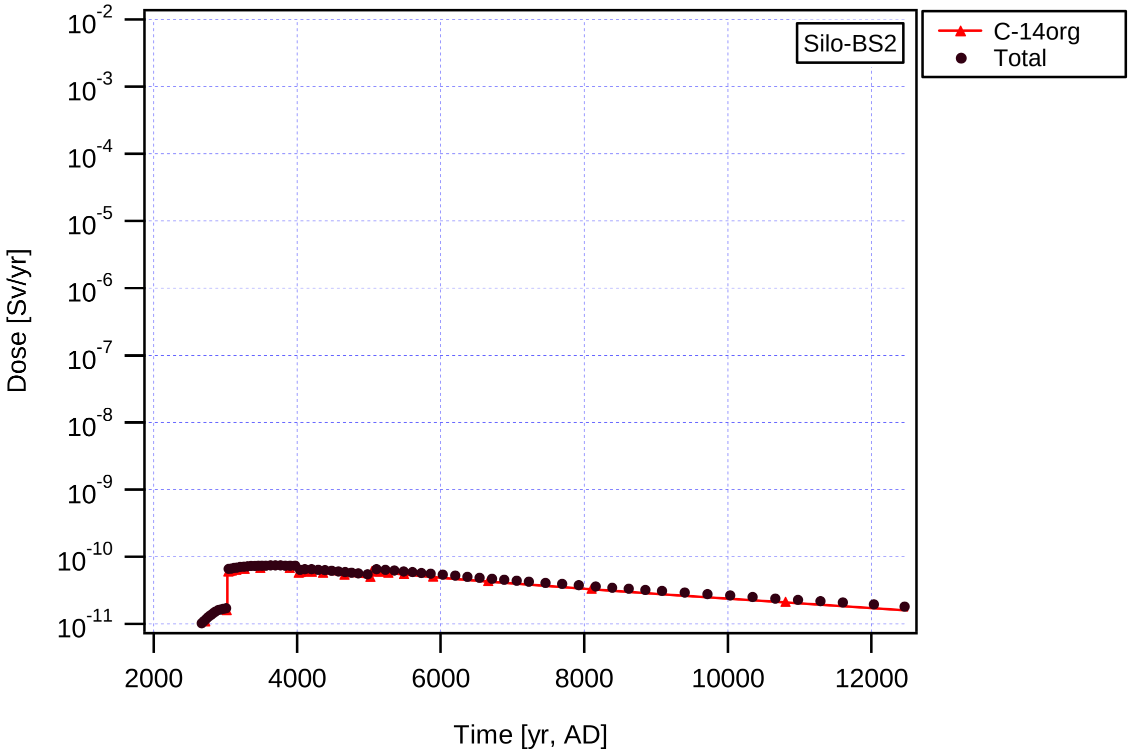

Figure 5-4. Dose from release of radionuclides from Silo to today's biosphere.

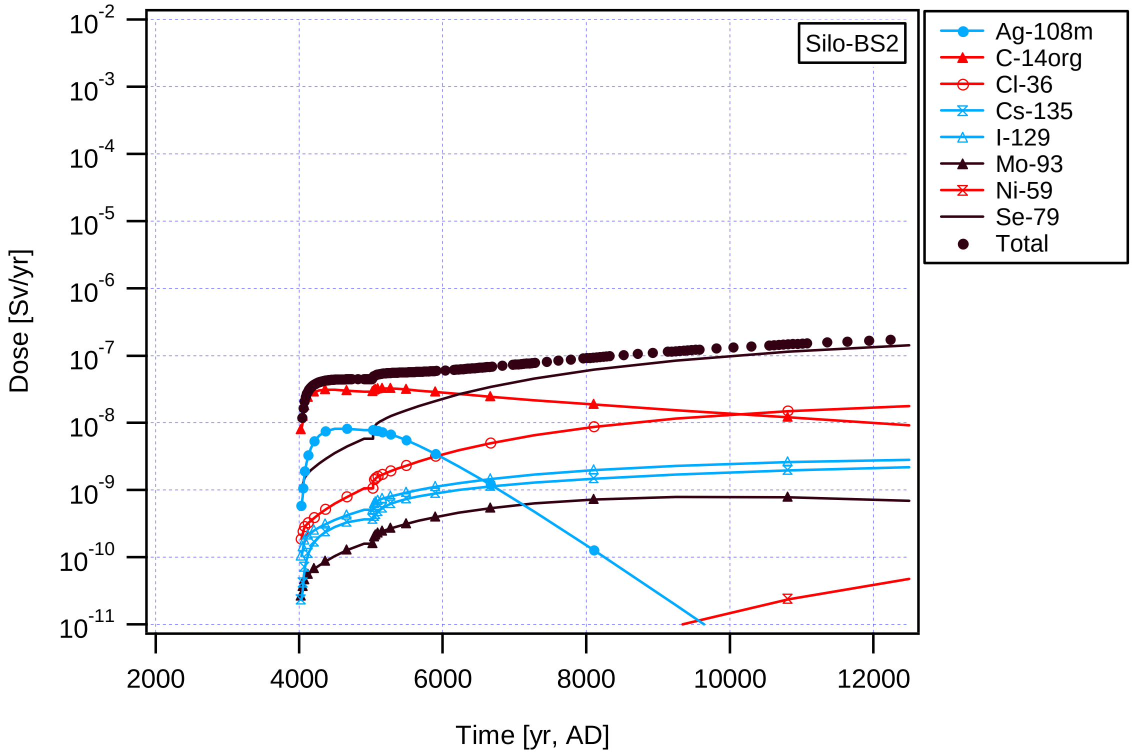

Figure 5-5. *Dose from release of radionuclides from Silo to a mire area.*

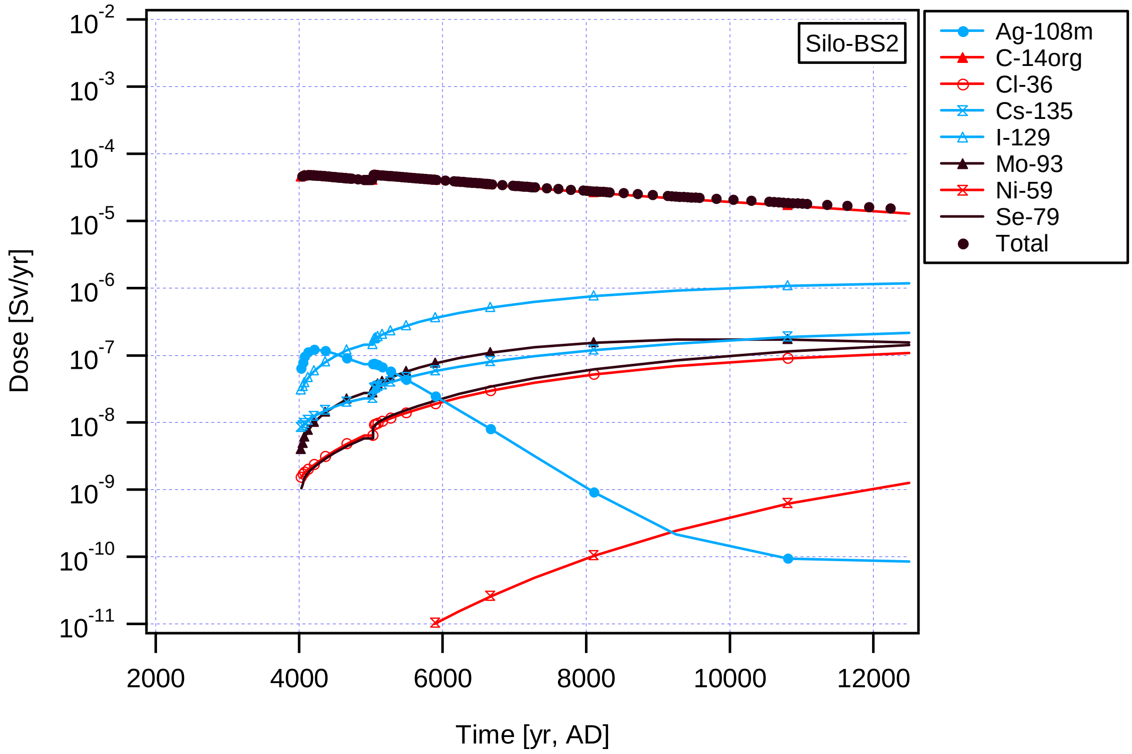

Figure 5-6. *Dose from release of radionuclides from Silo to a well.*

5.1.2 Degraded barriers

Degradation of concrete and bentonite barriers leads to an increased water flow through the Silo. The magnitude and direction of the water flow has been estimated based on the results from the hydrogeology modelling with an increased hydraulic conductivity in the Silo (Holmén and Stigsson, 2001a). In the hydrogeology model a homogeneous conductivity, except for the gravel in the top, was assumed for this case. However, even though the barriers are degraded or fractured the hydraulic properties of the Silo should be such that an axial flow through the part of the Silo where the waste is located is dominating. A vertical flow through this part is therefore assumed in the migration model. The flow is directed upward during the first thousand years from repository closure and thereafter downward.

The results for a Silo being degraded 1000 years after repository closure are shown in *Figure 5-7* to *Figure 5-12*. Since the Silo is assumed to be intact during the first 1000 years, the water flow rate through the Silo, and thus the near-field release rate, during this time period are identical to that for the main case with intact barriers discussed in Section 5.1.1. The increase in flow 3000 AD leads to an increase in release rate compared to the main case. For ^{59}Ni between one and two orders of magnitude higher release rate from the near field is obtained, and for ^{36}Cl, ^{79}Se, ^{93}Mo, ^{108m}Ag, ^{129}I and ^{135}Cs the release rate is a factor seven to ten higher. The maximum near-field release rate of organic ^{14}C is a factor four higher than for the main case.

The delay in the far field may in this case with less retention in the near field be of more importance than in the case with intact barriers. However, the far field is of most importance for the short-lived nuclides and since this case is equal to the case with intact barriers the first 1000 years, the influence of the far -field is not markedly higher than in the case with intact barriers.

The maximum total dose for release to reasonable biosphere, today’s recipient, mire area and well is $9 \cdot 10^{-6}$ Sv/yr, $3 \cdot 10^{-10}$ Sv/yr, $5 \cdot 10^{-6}$ Sv/yr and $2 \cdot 10^{-4}$ Sv/yr, respectively.

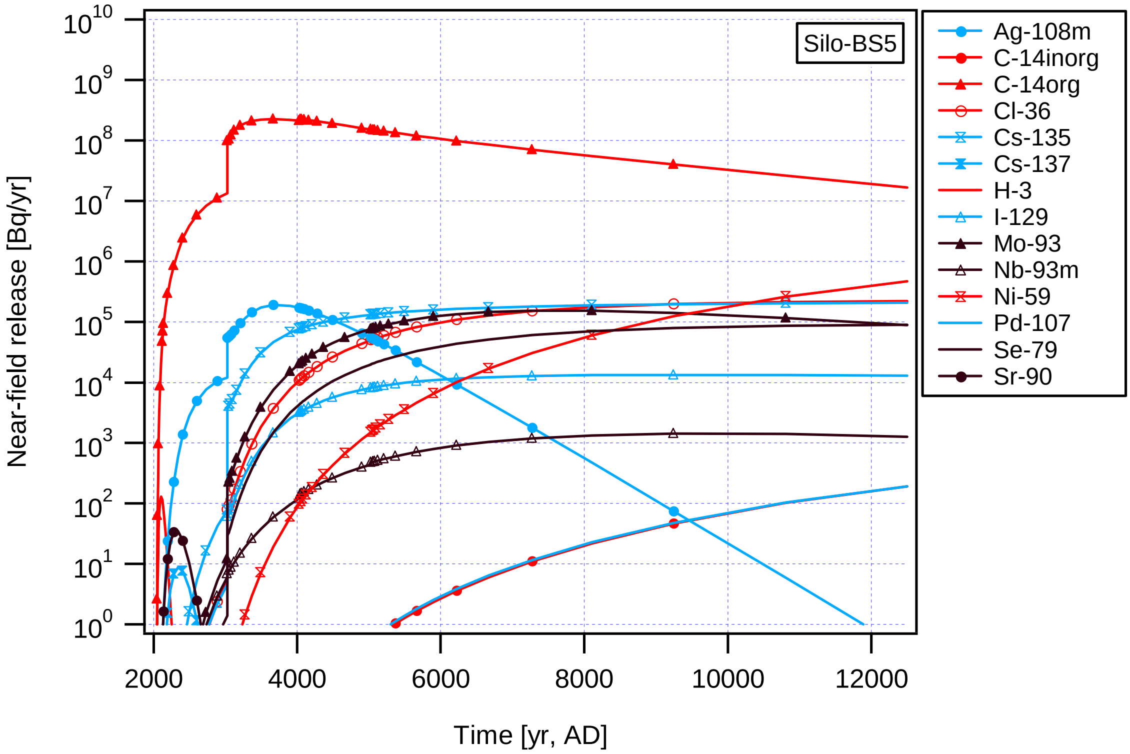

Figure 5-7. *Near-field release rate from a Silo being degraded from 3000 AD.*

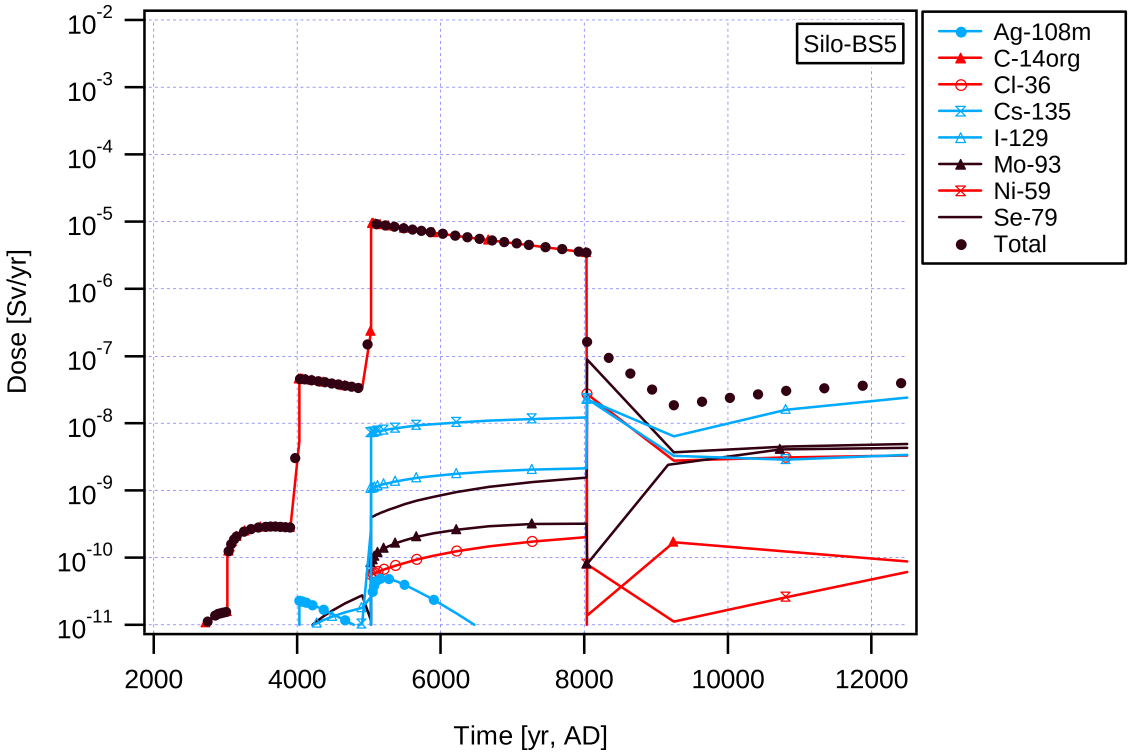

Figure 5-8. *Dose from release of radionuclides from a Silo being degraded from 3000 AD to the reasonable biosphere (calculations performed for dominating nuclides only).*

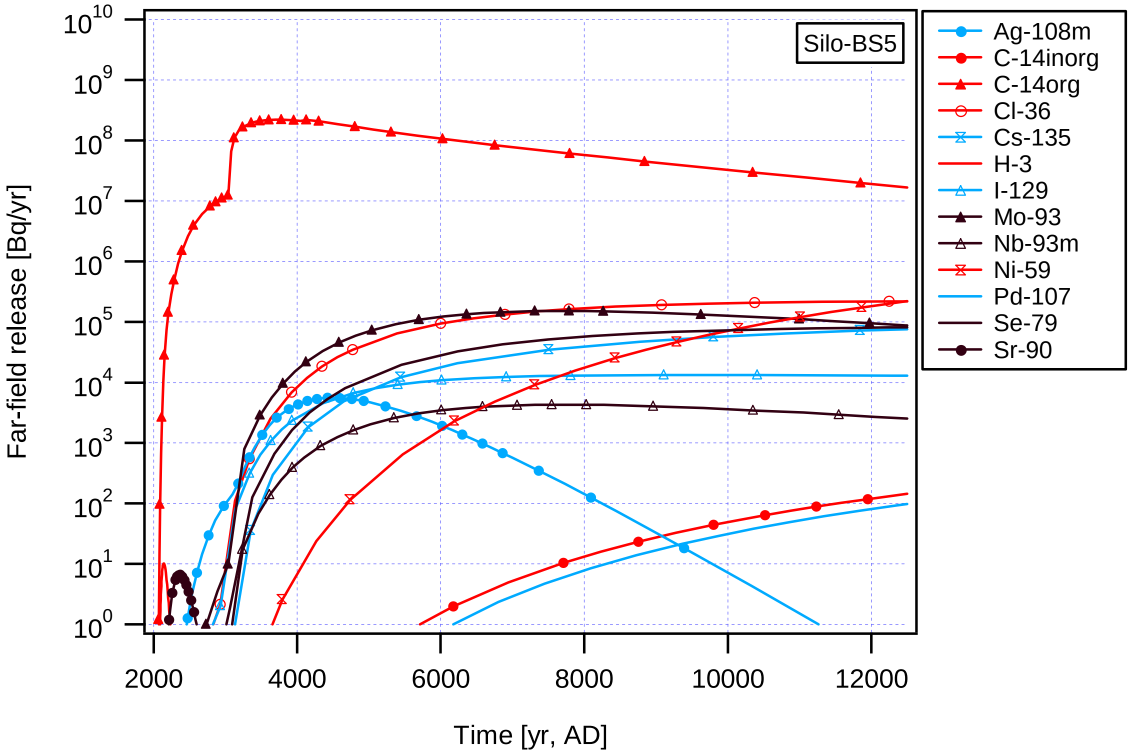

Figure 5-9. *Far-field release rate from a Silo being degraded from 3000 AD.*

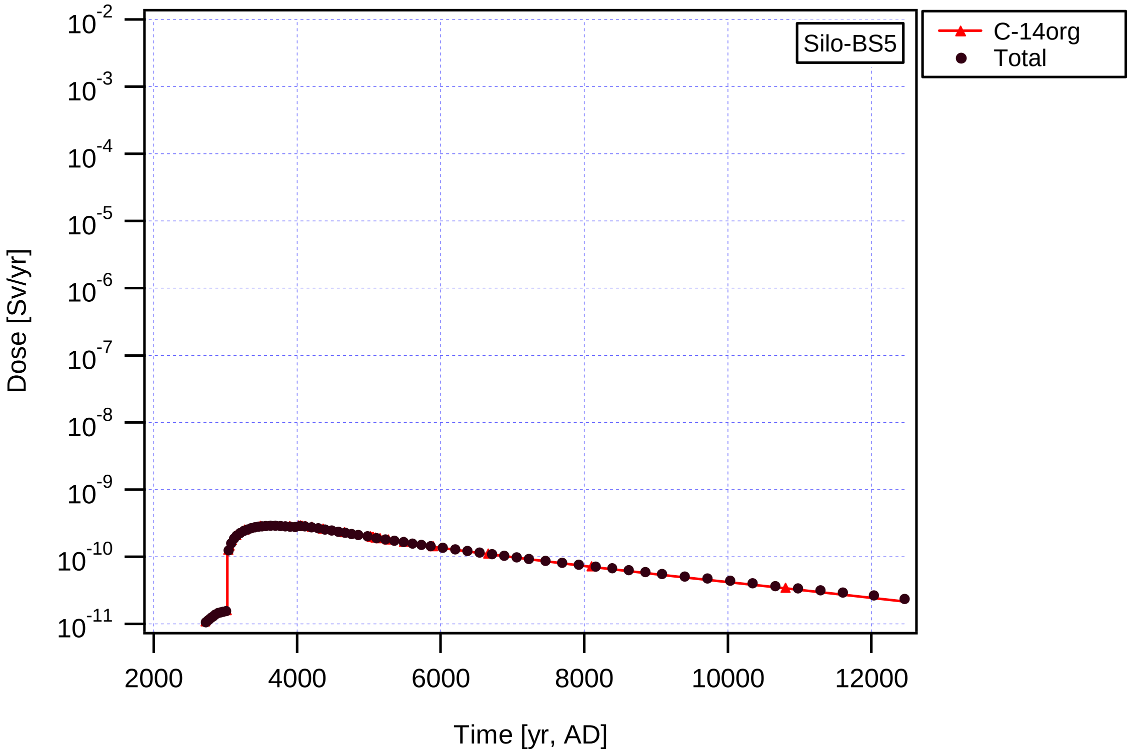

Figure 5-10. *Dose from release of radionuclides from a Silo being degraded from 3000 AD to today's biosphere (calculations performed for dominating nuclides only).*

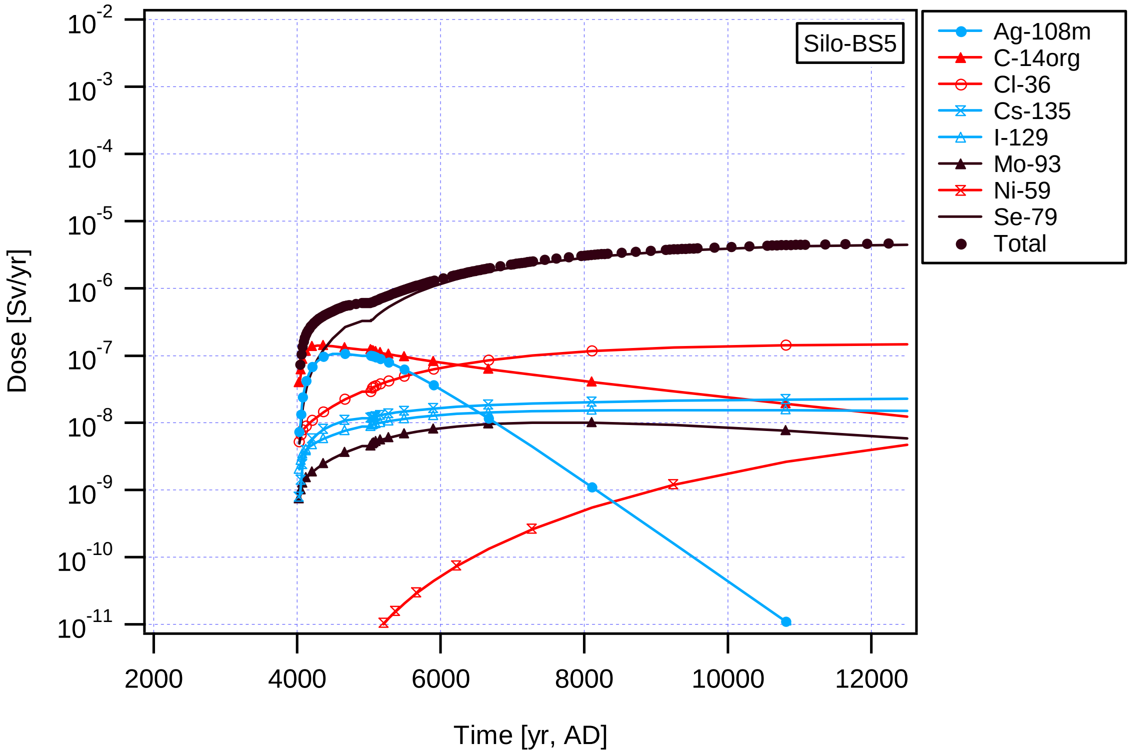

Figure 5-11. *Dose from release of radionuclides from a Silo being degraded from 3000 AD to a mire area (calculations performed for dominating nuclides only).*

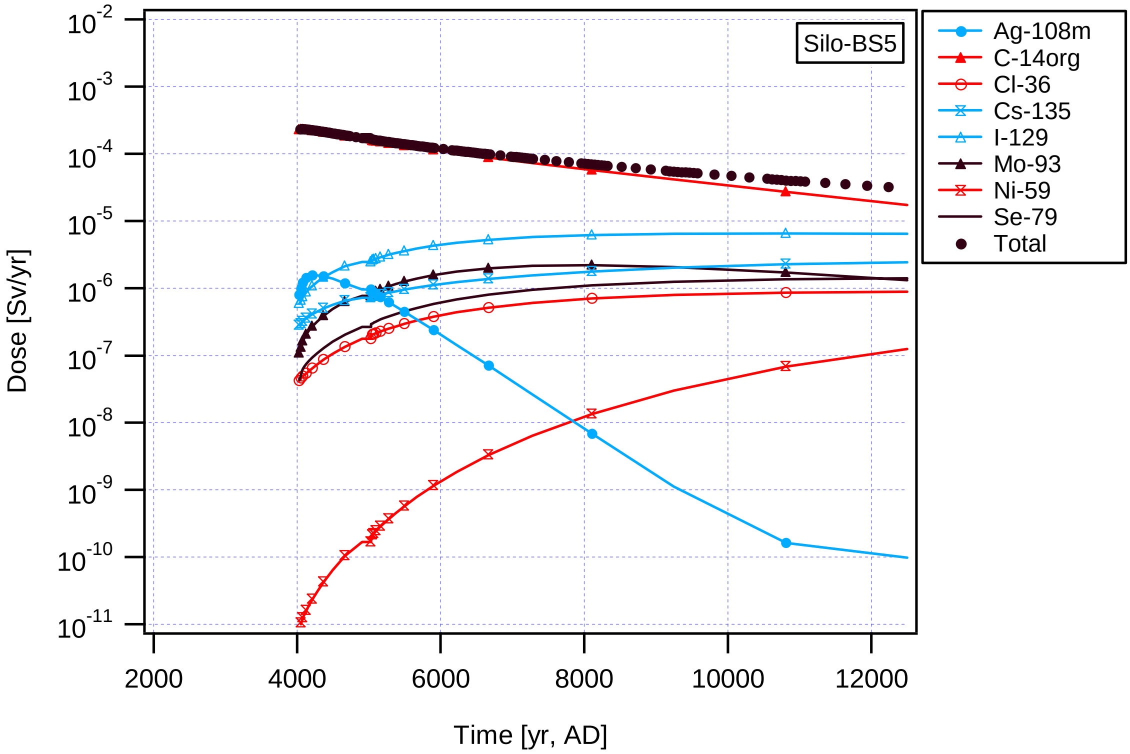

Figure 5-12. *Dose from release of radionuclides from a Silo being degraded from 3000 AD to a well (calculations performed for dominating nuclides only).*

5.2 BMA

5.2.1 Intact barriers

The results for BMA for the base scenario are shown in *Figure 5-13* to *Figure 5-18*. The near-field release rate is dominated by organic ^{14}C, and from about 5800 AD and onwards by ^{59}Ni. The exception is the first few years after repository closure when ^{90}Sr results in a somewhat higher release rate than organic ^{14}C. ^{90}Sr gives a significant release rate for about 200 years. ^{3}H and ^{137}Cs are also among the nuclides dominating the near-field release shortly after repository closure.

Organic ^{14}C also dominates the total dose for the reasonable biosphere development until 8000 AD (see *Figure 5-14*). When the recipient changes from a lake to agricultural land at 8000 AD the dose corresponding to organic ^{14}C drops drastically but for some other nuclides it increases, and the total dose increases to $2 \cdot 10^{-7}$ Sv/yr. During the agricultural period several nuclides contribute to the total dose, ^{36}Cl, ^{59}Ni, ^{79}Se, ^{93}Mo, ^{135}Cs and ^{129}I. ^{79}Se dominates the dose between 8000 AD and 9000 AD and later ^{129}I dominates. The maximum total dose for BMA is $5 \cdot 10^{-7}$ Sv/yr, obtained at about 5000 AD.

The result on release from the far field is shown in *Figure 5-15*. The influence of the far-field rock on the release of radionuclides from BMA is a delay and thereby reduced release rates for especially sorbing short-lived nuclides. For example the release rate of ^{90}Sr, ^{137}Cs and ^{63}Ni decrease one or several orders of magnitude. The dose dominating nuclides are however only slightly influenced by the far field.

When the nuclides are released to today's biosphere the whole studied period the maximum total dose for release of radionuclides from BMA is very low (see *Figure 5-16*). A maximum dose of $2 \cdot 10^{-10}$ Sv/yr is obtained and is dominated by the release of organic ^{14}C.

If the recipient is a mire area, the dose dominating nuclide is ^{79}Se. ^{36}Cl, ^{59}Ni and ^{108m}Ag each gives a dose that is about an order of magnitude lower. The dose from ^{59}Ni is still increasing at the end of the calculations. The total dose is almost constant during the studied time period with a maximum of $3 \cdot 10^{-6}$ Sv/yr.

Release to a well results in an even higher total dose. The maximum dose is obtained at 4000 AD and is caused by the release of organic ^{14}C. Organic ^{14}C dominates the dose until 6000 AD. From then, ^{129}I and later ^{59}Ni are dominating nuclides. However, other nuclides, e.g. ^{93}Mo and ^{135}Cs, give a significant contribution to the total dose.

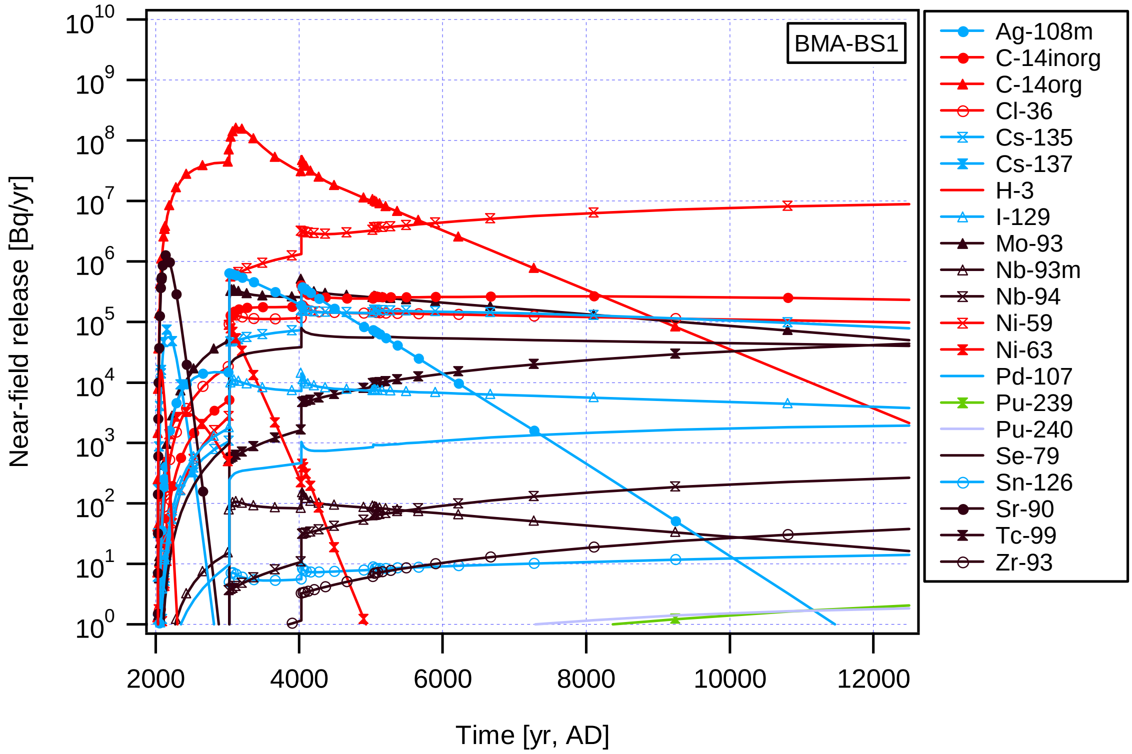

Figure 5-13. *Near-field release rate from BMA.*

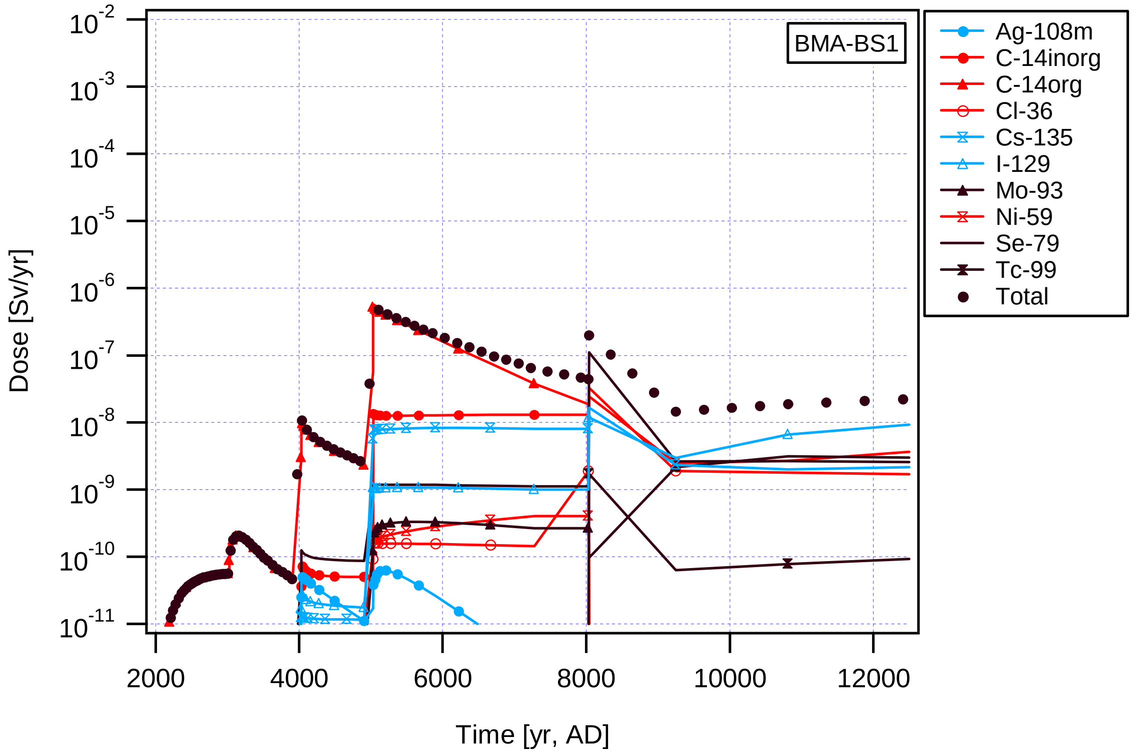

Figure 5-14. *Dose from release of radionuclides from BMA to the reasonable biosphere.*

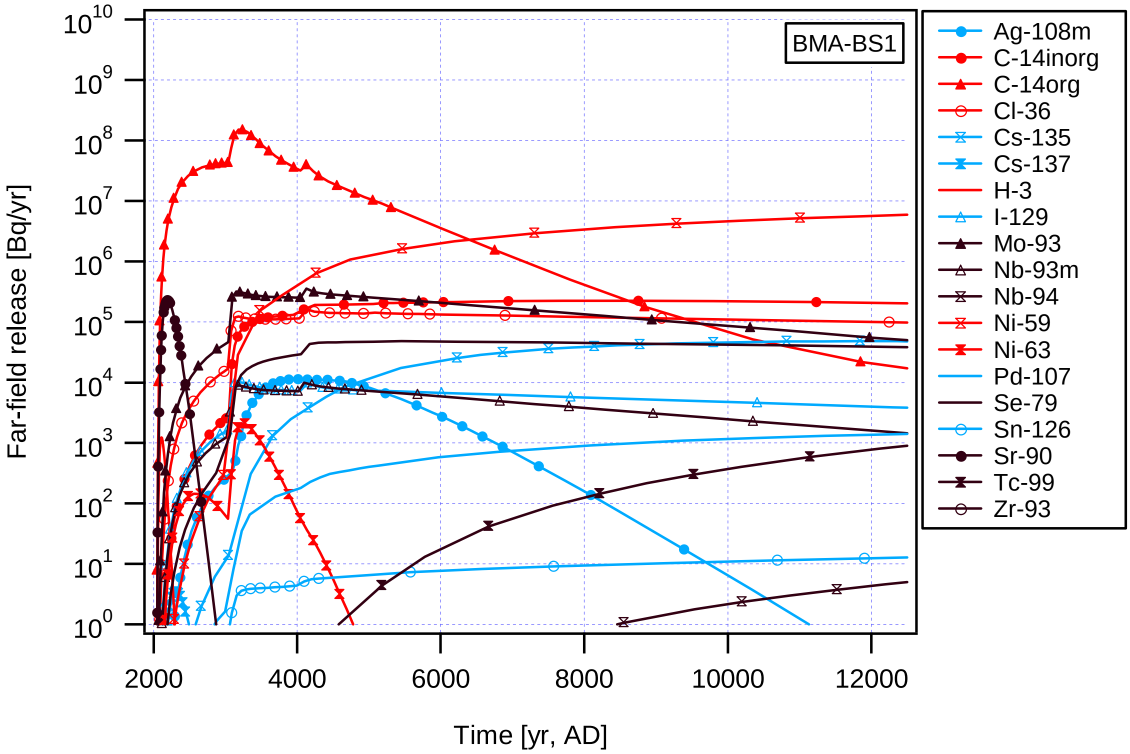

Figure 5-15. *Far-field release rate from BMA.*

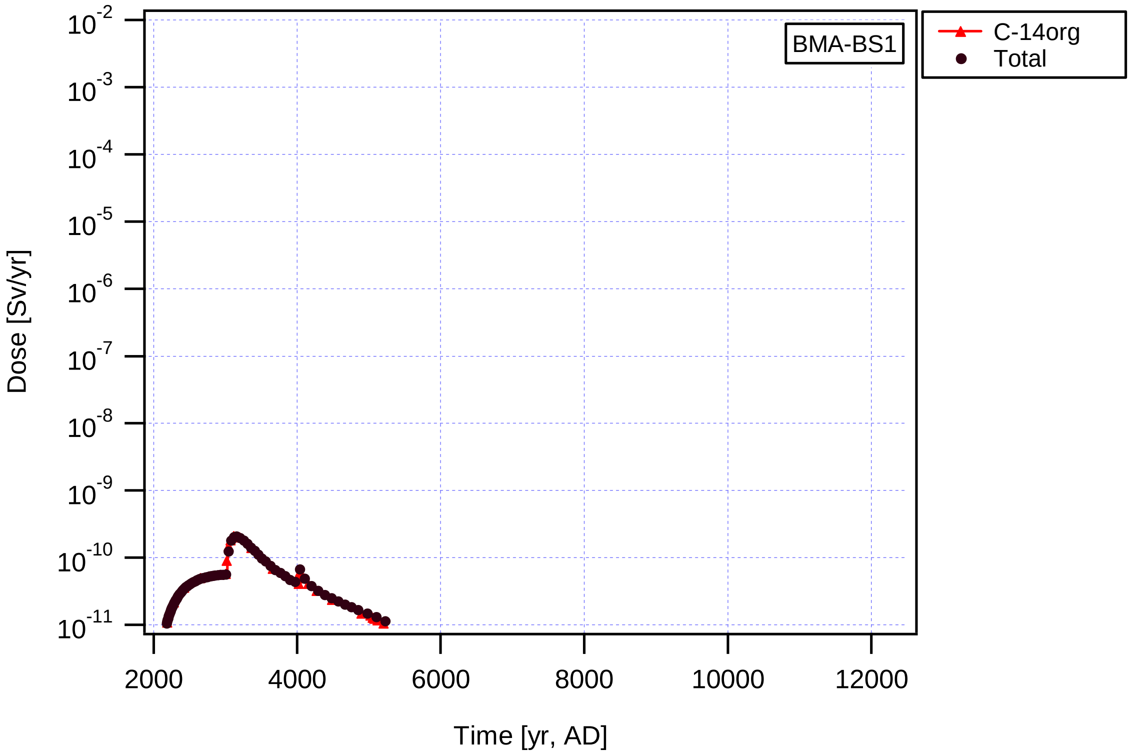

Figure 5-16. *Dose from release of radionuclides from BMA to today's biosphere.*

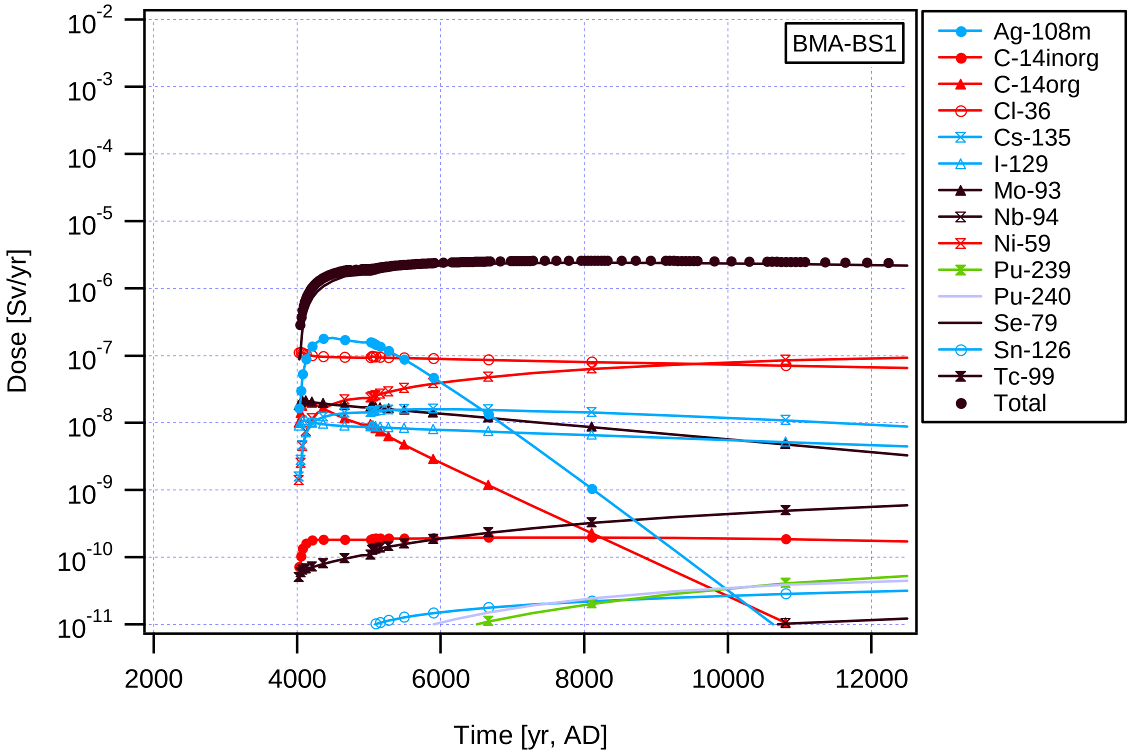

Figure 5-17. *Dose from release of radionuclides from BMA to a mire area.*

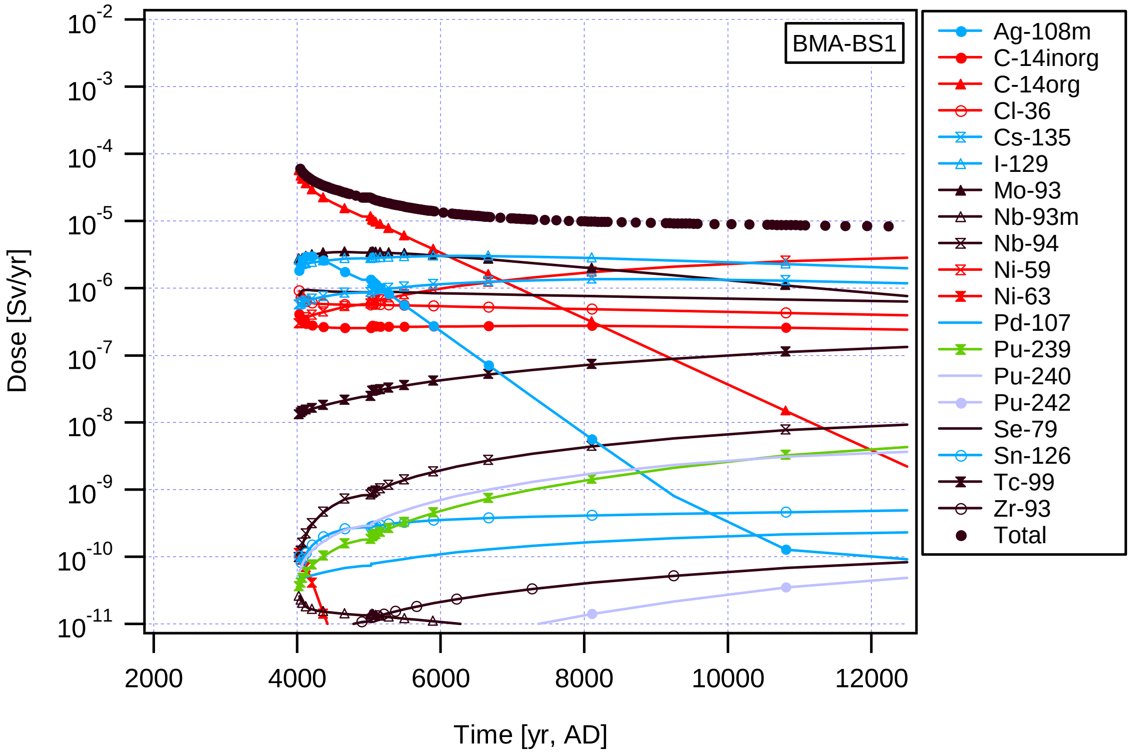

Figure 5-18. *Dose from release of radionuclides from BMA to a well.*

5.2.2 Degraded barriers

Degradation of the encapsulation in BMA, for example by leaching of components in the concrete structures, may lead to fracturing. It is foreseen that the largest effect on release from a degraded encapsulation is obtained where fracture zone 6 intersects BMA, since this is where the ground-water flow is highest. Fracture zone 6 intersects BMA at room 12 why it is assumed that this room is degraded. In this case it is assumed that degradation occurs instantaneously at 3000 AD (see Chapter 3). A fracture through this room have a limited influence on the total flow through BMA (Holmén and Stigsson, 2001a). A small redistribution of the flow is obtained, but the main effect is a significant increase in flow through the encapsulation at room 12.

The release rate from the near field for this case is shown in *Figure 5-19*. Since the flow through the repository between 2000 AD and 3000 AD is the same as for the main case shown in *Figure 5-13* above, the release rate for this period of time is identical. However, the higher water flow rate from 3000 AD compared to the main case generally results in an increased nuclide release rate. For certain time periods the release rate of some nuclides (e.g. inorganic ^{14}C, ^{59}Ni and ^{99}Tc) is between one and two orders of magnitude higher. Other nuclides, such as organic ^{14}C, ^{36}Cl, ^{93}Mo, ^{129}I and ^{135}Cs is only marginally affected by a higher water flow rate through room 12.

A significant difference between intact and degraded barriers in BMA is that the dose from release of ^{59}Ni, ^{239}Pu and ^{240}Pu to the reasonable biosphere after 8000 AD increases significantly with degraded barriers. This leads to that ^{59}Ni dominates until 10 500 AD and thereafter the two plutonium isotopes dominate the dose. The maximum total dose for release to reasonable biosphere in this case is $1 \cdot 10^{-6}$ Sv/yr.

The release rate from the far field for this case is shown in *Figure 5-21*. Even though the retention in the near field barriers is smaller in this case compared to the case with intact barriers the influence of the far field is small for most of the dose dominating nuclides, except for ^{239}Pu and ^{240}Pu. The release of these nuclides is reduced more than two orders of magnitude.

The maximum total dose for release to today's biosphere, mire area and well is $2 \cdot 10^{-10}$ Sv/yr, $3 \cdot 10^{-6}$ Sv/yr and $7 \cdot 10^{-5}$ Sv/yr, respectively.

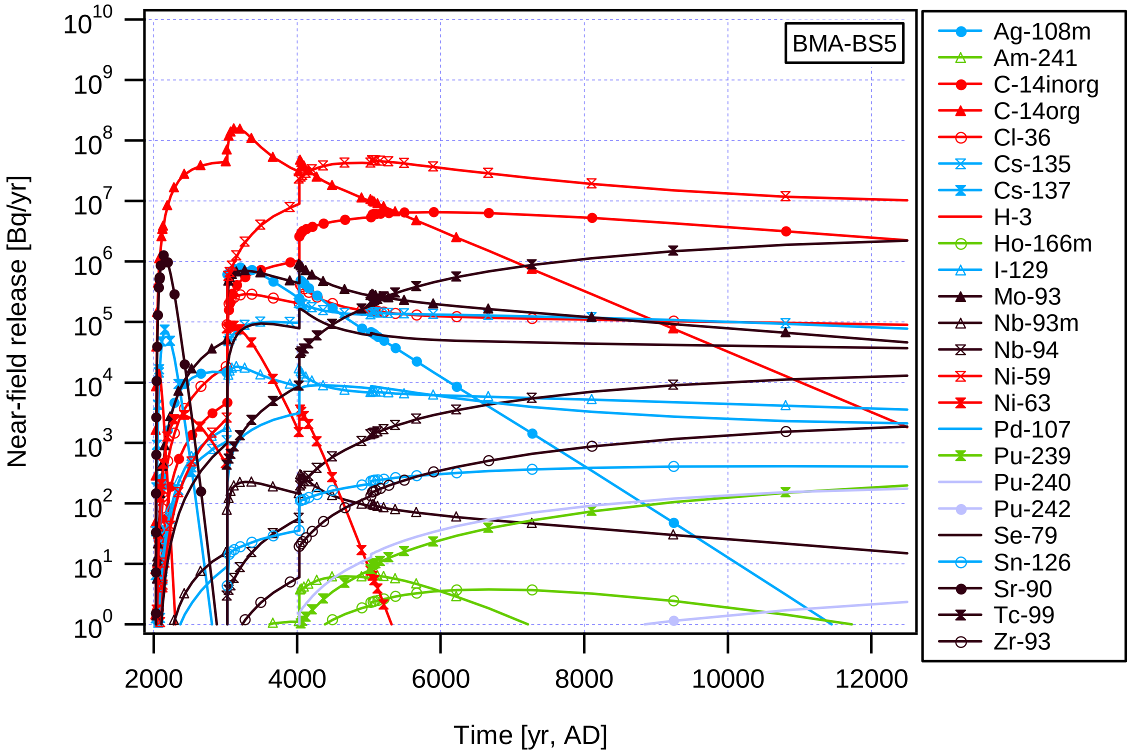

Figure 5-19. *Near-field release rate from BMA with an encapsulation being degraded from 3000 AD.*

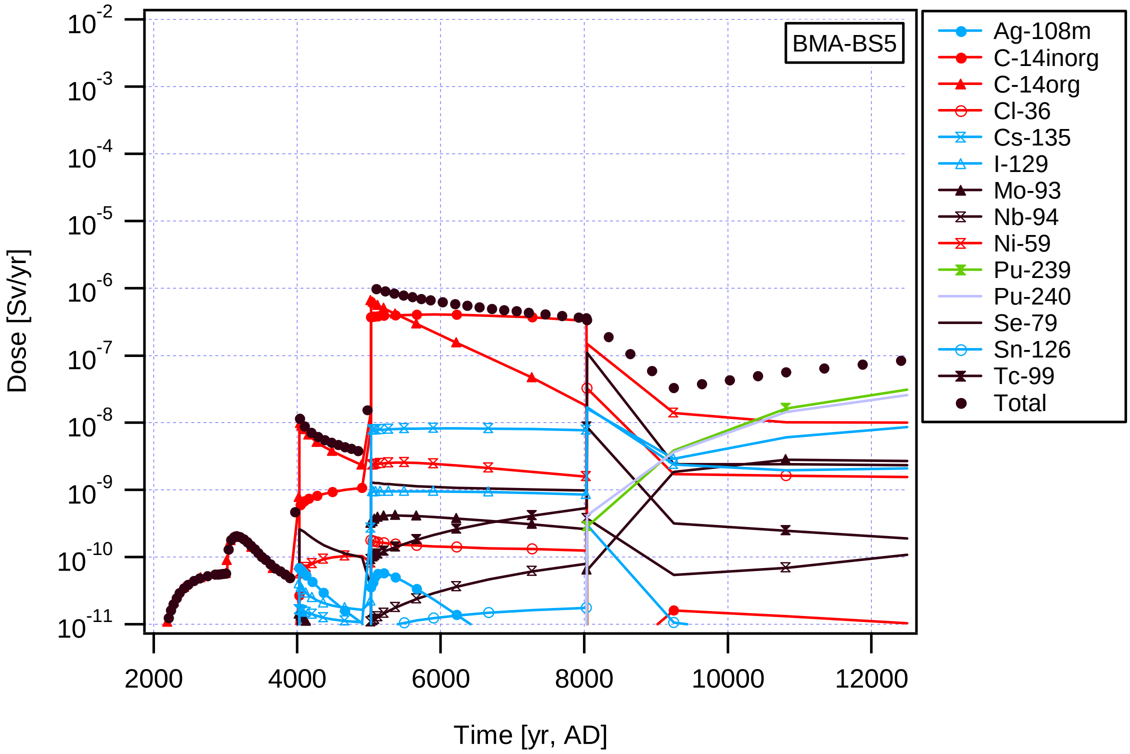

Figure 5-20. *Dose from release of radionuclides from BMA with an encapsulation being degraded from 3000 AD to the reasonable biosphere (calculations performed for dominating nuclides only).*

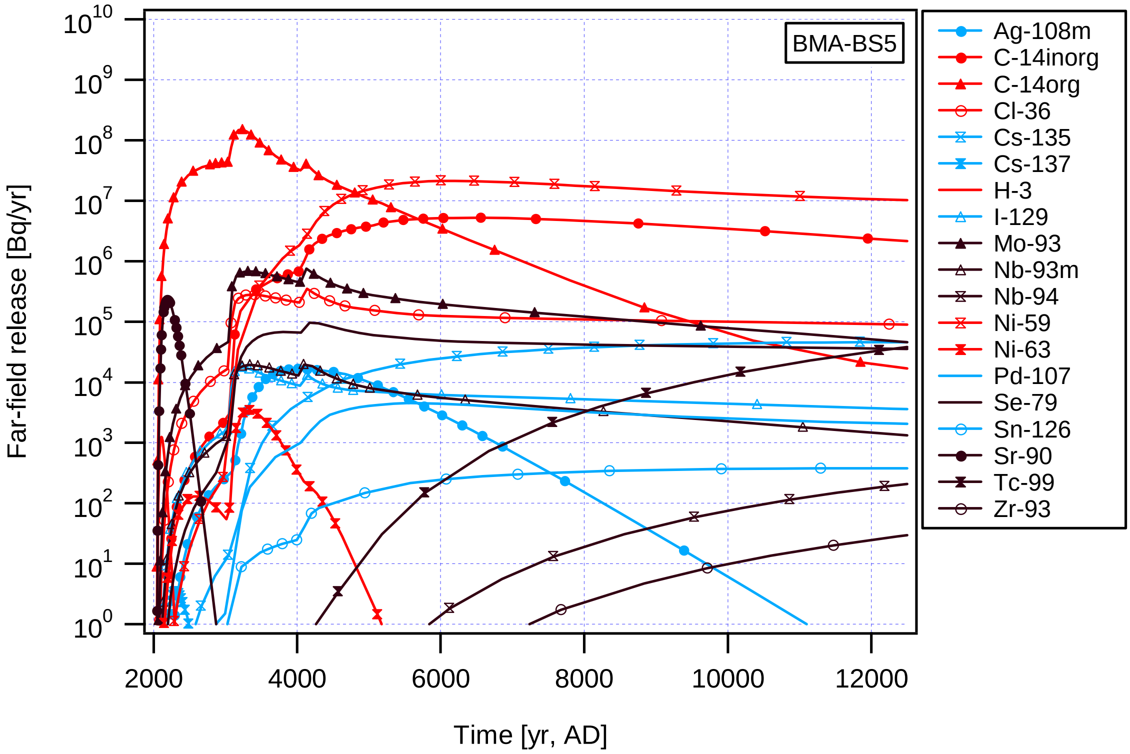

Figure 5-21. *Far-field release rate from BMA with an encapsulation being degraded from 3000 AD.*

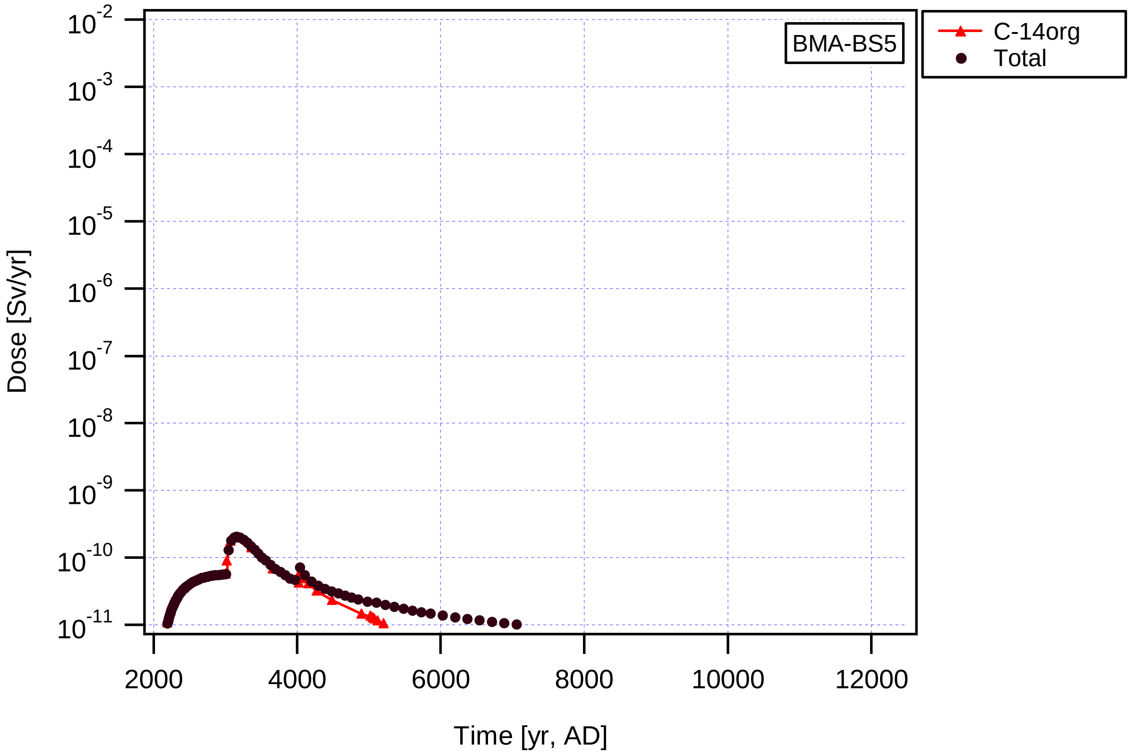

Figure 5-22. *Dose from release of radionuclides from BMA with an encapsulation being degraded from 3000 AD to today's biosphere (calculations performed for dominating nuclides only).*

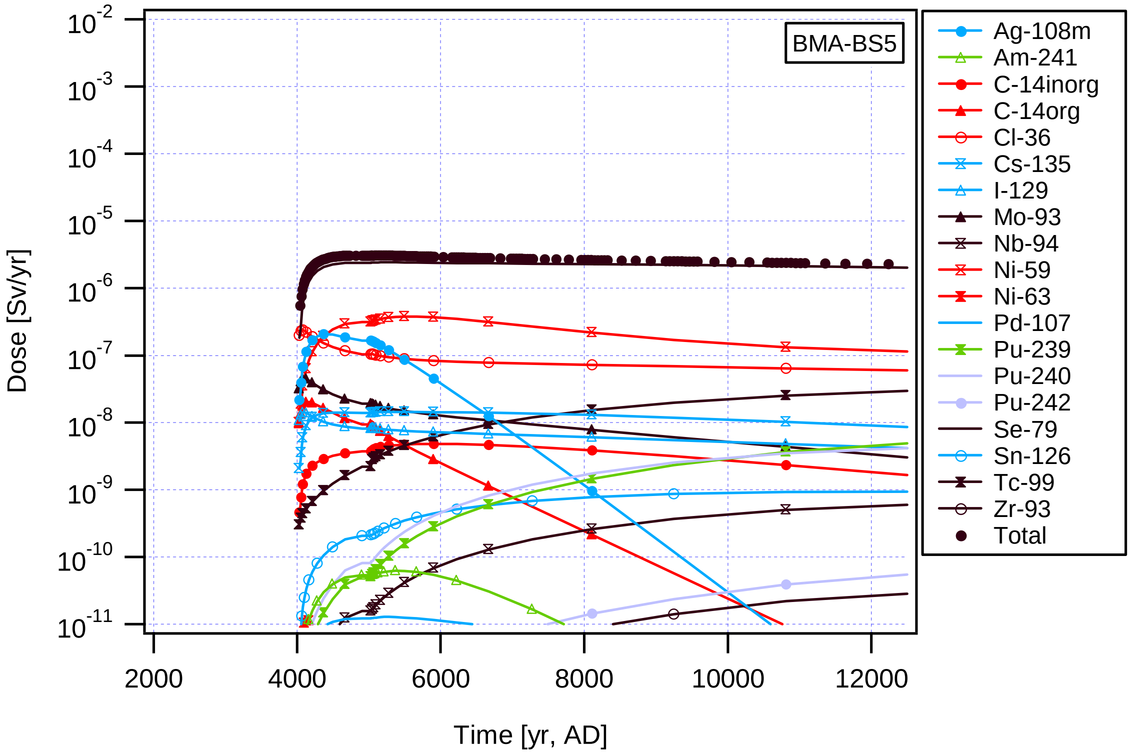

Figure 5-23. *Dose from release of radionuclides from BMA with an encapsulation being degraded from 3000 AD to a mire area (calculations performed for dominating nuclides only).*

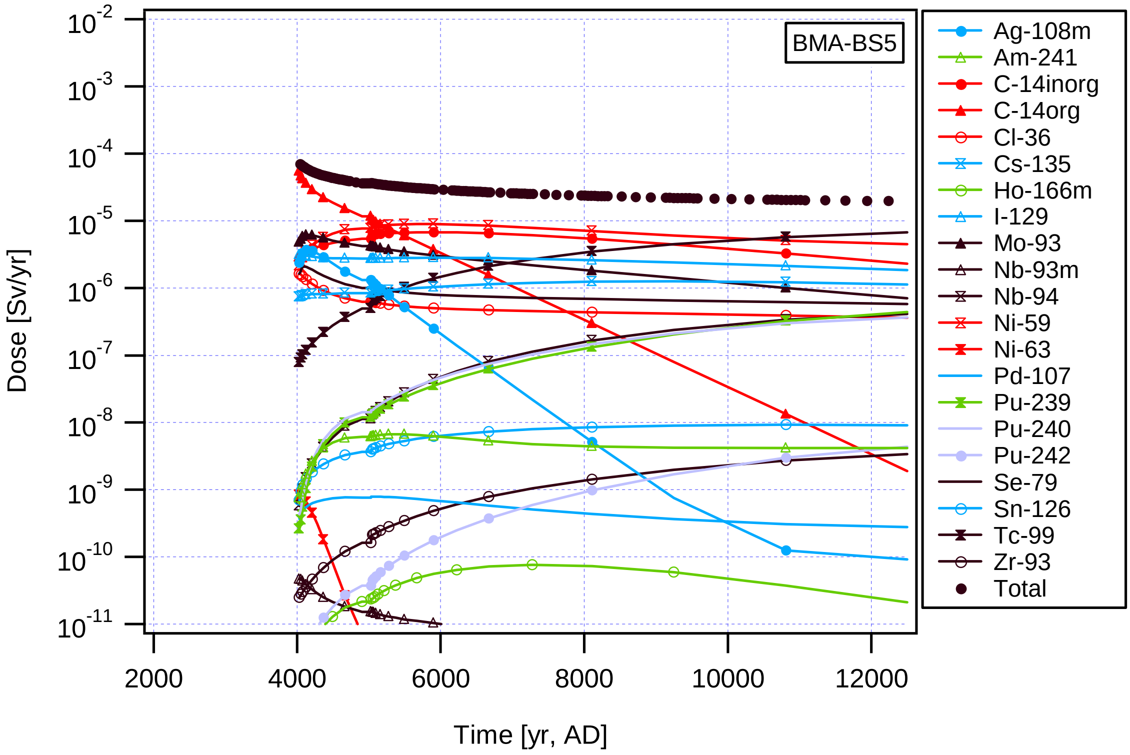

Figure 5-24. *Dose from release of radionuclides from BMA with an encapsulation being degraded from 3000 AD to a well (calculations performed for dominating nuclides only).*

5.3 1BTF

5.3.1 Intact barriers

The results for the modelling of radionuclide transport within the near field of 1BTF are shown in *Figure 5-25*. The release is to a major part similar to that from BMA in terms of dominating nuclides. The maximum release rate for organic ^{14}C is $2\cdot10^{8}$ Bq/yr which is obtained a thousand years after repository closure. From that point the release rate of organic ^{14}C decreases. Instead, the highest release rate is obtained by ^{59}Ni and inorganic ^{14}C from 6000 AD.

For release to the reasonable biosphere (*Figure 5-26*) the total dose is in the beginning dominated by organic ^{14}C. When the recipient for the nuclides is changed from a coastal area to a lake (at 5000 AD) there is a steep increase in dose. This increase is especially evident for inorganic ^{14}C, but organic ^{14}C is still resulting in the highest dose. The dose corresponding to inorganic ^{14}C is slowly increasing between 5000 AD and 8000 AD but that from organic ^{14}C is decreasing. The total dose is therefore dominated by inorganic ^{14}C between 6000 AD and 8000 AD. At 8000 AD the recipient is changed to an agricultural land, and consequently the dose from both organic and inorganic ^{14}C is significantly reduced. Several nuclides then significantly contribute to the dose, ^{36}Cl, ^{59}Ni, ^{79}Se, ^{93}Mo, ^{129}I and ^{135}Cs. At 8000 AD the dose is dominated by ^{36}Cl and later by ^{129}I. The maximum total dose, $4\cdot10^{-7}$ Sv/yr, is obtained at 5000 AD.

The influence of the far-field rock on the release of radionuclides from 1BTF is shown in *Figure 5-27*. The maximum far-field release rate of organic ^{14}C is a factor two lower than that from the near field. Other dose dominating nuclides, inorganic ^{14}C, ^{36}Cl, ^{79}Se and ^{129}I, are also slightly influenced by the far field. Short-lived sorbing nuclides are more influenced than the dose dominating nuclides. For example ^{90}Sr, ^{137}Cs, ^{108m}Ag and ^{63}Ni decrease one or several orders of magnitude in the far field.

The dose obtained from a release of radionuclides in 1BTF to today's biosphere is dominated by organic ^{14}C with a maximum total dose of $3\cdot10^{-10}$ Sv/yr.

Release of radionuclides in 1BTF to a mire area gives a dose that is dominated by ^{79}Se. ^{108m}Ag are among the dose dominating nuclides in the time period 4000 AD to 5000 AD (see *Figure 5-29*). Other nuclides of importance for the total dose are ^{36}Cl and ^{59}Ni, but they give a dose that is about an order of magnitude lower than ^{79}Se.

Organic ^{14}C dominates the dose between 4000 AD and 6000 AD when nuclides in 1BTF are released to a well (see *Figure 5-30*). For longer times several nuclides give a major contribution to the total dose, e.g. inorganic ^{14}C, ^{59}Ni, ^{93}Mo, ^{129}I and ^{135}Cs. The maximum total dose, obtained 4000 AD, is $7\cdot10^{-5}$ Sv/yr.

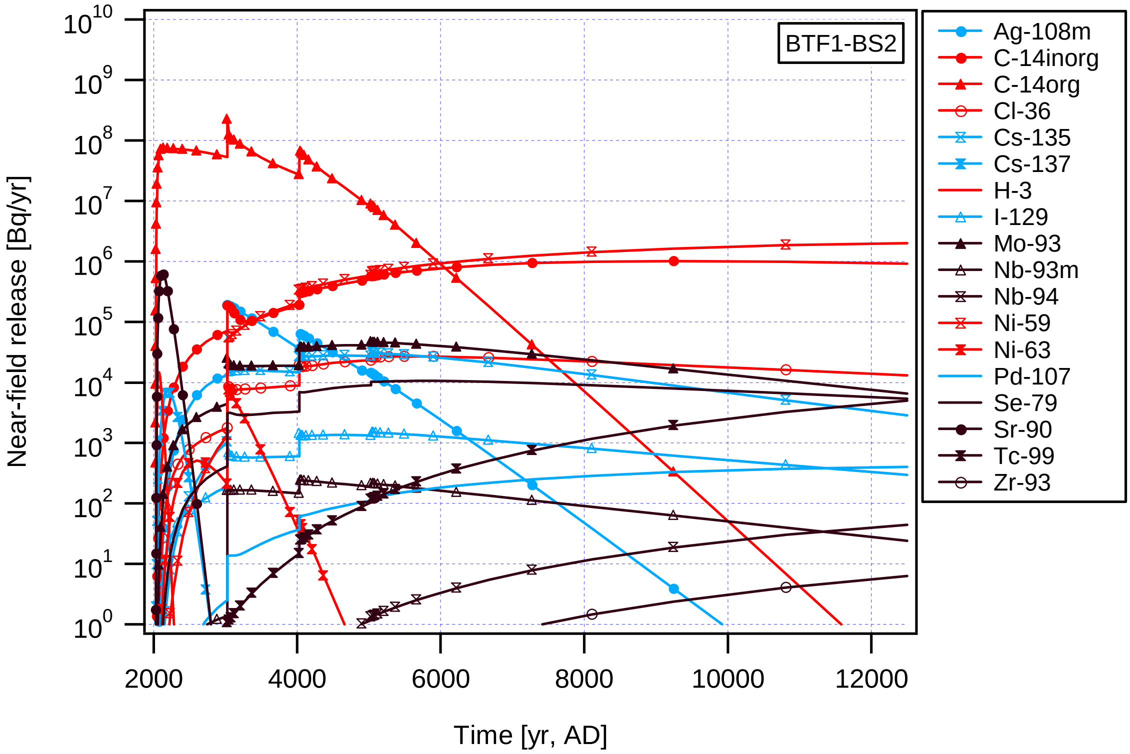

Figure 5-25. *Near-field release rate from 1BTF.*

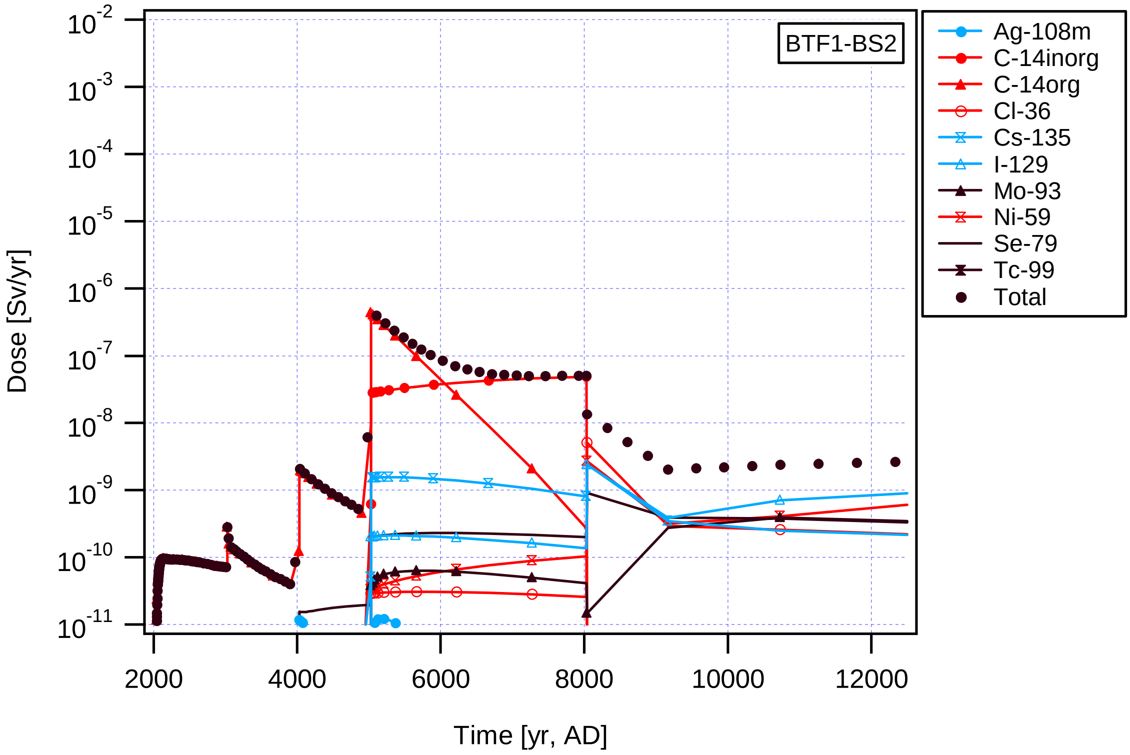

Figure 5-26. *Dose from release of radionuclides from 1BTF to the reasonable biosphere.*

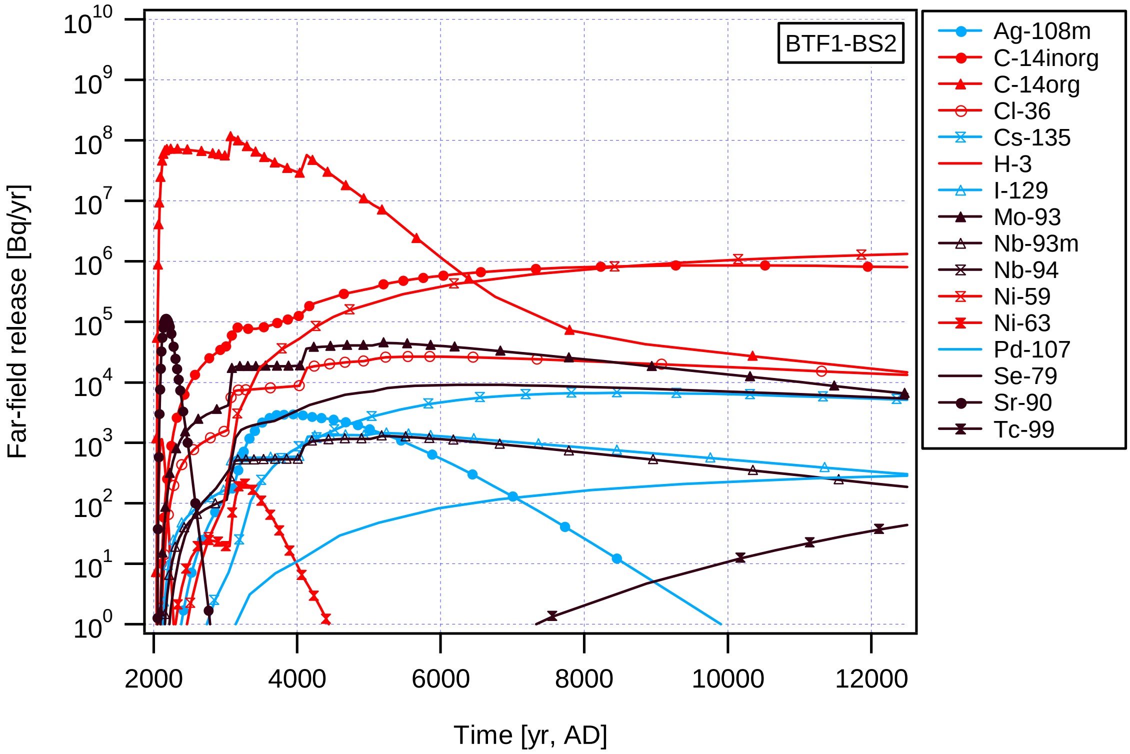

Figure 5-27. Far-field release rate from 1BTF.

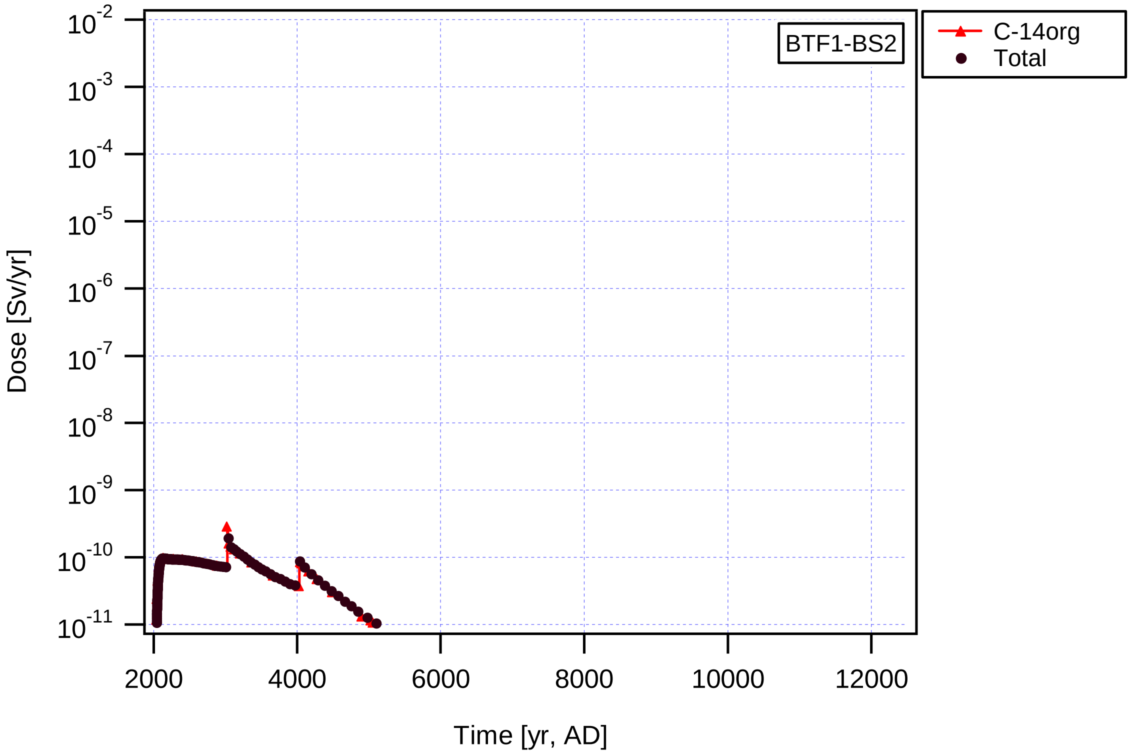

Figure 5-28. Dose from release of radionuclides from 1BTF to today's biosphere.

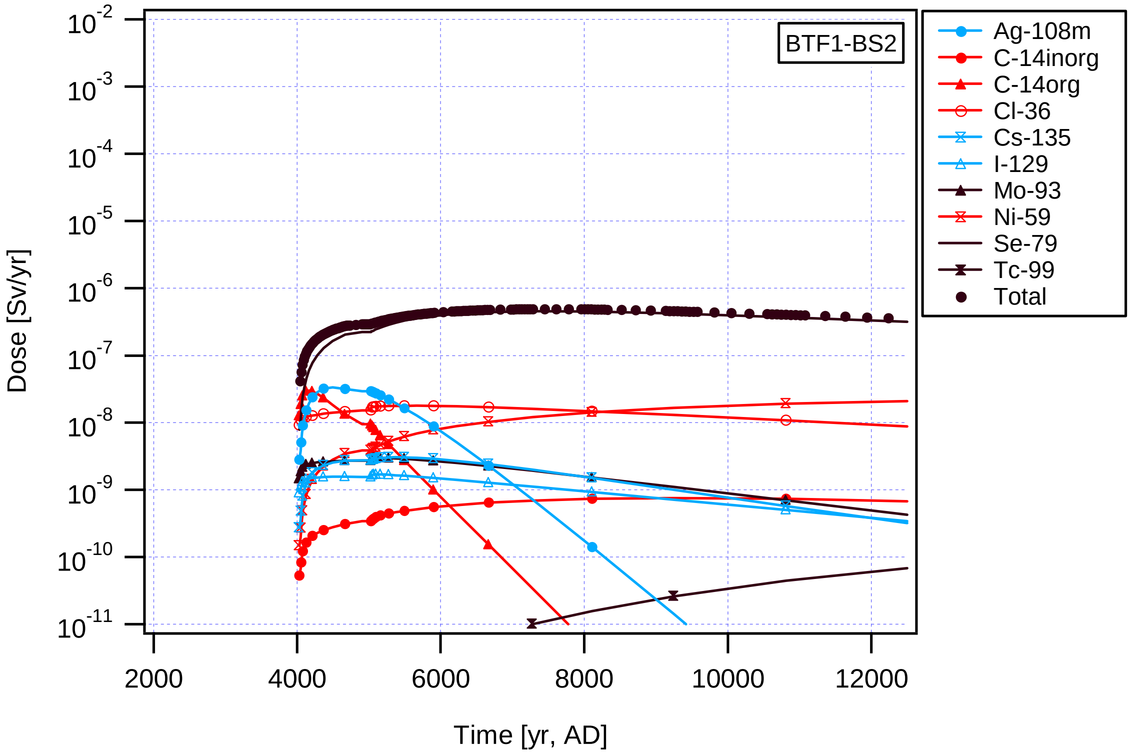

Figure 5-29. *Dose from release of radionuclides from 1BTF to a mire area.*

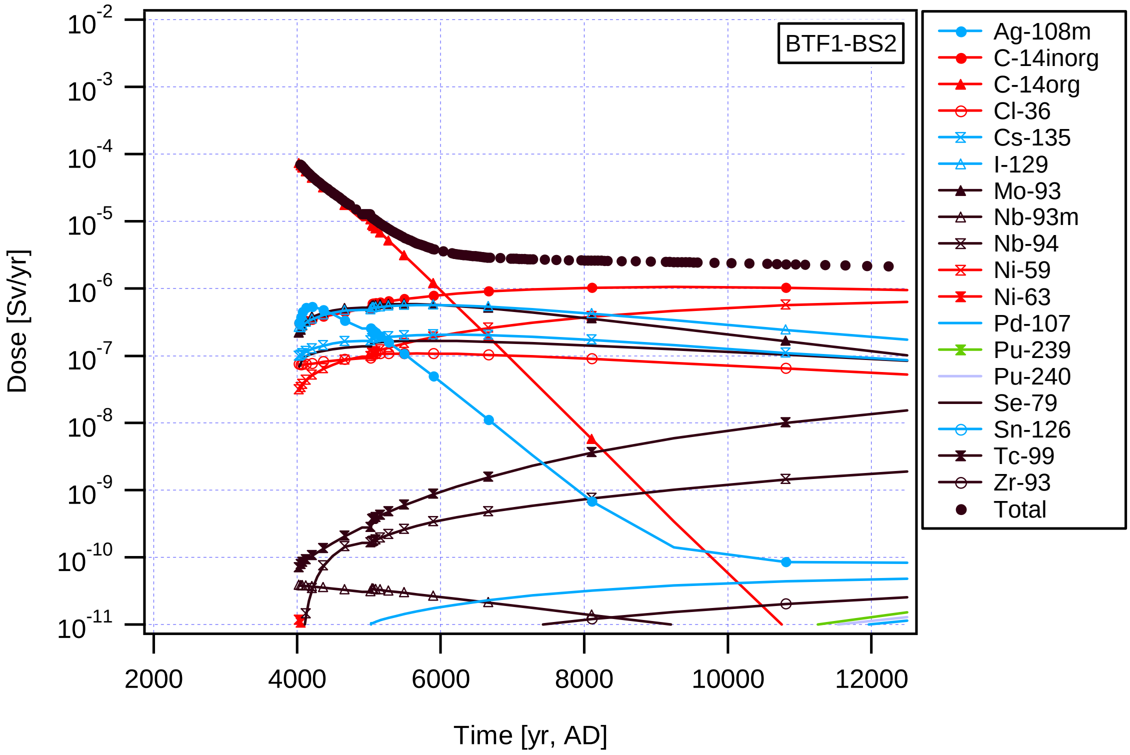

Figure 5-30. *Dose from release of radionuclides from 1BTF to a well.*

5.3.2 Degraded barriers

The effect of degradation of barriers in 1BTF from 3000 AD has also been estimated. The water flow through 1BTF where a 17 m long section of the repository, located where fracture zone 6 intersects the vault, is given an insignificant flow resistance has been modelled (Holmén and Stigsson, 2001a). The results show that the water flow rate through the waste and surrounding concrete backfill is up to a factor six higher than for an intact barrier. Furthermore, it is concluded that the main part of the water in 1BTF (90 %) flows through the degraded part. However, the total water flow through the whole vault increases with no more than a factor two.

No radionuclide migration calculations have been made for this case. However, based on the results discussed in the previous paragraph, it is concluded that only waste packages in the degraded part will be affected by the higher flow rate obtained with a degraded barrier. Theoretically, in comparison to the nuclide release rate from an intact barrier, the release rate from these packages can increase with a factor corresponding to the increase in flow for the nuclides of importance. Radionuclides with short half-life may increase more. An increased release rate from the non-degraded part of the vault will not be obtained since the water flow rate through this part is not foreseen to increase. A 17 m wide section corresponds to about 10 % of the total waste volume. A flow increase of a factor six for 10 % of the waste together with essentially an uninfluenced water flow rate through the rest of the waste, and an increase in total flow through the vault of a factor two, both indicate that the near-field release rate should not be more than a factor two higher in comparison to the main case. Thus, the maximum total dose is estimated to be $8 \cdot 10^{-7}$ Sv/yr for the reasonable biosphere development.

5.4 2BTF

5.4.1 Intact barriers

The results for the near-field release from 2BTF resembles that from BMA (compare *Figure 5-31* and *Figure 5-13*). In the beginning the release is dominated by organic ^{14}C and later by ^{59}Ni. The release rate of organic ^{14}C from 2BTF is about a factor five lower than that from BMA. The difference for ^{59}Ni is about a factor three.

The dose obtained for release of radionuclides from 2BTF for the reasonable biosphere development is shown in *Figure 5-32*. It is the same nuclides that dominate the dose as for BMA. The dose obtained from organic ^{14}C released from 2BTF is between a factor five to eight lower than the corresponding release from BMA. The maximum total dose is $9 \cdot 10^{-8}$ Sv/yr at 5000 AD. When the lake is transferred into agricultural land at 8000 AD the total dose is $5 \cdot 10^{-8}$ Sv/yr. ^{79}Se dominates the dose at this point of time followed by ^{36}Cl and ^{59}Ni. The dose decrease until 9000 AD, after that the dose increase slightly. During this time period ^{36}Cl, ^{59}Ni, ^{79}Se, ^{93}Mo, ^{129}I and ^{135}Cs dominate the dose.

The influence of the far-field rock on the release of radionuclides from 2BTF is shown in *Figure 5-33*. The dose dominating nuclides, organic ^{14}C, ^{36}Cl, ^{59}Ni, ^{79}Se and ^{129}I, are slightly influenced by the far field. Short-lived sorbing nuclides are more influenced than the dose dominating nuclides. For example ^{90}Sr, ^{137}Cs, ^{108m}Ag and ^{63}Ni decrease one or several orders of magnitude in the far field.

The total dose obtained when nuclides from 2BTF are released to today's biosphere is dominated by the release of organic ^{14}C, with a total dose less than 10^{-10} Sv/yr (see *Figure 5-34*).

Figure 5-35 shows the dose obtained for release to a mire area. The result for 2BTF is very similar to that obtained for BMA (*Figure 5-17*) in terms of dominating nuclides (^{36}Cl, ^{59}Ni, ^{79}Se and ^{108m}Ag). The maximum total dose for 2BTF is however somewhat lower ($7 \cdot 10^{-7}$ Sv/yr).

The results for 2BTF and BMA are also similar for a release to a well. Organic ^{14}C dominates the dose up to about 6000 AD and thereafter the dose is dominated by ^{93}Mo, ^{129}I and ^{59}Ni (see *Figure 5-36*). ^{36}Cl, ^{79}Se and ^{135}Cs also contribute to the total dose. The total dose from release from 2BTF is however somewhat lower than for BMA. The results for 2BTF gives a maximum total dose of $1 \cdot 10^{-5}$ Sv/yr about 4000 AD.

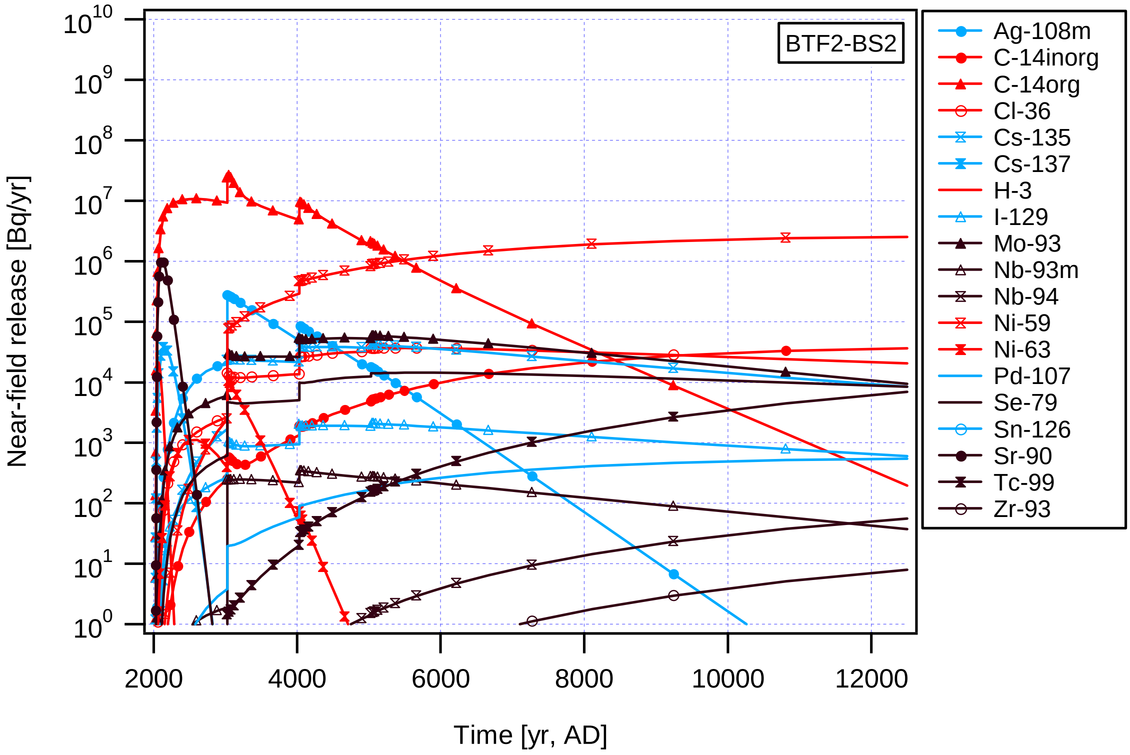

Figure 5-31. *Near-field release rate from 2BTF.*

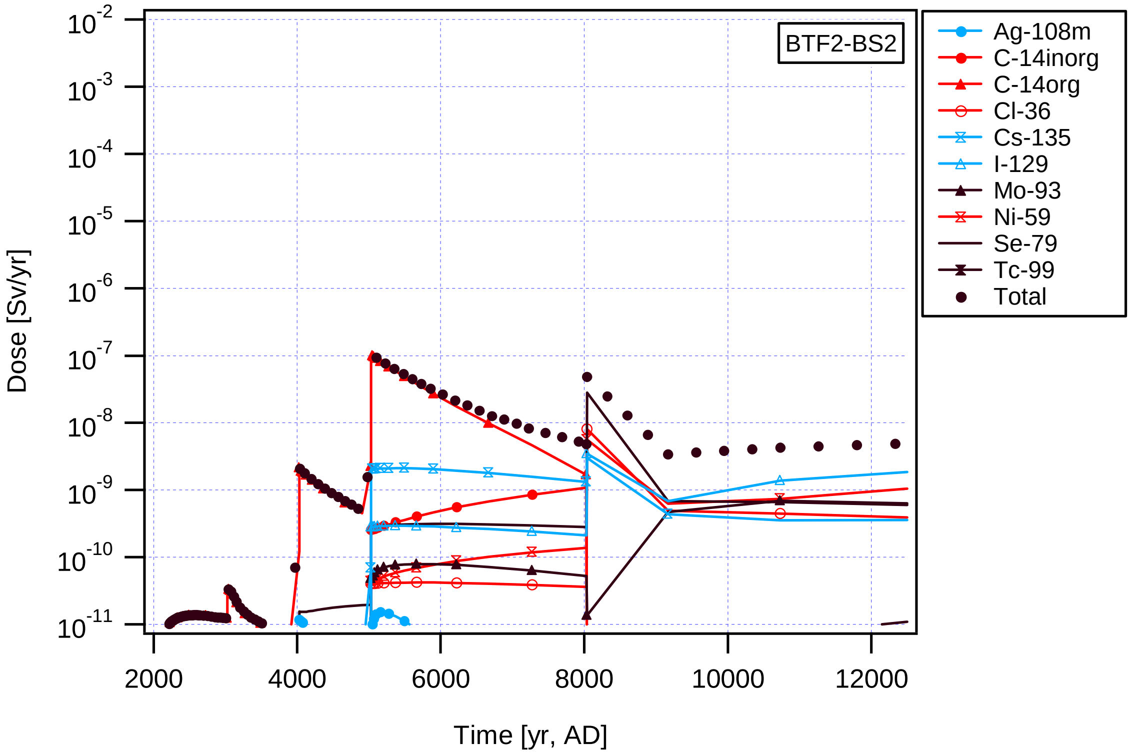

Figure 5-32. *Dose from release of radionuclides from 2BTF to the reasonable biosphere.*

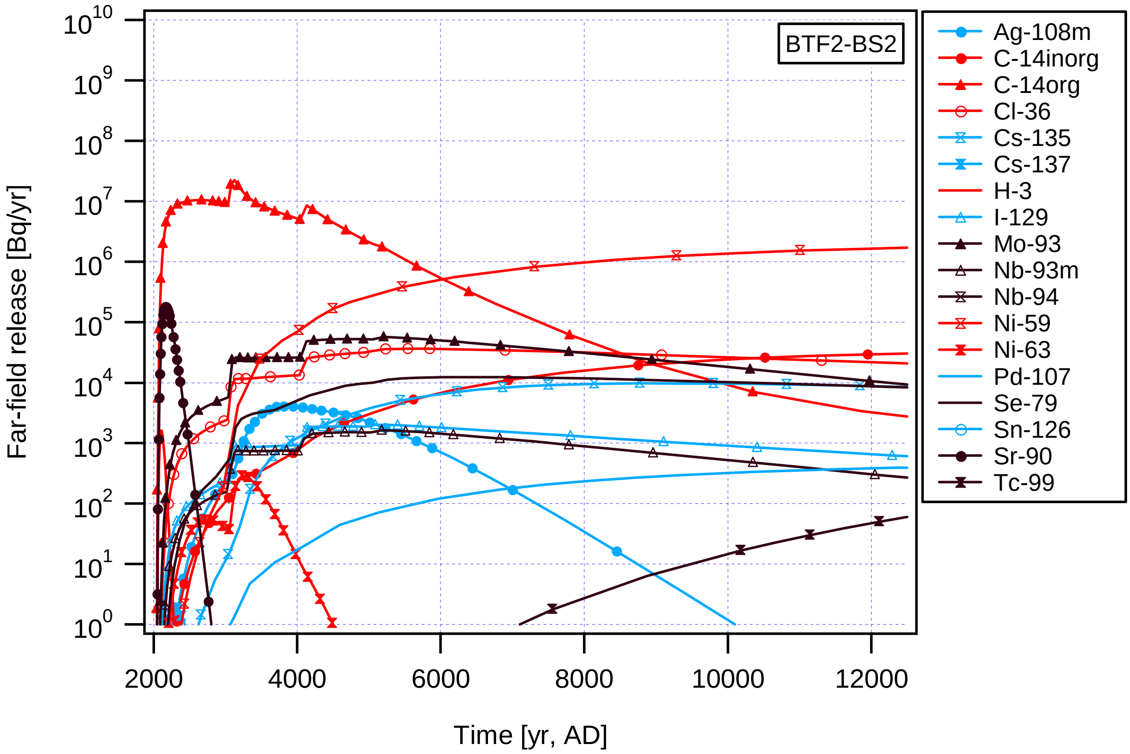

Figure 5-33. *Far-field release rate from 2BTF.*

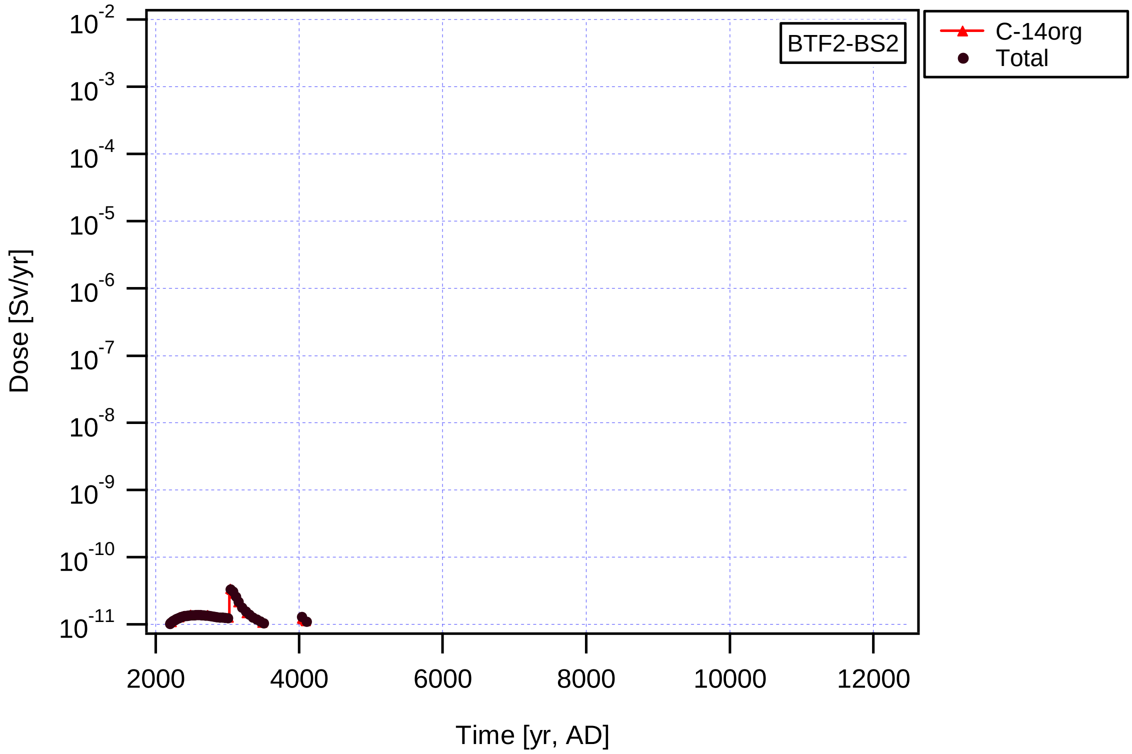

Figure 5-34. *Dose from release of radionuclides from 2BTF to today's biosphere.*

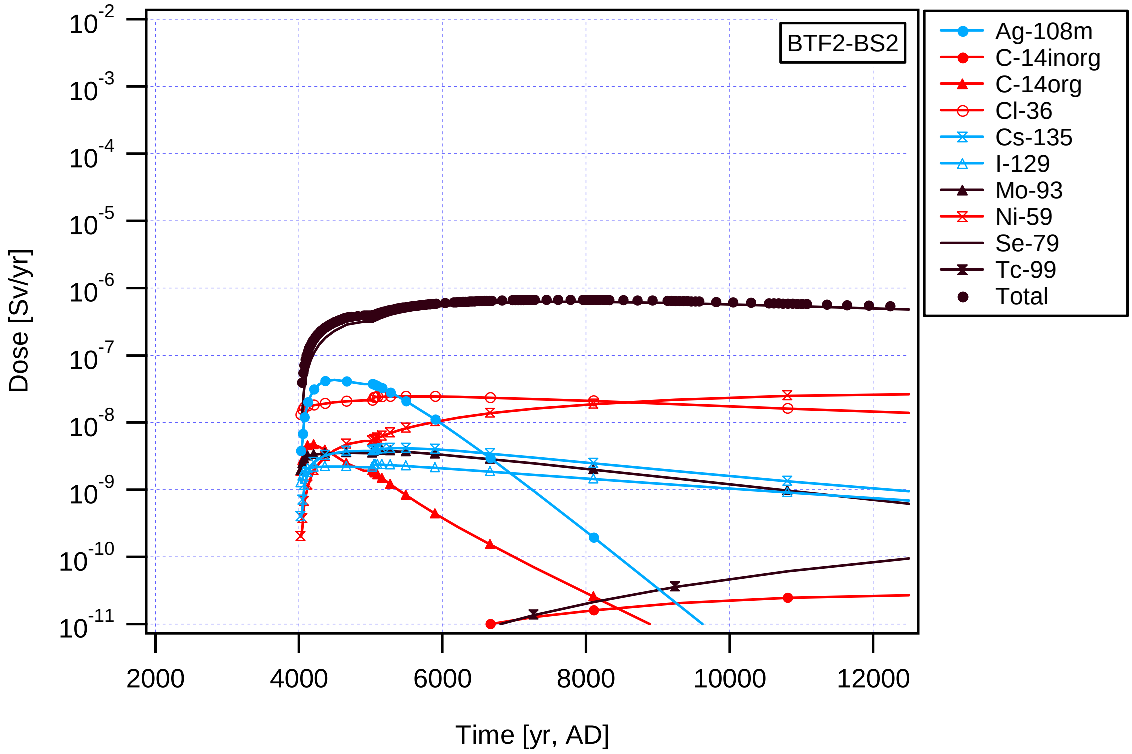

Figure 5-35. *Dose from release of radionuclides from 2BTF to a mire area.*

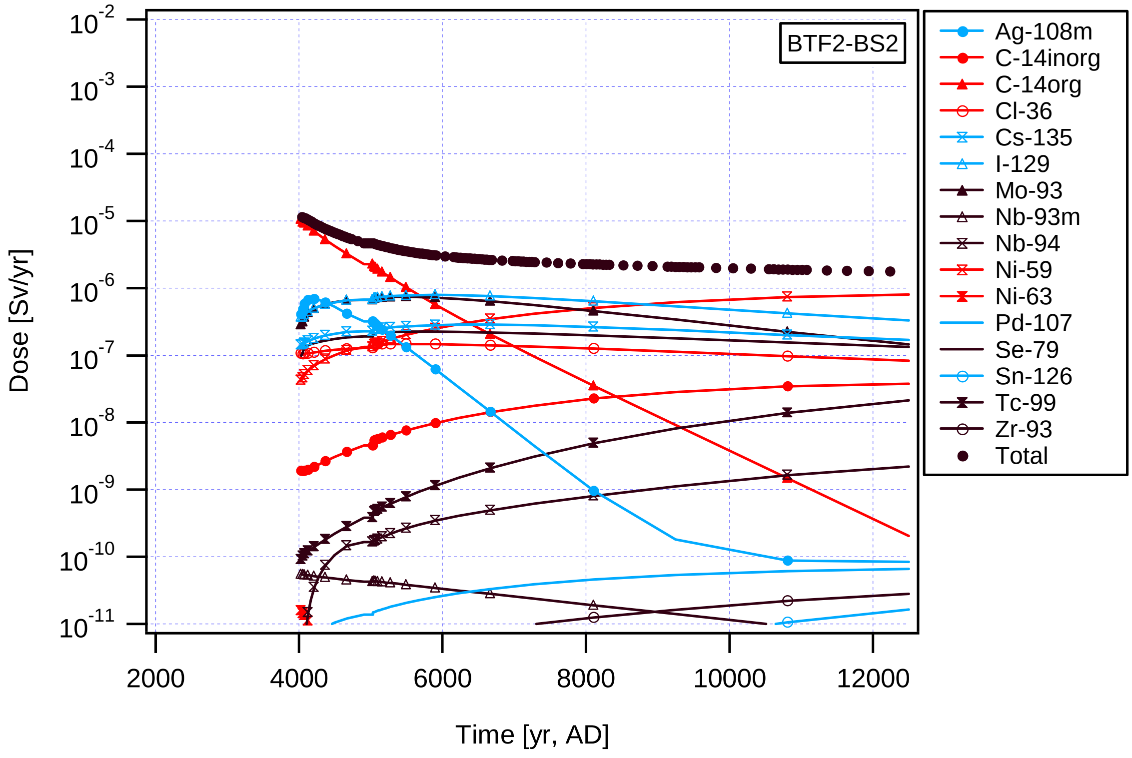

Figure 5-36. *Dose from release of radionuclides from 2BTF to a well.*

5.4.2 Degraded barriers

Fracture zone 6 intersects approximately half way into 2BTF as for 1BTF and BMA. The development and the effect of such a degradation of 2BTF are therefore foreseen to be the same as for 1BTF. The maximum total dose is estimated to be $2{\cdot}10^{-7}$ Sv/yr for the reasonable biosphere development.

5.5 BLA

Since no barriers have been accounted for in the migration model for BLA, the radionuclides can be transported momentarily from the waste to the surrounding rock. Consequently, a high release rate of radionuclides is obtained instantaneously (see *Figure 5-37*). The nuclides dominating the release a very short period of time after repository closure are shortlived nuclides like ^{60}Co, ^{63}Ni, ^{90}Sr and ^{137}Cs. The releases of most of these nuclides decrease rapidly and after 700 years the nuclides dominating the release are inorganic ^{14}C, ^{59}Ni and ^{99}Tc.

The dose for the reasonable biosphere development from radionuclide release from BLA is shown in *Figure 5-38* and *Figure 5-39*. The latter figure shows a detail of the dose during the first 1000 years. The release obtained directly after repository closure results in a total dose of approximately $1{\cdot}10^{-8}$ Sv/yr, dominated by ^{137}Cs. After about 300 years inorganic ^{14}C is the dominating nuclide until about 7000 AD. From 7000 AD the dose is dominated by ^{239}Pu and ^{240}Pu. At 8000 AD the dose increase markedly and reaches its maximum, $2{\cdot}10^{-7}$ Sv/yr.

The far field is a more important barrier for release of radionuclides from BLA than for release from the other repository parts. As shown in *Figure 5-37* there is a significant release of radionuclides in BLA from the near field from the very beginning, and all nuclides reach its maximum release rate within about 1000 years from repository closure. When the nuclides are transported through the far-field rock the maximum release rate is reduced. How strong the effect is depends on the nuclide's half-life and its ability to sorb within the far-field rock. The maximum release rate of inorganic ^{14}C from the far field is less than a factor two lower than that from the near field. The corresponding factor is 3 for ^{59}Ni and 10 – 100 for ^{63}Ni, ^{90}Sr and ^{99}Tc. For ^{239}Pu and ^{240}Pu a reduction of three orders of magnitude is obtained, for ^{137}Cs four orders of magnitude and for ^{60}Co five orders of magnitude.

Transport through the far field also delays the release to the biosphere. Comparing the release curves from the near field (see *Figure 5-37*) and the far field (see *Figure 5-40*) for a specific nuclide this is evident. The far-field release of inorganic ^{14}C and ^{59}Ni resembles that from the near field to begin with and the time when the maximum release rate is obtained is roughly the same for the near field and the far field. However, when the maximum release rate has been obtained the reduction in far-field release rate with time is moderate in comparison to that from the near field. The far-field release rate of inorganic ^{14}C and ^{59}Ni therefore exceeds that from the near field as from 4000 AD. Other nuclides are transported more slowly through the far field. The release of ^{99}Tc, for example, is increasing with time and is of the same order of magnitude as for inorganic ^{14}C and ^{59}Ni around 8000 AD, with a maximum release rate obtained at12 000 AD. Several other nuclides, e.g. ^{239}Pu and ^{240}Pu, behave in the same way.

The far field is neglected in the base scenario. However, the extended release in time obtained from the far field in comparison to that from the near field of BLA, indicates that a higher dose could have been obtained if the dose was based on the release from the far field. The dose obtained from a far-field release to the reasonable biosphere has therefore been estimated for ^{59}Ni, ^{99}Tc, ^{239}Pu and ^{240}Pu. The obtained dose is shown in *Figure 5-41*.

The dose from the far-field release of ^{59}Ni exceeds that obtained from the near-field release from 4000 AD. When nuclides are released to a lake (5000 AD – 8000 AD) the dose is between one and two orders of magnitude higher. When the recipient changes to agricultural land the difference in dose between near-field and far-field release is even larger, up to four orders of magnitude.

The K_d-value for sorption of ^{99}Tc on the rock is higher than for ^{59}Ni. Accordingly, it takes longer time before the dose from the far-field release exceeds that from the near-field release (6000 AD). In the beginning of the agricultural period (8000 AD) the dose from the far-field and near-field release increase to the same maximum level about $2 \cdot 10^{-9}$ Sv/yr. Thereafter the dose from the near-field release decrease markedly while the dose from the far-field release remains at almost the same level.

Plutonium has even better sorption characteristics. The dose obtained from the far-field release of ^{239}Pu and ^{240}Pu is therefore lower than that obtained from the near-field release.

BLA is the repository part giving the highest dose when the nuclides are released to today's biosphere (see *Figure 5-42*). The maximum total dose is about $1 \cdot 10^{-8}$ Sv/yr. This dose is obtained directly after repository closure from release of ^{137}Cs. Besides the instant peak in dose, the maximum total dose is less than 10^{-10} Sv/yr.

^{239}Pu and ^{240}Pu are the two dominating nuclides in terms of dose when released from BLA to a mire area. The maximum total dose is $3 \cdot 10^{-6}$ Sv/yr which is obtained 4500 AD (see *Figure 5-43*). Around 4000 AD ^{99}Tc is also one of the dominating nuclides but its contribution is reduced rapidly with time. The third most important nuclide in terms of dose is ^{79}Se, but it gives a dose that is about one order of magnitude lower than the two plutonium isotopes.

When nuclides in BLA are released to a downstream well a dose exceeding 10^{-4} Sv/yr are obtained instantaneously (maximum total dose is $2{\cdot}10^{-4}$ Sv/yr). ^{239}Pu and ^{240}Pu dominate the dose for the whole time period studied (see *Figure 5-44*). Initially, ^{99}Tc gives an important contribution to the total dose as well.

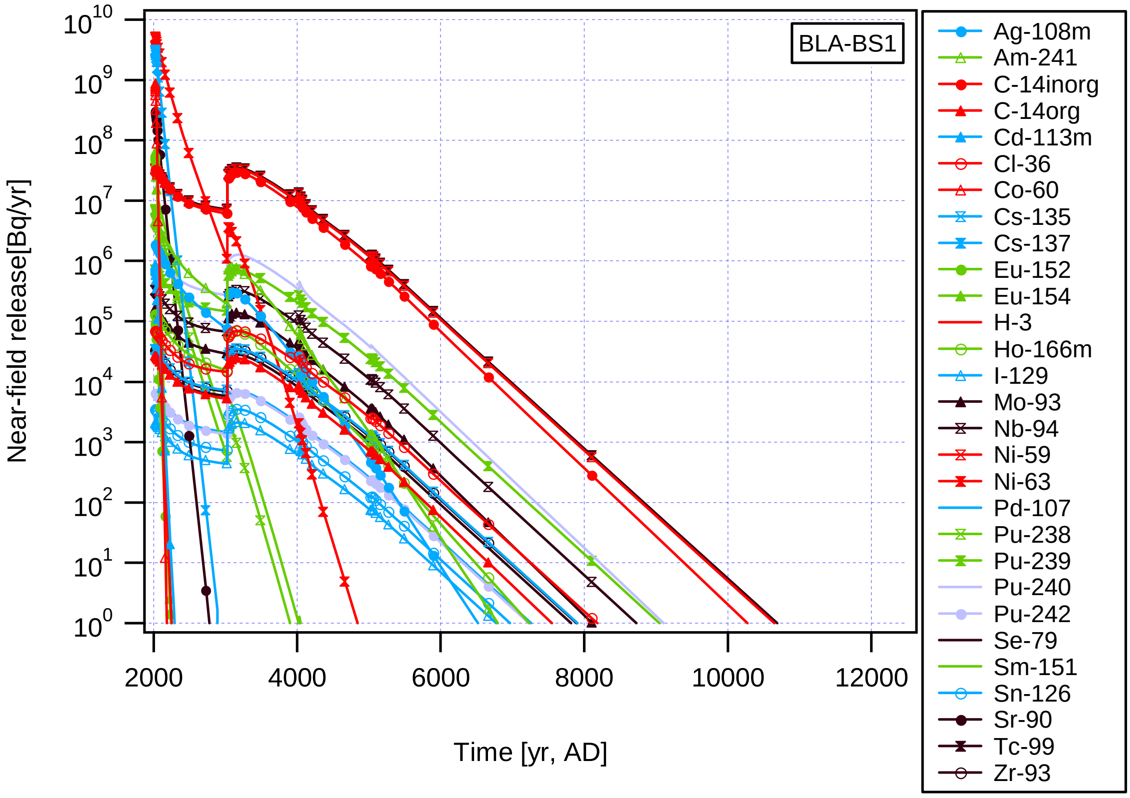

Figure 5-37. *Near-field release rate from BLA.*

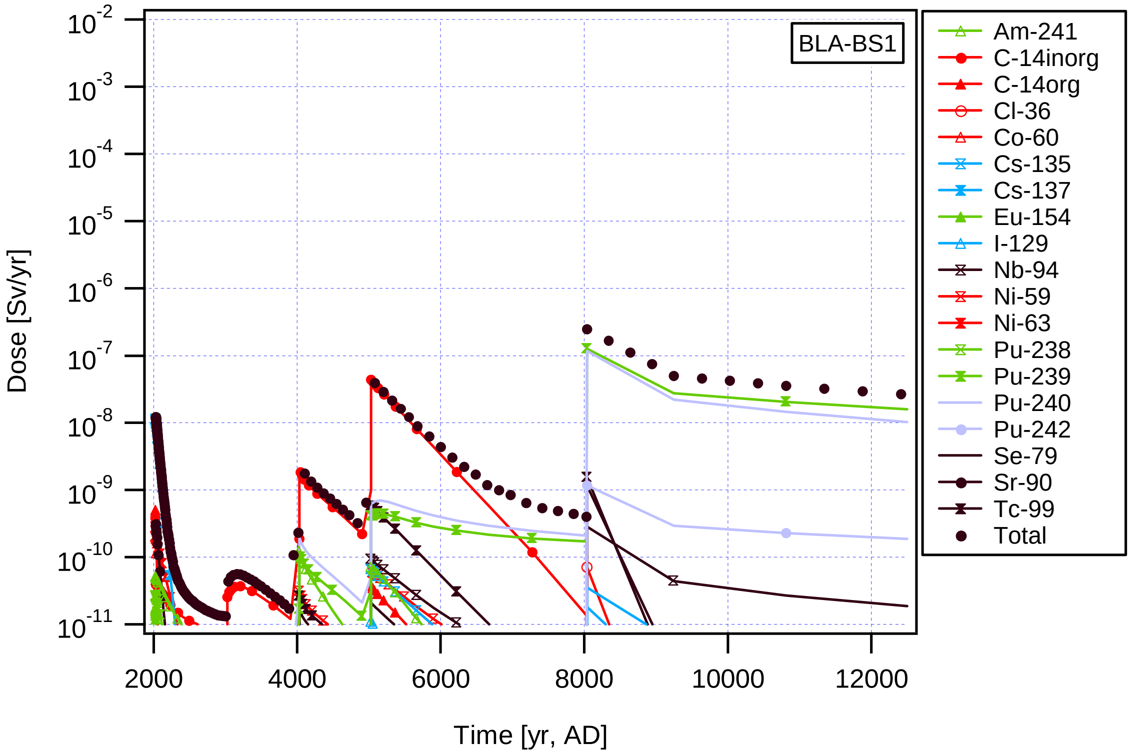

Figure 5-38. *Dose from release of radionuclides from BLA to reasonable biosphere based on near-field release.*

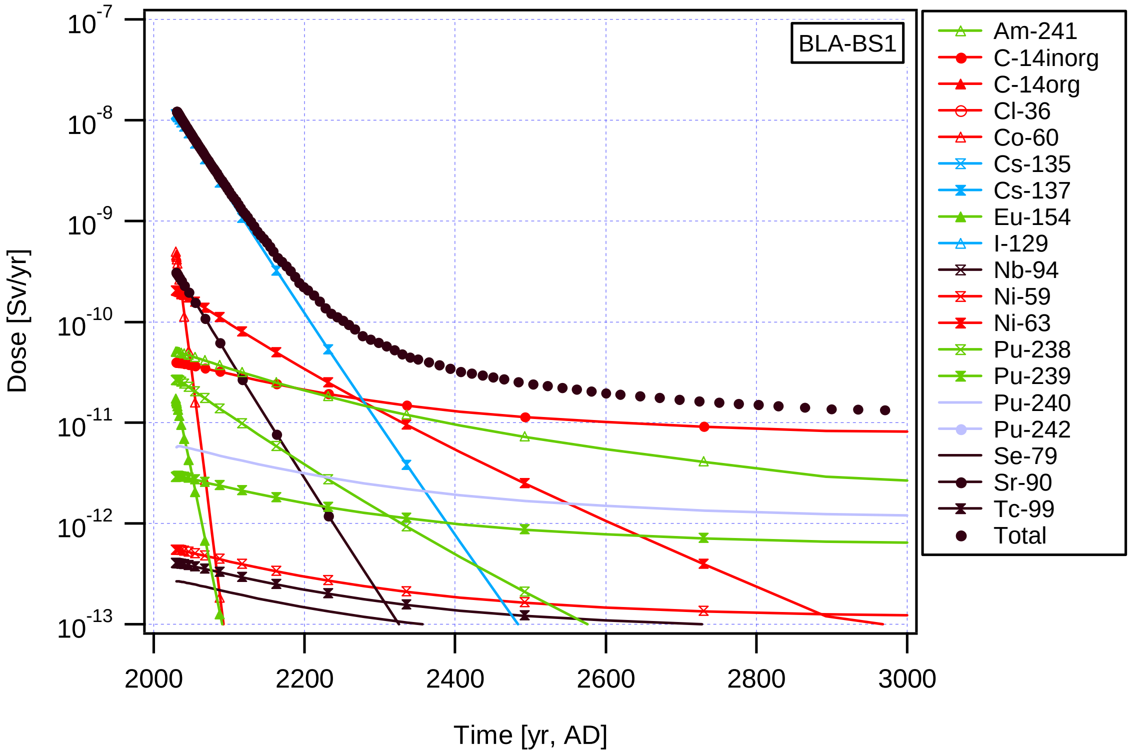

Figure 5-39. *Dose from release of radionuclides from BLA to reasonable biosphere during the time period 2000 AD to 3000 AD based on near-field release.*

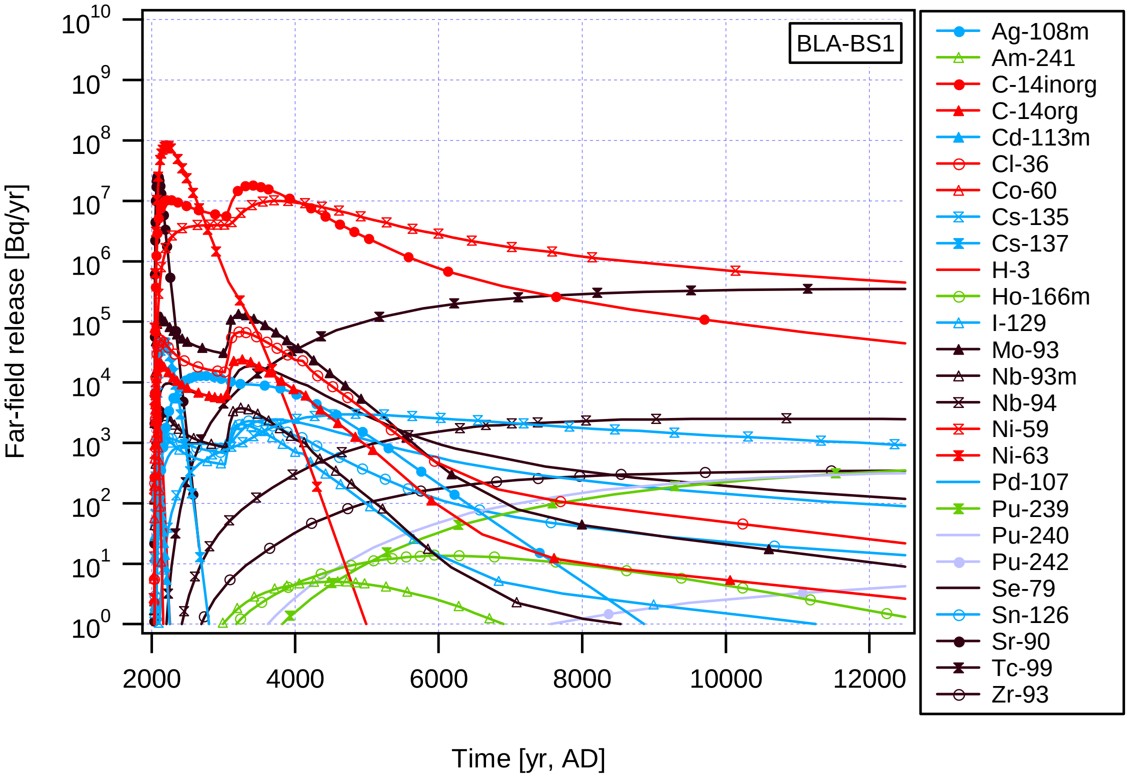

Figure 5-40. *Far-field release rate from BLA.*

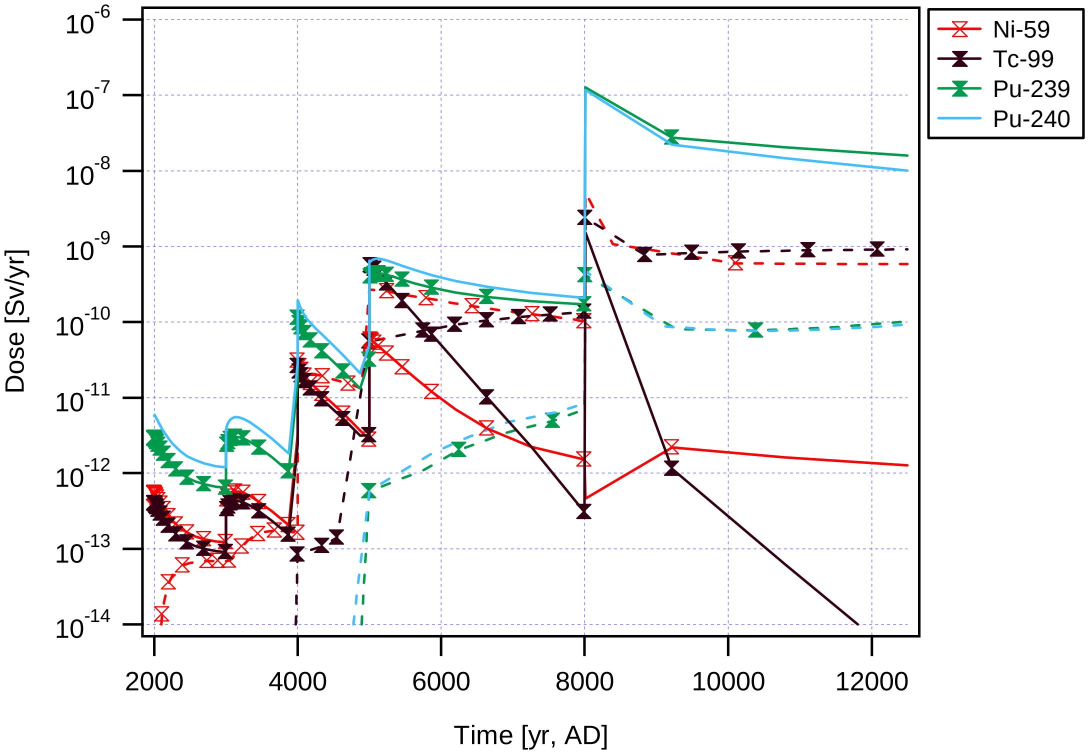

Figure 5-41. *Comparison of dose from release of radionuclides from BLA to reasonable biosphere. Based on release from a) near field (solid line) and b) far field (dashed line).*

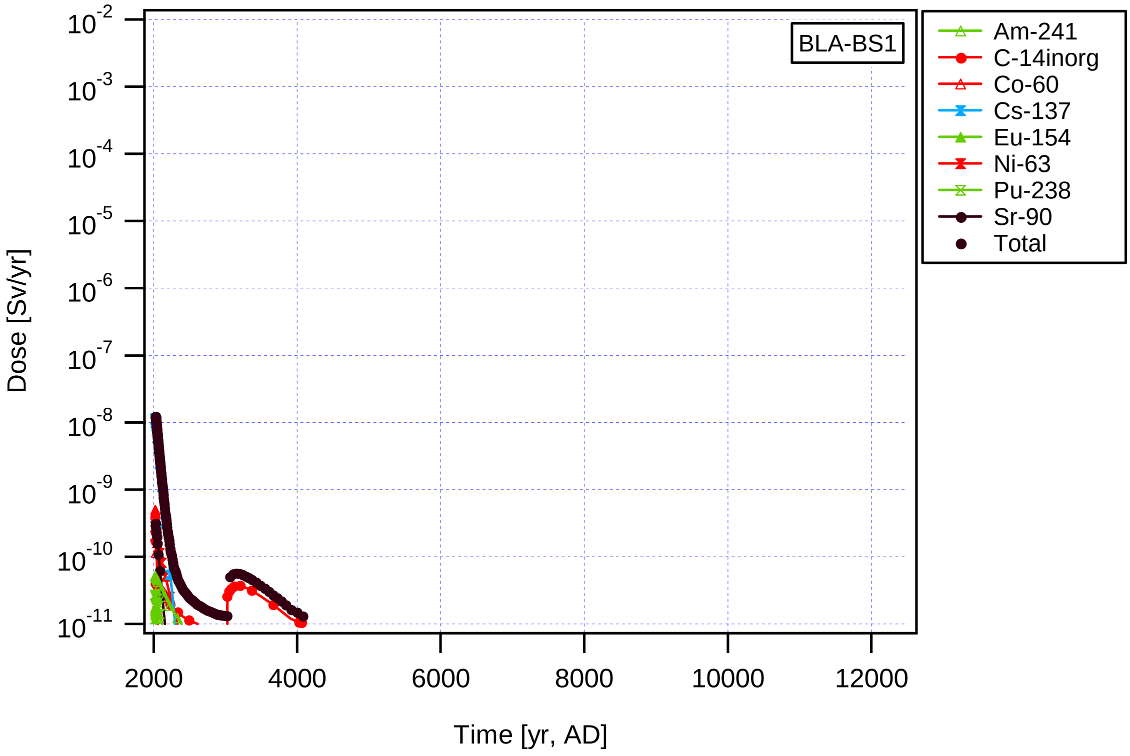

Figure 5-42. *Dose from release of radionuclides from BLA to today's biosphere based on near-field release.*

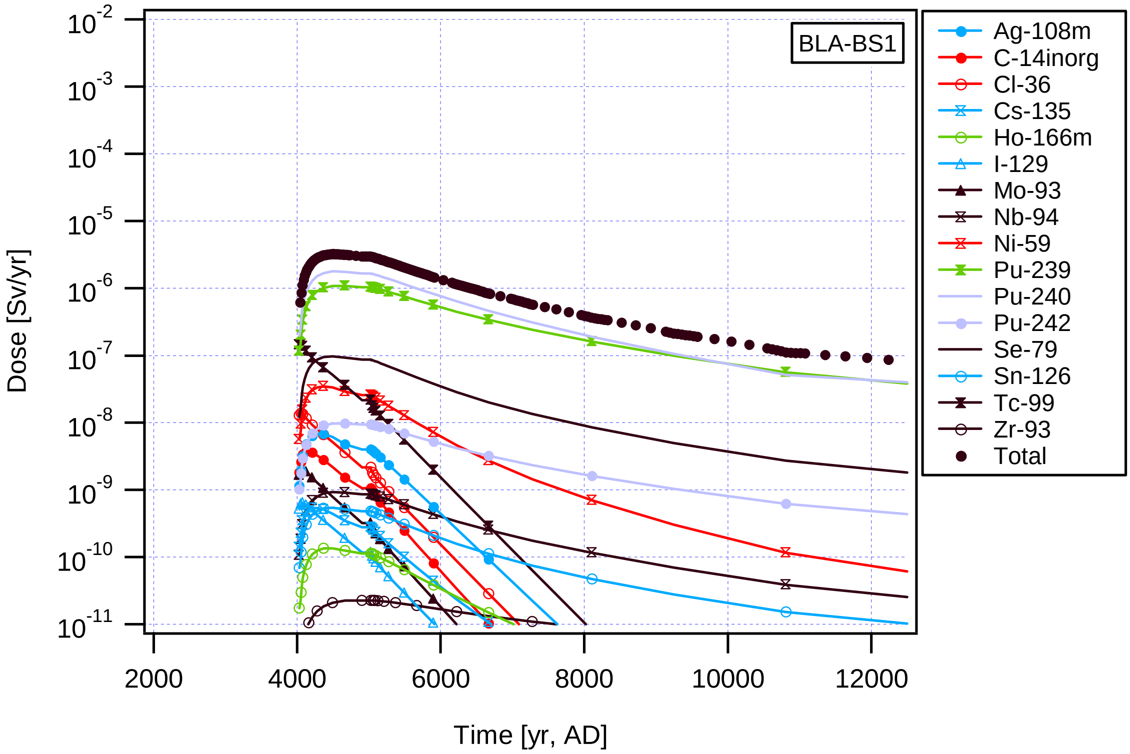

Figure 5-43. *Dose from release of radionuclides from BLA to a mire area based on near-field release.*

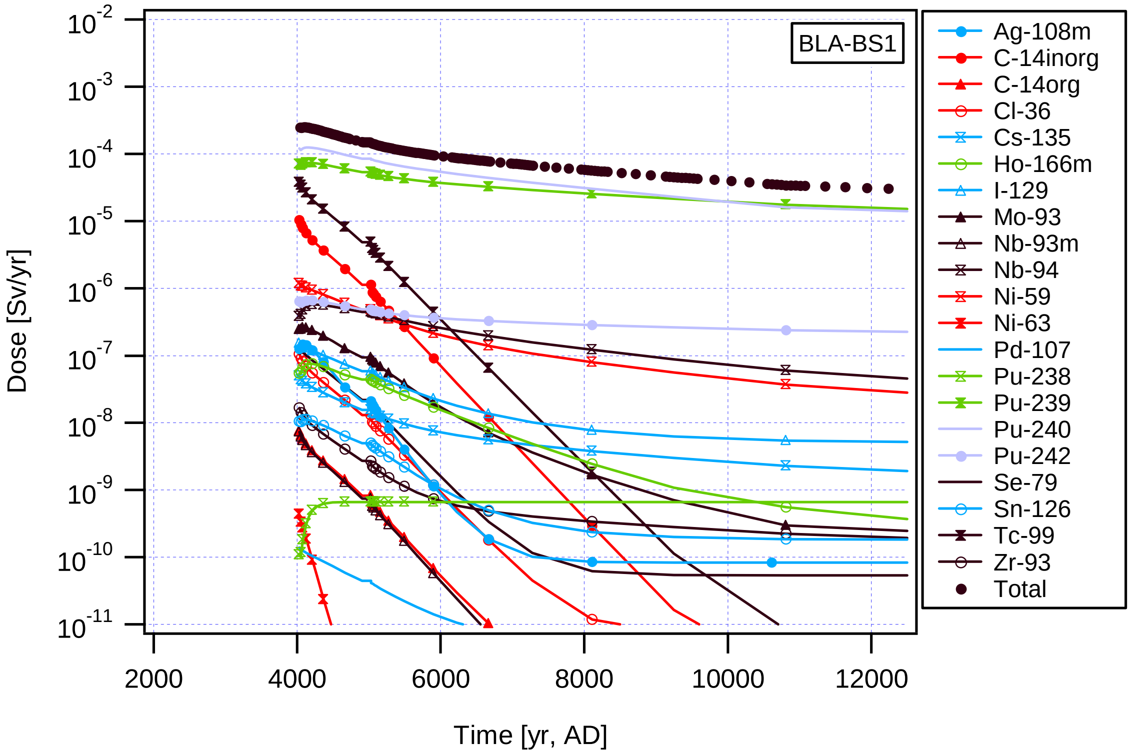

Figure 5-44. *Dose from release of radionuclides from BLA to a well based on near-field release.*

6 Results - Other scenarios

The results for scenarios not included in the base scenario are summarised in this chapter. Four scenarios are studied. These are the influence of:

- initially degraded barriers
- chemicals in waste
- permafrost
- human intrusion (drilling of a well into the repository).

6.1 Initially degraded barriers

In the main case within the base scenario it is assumed that the properties of the technical barriers fulfil the specifications. A case in which the barriers are degraded thousand years after repository closure is also investigated in the base scenario. But what happens if the properties of barriers and waste are not as good as assumed already at repository closure? A case in which there are one or several large fractures in the concrete structure in BMA already at repository closure has therefore been investigated. The fractures are formed close to fracture zone 6 that intersects the vault. It is the same scenario as the case with degraded barriers within the base scenario except for that there are fractures already at repository closure.

The main effect of an initial fracture through the concrete encapsulation in room 12 of BMA is a significant increase in water flow through that room and changed release paths from BMA. Initially the result is a decreased near-field release rate compared to the base case, but the higher water flow rate through room 12 causes the release to increase faster. For some nuclides it takes tens of years or less before the release rate with an initial fracture exceeds that for an intact structure. For other nuclides it takes hundreds of years. The increase in release rate during the first thousand years is a factor five or less. For organic ^{14}C for example the increase is a factor three at most. After 3000 AD the water flow is identical to the case in which the structure is assumed to be degraded after 1000 years from repository closure, see section 5.2.2. Between 3000 AD and 4000 AD small differences in nuclide release rate is obtained and for longer times the two cases are almost identical.

The total dose for release from an initially degraded BMA to the reasonable biosphere is estimated to be somewhat higher during the first thousand years after repository closure than for the case with degraded barriers after 1000 years (compare near-field release rate in *Figure 6-1* and *Figure 5-19*). Later only small differences will be obtained.

The effect of an initially degraded barrier in 1BTF or 2BTF on the maximum total dose for a reasonable biosphere will be the same as when the barrier is assumed to be degraded after 1000 years, see Section 5.3.2.

An initial fracture in the concrete bottom of the Silo does not affect the water flow rate through the Silo as long as the bentonite barriers are intact. The case with an initially degraded Silo has therefore not been studied.

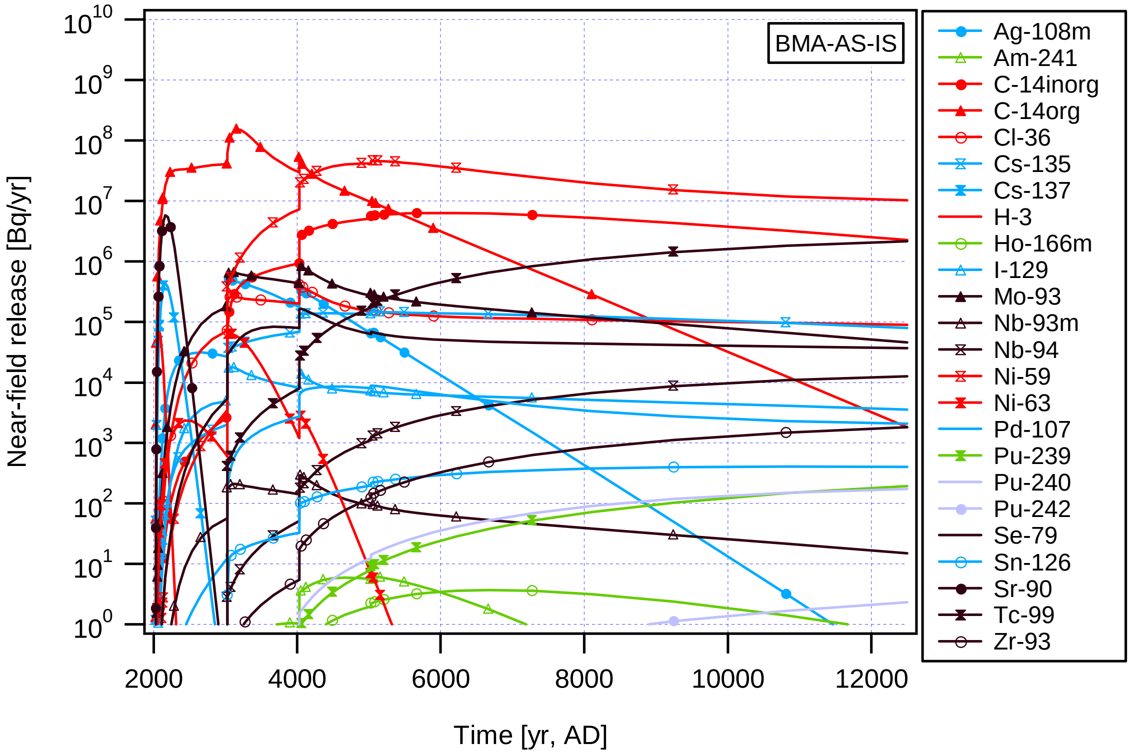

Figure 6-1. *Near-field release rate from BMA with an initially degraded room 12.*

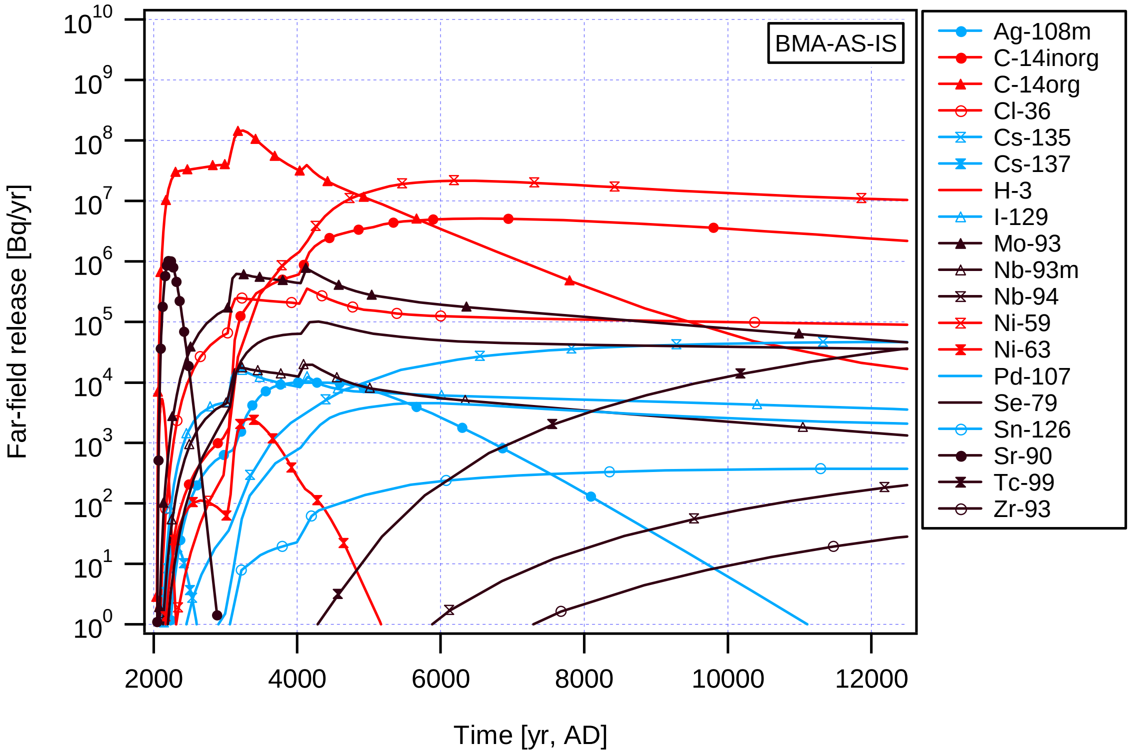

Figure 6-2. *Far-field release rate from BMA with an initially degraded room 12.*

6.2 Chemicals

The waste contains chemicals that may act as complexing agents for radionuclides. The waste also contains cellulose, which through alkaline degradation can form the strong complexing agent iso-saccarinic acid (ISA). Presence of complexing agents may reduce the nuclide's ability to sorb on different barrier materials within the repositories. In this study, this has been analysed by reducing the K_d value in concrete/cement, bentonite, sand/bentonite and gravel of trivalent, tetravalent and pentavalent ions (SKB, 2001a). All other data are identical to the main case within the base scenario. Since no sorption is accounted for in the migration model for BLA, no analysis has been made for this repository part.

The main part of the nuclides dominating the near-field release rate and/or the dose in reasonable biosphere for the main case in the base scenario for Silo, BMA, 1BTF and 2BTF are not affected by chemicals. The exception is ^{59}Ni, ^{63}Ni, ^{94}Nb, ^{99}Tc, ^{126}Sn and different plutonium isotopes. Other nuclides are also affected but they give a limited contribution to the total dose.

The release of radionuclides from Silo and BMA has also been calculated for a combined effect of chemicals and a degraded barrier after thousand years. No calculations have been made for 1BTF and 2BTF. Instead, based on the results for the case with chemicals and intact barriers and the knowledge of the effect of water flow through a degraded 1BTF and 2BTF, the effect of chemicals together with degraded barriers has been estimated.

The results for each repository part are presented graphically in the next sections. The release rate from near field and far field is calculated for all 30 modelled nuclides. However, nuclides foreseen to be insignificant in terms of contribution to the total dose in recipient are not included in the biosphere modelling.

6.2.1 Silo

Intact barriers

The main difference for the near-field release between the main case (*Figure 5-1*) and this case is that the release rates of ^{59}Ni and ^{99}Tc approaches that of organic ^{14}C when influenced by chemicals, *Figure 6-3*. Also, more nuclides reach a release rate of between 10^3 and 10^5 Bq/yr.

For the reasonable biosphere development ^{99}Tc becomes the dominating nuclide from 8000 AD and onwards. However, the maximum total dose is the same as for the main case, dominated by organic ^{14}C that is not influenced by chemicals. The maximum total dose from release to today's biosphere is also the same dominated by organic ^{14}C. For release to mire area on the other hand, the dose corresponding to the release of ^{59}Ni and ^{99}Tc increase and is about the same as for ^{79}Se (not influenced by chemicals) (see *Figure 6-7*). The total dose from 6000 AD and onwards, and thus also the maximum total dose, is therefore increased by approximately a factor three. The maximum total dose from release to a well is obtained initially at 4000 AD dominated by organic ^{14}C not influenced by chemicals. The total dose after that is increased by two to three times, mainly due to increase in dose from ^{99}Tc. ^{99}Tc becomes the dose dominating nuclide from about 11 000 AD.

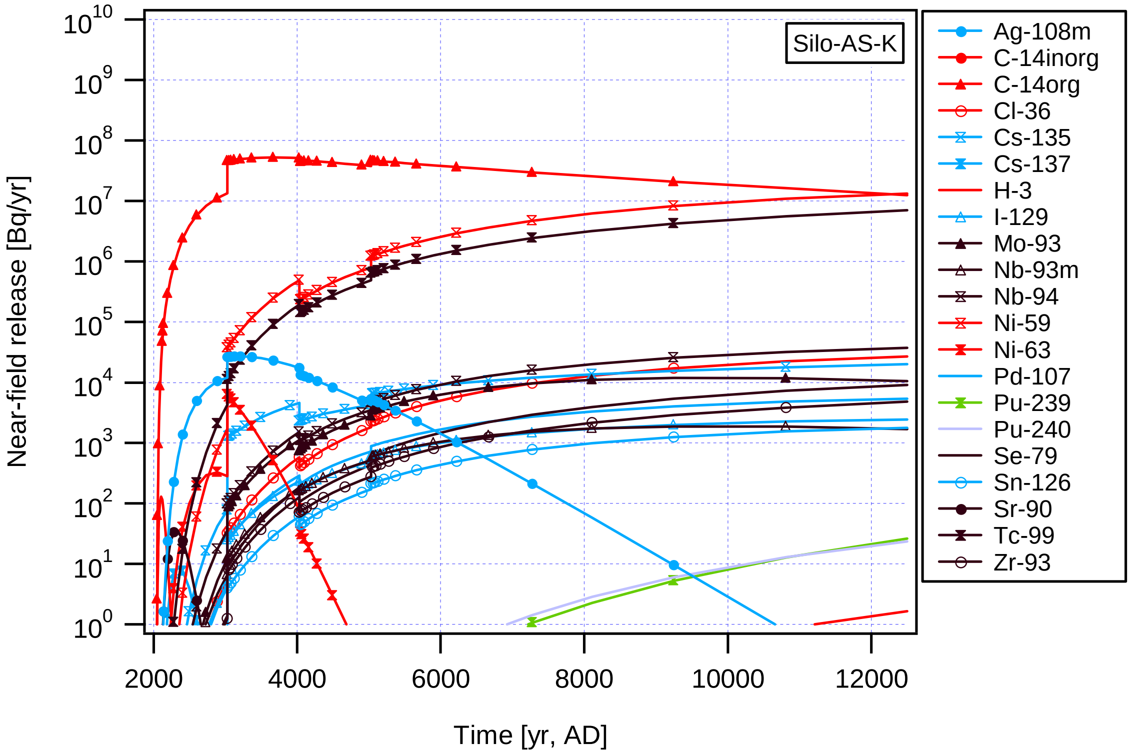

Figure 6-3. *Near-field release rate from an intact Silo affected by chemicals.*

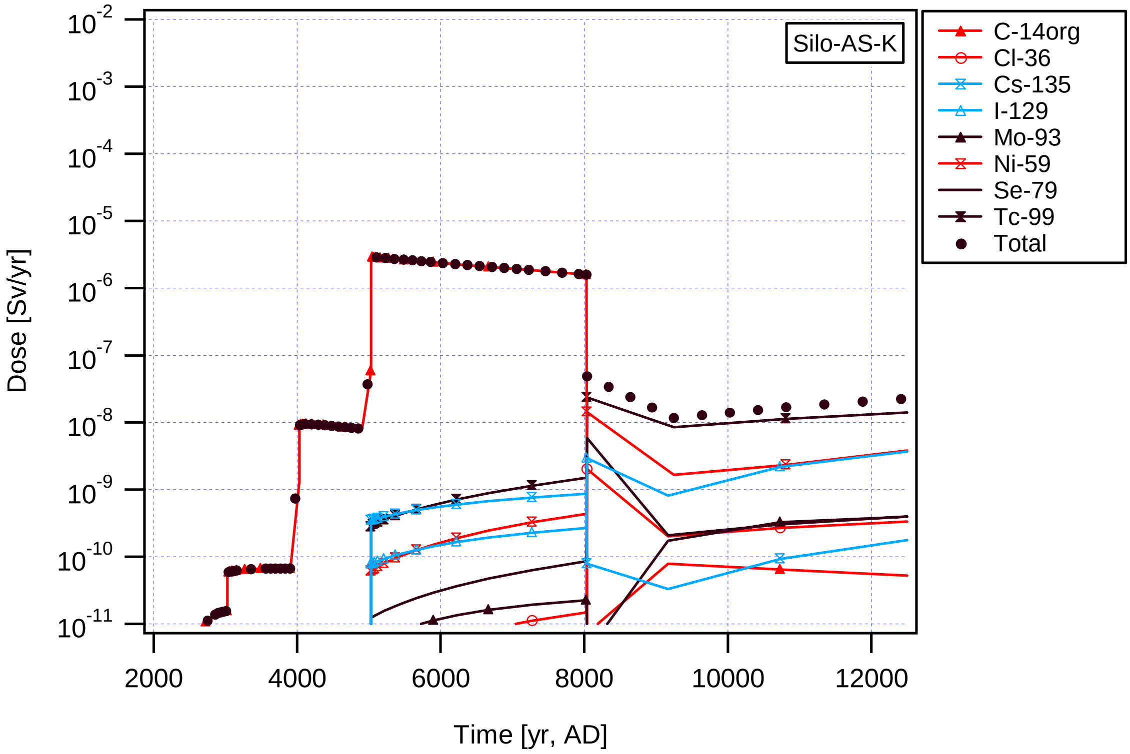

Figure 6-4. *Dose from release of radionuclides from an intact Silo affected by chemicals to the reasonable biosphere (calculations performed for dominating nuclides only).*

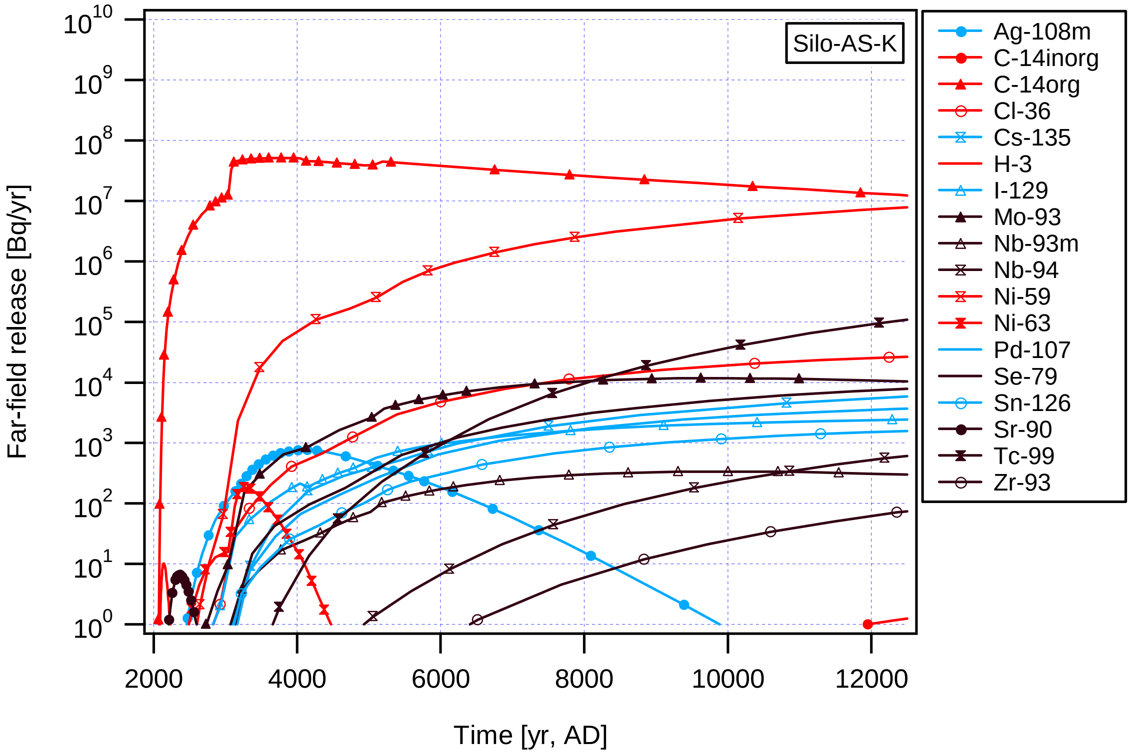

Figure 6-5. *Far-field release rate from an intact Silo affected by chemicals.*

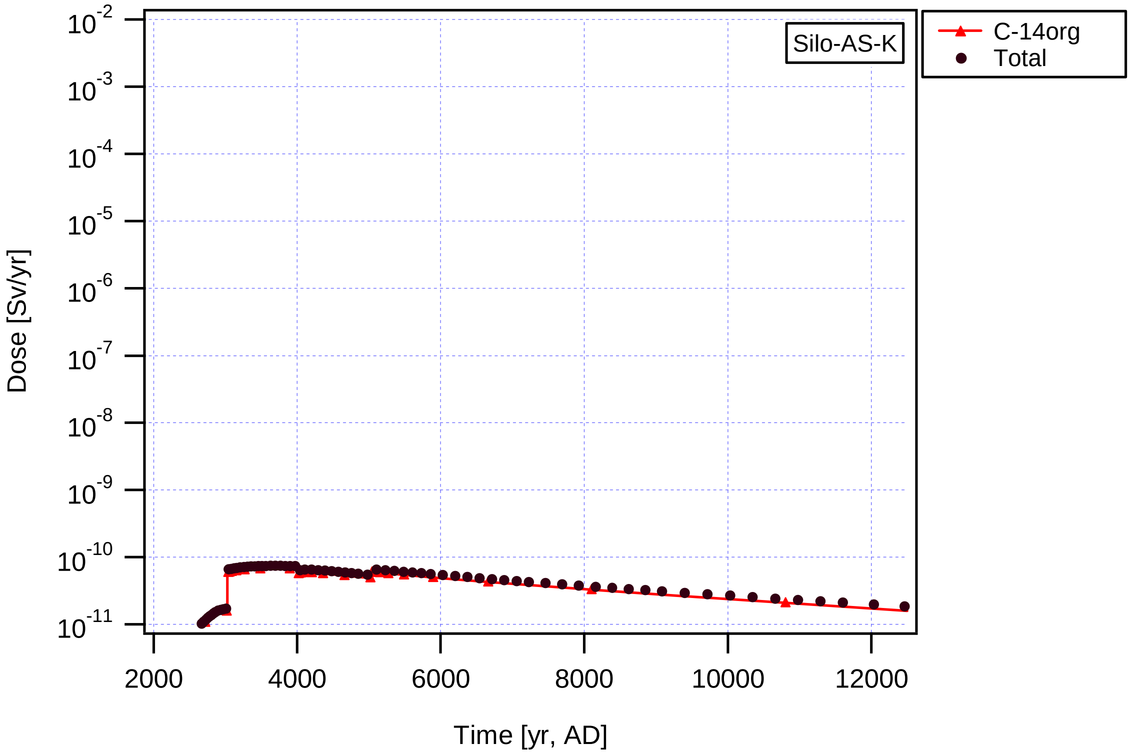

Figure 6-6. *Dose from release of radionuclides from an intact Silo affected by chemicals to today's biosphere (calculations performed for dominating nuclides only).*

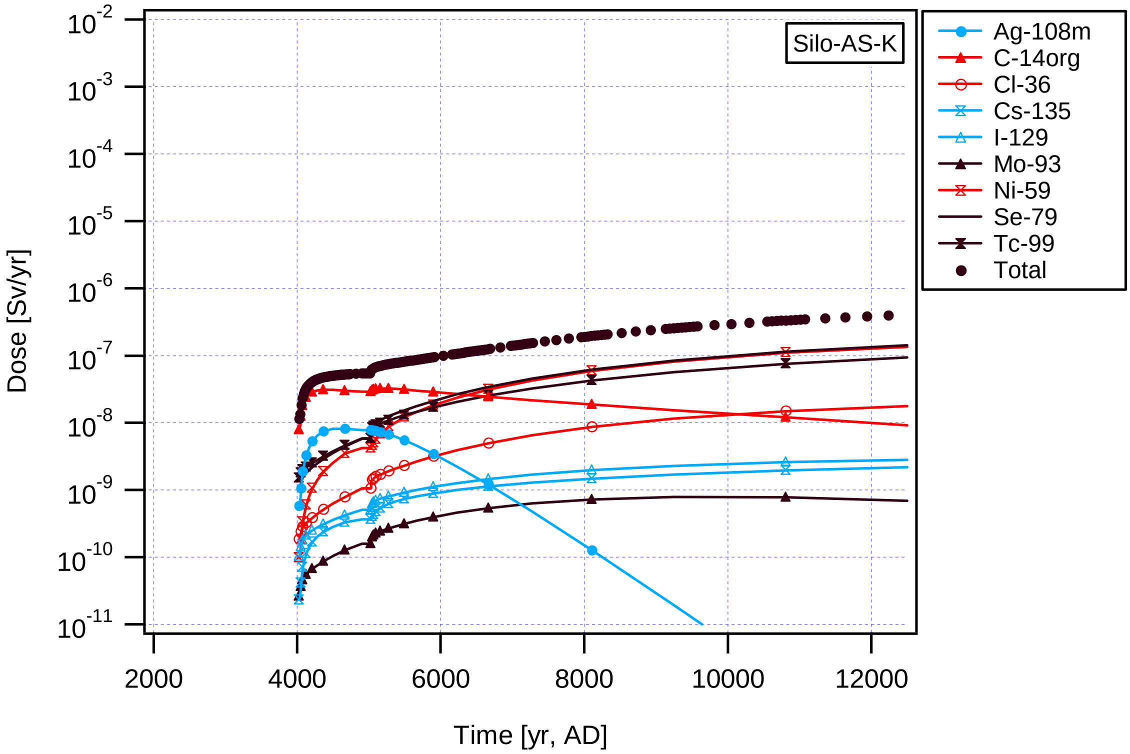

Figure 6-7. *Dose from release of radionuclides from an intact Silo affected by chemicals to a mire area (calculations performed for dominating nuclides only).*

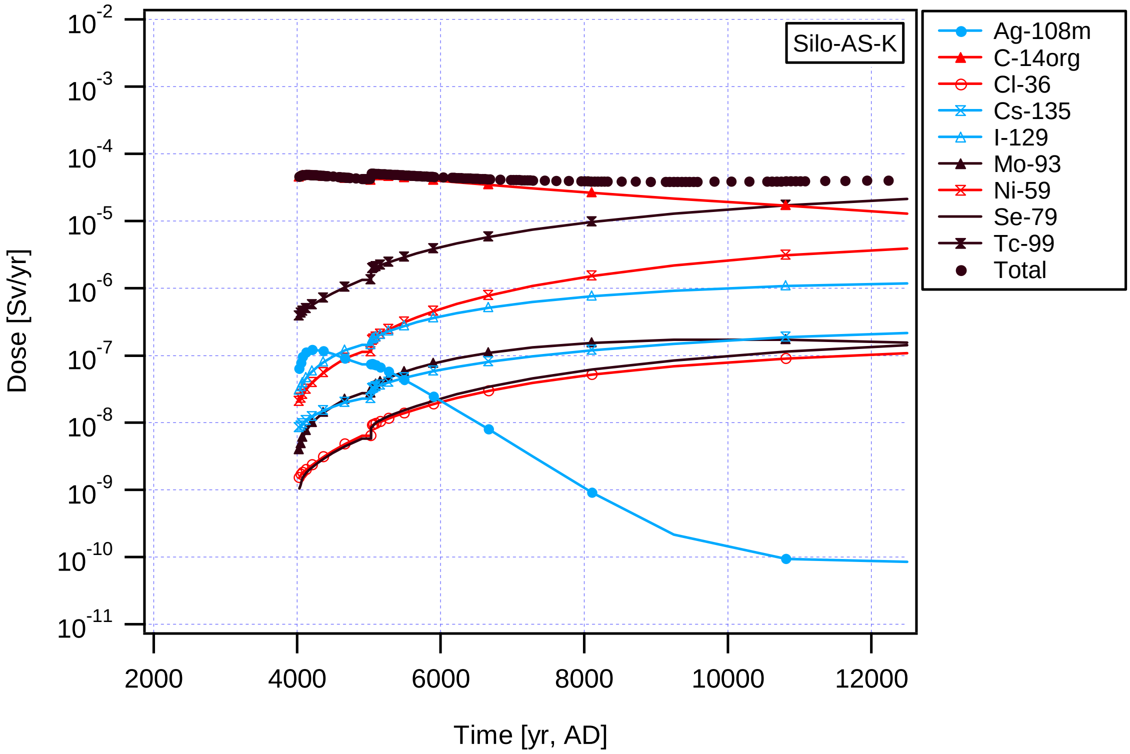

Figure 6-8. *Dose from release of radionuclides from an intact Silo affected by chemicals to a well (calculations performed for dominating nuclides only).*

Degraded barriers

The release rates of many of the nuclides in the waste in the Silo, e.g. ^{59}Ni and ^{99}Tc, are affected both by chemicals and by degraded barriers. The near-field release rate of ^{59}Ni and ^{99}Tc for this case, shown in *Figure 6-9*, is about one order of magnitude higher than the case with only chemicals discussed previously in this section. Organic ^{14}C dominating the total dose for the reasonable biosphere is, however, considered to be unaffected by chemicals.

The maximum total dose from release to the reasonable biosphere is about $1 \cdot 10^{-5}$ Sv/yr at 5000 AD given by organic ^{14}C, identical to that obtained for the case with degraded barriers after 1000 years, see Section 5.1.2. After 8000 AD, the total dose is dominated by ^{99}Tc.

When the release occur to a mire area after 4000 AD, the maximum total dose is estimated to be $7 \cdot 10^{-6}$ Sv/yr, predominantly given by ^{79}Se. If the nuclides are released to a well, the total dose is approximately constant in time, with a maximum dose of $3 \cdot 10^{-4}$ Sv/yr. The dose is initially dominated by organic ^{14}C, followed by ^{99}Tc from about 6000 AD.

Dose in today's biosphere has not been estimated for this case, since the dose is expected to be low.

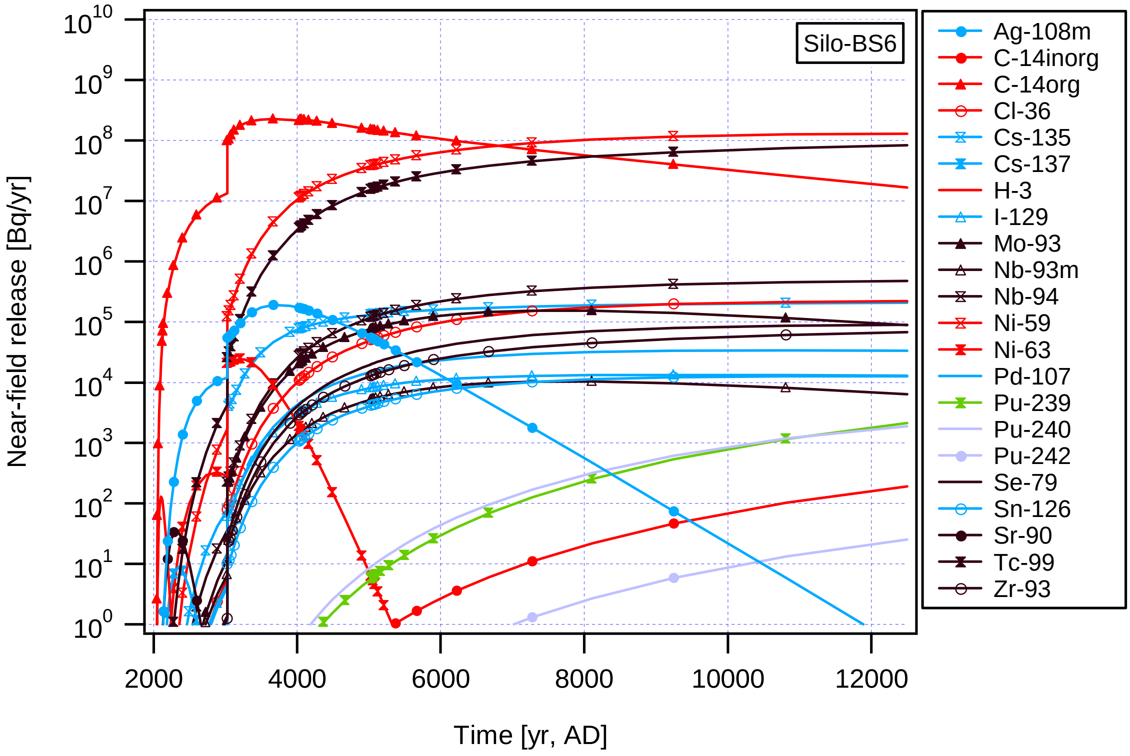

Figure 6-9. *Near-field release rate from Silo affected by chemicals and being degraded from 3000 AD.*

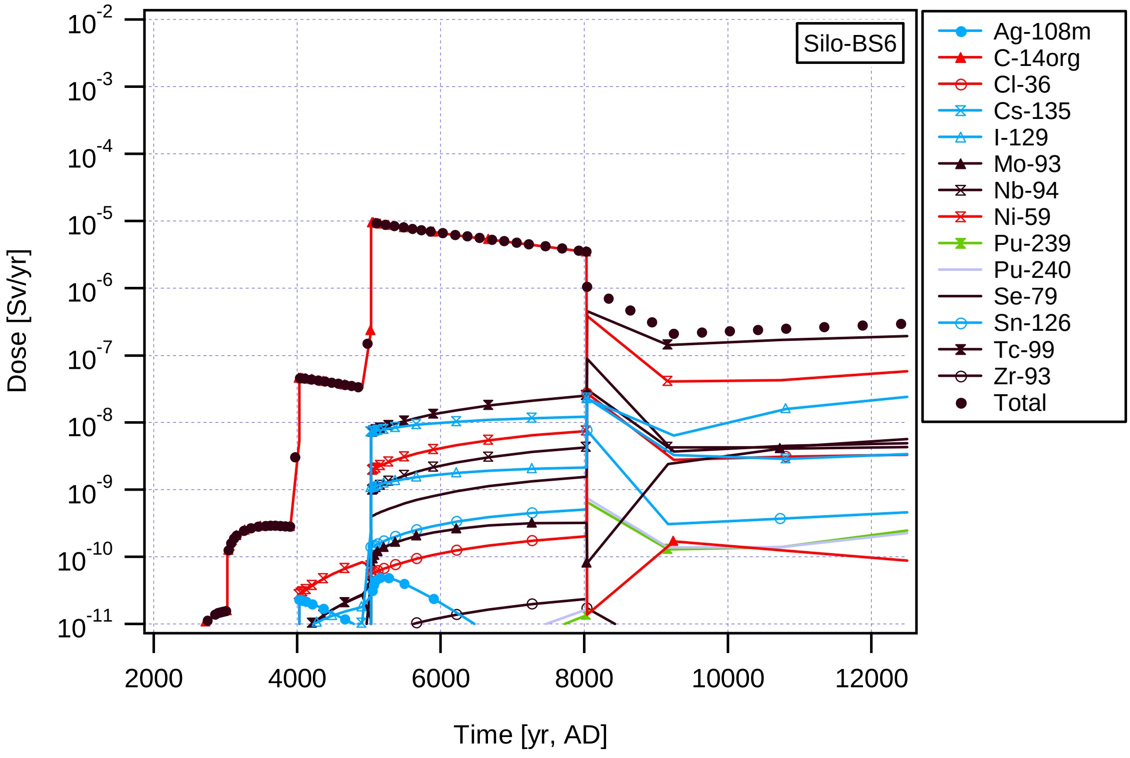

Figure 6-10. *Dose from release of radionuclides from Silo affected by chemicals and being degraded from 3000 AD to the reasonable biosphere (calculations performed for dominating nuclides only).*

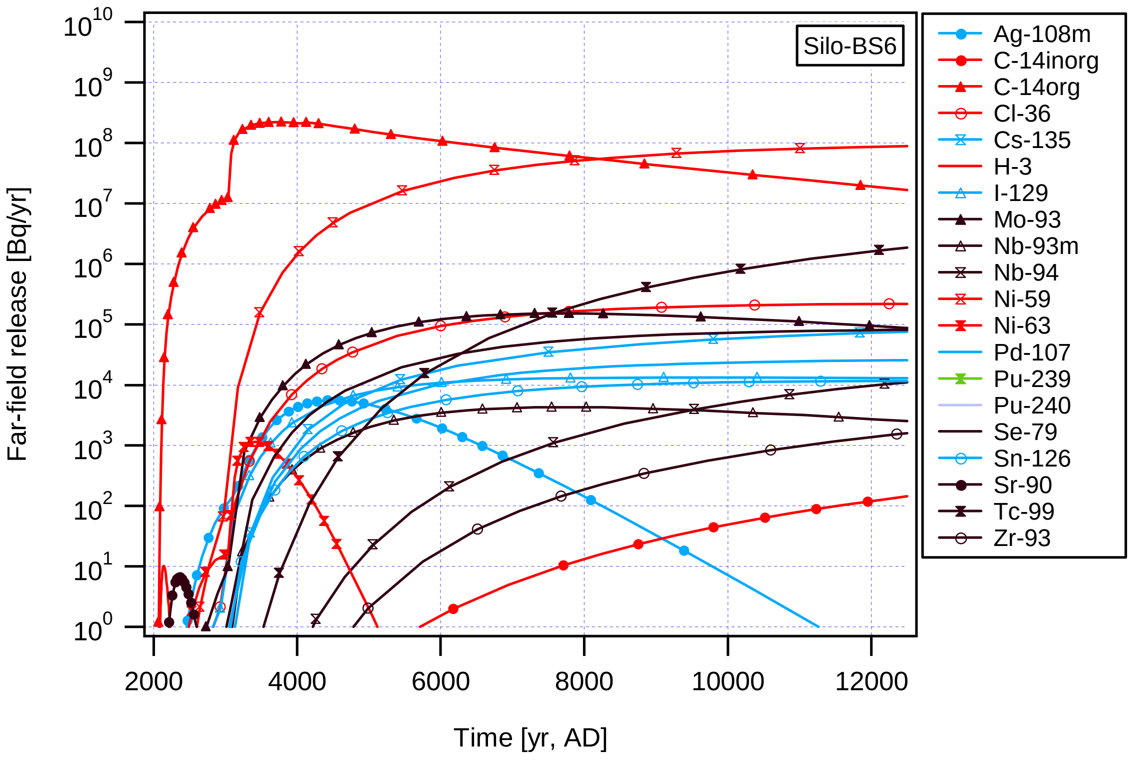

Figure 6-11. *Far-field release rate from Silo affected by chemicals and being degraded from 3000 AD.*

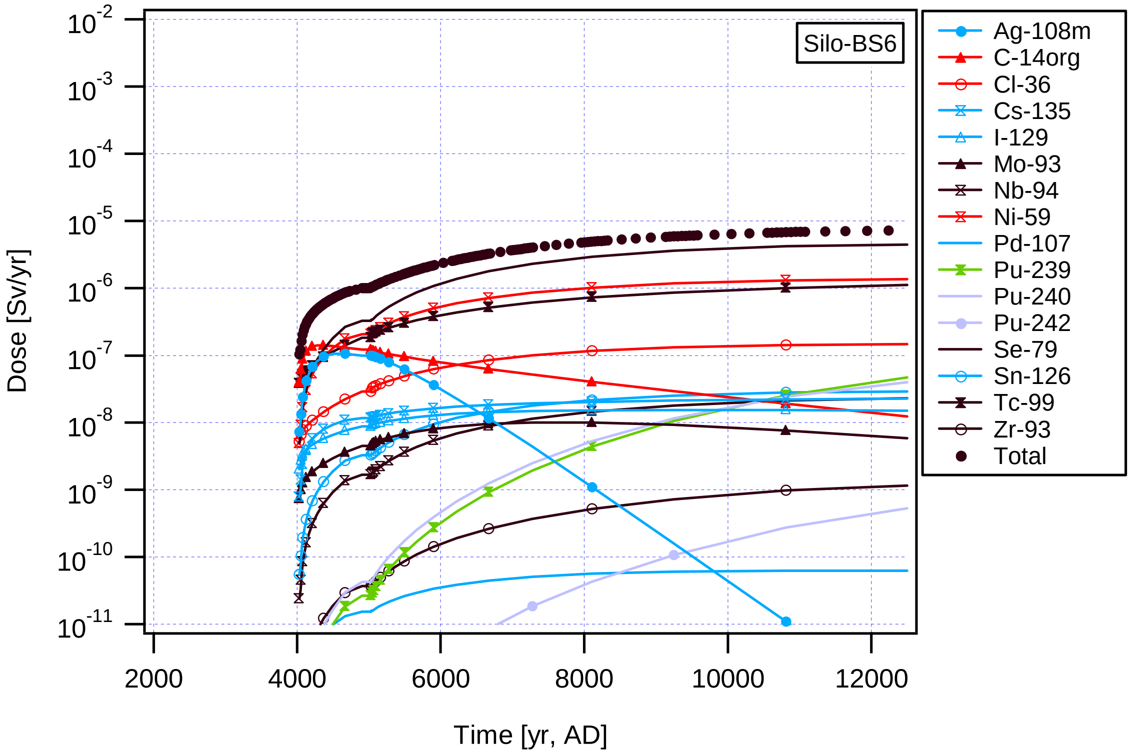

Figure 6-12. Dose from release of radionuclides from Silo affected by chemicals and being degraded from 3000 AD to a mire area (calculations performed for dominating nuclides only).

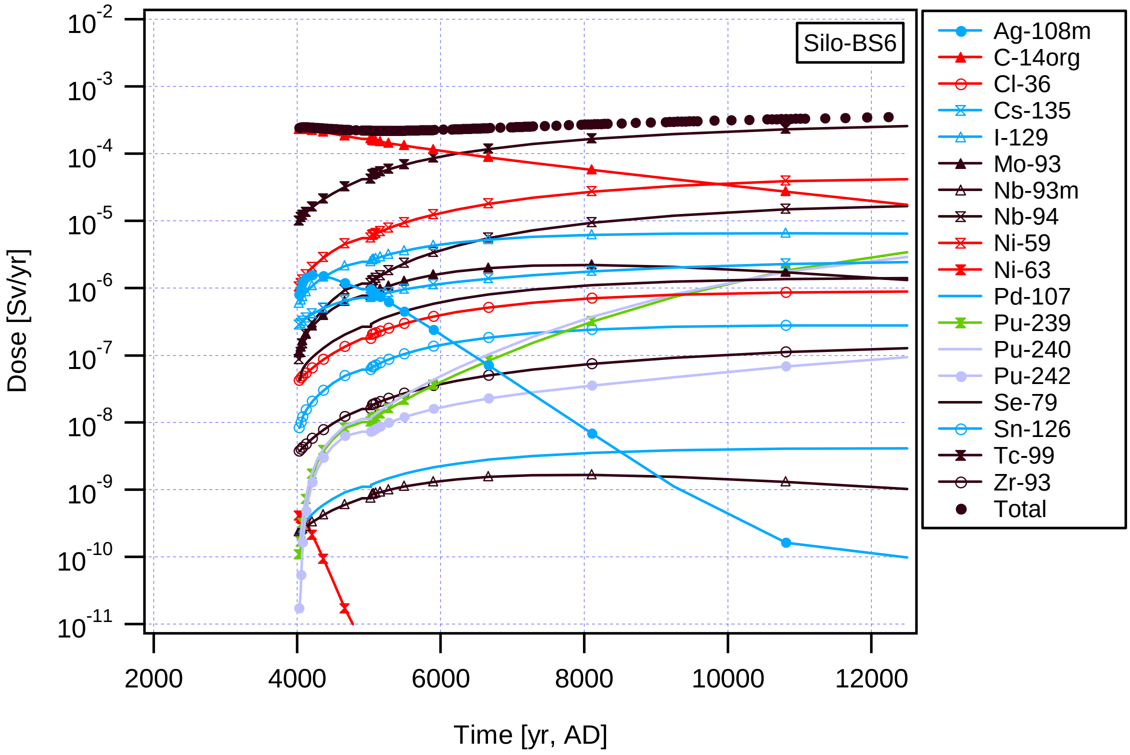

Figure 6-13. Dose from release of radionuclides from Silo affected by chemicals and being degraded from 3000 AD to a well (calculations performed for dominating nuclides only).

6.2.2 BMA

Intact barriers

The release rate of ^{59}Ni and ^{99}Tc from the near field increases and exceeds that of organic ^{14}C from about 3400 AD and 3900 AD, respectively (see *Figure 6-14*). The release rate of these two nuclides (10^8 Bq/yr) is approximately constant in time from about 4000 AD.

The total dose for the reasonable biosphere development is determined by the release of organic ^{14}C up to 7000 AD and since ^{14}C is not influenced by chemicals the dose is unchanged. From 8000 AD and onwards the total dose increased about an order of magnitude when the effect of chemicals is accounted for in comparison to the main case within the base scenario (compare *Figure 6-15* and *Figure 5-14*).

The influence on dose in today's biosphere is negligible (compare *Figure 6-17* and *Figure 5-16*). If the recipient is a mire area the total dose will increase two to three times from 4000 AD and onwards. This is caused by the increased release of ^{59}Ni, ^{99}Tc, ^{239}Pu and ^{240}Pu (compare *Figure 6-18* and *Figure 5-17*). The dose in well is also higher when chemicals are accounted for. A total dose of about 0.2 – 0.3 mSv/yr is obtained between 4000 AD and 12 000 AD. ^{99}Tc is the dose dominating nuclide but ^{59}Ni, ^{94}Nb, ^{239}Pu and ^{240}Pu also give a dose exceeding the total dose for the main case within the base scenario from about 5000 AD.

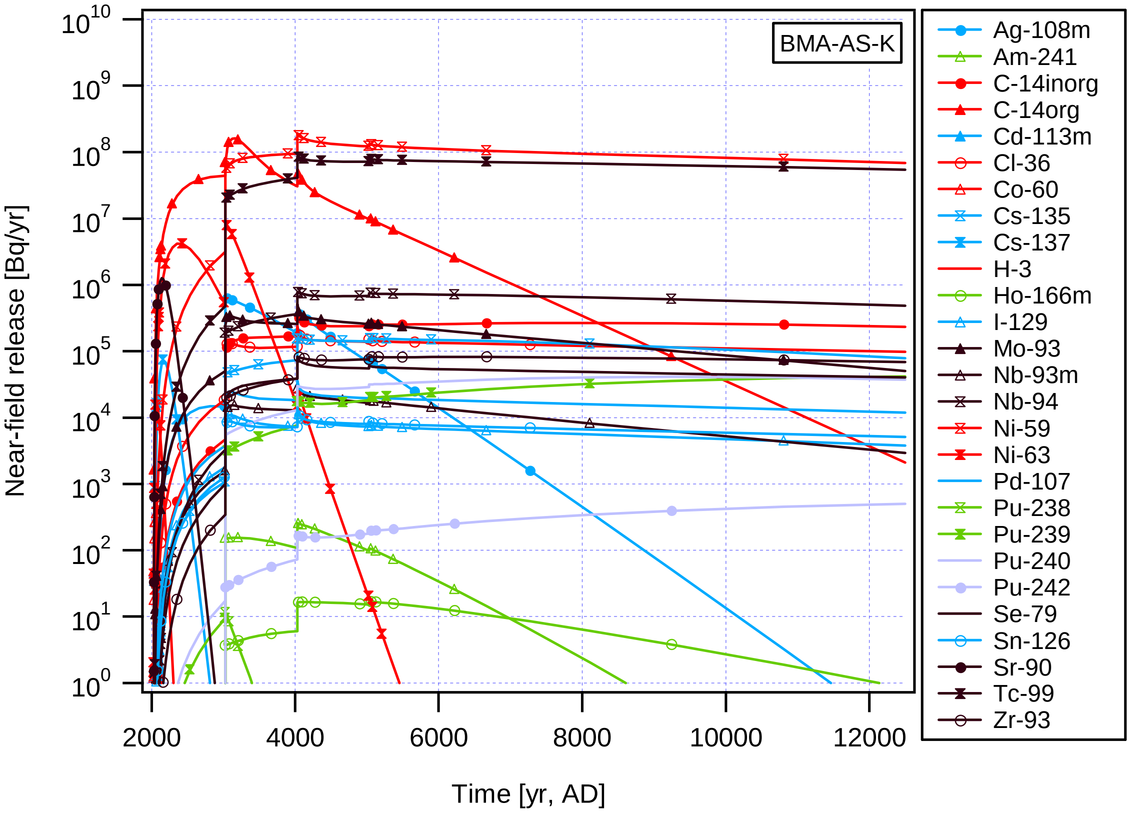

***Figure 6-14.** Near-field release rate from an intact BMA affected by chemicals.*

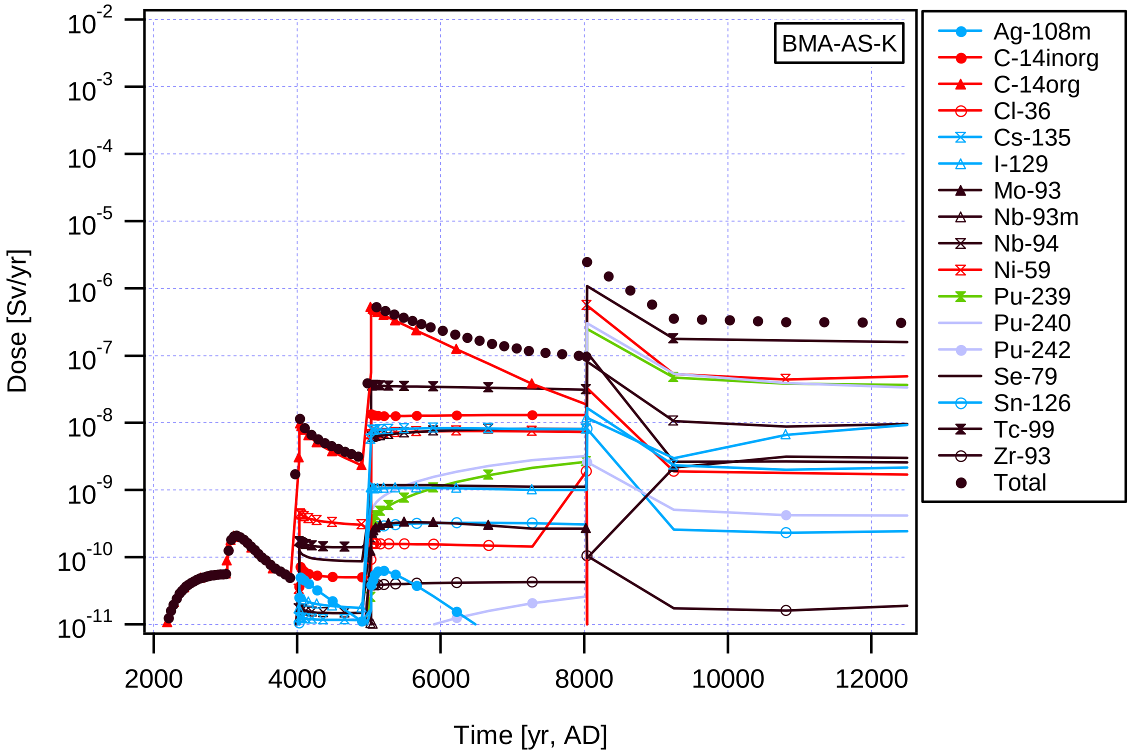

Figure 6-15. *Dose from release of radionuclides from an intact BMA affected by chemicals to the reasonable biosphere (calculations performed for dominating nuclides only).*

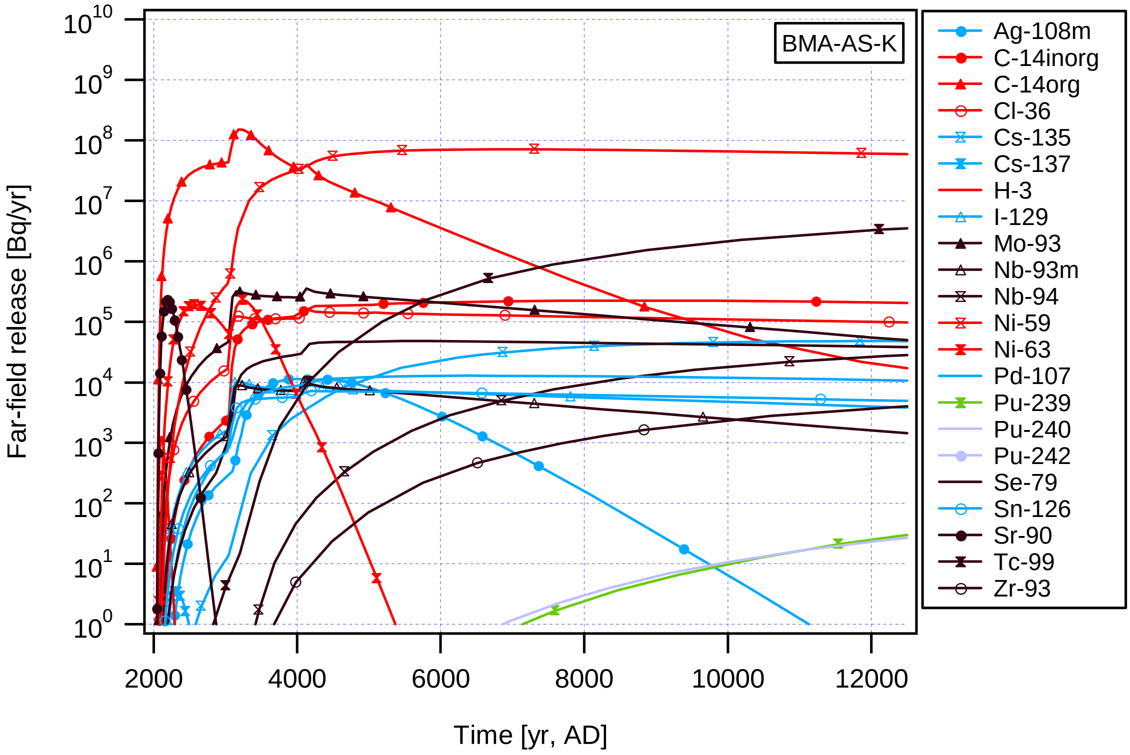

Figure 6-16. *Far-field release rate from an intact BMA affected by chemicals.*

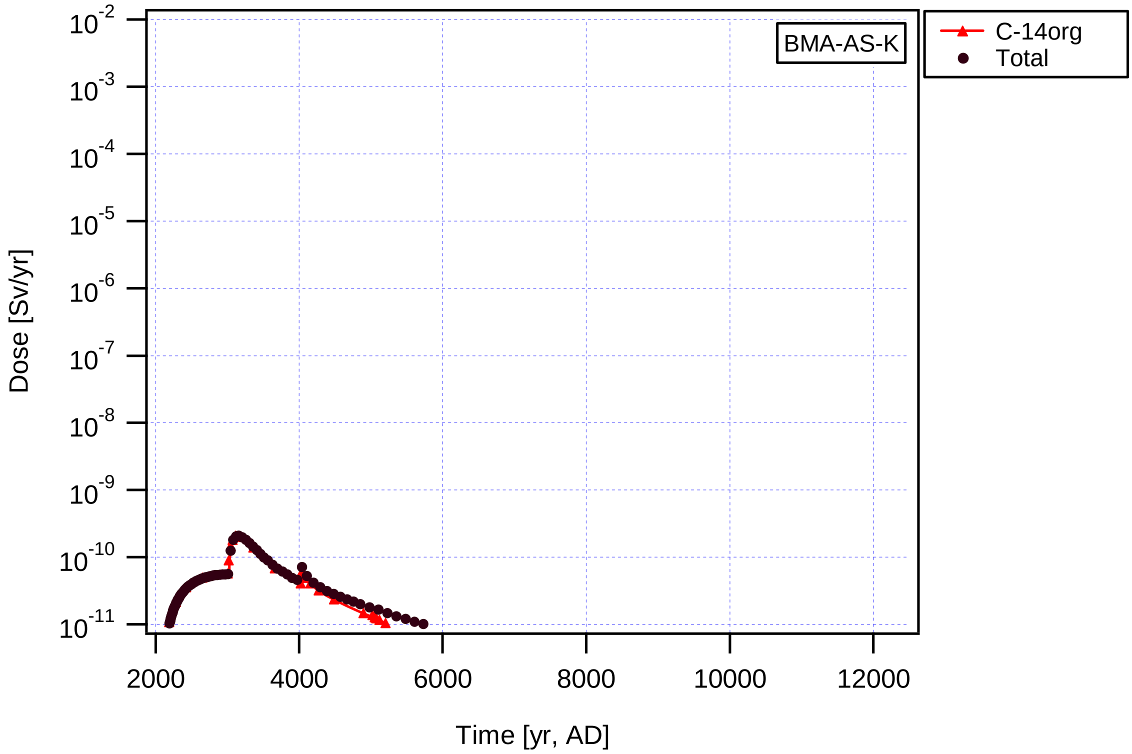

***Figure 6-17.** Dose from release of radionuclides from an intact BMA affected by chemicals to today's biosphere (calculations performed for dominating nuclides only).*

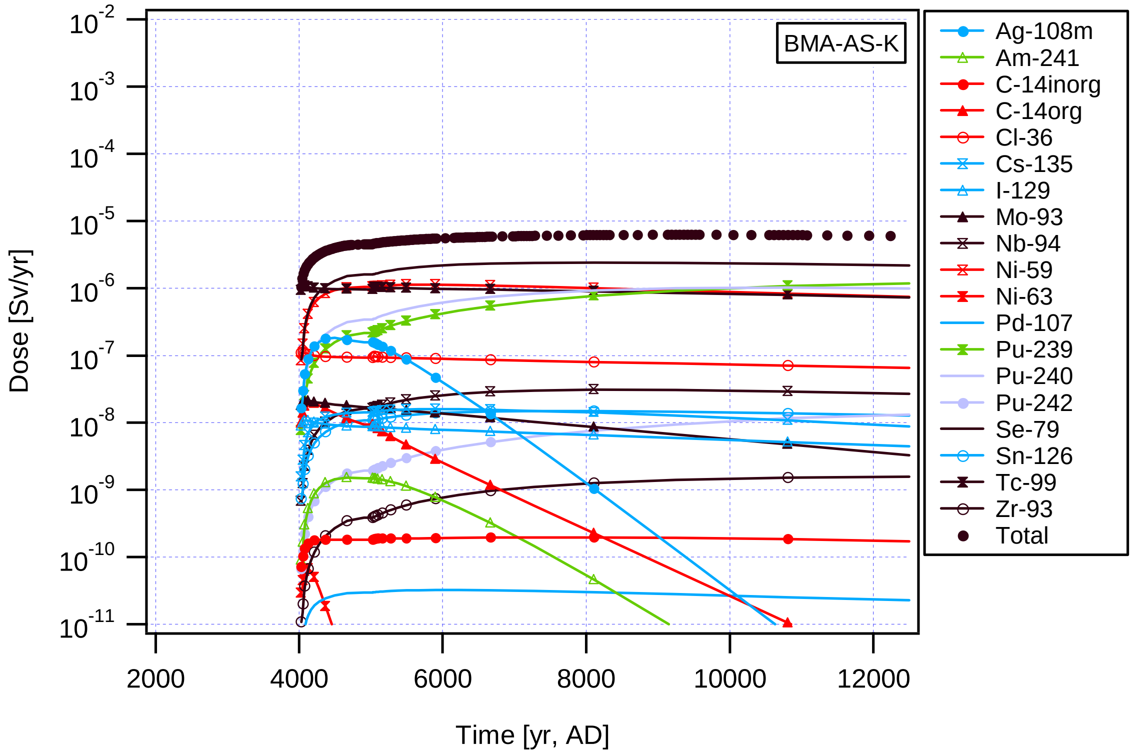

***Figure 6-18.** Dose from release of radionuclides from an intact BMA affected by chemicals to a mire area (calculations performed for dominating nuclides only).*

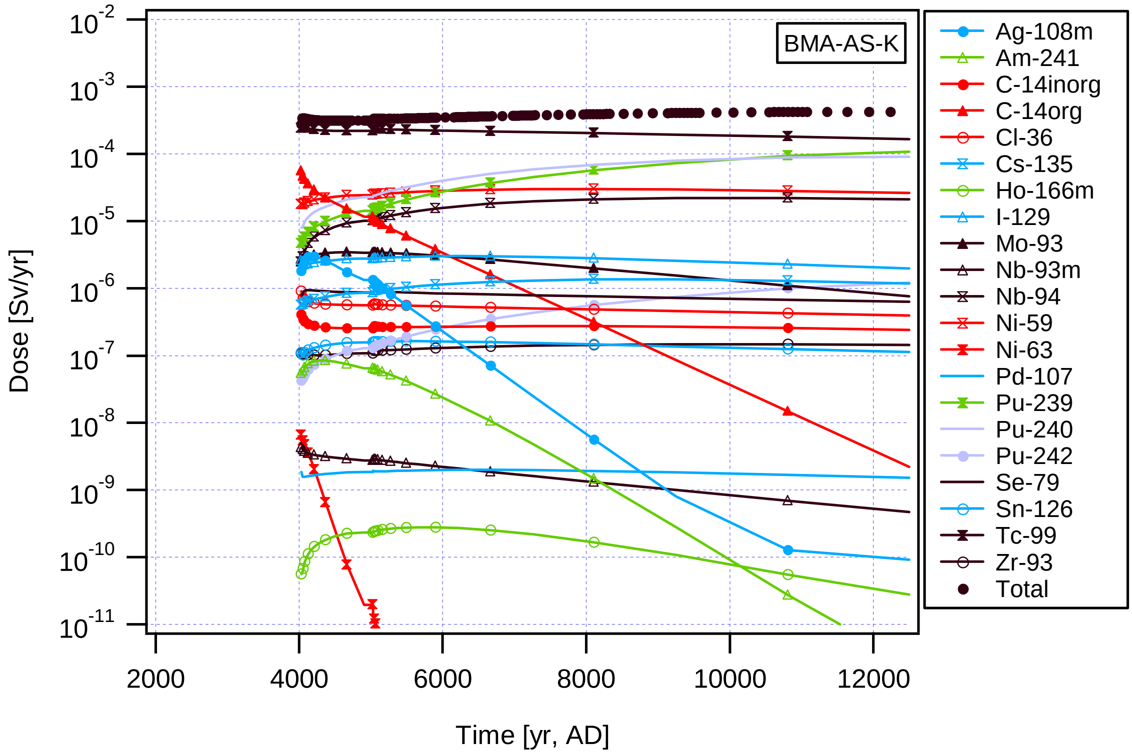

Figure 6-19. *Dose from release of radionuclides from an intact BMA affected by chemicals to a well (calculations performed for dominating nuclides only).*

Degraded barriers

The combined effect of chemicals and degraded barriers has a smaller impact on the results for BMA than for the Silo. Comparing the near-field release rate for this case (*Figure 6-20*) with the case affected by chemicals (*Figure 6-14*) it is seen that there is a small increase in the release rate of ^{59}Ni and ^{99}Tc between 3000 AD and 4000 AD for the combined effect. From 5000 AD, however, the release rate is approximately the same for the two cases. For other nuclides, e.g. ^{166m}Ho, ^{239}Pu, ^{240}Pu and ^{241}Am, there is a larger difference. The release rates of ^{239}Pu and ^{240}Pu are at most one order of magnitude higher for the case with the combined effect. This is obtained around 5000 AD. The difference decreases with time and around 12 000 AD the release rate of ^{239}Pu and ^{240}Pu are more or less the same for the two cases. As was stated in Chapter 5, the near-field release rate of organic ^{14}C is almost unaffected by the increase in water flow caused by degradation, and is not affected by chemicals. Accordingly, the near-field release rate of organic ^{14}C for the combined effect of chemicals and degraded barriers is identical to that for degraded barriers (see Section 5.2.2).

The total dose for release of radionuclides from BMA to the reasonable biosphere will initially to a large extent be the same as for the case with chemicals and intact barriers discussed in the previous section. The total dose up to 8000 AD is equivalent to that obtained for degraded barriers, see Section 5.2.2, since the dominating nuclides, organic ^{14}C and inorganic ^{14}C, are not affected by chemicals. For longer times, after 8000 AD, ^{239}Pu and ^{240}Pu result in the highest dose. An increase in total dose from 8000 AD and onwards of less than a factor two in comparison to that shown in *Figure 6-15* is obtained.

If the nuclides are released to a mire area instead, the dose corresponding to ^{79}Se, ^{239}Pu and ^{240}Pu will predominantly dominate the dose. Dose from release to a well is dominated by ^{99}Tc, ^{239}Pu and ^{240}Pu. The maximum total dose for release to mire area is about $1{\cdot}10^{-5}$ Sv/yr and for release to a well about $9{\cdot}10^{-4}$ Sv/yr.

Dose in today's biosphere has not been estimated for this case. The dose is expected to be low based on the results from the case with increased water flow rate through BMA discussed in Chapter 5 and the effect of chemicals in an intact BMA discussed above.

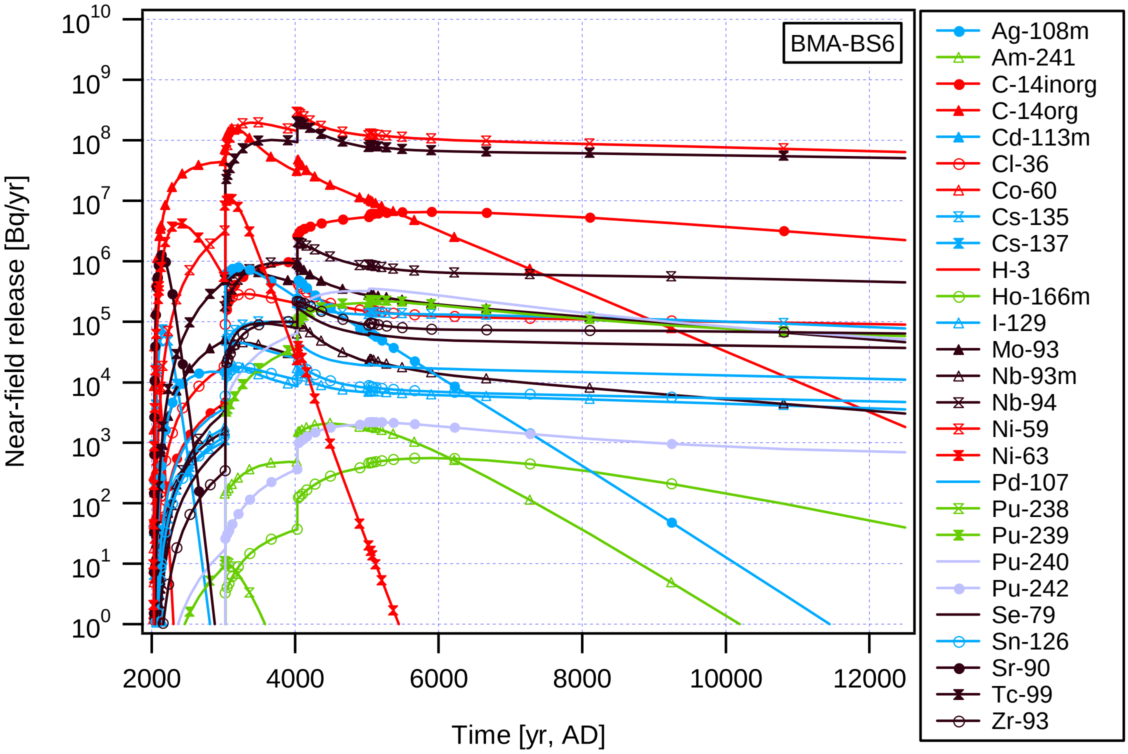

Figure 6-20. *Near-field release rate from BMA affected by chemicals and being degraded from 3000 AD.*

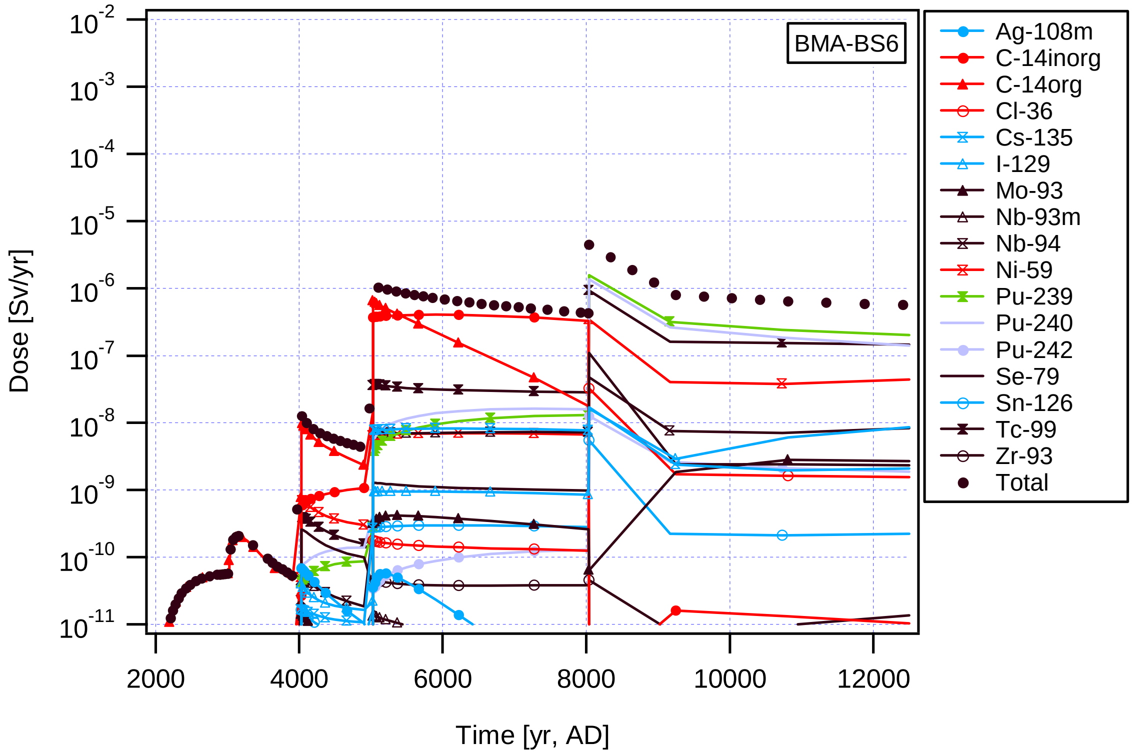

***Figure 6-21.** Dose from release of radionuclides from BMA affected by chemicals and being degraded from 3000 AD to the reasonable biosphere (calculations performed for dominating nuclides only).*

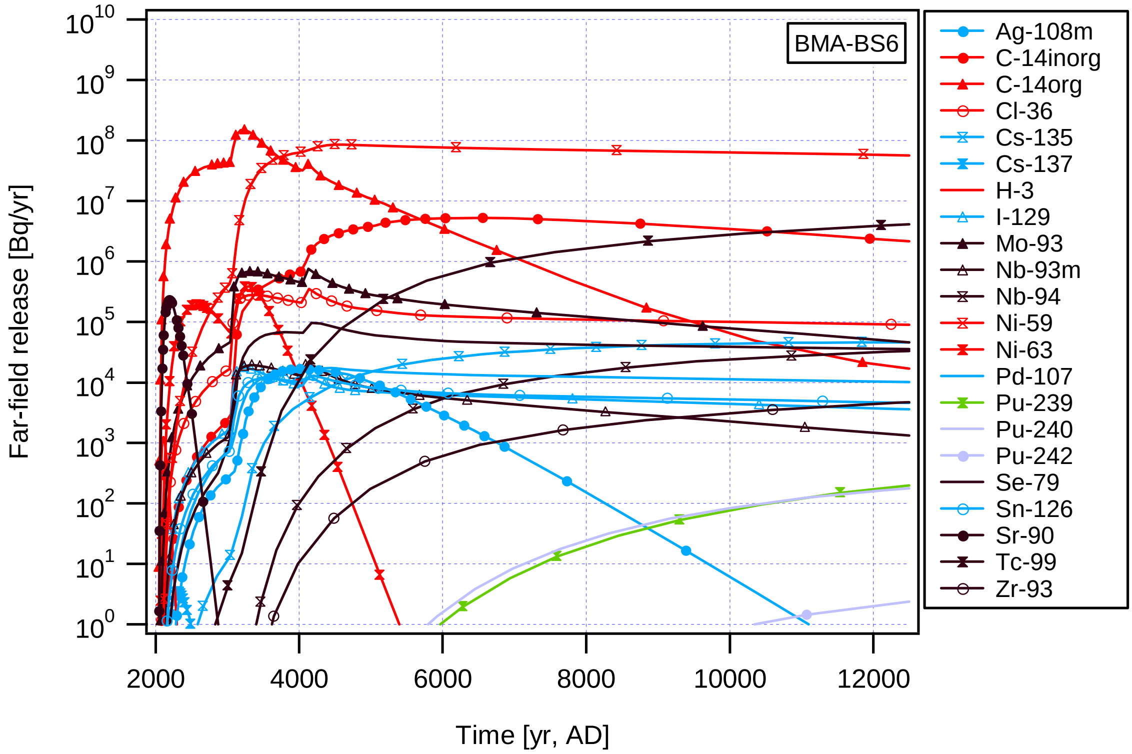

***Figure 6-22.** Far-field release rate from BMA affected by chemicals and being degraded from 3000 AD.*

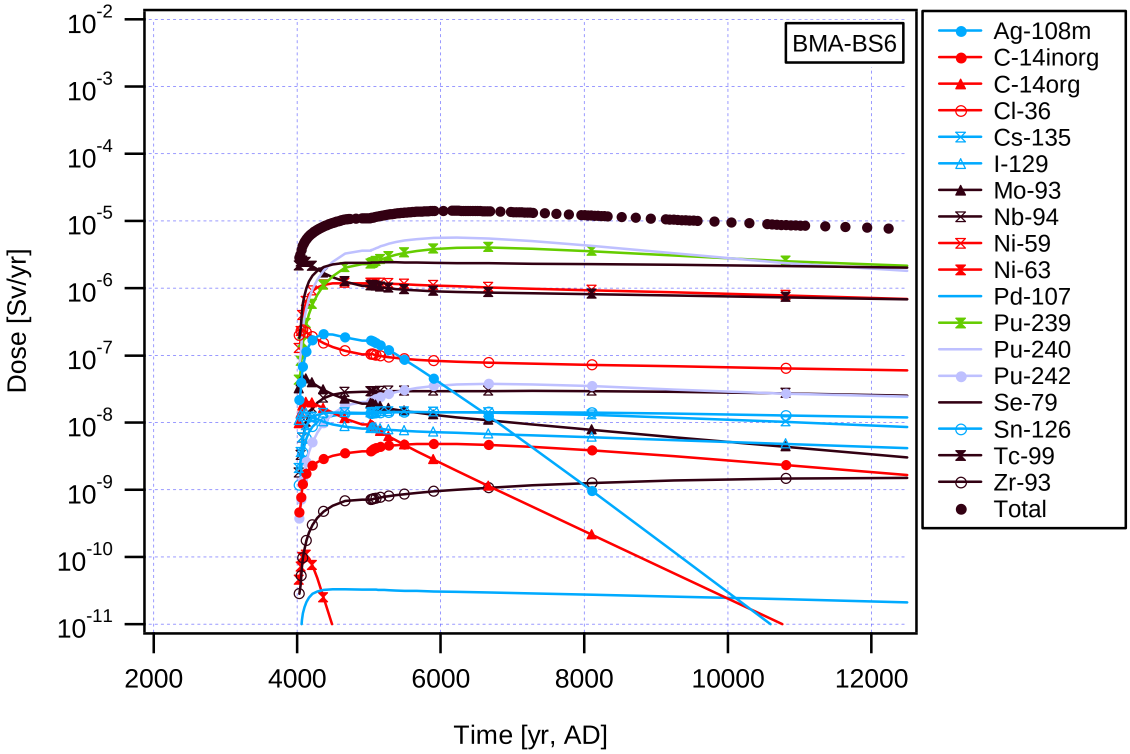

Figure 6-23. *Dose from release of radionuclides from BMA affected by chemicals and being degraded from 3000 AD to a mire area (calculations performed for dominating nuclides only).*

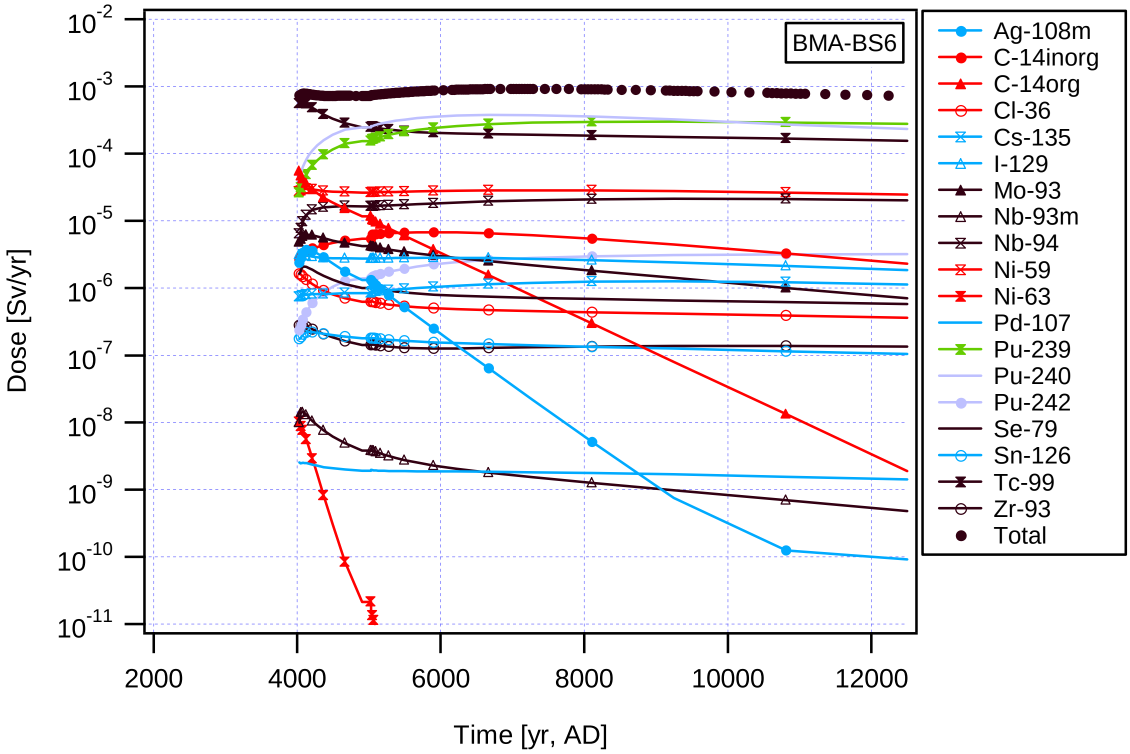

Figure 6-24. *Dose from release of radionuclides from BMA affected by chemicals and being degraded from 3000 AD to a well (calculations performed for dominating nuclides only).*

6.2.3 1BTF

Intact barriers

The results for the near-field release rate of nuclides affected by chemicals in 1BTF are given in *Figure 6-25*. The release rate of ^{59}Ni and ^{99}Tc exceeds that of organic ^{14}C from about 4800 AD. The release rate of these two nuclides is about one order of magnitude lower than from BMA.

The main effect of chemicals on the dose is caused by the increased release of ^{59}Ni, ^{99}Tc, ^{239}Pu and ^{240}Pu. This causes the maximum total dose for release to a mire area to increase by a factor two in comparison to the main case within the base scenario discussed in Section 5.3.1, even though ^{79}Se still dominates the total dose (see *Figure 6-29*). The maximum dose for release to the reasonable biosphere (*Figure 6-26*) or a well (*Figure 6-30*) increases marginally in comparison to the main case, to today's biosphere (*Figure 6-28*) not at all. However, in contradiction to the main case, the total dose in the well is almost constant from about 4000 AD to 12 000 AD when the effect of chemicals is accounted for (see *Figure 6-30*).

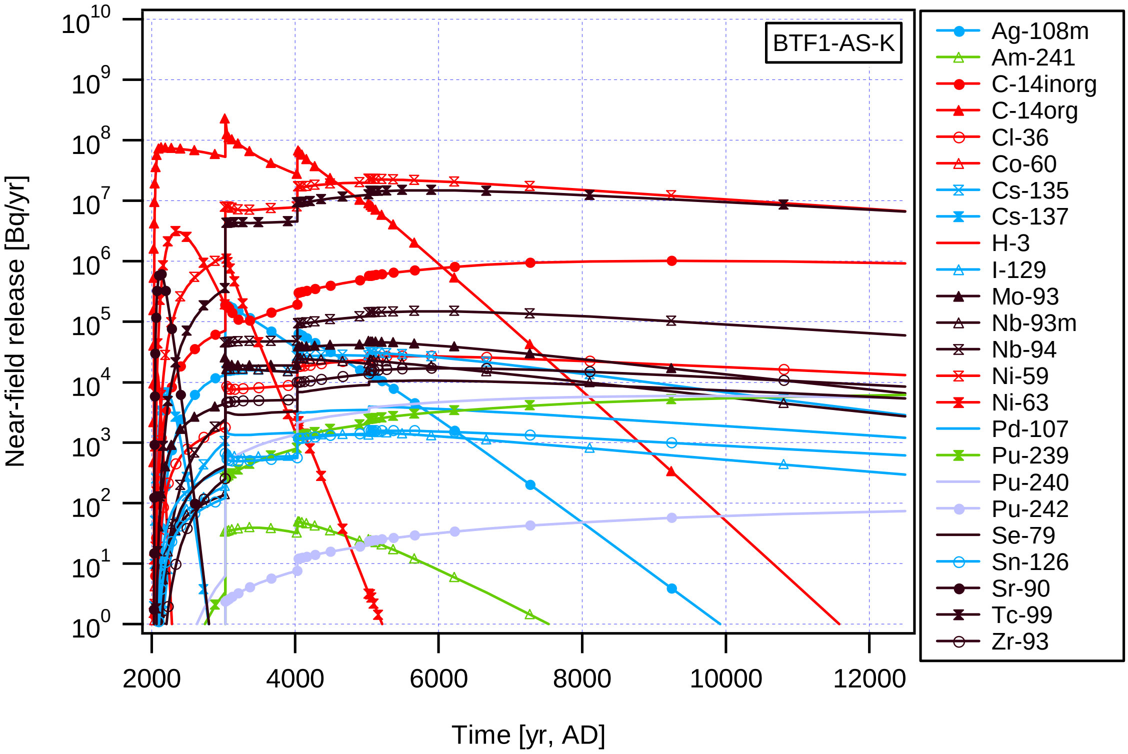

Figure 6-25. *Near-field release rate from an intact 1BTF affected by chemicals.*

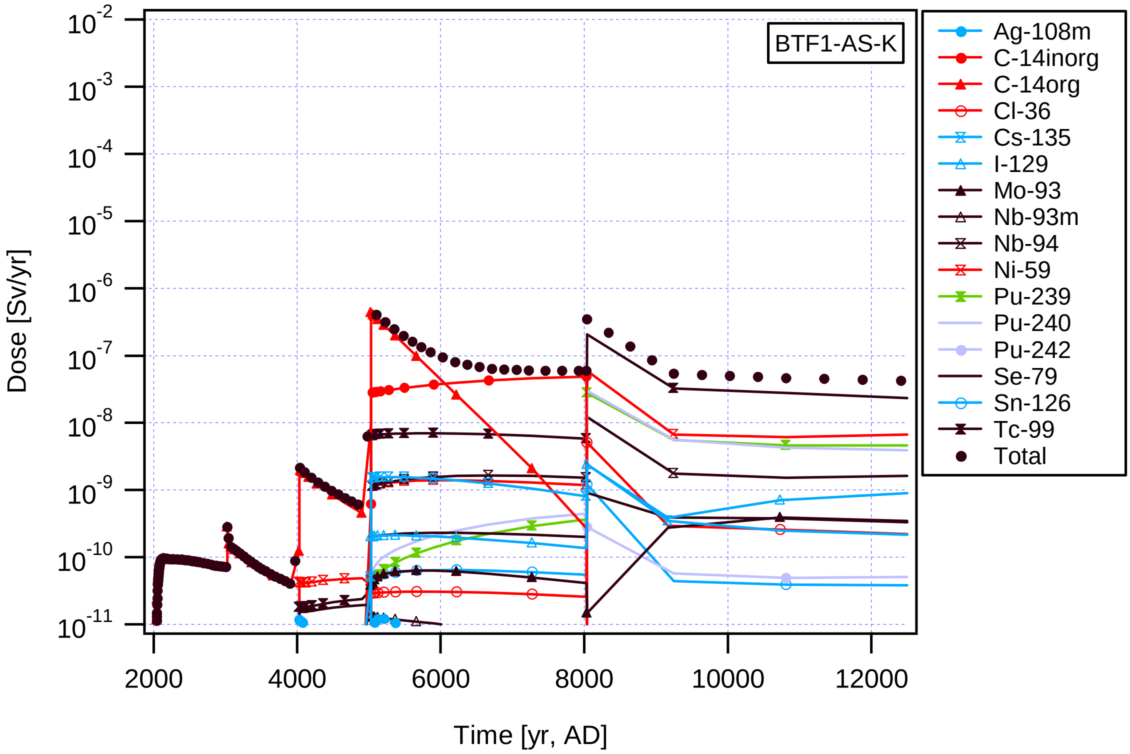

__Figure 6-26.__ Dose from release of radionuclides from an intact 1BTF affected by chemicals to the reasonable biosphere (calculations performed for dominating nuclides only).

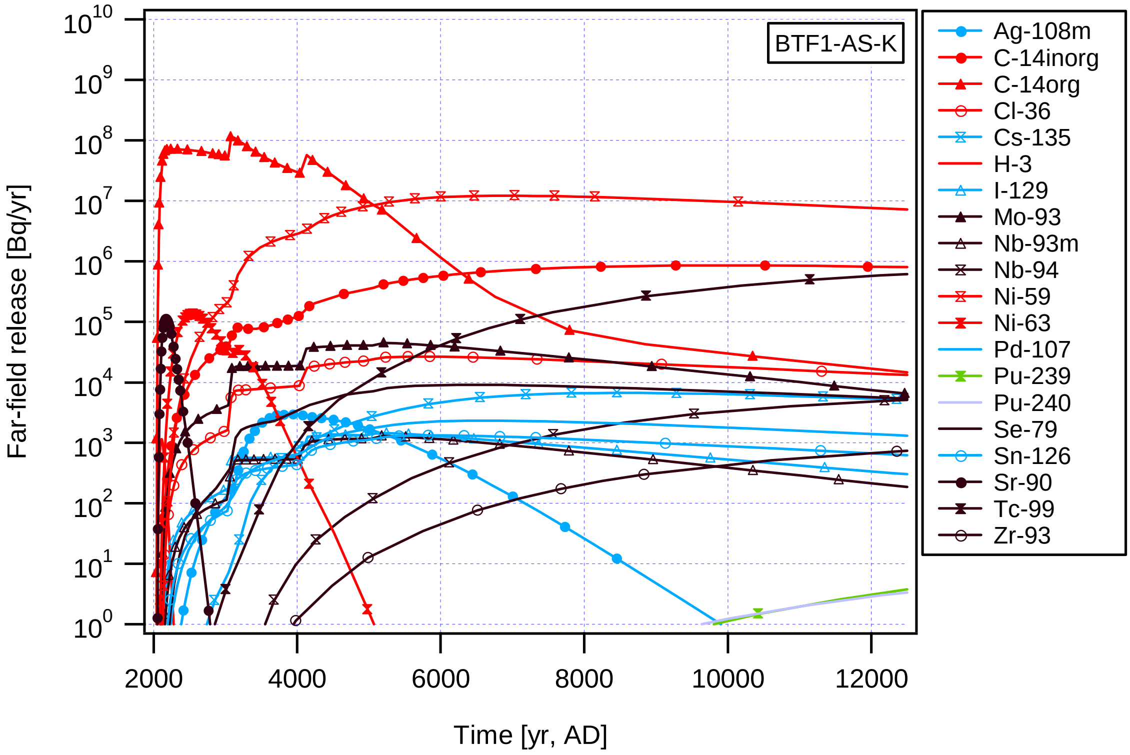

__Figure 6-27.__ Far-field release rate from an intact 1BTF affected by chemicals.

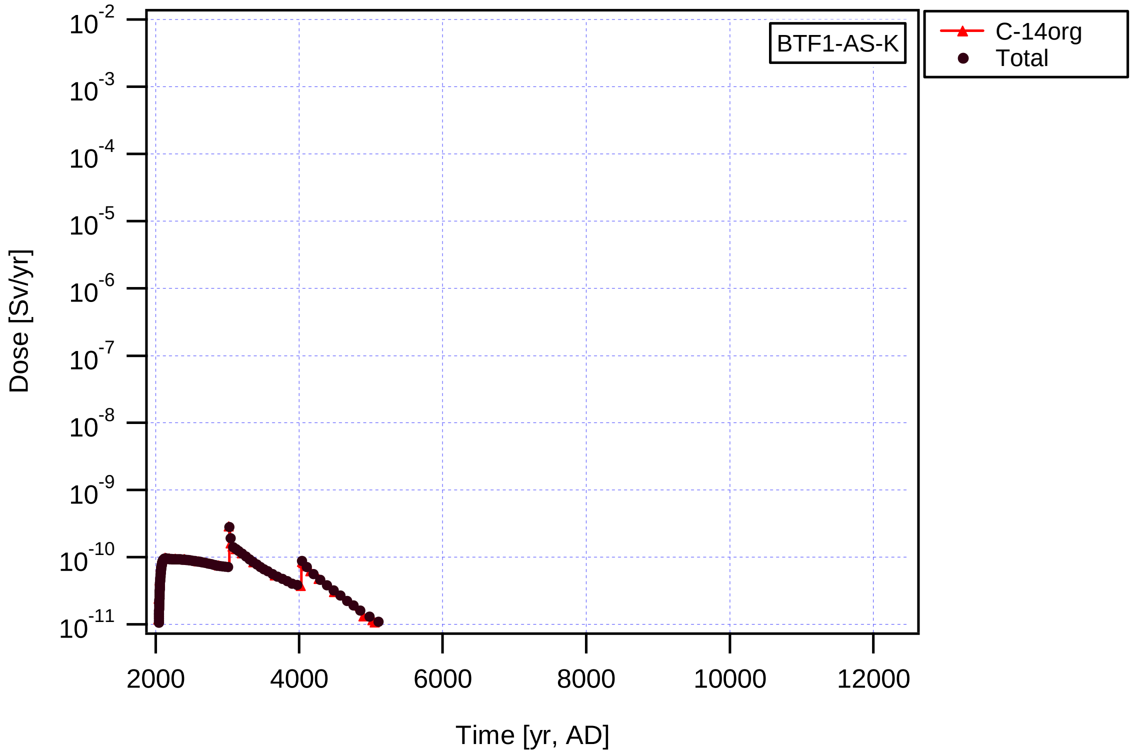

Figure 6-28. *Dose from release of radionuclides from an intact 1BTF affected by chemicals to today's biosphere (calculations performed for dominating nuclides only).*

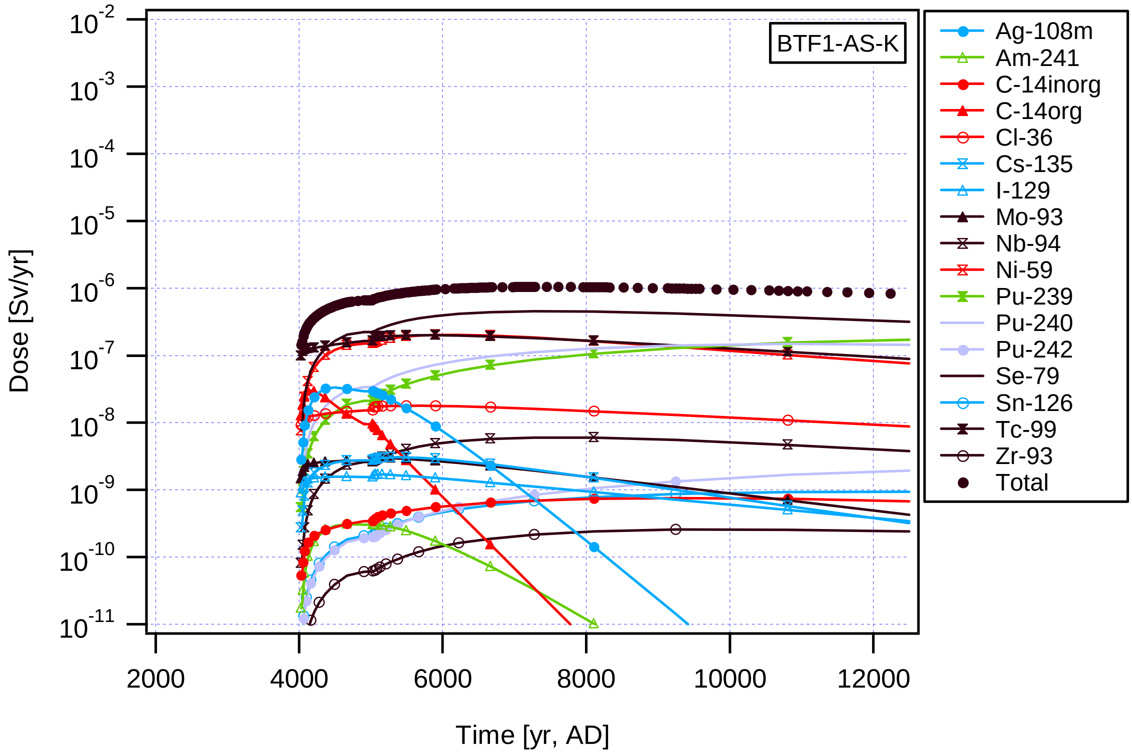

Figure 6-29. *Dose from release of radionuclides from an intact 1BTF affected by chemicals to a mire area (calculations performed for dominating nuclides only).*

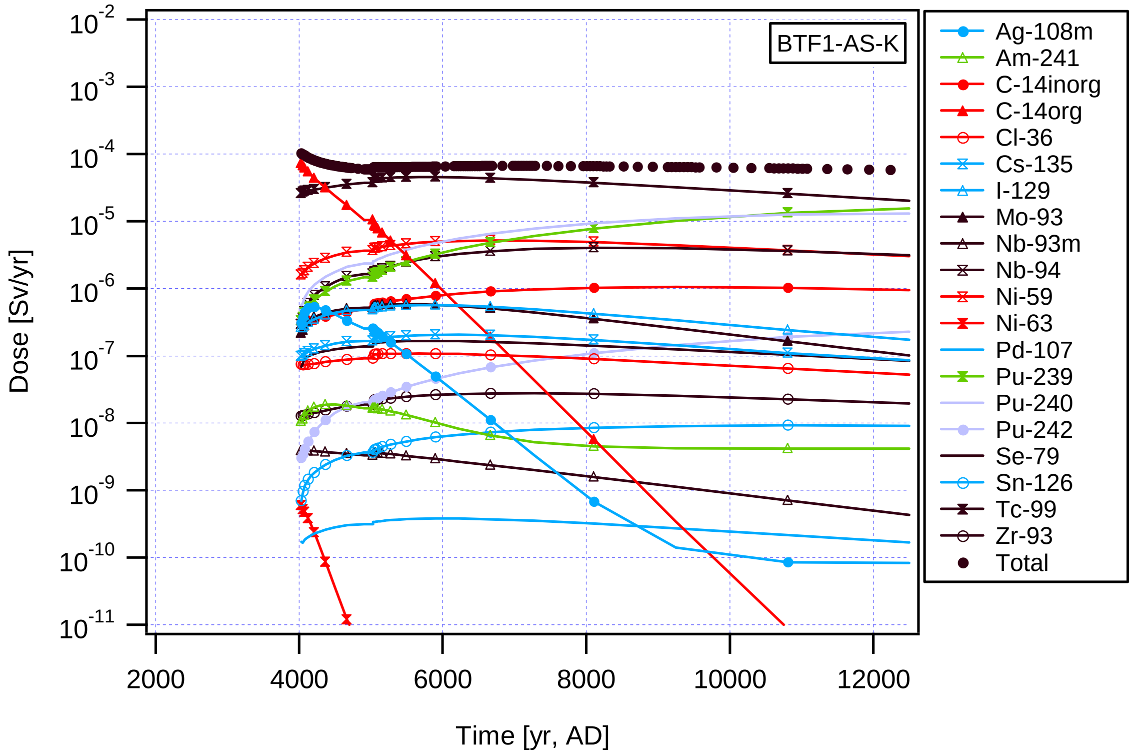

Figure 6-30. *Dose from release of radionuclides from an intact 1BTF affected by chemicals to a well (calculations performed for dominating nuclides only).*

Degraded barriers

In Section 5.3.2 it was stated that the water flow through 1BTF with part of the vault being degraded locally increases up to a factor six. However, the total water flow through the whole vault increases with no more than a factor two in comparison to an intact barrier. In accordance with the discussion in Section 5.3.2, a combined effect of chemicals and degraded barriers in 1BTF could give a total dose for the reasonable biosphere that is not more than a factor two higher than that for the case with chemicals and intact barriers. The total dose is expected to be dominated by organic and inorganic ^{14}C until 8000 AD and from that by ^{99}Tc.

6.2.4 2BTF

Intact barriers

The near-field release rate for nuclides affected by chemicals from an intact 2BTF is shown in *Figure 6-31*. ^{59}Ni and ^{99}Tc gives the highest near-field release rate from about 3500 AD.

The effect of chemicals in 2BTF on dose in recipients is to a large extent the same as for 1BTF discussed in Section 6.2.3. The increase in dose in the reasonable biosphere development is however larger than for 1BTF. The maximum dose is in this case mainly achieved from ^{99}Tc at 8000 AD and is $4{\cdot}10^{-7}$ Sv/yr.

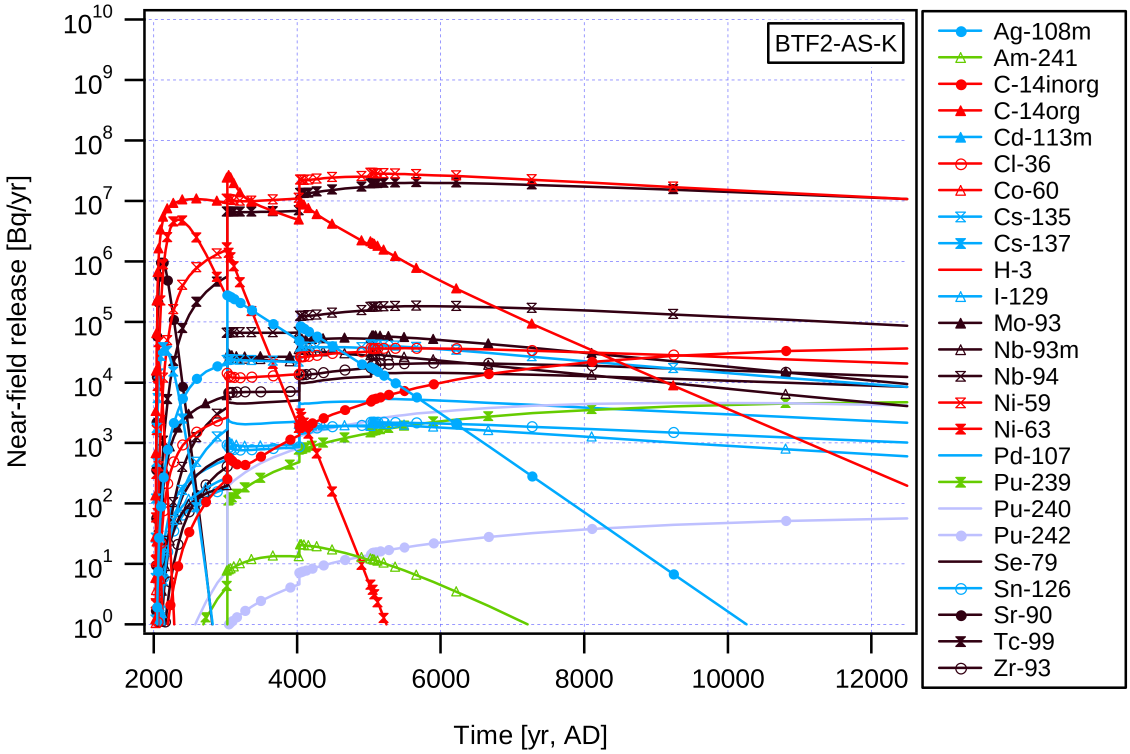

Figure 6-31. Near-field release rate from an intact 2BTF affected by chemicals.

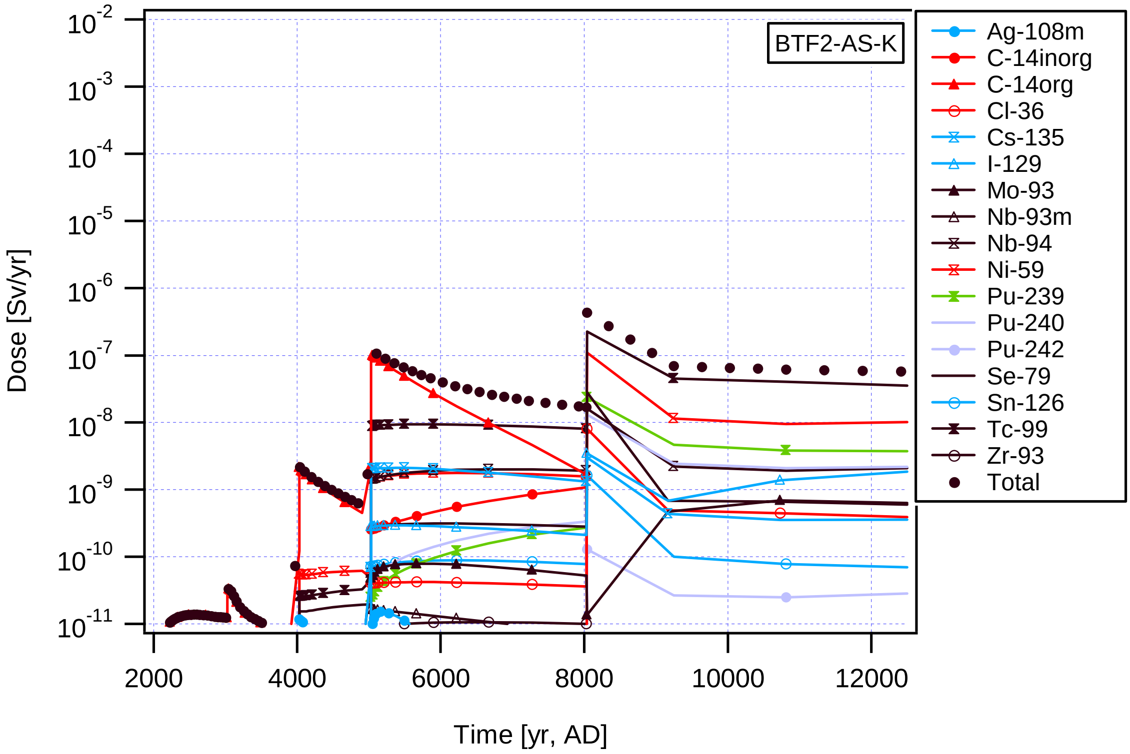

Figure 6-32. *Dose from release of radionuclides from an intact 2BTF affected by chemicals to the reasonable biosphere (calculations performed for dominating nuclides only).*

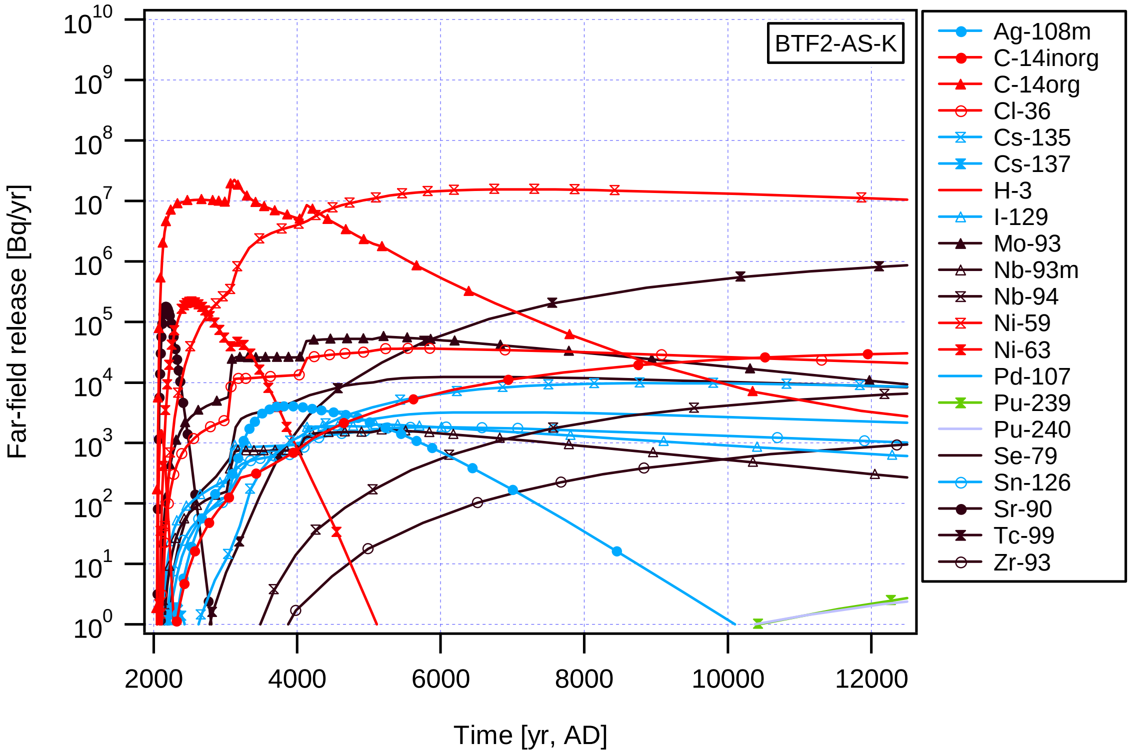

Figure 6-33. *Far-field release rate from an intact 2BTF affected by chemicals.*

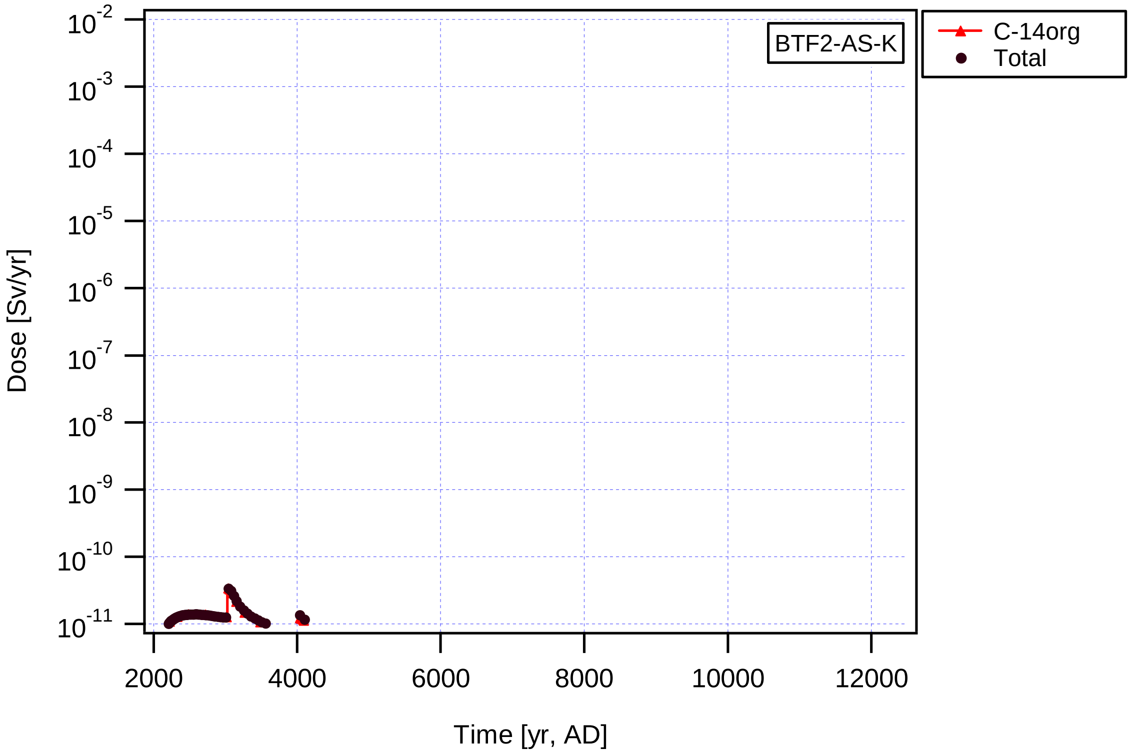

Figure 6-34. *Dose from release of radionuclides from an intact 2BTF affected by chemicals to today's biosphere (calculations performed for dominating nuclides only).*

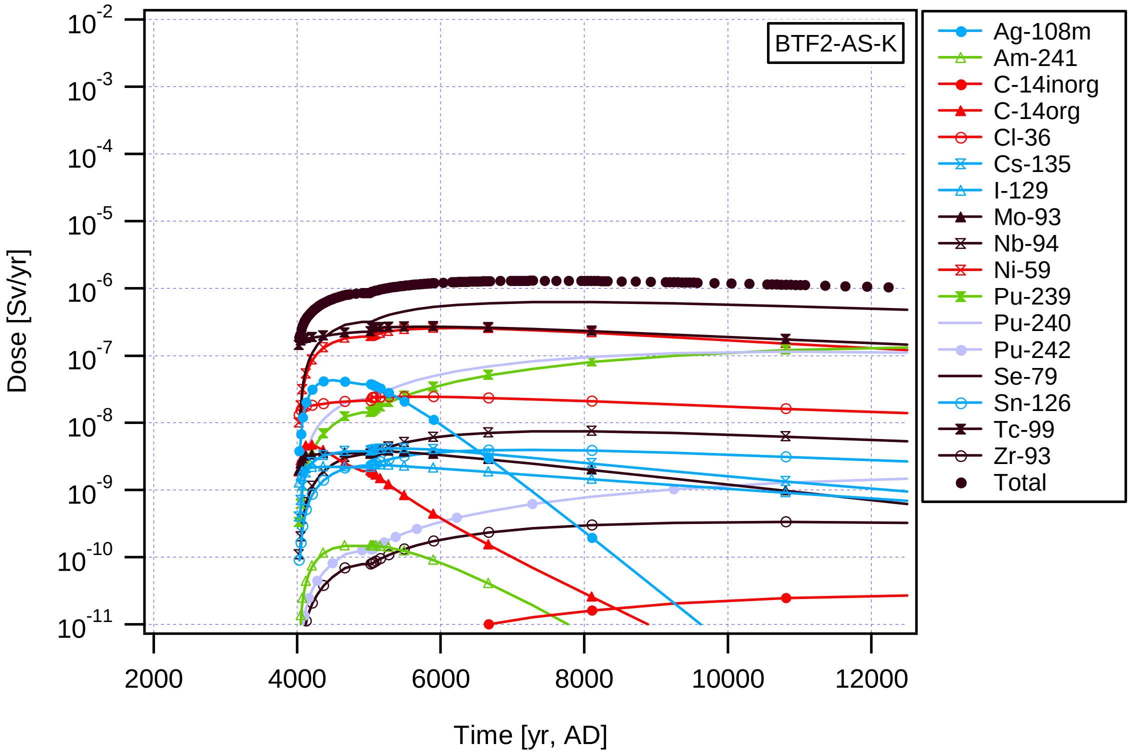

Figure 6-35. *Dose from release of radionuclides from an intact 2BTF affected by chemicals to a mire area (calculations performed for dominating nuclides only).*

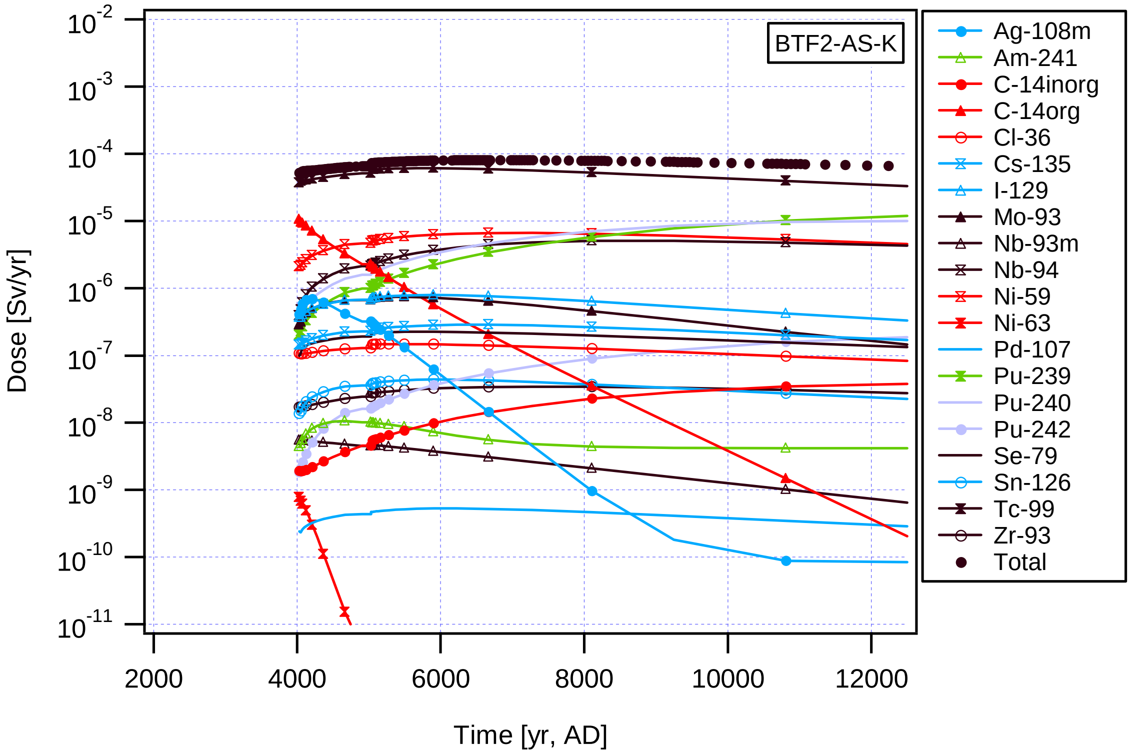

Figure 6-36. *Dose from release of radionuclides from an intact 2BTF affected by chemicals to a well (calculations performed for dominating nuclides only).*

Degraded barriers

The results for chemicals and degraded barriers in 2BTF are to a large extent foreseen to be the same as for the same case for 1BTF. However, the total dose for the reasonable biosphere development is expected to be dominated by organic ^{14}C for a shorter period of time, but will be followed by ^{99}Tc for 2BTF as well. The maximum dose will probably be determined by ^{99}Tc at 8000 AD as in the case with chemicals and intact barriers.

6.3 Permafrost

The climate is foreseen to be colder in the future, and thus permafrost could be obtained in the region. It has been estimated that this could happen earliest in 7000 AD (SKB, 2001b). To get a rough estimate of the consequence of permafrost, it is assumed that the repository is a frozen system from repository closure until 12 000 AD when the permafrost period is assumed to have ended. No radionuclides have been released before 12 000 AD, but radioactive decay for 10 000 years has caused the initial inventory to be reduced. All materials within the repository are mechanically degraded. The water flow is therefore homogeneously distributed within each repository part, and the radionuclides are transported out with the total flow in the repository part. The magnitude of the water flow rate is chosen to be the highest flow obtained within the hydrogeology modelling of SFR 1 (Holmén and Stigsson, 2001a). Sorption has been accounted for all barrier materials that are included in the near-field models.

The release is calculated as an instant release at 12 000 AD and the dose is calculated for the recipient that is representative for today's biosphere conditions. The result in terms of total dose from each repository part is shown in *Figure 6-37*. Organic ^{14}C dominates the dose for the Silo, BMA, 1BTF and 2BTF. For BLA the dose dominating nuclides are inorganic ^{14}C, ^{239}Pu and ^{240}Pu. Since there is a significant dilution in the recipient (Öregrundsgrepen), the dose is very low. The total dose for SFR 1 is $1{\cdot}10^{-9}$ Sv/yr.

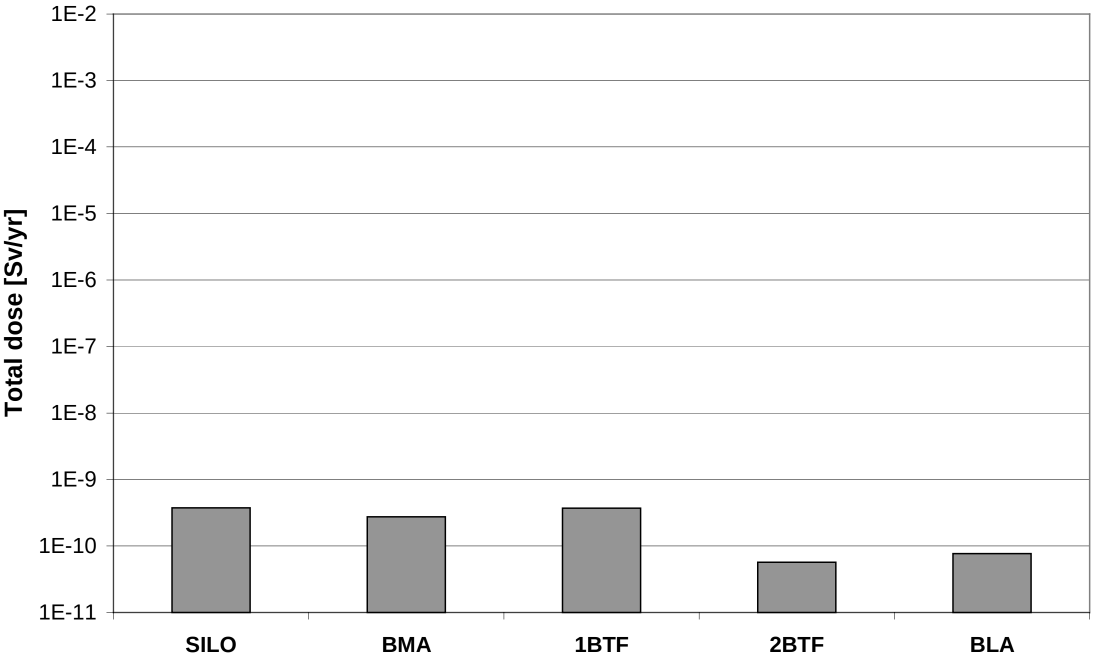

Figure 6-37. *Total dose at 12 000 AD for permafrost scenario.*

6.4 Human intrusion

A human intrusion scenario has been analysed in which a well is sunk directly into the gravel backfill in each repository part. Long-term effects have not been considered. Instead, the dose to man obtained at the time when the well is sunk is evaluated. This scenario can not be realised until the coastline has past the repository, i.e. from 3000 AD. Here, the scenario has been analysed assuming the well is sunk at 3000 AD, 4000 AD or 5000 AD.

In the calculations it is assumed for each repository part that the nuclide concentration in the well water is the same as the highest concentration in any part of the gravel backfill when the well is sunk. The concentrations are obtained from the migration calculations for the main case within the base scenario. The nuclide concentrations has been transformed into a dose using ingestion dose conversion factors (EU, 1996) and assuming a water consumption rate of 600 l/yr.

The total dose for each repository part for the defined intrusion scenario is shown in *Figure 6-38*. The highest total dose is obtained from a well in BLA if the well is sunk at 3000 AD. If the well is sunk at 4000 AD or 5000 AD on the other hand, a well in the Silo will result in the highest total dose. The dose dominating nuclide in BLA is ^{240}Pu whereas ^{14}C dominate in the other repositories.

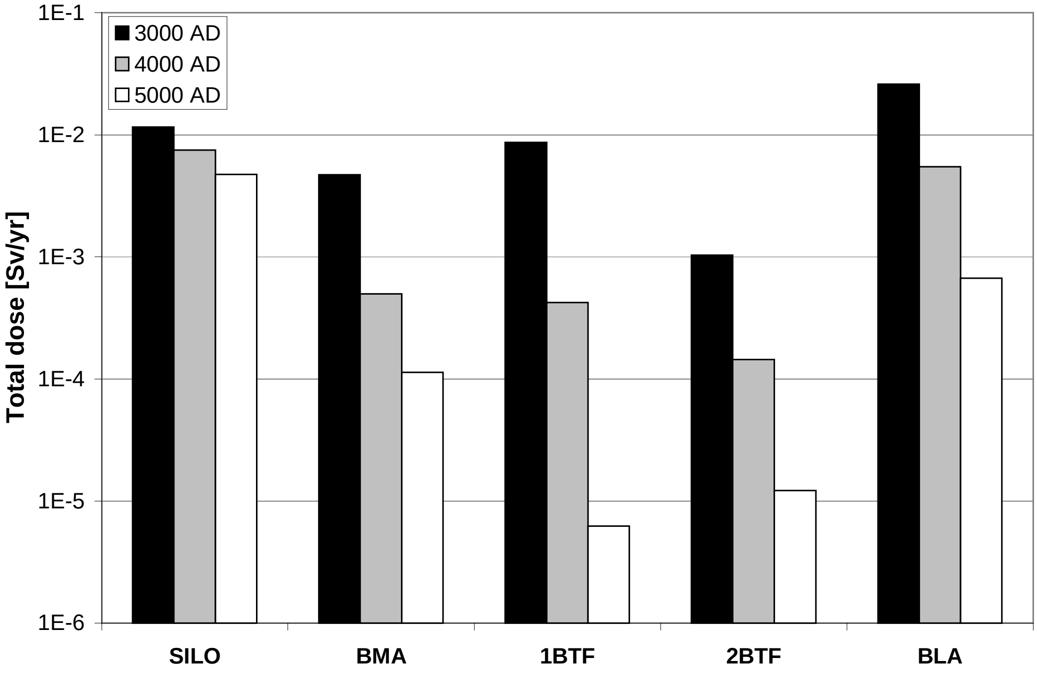

Figure 6-38. *Total dose for the analysed human intrusion scenario.*

7 Summary of results

The consequences of migration of radionuclides from SFR 1 have been analysed for a base scenario. The base scenario describes the expected evolution of the repository's near field. Three different cases are defined within the base scenario. Intact barriers (main case) and degraded barriers after 1000 years are discussed in this report. The third case, gas influenced nuclide transport, is analysed in Moreno *et al.* (2001). Uncertainties in the biosphere development are taken into account by evaluating the consequences of releases to a reasonable biosphere, to today's biosphere, to a mire area and to a well.

Besides the base scenario, the effect of initially degraded barriers and the effect of the presence of materials in the waste that drastically deteriorate the possibility for nuclides to sorb on the barriers are analysed. In addition, a permafrost scenario and a human intrusion scenario are analysed.

In this last chapter, a conclusive summary of the results from the modelling of migration of radionuclides and corresponding doses in the biosphere is made. The main part of this chapter is devoted to the results for the base scenario, and then mainly the main case. Other scenarios are discussed more briefly. The maximum dose for all investigated cases is summarised in Table 7-1.

7.1 Base scenario

7.1.1 Intact barriers

The total dose from release of radionuclides from an intact SFR 1 with a reasonable biosphere development is shown in *Figure 7-1*. The total dose is initially dominated by the release of ^{137}Cs from BLA. From about 2250 AD to 4000 AD the dose is dominated by the release of organic ^{14}C from 1BTF and BMA. Between 4000 AD and 8000 AD organic ^{14}C from the Silo dominates the dose. The dominating pathway for exposure from ^{137}Cs as well as from organic ^{14}C is, during this whole time period, consumption of fish. The maximum total dose from SFR 1, $4 \cdot 10^{-6}$ Sv/yr, is obtained when the recipient is changed from coast to a lake at 5000 AD. The dose from organic ^{14}C is reduced significantly when the recipient is changed from a lake to agricultural land at 8000 AD. Instead, ^{239}Pu and ^{240}Pu in BLA dominate the dose. The reason for the drastically decrease in dose from organic ^{14}C is the fact that carbon is not taken up in vegetation by roots. The exposure in the agricultural land model (which for most radionuclides is a product of root uptake) is therefore much lower. The uptake of carbon in fish is very large in the lake model comparing to most other nuclides making this contrast even larger. The most important pathways for exposure from ^{239}Pu and ^{240}Pu is inhalation of contaminated dust.

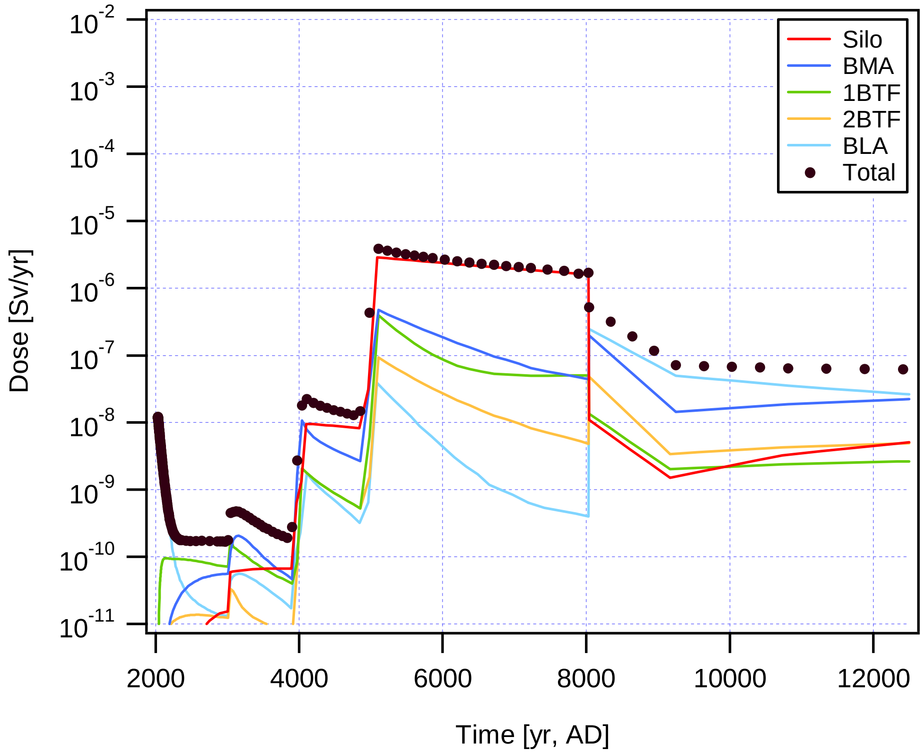

Figure 7-1. *Total dose from release of radionuclides from SFR 1 to the reasonable biosphere.*

An alternative to the reasonable biosphere development (coast, lake and agricultural land) is the development of mire. A mire can be formed at 4000 AD earliest (Kautsky, 2001). The total dose from release to a mire area from an intact SFR 1 is shown in *Figure 7-2*. Initially the total dose is dominated by the release of ^{239}Pu and ^{240}Pu from BLA, but the dose from radionuclides from BMA increases with time and exceeds that for BLA from 5400 AD. The dose from radionuclides in BMA is completely dominated by the release of ^{79}Se. The total dose is more or less constant in time with a maximum of $6 \cdot 10^{-6}$ Sv/yr around 4700 AD. The dose gained from exposure from ^{239}Pu and ^{240}Pu is due to inhalation of contaminated dust from the mire area. In contrast, the exposure from ^{79}Se is mainly through consumption of cereals and also through consumption of milk. ^{79}Se is to a large extent retained on the solid phase of the peat. This in combination with a large uptake by vegetation makes the potential of exposure large compared to other nuclides when a mire is chosen as a recipient.

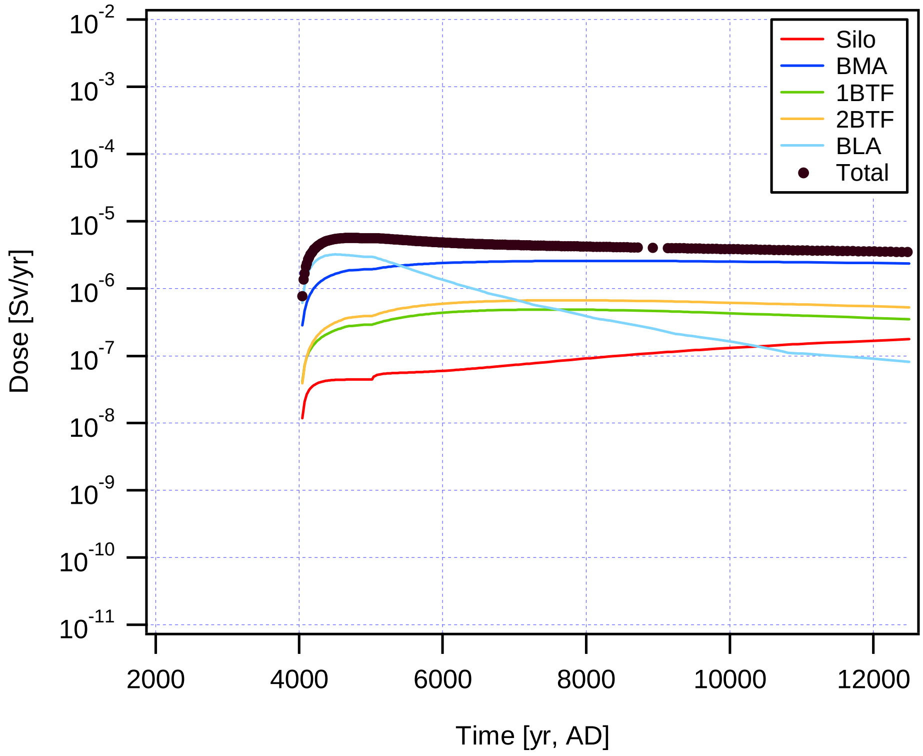

Figure 7-2. *Total dose from release of radionuclides from SFR 1 to a mire area.*

Release to a well has also been analysed. It is assumed that the well has a capacity of 2.37 m^3/day and that it can be sunk no earlier than 4000 AD. Furthermore, the hydrogeological calculations show that the well may be placed so that either the release from all vaults or the release from the Silo will end up in the well (Holmén and Stigsson, 2001a).

The consequence of a release from an intact SFR 1 to a well is shown in *Figure 7-3*. ^{239}Pu and ^{240}Pu in BLA dominates the total dose for release from the vaults and organic ^{14}C dominate the release from the Silo. The maximum total dose for release from the vaults is $4{\cdot}10^{-4}$ Sv/yr and from the Silo $5{\cdot}10^{-5}$ Sv/yr. The dominating pathway for exposure from ^{239}Pu and ^{240}Pu is inhalation of contaminated dust from a garden plot, which is irrigated with the well water. For exposure from organic ^{14}C consumption of water is the most important exposure pathway followed by consumption of root crops and milk.

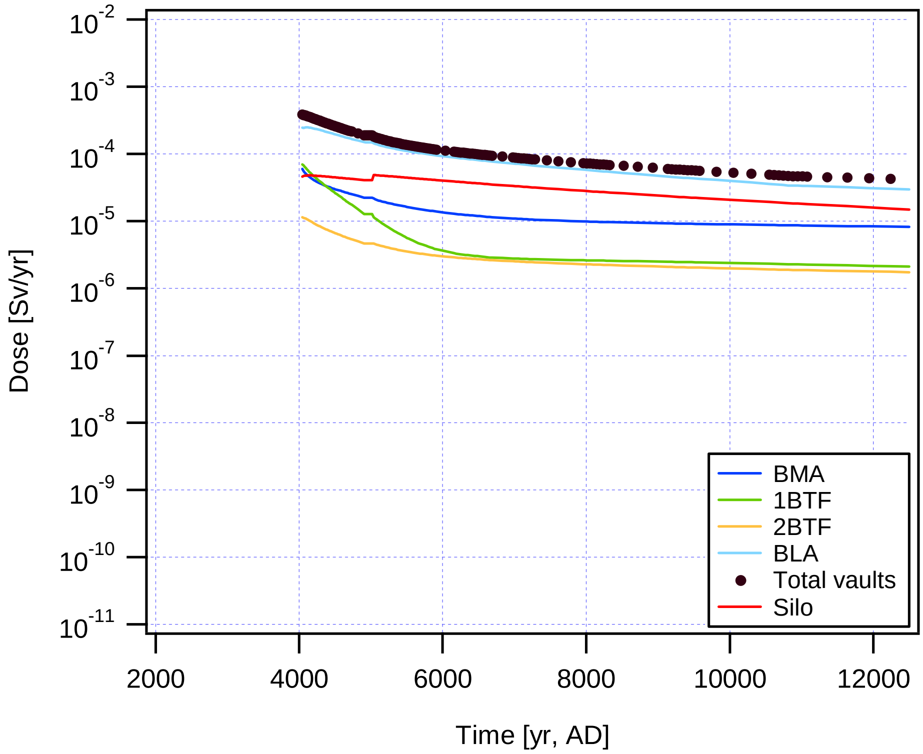

Figure 7-3. *Total dose from release of radionuclides from SFR 1 to a well.*

Release to today's biosphere results in a maximum dose of $1{\cdot}10^{-8}$ Sv/yr obtained shortly after repository closure. With the exception of this instant release the maximum release rate is less than $6{\cdot}10^{-10}$ Sv/yr.

7.1.2 Degraded barriers

Degraded barriers lead to a higher flow rate of water through the repository, and thus an increased release rate for some nuclides. The effect of a degraded barrier in Silo and BMA 1000 years after repository closure on total dose for the reasonable biosphere development is shown in *Figure 7-4*. The maximum total dose for a degraded Silo increases with a factor of three in comparison to intact barriers ($9{\cdot}10^{-6}$ Sv/yr vs $3{\cdot}10^{-6}$ Sv/yr). From 8000 AD and onwards this ratio increases to about an order of magnitude. It is the same nuclides that dominate the dose for both cases.

The main difference between an intact and a degraded barrier in BMA is that the release rate of inorganic ^{14}C increases up to a factor 20 with the higher water flow rate, and that ^{239}Pu and ^{240}Pu become two of the dose dominating nuclides from 8000 AD and onwards. For an intact BMA organic ^{14}C dominates the dose until 8000 AD (see Figure 5-14). However, when BMA has degraded after 1000 years organic and inorganic ^{14}C give about equal contributions to the maximum total dose at 5000 AD (see Figure 5-20). From that point, the dose from organic ^{14}C decreases why inorganic ^{14}C becomes the dose dominating nuclide between 5500 AD and 8000 AD. The maximum total dose for a degraded BMA is $1{\cdot}10^{-6}$ Sv/yr which is a factor two higher than for an intact barrier in BMA.

Based on results from the hydrogeology modelling (Holmén and Stigsson, 2001a) it is estimated that the total dose for 1BTF and 2BTF should not increase with more than a factor two in comparison to the main case.

The total release from vaults and Silo will give a maximum total dose for the reasonable biosphere of $1{\cdot}10^{-5}$ Sv/yr. For the alternative recipients the maximum total dose will be $1{\cdot}10^{-8}$ Sv/yr (today's biosphere) and $< 2{\cdot}10^{-5}$ Sv/yr (mire area), respectively. Release to a well from all vaults will give a maximum total dose of no more than $5{\cdot}10^{-4}$ Sv/yr or from the Silo $2{\cdot}10^{-4}$ Sv/yr.

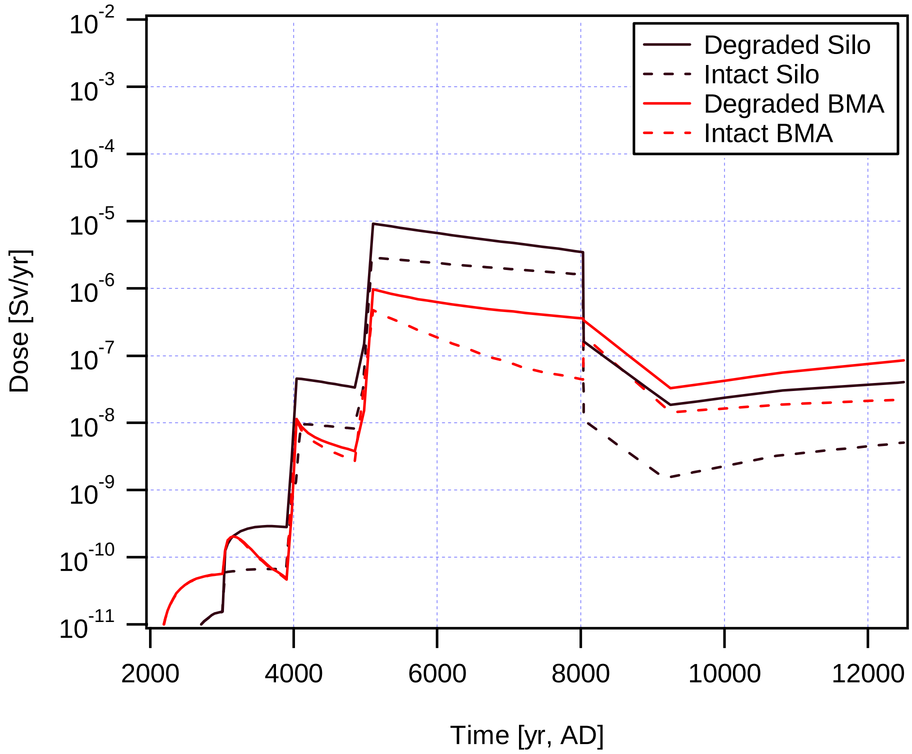

***Figure 7-4.** Comparison of total dose for a reasonable biosphere from release of radionuclides in Silo and BMA when the repository is a) intact and b) degraded.*

7.2 Initially degraded barriers

A calculation made for an initial fracture through the concrete encapsulation in room 12 of BMA shows that slightly higher near-field release rates can be obtained during the first 1000 years after repository closure compared to the release rates obtained when the fracture arises 1000 years after closure. The release rates for the two cases are almost the same after 1000 years. Thus, it is estimated that the maximum total dose will be the same regardless of if there is an initial fracture or if it arises after 1000 years. This will also be the case for a fracture through 1BTF or 2BTF. An initial fracture in the concrete bottom of the Silo is not foreseen to affect release rates from the Silo as long as the bentonite barriers are intact.

7.3 Chemicals

This scenario analyses the effect of a reduced possibility for nuclides to sorb on the barriers. The most important effect of chemicals is a significant increase in near-field release rate of ^{59}Ni, ^{99}Tc, ^{239}Pu and ^{240}Pu. ^{59}Ni and ^{99}Tc give a significant contribution to the dose for release to the reasonable biosphere (especially when the recipient is agricultural land), mire area and well. The maximum dose for the reasonable biosphere development is obtained at 5000 AD, dominated by organic ^{14}C from the Silo. At 8000 AD the dose is dominated by ^{99}Tc from BMA at almost the same level as the maximum dose. Release to a well is dominated by the release from BMA. The maximum total dose is $4 \cdot 10^{-4}$ Sv/yr dominated by ^{99}Tc, ^{239}Pu and ^{240}Pu. Dose obtained in mire area by release from a repository uninfluenced by chemicals is entirely dominated by ^{79}Se. The same nuclide dominate the dose in mire area also for the scenario "Chemicals" but several other nuclides (e.g. ^{59}Ni, ^{99}Tc, ^{239}Pu and ^{240}Pu) add to the total dose. Today's biosphere is to a large extent unaffected by chemicals. Since sorption is not accounted for in BLA in any of the studied cases, no analysis of the effect of chemicals in BLA has been made. The same result is therefore used for BLA when estimating the total dose for SFR 1 with and without the effect of chemicals.

There is an increase in total dose for the reasonable biosphere from 8000 AD and onwards and for the wells, which mainly is caused by the higher release rate of ^{99}Tc. The dominating pathway for exposure from this nuclide is in both recipients the consumption of vegetables. Unfortunately, a too high translocation factor was used in the biosphere modelling of ^{99}Tc by mistake. This is only of importance when the well is used as recipient and the calculated doses are estimated to be about 20 % too high.

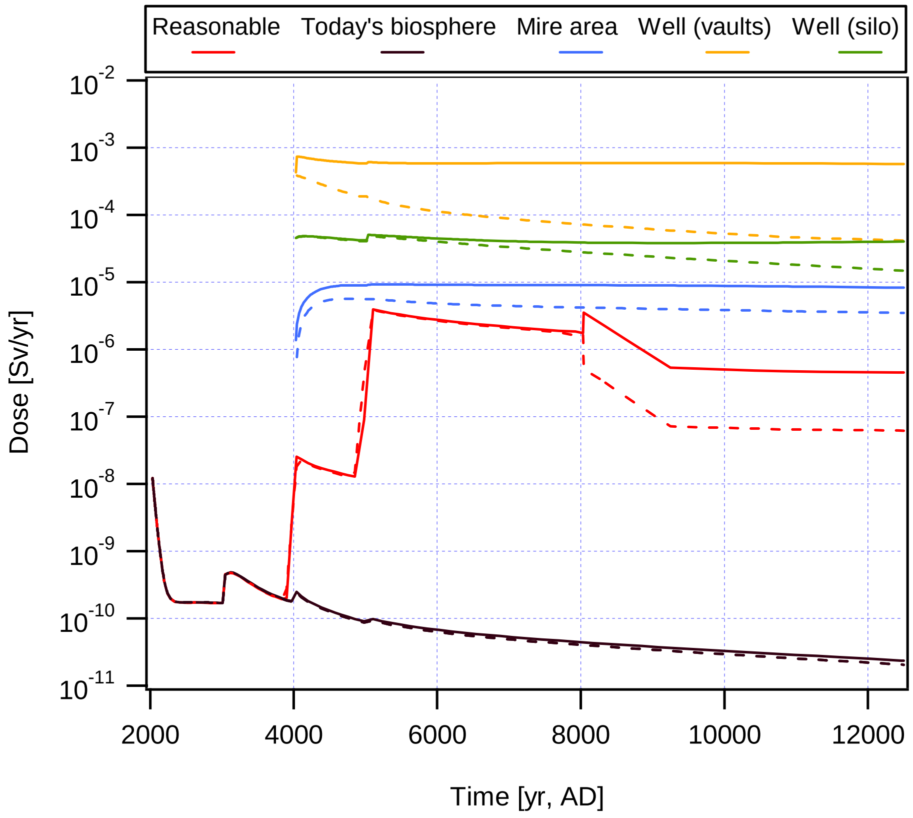

Figure 7-5. *Comparison of total doses for different biospheres from release of radionuclides from an intact SFR 1 a) with (solid line) and b) without (dashed line) the effect of chemicals.*

The combined effect of chemicals and degraded barriers after 1000 years in Silo and BMA gives a maximum dose for the reasonable biosphere of $9 \cdot 10^{-6}$ Sv/yr and $4 \cdot 10^{-6}$ Sv/yr, respectively. The corresponding dose for release to a mire area is $7 \cdot 10^{-6}$ Sv/yr (Silo) and $1 \cdot 10^{-5}$ Sv/yr (BMA), and for release to a well $3 \cdot 10^{-4}$ Sv/yr (Silo) and $9 \cdot 10^{-4}$ Sv/yr (BMA).

7.4 Far field

Transport through the far field (geosphere) delays the release of radionuclides to the biosphere. How effective the far field rock is as a barrier varies from nuclide to nuclide, but is also dependent on the effectiveness of the barriers in the near field. The influence of the far field on the release rate of the majority of the dose dominating nuclides is in general small. The far field has the largest effect on the release of short-lived nuclides like ^{3}H, ^{63}Ni, ^{90}Sr, ^{108m}Ag and ^{137}Cs. However, these nuclides have a limited influence on the maximum total dose for the different repository parts, with the exception of BLA.

The far field has a larger effect on the release of radionuclides from BLA to the biosphere than for the other repository parts. This is due to the limited technical barrier system in BLA. The far field delays the release, which for the cases with unchanged biosphere with time implies a lower dose. However, for the reasonable biosphere development the delay implies that the dose obtained for some nuclides is higher when the far filed is included.

7.5 Permafrost

The analysis of the permafrost scenario gives a total dose that is less than 10^{-9} Sv/yr assuming a recipient corresponding to today’s biosphere. This dose is a factor ten lower than the maximum total dose for release to today’s biosphere within the base scenario.

7.6 Human intrusion

The human intrusion scenario is represented by a case in which a well is sunk directly into one of the vaults or the Silo. It is assumed that someone drinks the water that is pumped out from the gravel backfill in each repository part. No dilution effects have been accounted for. The resulting doses are $1 \cdot 10^{-2}$ Sv/yr (Silo), $5 \cdot 10^{-3}$ Sv/yr (BMA), $9 \cdot 10^{-3}$ Sv/yr (1BTF), $1 \cdot 10^{-3}$ Sv/yr (2BTF) and $3 \cdot 10^{-2}$ Sv/yr (BLA).

7.7 Summary of doses

The maximum doses obtained for the different cases studied are compiled in Table 7-1.

Table 7-1. Maximum dose for the investigated cases.

	Maximum total dose [Sv/yr]						
Case	**Silo**	**BMA**	**1BTF**	**2BTF**	**BLA**	**Total**	**Biosphere**
Base scenario							
Intact barriers	$3\cdot10^{-6}$	$5\cdot10^{-7}$	$4\cdot10^{-7}$	$9\cdot10^{-8}$	$2\cdot10^{-7}$	$4\cdot10^{-6}$	Reasonable biosphere development
	$2\cdot10^{-7}$	$3\cdot10^{-6}$	$5\cdot10^{-7}$	$7\cdot10^{-7}$	$3\cdot10^{-6}$	$6\cdot10^{-6}$	Mire area > 4000 AD
	$5\cdot10^{-5}$	$6\cdot10^{-5}$	$7\cdot10^{-5}$	$1\cdot10^{-5}$	$2\cdot10^{-4}$	$4\cdot10^{-4}$ a)	Well >4000 AD
	$7\cdot10^{-11}$	$2\cdot10^{-10}$	$3\cdot10^{-10}$	$3\cdot10^{-11}$	$1\cdot10^{-8}$	$1\cdot10^{-8}$	Today's biosphere
Degraded barriers	$9\cdot10^{-6}$	$1\cdot10^{-6}$	$\leq 8\cdot10^{-7}$ b)	$\leq 2\cdot10^{-7}$ b)	$2\cdot10^{-7}$ c)	$1\cdot10^{-5}$	Reasonable biosphere development
	$5\cdot10^{-6}$	$3\cdot10^{-6}$	$\leq 1\cdot10^{-6}$ b)	$\leq 1\cdot10^{-6}$ b)	$3\cdot10^{-6}$ c)	$\leq 2\cdot10^{-5}$ b)	Mire area > 4000 AD
	$2\cdot10^{-4}$	$7\cdot10^{-5}$	$\leq 1\cdot10^{-4}$ b)	$\leq 2\cdot10^{-5}$ b)	$2\cdot10^{-4}$ c)	$\leq 5\cdot10^{-4}$ a,b)	Well >4000 AD
	$3\cdot10^{-10}$	$2\cdot10^{-10}$	$\leq 10^{-9}$ b)	$\leq 6\cdot10^{-11}$ b)	$1\cdot10^{-8}$ c)	$1\cdot10^{-8}$	Today's biosphere
Other scenarios							
Initially degraded barriers	$9\cdot10^{-6}$	$1\cdot10^{-6}$	$\leq 8\cdot10^{-7}$ b)	$\leq 2\cdot10^{-7}$ b)	$2\cdot10^{-7}$ c)	$1\cdot10^{-5}$	Reasonable biosphere development
	$5\cdot10^{-6}$	$3\cdot10^{-6}$	$\leq 1\cdot10^{-6}$ b)	$\leq 1\cdot10^{-6}$ b)	$3\cdot10^{-6}$ c)	$\leq 2\cdot10^{-5}$ b)	Mire area > 4000 AD
	$2\cdot10^{-4}$	$7\cdot10^{-5}$	$\leq 1\cdot10^{-4}$ b)	$\leq 2\cdot10^{-5}$ b)	$2\cdot10^{-4}$ c)	$\leq 5\cdot10^{-4}$ a,b)	Well >4000 AD
	$3\cdot10^{-10}$	$2\cdot10^{-10}$	$\leq 10^{-9}$ b)	$\leq 6\cdot10^{-11}$ b)	$1\cdot10^{-8}$ c)	$1\cdot10^{-8}$	Today's biosphere
Chemicals – intact barriers	$3\cdot10^{-6}$	$2\cdot10^{-6}$	$4\cdot10^{-7}$	$4\cdot10^{-7}$	$2\cdot10^{-7}$ c)	$4\cdot10^{-6}$	Reasonable biosphere development
	$4\cdot10^{-7}$	$6\cdot10^{-6}$	$1\cdot10^{-6}$	$1\cdot10^{-6}$	$3\cdot10^{-6}$ c)	$1\cdot10^{-5}$	Mire area > 4000 AD
	$5\cdot10^{-5}$	$4\cdot10^{-4}$	$1\cdot10^{-4}$	$8\cdot10^{-5}$	$2\cdot10^{-4}$ c)	$7\cdot10^{-4}$ a)	Well >4000 AD
	$7\cdot10^{-11}$	$2\cdot10^{-10}$	$3\cdot10^{-10}$	$3\cdot10^{-11}$	$1\cdot10^{-8}$ c)	$1\cdot10^{-8}$	Today's biosphere
Chemicals – degraded barriers	$9\cdot10^{-6}$	$4\cdot10^{-6}$	$\leq 8\cdot10^{-7}$ b)	$\leq 8\cdot10^{-7}$ b)	$2\cdot10^{-7}$ c)	$1\cdot10^{-5}$	Reasonable biosphere development
	$7\cdot10^{-6}$	$1\cdot10^{-5}$	$\leq 2\cdot10^{-6}$ b)	$\leq 2\cdot10^{-6}$ b)	$3\cdot10^{-6}$ c)	$\leq 2\cdot10^{-5}$ b)	Mire area > 4000AD
	$3\cdot10^{-4}$	$9\cdot10^{-4}$	$\leq 2\cdot10^{-4}$ b)	$\leq 2\cdot10^{-4}$ b)	$2\cdot10^{-4}$ c)	$\leq 1\cdot10^{-3}$ a,b)	Well >4000 AD
Permafrost	$4\cdot10^{-10}$	$3\cdot10^{-10}$	$4\cdot10^{-10}$	$6\cdot10^{-11}$	$8\cdot10^{-11}$	10^{-9}	Today's biosphere
Intrusion – well in repository	$1\cdot10^{-2}$	$5\cdot10^{-3}$	$9\cdot10^{-3}$	$1\cdot10^{-3}$	$3\cdot10^{-2}$		Drinking well water

a) Total maximum dose for vaults

b) Estimated doses for 1BTF och 2BTF

c) Base scenario valid for this case also, since BLA has no barriers

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Appendix A: Check of screening of nuclides

The inventory for SFR comprises 59 radionuclides (Riggare and Johansson, 2001) but only 42 of these are considered to be of importance for the safety assessment (SKB, 2001). However, in order to reduce the time needed for calculation of radionuclide release and dose, the number of nuclides studied was reduced to 30. The inventory for ^{241}Pu was included in ^{241}Am, which simplifies the calculations and give a reasonable description of the release of both nuclides. This implies that calculations were performed for 29 nuclides.

Based on experience of the influence of sorption on the radionuclide release from other studies of for example SFR and SFL 3-5 totally 12 nuclides were excluded since they were expected to give a negligible contribution to the calculated total dose. The 12 nuclides that were excluded from the calculations are ^{232}U, ^{234}U, ^{235}U, ^{236}U, ^{238}U, ^{237}Np, ^{242m}Am, ^{243}Am, ^{243}Cm, ^{244}Cm, ^{245}Cm and ^{246}Cm. In this Appendix this expectation is checked.

The steps in the check are:

- Looking at the initial inventory and influence of chain decay. If, during the studied time period, significant contribution from mother(s) is achieved the whole contribution were included as initial inventory.
- Based on the sorption data reference nuclides were chosen. The calculated dose from the reference nuclide in relation to the total dose for the different calculation cases and biospheres are used to estimate whether the actual nuclide contribute to the total dose or not.
- A relative dose was calculated, i.e. the dose calculated from ingestion of the initial inventory (including the contribution from mother) for the nuclide in comparison to the reference nuclide.
- Possible difference in uptake mechanisms in the biosphere of the actual nuclide and the reference nuclide was controlled by comparison between dose conversion factors from SR 97.

The influence of chain decay is negligible for most of the 12 nuclides, since they are either mothers or daughters to long-lived mothers. This concerns ^{232}U, ^{235}U, ^{238}U, ^{242m}Am, ^{243}Am, ^{243}Cm, ^{244}Cm, ^{245}Cm and ^{246}Cm. For three nuclides the contribution from mothers must be included. For ^{234}U contribution from ^{238}Pu results in a 120 % higher initial inventory if all the decay of the mothers is included in the initial inventory. For ^{236}U the contribution from the mother is totally 60 % during all time. The contribution to ^{237}Np is 50 % for the tunnels and 400 % for the Silo.

The choice of reference nuclide is based on sorption data, see Table A-1. As can be seen in the table uranium and neptunium have sorption data equal to plutonium in concrete/cement as well as in sand/gravel. This implies that ^{240}Pu is chosen as reference for BMA, 1BTF and 2BTF. Although no sorption is accounted for in BLA, ^{240}Pu is chosen as reference also for this tunnel. The sorption in bentonite is, however, lower for uranium and neptunium than plutonium why another reference nuclide must be chosen for the Silo. In order not to overestimate the sorption capacity ^{126}Sn is chosen. Sorption data for curium is equal to americium and hence ^{241}Am is suitable as reference nuclide both for curium and americium nuclides, but since the half-life of ^{241}Am is shorter than for some of these nuclides it is only used as reference for ^{242m} Am, ^{243}Cm and ^{244}Cm. For the three remaining nuclides ^{243}Am, ^{243}Cm and ^{246}Cm the reference nuclide was chosen to be ^{93}Zr, even though the sorption is less in all barriers. The performed radionuclide release calculations show a negligible contribution from the reference nuclides ^{126}Sn, ^{241}Am and ^{93}Zr on the total dose rate for all repository parts and biospheres. The reference nuclide ^{240}Pu contributes to the total dose rate for BLA when the recipient is a well, but not for any of the other repository parts or biospheres studied.

The calculated relative dose, i.e. the dose calculated from dose conversion factors for ingestion (Table A-1 (EU, 1996)) and the initial inventory (including the contribution from mother) for the nuclide in comparison to the reference nuclide, are shown in Table A-2. As can be seen in the table ^{234}U, ^{236}U, ^{238}U and ^{237}Np in the Silo exceed the dose from the reference nuclide. However, the choice of ^{126}Sn as reference nuclide implies that the sorption in the barriers is underestimated. The dose from ^{126}Sn from the Silo is small in comparison to the total dose and hence also the nuclides compared to ^{126}Sn have negligible influence on the total dose. For BLA the nuclides compared to ^{240}Pu show several orders of magnitude lower relative dose and hence even if ^{240}Pu contribute to the total dose in a well these nuclides will not. The relative dose for ^{243}Am and ^{245}Cm indicate a higher dose than the dose from the reference nuclide ^{93}Zr. Again, the reference nuclide sorbs less in all barriers and in the performed radionuclide release calculations for ^{93}Zr the dose only exceeds 1/10 000 in the cases with influence of chemicals and for BMA with degraded barriers. The influence of chemicals is however less for americium and curium than for zirconium. This implies that ^{243}Am may contribute to some extent to the total dose and therefore a radionuclide release calculation for BMA for the case with chemicals and degraded barriers was performed. No biosphere calculations were performed, but comparison to ^{239}Pu and ^{93}Zr shows that it may be possible that the dose from ^{243}Am is only one order of magnitude less than the total dose and hence would contribute marginally to the total dose.

The dose conversion factors used in SR97 (Nordlinder et al, 1999) for different ecosystems, coast, open coast, agricultural soil, peat and small peat was used to check that the uptake mechanisms in the biosphere for the reference nuclide and actual nuclide are similar. This comparison showed that the change in dose conversion factor compared to the reference nuclide is within a factor of thirty for all nuclides and ecosystems. The consequence of an increase of a factor 30 if one of the 12 nuclides is released to an ecosystem that implies higher relative dose than for the reference nuclide will not lead to a dose that contribute to the total dose, except maybe for ^{243}Am. This implies that the exclusion of these 12 nuclides does not influence the total dose, except for ^{243}Am that maybe would contribute marginally to the dose in some case for BMA.

Table A-1. Dose conversion factors (Sv/Bq) and distribution coefficients (m^3/kg)

Nuclide	Half life (yr)	Dose conversion factor, ingestion (Sv/Bq)	Distribution coefficients (m^3/kg)			
			Concrete/ Cement	Sand/ gravel	Bentonite	bentonite/ sand 10/90
Zr-93	$1.53{\cdot}10^6$	$1.10{\cdot}10^{-9}$	0.5	0.5	0.05	0.5
Sn-126	$1.00{\cdot}10^5$	$4.70{\cdot}10^{-9}$	0.5	0	0.01	0.001
Pu-240	$6.56{\cdot}10^3$	$2.50{\cdot}10^{-7}$	5	1	1	1
Am-241	$4.32{\cdot}10^2$	$2.00{\cdot}10^{-7}$	1	1	1	1
U-232	$6.89{\cdot}10^1$	$3.30{\cdot}10^{-7}$	5	1	0.01	0.9
U-234	$2.46{\cdot}10^5$	$4.90{\cdot}10^{-8}$	5	1	0.01	0.9
U-235	$7.04{\cdot}10^8$	$4.70{\cdot}10^{-8}$	5	1	0.01	0.9
U-236	$2.34{\cdot}10^7$	$4.70{\cdot}10^{-8}$	5	1	0.01	0.9
U-238	$4.47{\cdot}10^9$	$4.50{\cdot}10^{-8}$	5	1	0.01	0.9
Np-237	$2.14{\cdot}10^6$	$1.10{\cdot}10^{-7}$	5	1	0.1	0.9
Am-242m	$1.41{\cdot}10^2$	$1.90{\cdot}10^{-7}$	1	1	1	1
Am-243	$7.37{\cdot}10^3$	$2.00{\cdot}10^{-7}$	1	1	1	1
Cm-243	$2.91{\cdot}10^1$	$1.50{\cdot}10^{-7}$	1	1	1	1
Cm-244	$1.81{\cdot}10^1$	$1.20{\cdot}10^{-7}$	1	1	1	1
Cm-245	$8.50{\cdot}10^3$	$2.10{\cdot}10^{-7}$	1	1	1	1
Cm-246	$4.73{\cdot}10^3$	$2.10{\cdot}10^{-7}$	1	1	1	1

Table A-2. Calculated relative doses for all repository parts.

Nuclide	Reference nuclide	Relative dose compared to "reference" nuclide				
		Silo	BMA	BTF1	BTF2	BLA
U-232	Tunnels: Pu-240 Silo: Sn-126	0.6	0.00005	0.00004	0.00005	0.00005
U-234	Tunnels: Pu-240 Silo: Sn-126	8	0.0006	0.0006	0.0006	0.0006
U-235	Tunnels: Pu-240 Silo: Sn-126	0.07	0.00001	0.00001	0.00001	0.00001
U-236	Tunnels Pu-240 Silo: Sn-126	2	0.0001	0.0001	0.0001	0.0001
U-238	Tunnels: Pu-240 Silo: Sn-126	1.3	0.0001	0.0001	0.0001	0.0001
Np-237	Tunnels: Pu-240 Silo: Sn-126	16	0.0004	0.0004	0.0004	0.0004
Am-242m	Am-241	0.001	0.009	0.009	0.009	0.009
Am-243	Zr-93	216	113	111	49	354
Cm-243	Am-241	0.001	0.009	0.008	0.009	0.009
Cm-244	Am-241	0.1	0.8	0.7	0.7	0.8
Cm-245	Zr-93	2	1.2	1.2	0.5	4
Cm-246	Zr-93	0.6	0.3	0.3	0.1	1.0

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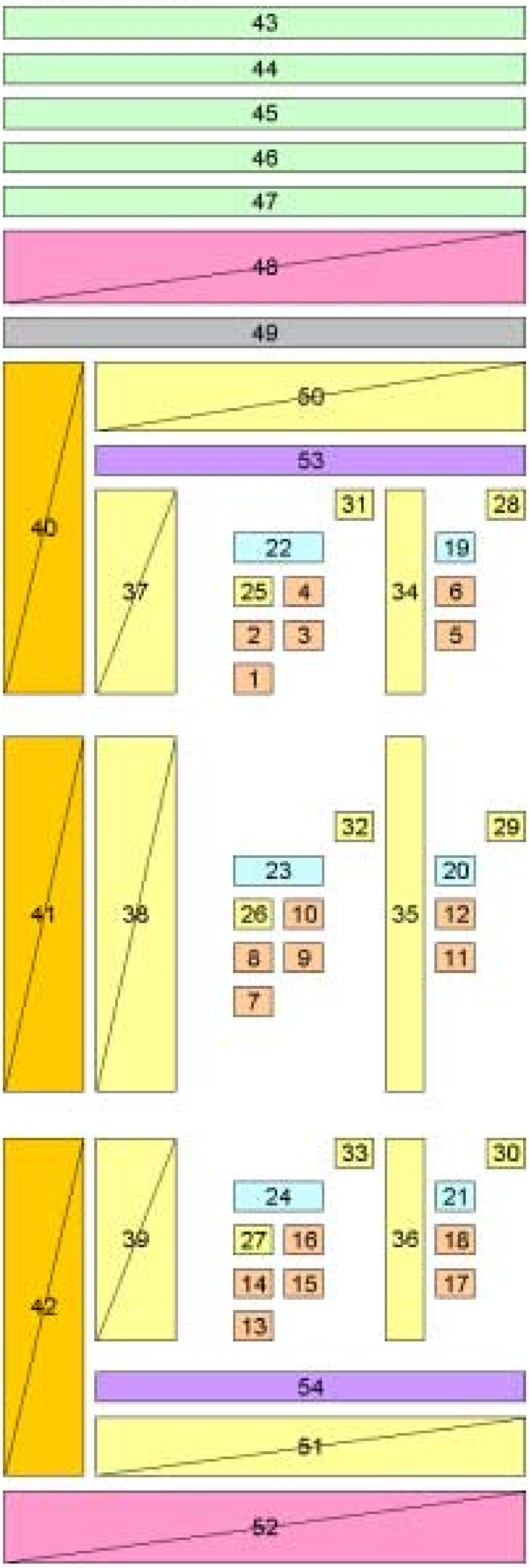
Appendix B: Discretization in near field models

Schematic figures of the discretizations used for the near field models used for the different repository parts.

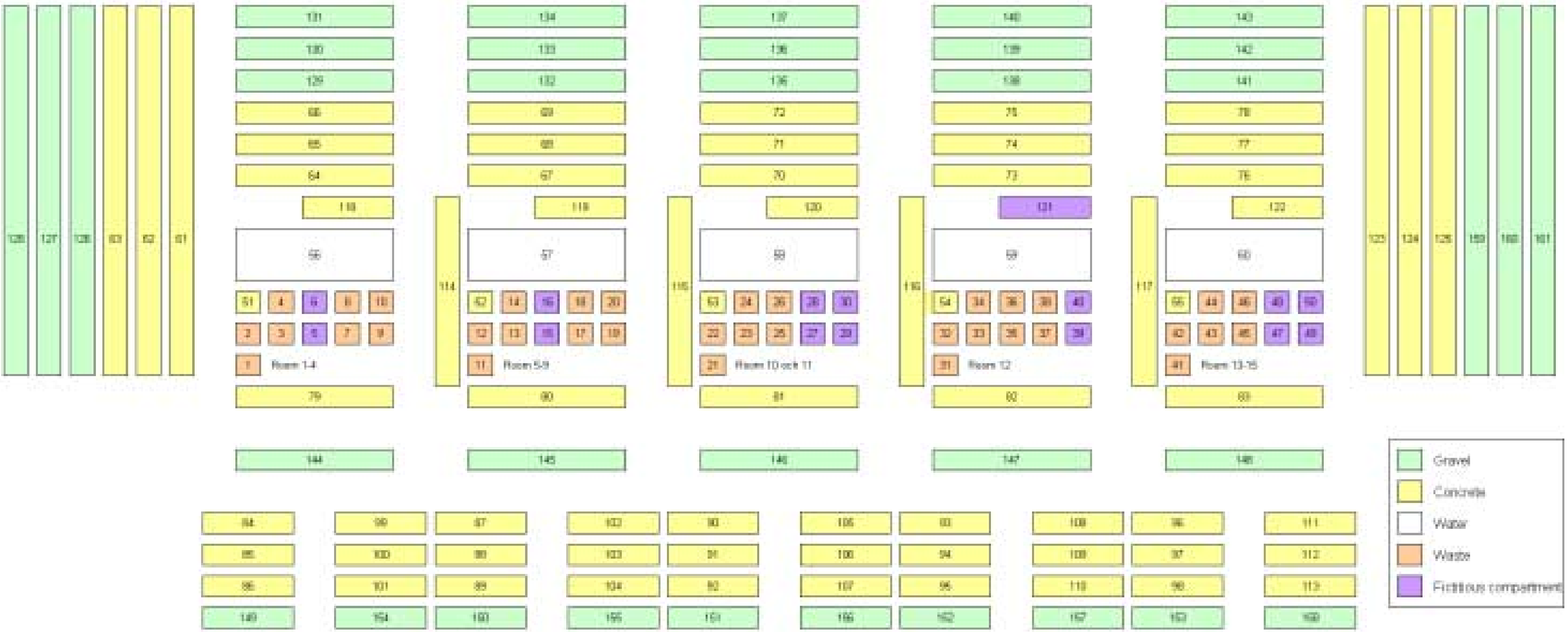
Modell of the SILO



🟩	Gravel
🟪	Fictitious compartment
🟥	Sand/Bentonite 90/10
⬛	Sand
🟨	Concrete
🟫	Waste
🟧	Bentonite
🟦	Porous concrete
◩	Divided into five compartments

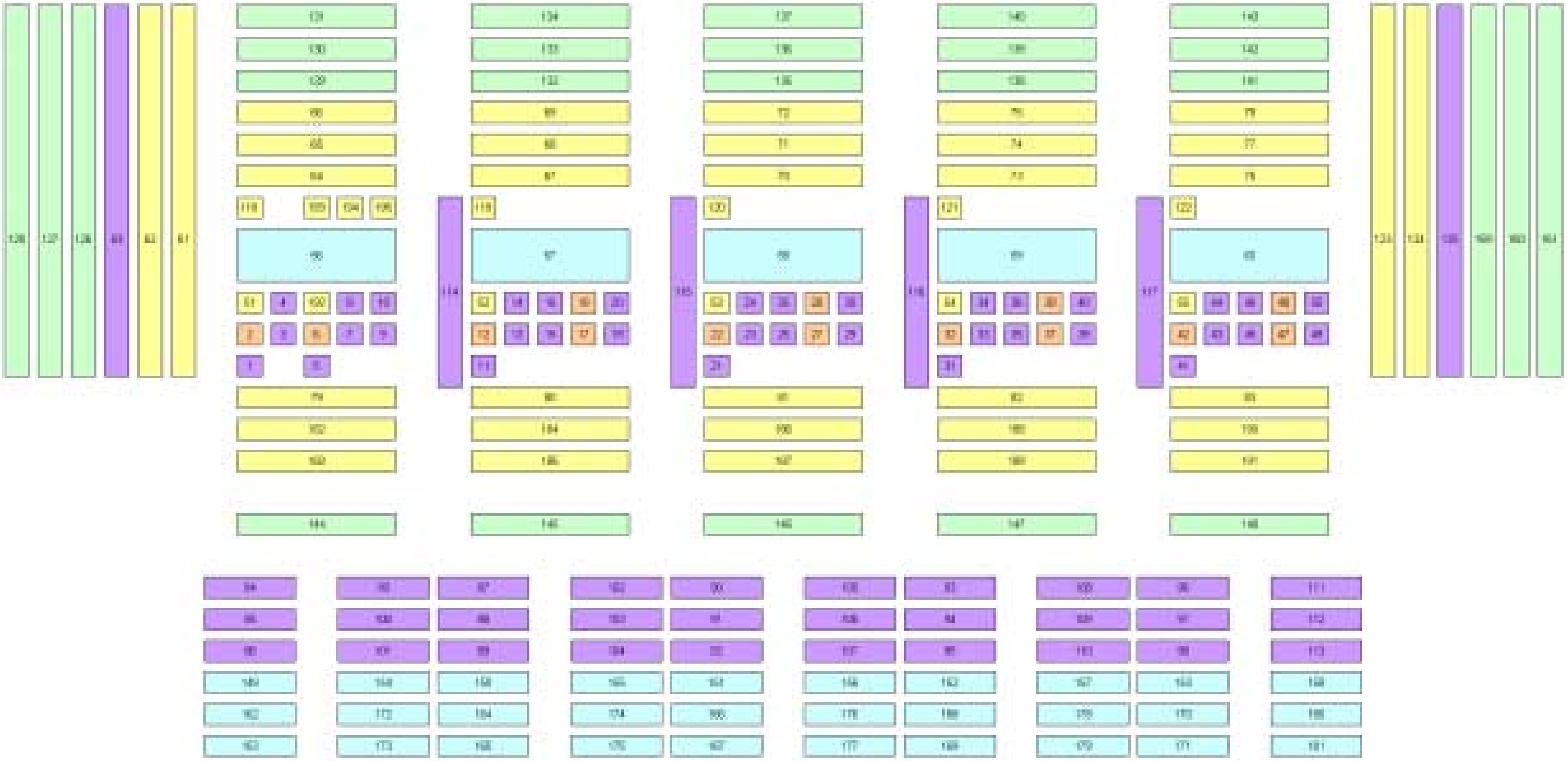
1-4, 7-10, 13-16	Waste stabilised with cement
5-6, 11-12, 17-18	Wate stabilised with bitumen
19-24	Porous concrete surrounding waste packages
25-27	Walls of concrete moulds
28-33	Shaft walls (used as sinks)
34-36	Shaft walls between parts with waste stabilised with bitumen and concrete respectively
37-39	Concrete walls of the silo
40-42	Bentonit between the concrte silo and rock
43-47	Gravel at the top
48	Sand/Bentonite at the top
49	Sand at the top
50	Concrete lid
51	Concrete bottom
52	Sand/Bentonite bottom
53-54	Fictitious compartments

Modell of BMA



1-2, 11-12, 21-22, 31-32, 41-42	Waste stabilised with cement in concrete moulds
3-4, 13-14, 23-24, 33-34, 43-44	Waste stabilised with cement in steel containers
25-26, 35-36, 45-46	Waste stabilised with cement in steel drums
7-8, 17-18, 37-38	Waste stabilised with bitumen in steel containers
9-10, 19-20	Waste stabilised with bitumen in steel drums
5-6, 15-16, 27-30, 39-40, 47-50	Fictitious source terms
51-55	Walls of concrete moulds
56-60	Water inside encapsulation
61-63	Wall at short side of the structure (passage)
64-78	Ceiling of the structure
79-83	Bottom of the structure
84-98	Wall on left side of the structure
99-113	Wall on right side of the structure
114	Inner wall between room 4 and 5
115	Inner wall between room 9 and 10
116	Inner wall between room 11 and 12
117	Inner wall between room 12 and 13
118	Inner wall between room 1 and 2, 2 and 3, 3 and 4 (sink)
119	Inner wall between room 5 and 6, 6 and 7, 7 and 8, 8 and 9 (sink)
120	Inner wall between room 10 and 11 (sink)
121	Fictitous compartment (No inner wall, only one room)
122	Inner wall between room 13 and 14/15 and between room 14 and 15 (sin
123-125	Wall at short side of the structure (loading zone)
126-128	Gravel at the end of the tunnel (passage)
129-143	Gravel at the top of the tunnel
144-148	Gravel at the bottom of the tunnel
149-153	Lateral gravel on the left side of the tunnel
154-158	Lateral gravel on the right side of the tunnel
159-161	Gravel at the end of the tunnel (loading zone)

Modell of 1BTF



2, 12, 22, 32, 42	Waste stabilised in cement in concrete tanks	64-78	Ceiling	149-153, 162-17	Porous concrete on left side
6	Waste in steel drums	79-83, 182-191	Bottom	154-158, 172-18	Porous concrete on right side
17, 18, 27-28, 37-38, 47-48	Waste in steel boxes (Bergöfslådor)	123-124	Wall at short side of the structure (loading zone)	159-161	Gravel at the end of the tunnel (loading zone)
51-55, 118-122	Walls of concrete tanks	126-128	Gravel at the end of the tunnel (passage)	192, 193	Cement between inner and outer drums
56-60	Porous concrete surrounding waste packages	129-143	Gravel at the top of the tunnel	194-195	Concrete moulds
61-62	Wall at short side of the structure (passage)	144-148	Gravel at the bottom of the tunnel		

- 🟩 Gravel
- 🟨 Concrete
- 🟦 Porous concrete
- 🟧 Waste
- 🟪 Fictitious compartment

Modell of 2BTF

2, 12, 22, 32, 42	Waste
51-55, 118-122	Walls of concrete containers
56-60	Porous concrete surrounding the waste
61-62	Concrete wall
64-78	Ceiling
79-83, 102	Bottom plate
123-124	Concrete wall
125-128	Gravel at the end of the tunnel (loadingzone)
129-143	Gravel at the top of the tunnel
144-148	Gravel at the bottom of the tunnel
149-153, 163-17	Porous concrete on left side
154-158, 172-18	Porous concrete on right side
159-161	Gravel at the end of the tunnel (loading zone)

Modell of BLA

1-5 Source term

6-7 Gravel at the end of the tunnel

Appendix C: Examples of input files for near-field calculations

Examples of input files for the organic ^{14}C in the main case in the base scenario for all repository parts

```
#  SILO CALCULATIONS
#  Problem Codification: BS2
#  Nuclide(s): C-14 org
#
#  Problem Description:
# PROPER VERSION INPUT DATA FORMAT
#
#  ITYPE    NGROUP    NSINKS    IWFLOW    NSOURC    NBSIZE    ISPSOL
   1        1         3         1         18        0         0
#
#  Flow stream conditions
#  NINFLW    NUTFLW                       % if IWFLOW = 1
   10        1
#
#  Inflow conditions (one line per inflow)
#  QINFW    NBWIN    NBNWIN               % if IWFLOW = 1
   0.00005         5                 1
   0.00015        11                 1
   0.00005        17                 1
   0.044          43                 1
   0.044          44                 1
   0.044          45                 1
   0.044          46                 1
   0.044          47                 1
   0.038          49                 1
   0.23           52                 1
#
#  Outflow conditions (one line per inflow)
#  QUTFW    NBWOUT    NBNWOUT             % if IWFLOW = 1
   0.48825  43        1
#
# Number of blocks connections and materials
#  NBLOCK    NBCOUP    NMAT
   54        66         10
#
#  Data on materials (one line per material)
#  Material 1 = Waste (Concrete moulds with cement)
#  Material 2 = Waste (Steel with cement)
#  Material 3 = Waste (Bitumen)
#  Material 4 = Porous concrete
#  Material 5 = Construction concrete (moulds silo internal)
#  Material 6 = Bentonite (outside silo walls)
#  Material 7 = Gravel
#  Material 8 = Sand/bentonite (bottom and top)
#  Material 9 = Sand (top)
#  Material 10 =Water
#  MAT        DENSM        PORM
   1          2250.0       0.295
   2          2250.0       0.173
   3          1030.0       0.119
   4          2428.6       0.300
   5          2529.4       0.150
   6          2692.3       0.610
   7          2700.0       0.300
   8          2666.7       0.250
   9          2700.0       0.300
   10         1000.0       1.000
#  Data on time series
#  TINIT     AGEO       RAT      TEND      NTERM      LREAD
   0.00      0.50       1.23     1000.00   90         0
#
#  Data on numerical parameters
#  EPS      EWT      NLOOP      MSPAR
```

```
   1.00E-06 1.00E-18 3          1
#
#  Data on group (one set of data per group common for all sources)
#
# Group No: 1
#  NNCH    ISPEC    ISPSOL
   1       1        0
#
# Nuclide: C-14 org
#  TAU        CSOLUB      AINV
   5.7300E+03 1.17E+01    7.6054E-01
#
#  CIRF                               % if ISPEC = 1
#
#  MAT       DEFM       SKDM          % one line per material
   1         0.00315    0.000
   2         0.00315    0.000
   3         0.06307    0.000
   4         0.00315    0.000
   5         0.00032    0.000
   6         0.00315    0.000
   7         0.01892    0.000
   8         0.00315    0.000
   9         0.01892    0.000
   10        0.06307    0.000
#
#  Data on sources
#  NSBCHA  ISEQ  MAT  IFWATB  VOLSOU  FINVEN  JINVEN
#
#  IBLOCK    ISSEQ          % if ISEQ = 1
#
#  XXX                      % if JINVEN = 1. One line for each group.
#
#  IBSOUR                   % if ISEQ = 0
#
#  IWINT                    % if IFWATB = 1
#
#  WBFLOW                   % if IFWATB = 1 and IWINT = 0
#
#  Waste
#  Source    1
  1  0  1  1  702.2400  1.0000000E+00  1
#
  4.6663405E-02
  1
  0
  1.868278E-01
#  Source    2
  1  0  1  1  175.5600  1.0000000E+00  1
#
  1.1665851E-02
  2
  0
  1.868278E-01
#  Source    3
  1  0  2  1  1053.5504  1.0000000E+00  1
#
  5.1720429E-02
  3
  0
  1.868278E-01
#  Source    4
  1  0  2  1  263.3876  1.0000000E+00  1
#
```

```
 1.2930107E-02
 4
 0
 1.868278E-01
#  Source    5
 1  0  3  1  0.0001  1.0000000E+00  1
#
 7.7020207E-02
 5
 0
 5.000000E-05
#  Source    6
 1  0  3  1  617.0864  1.0000000E+00  1
#
 0.0000000E+00
 6
 0
 5.000000E-05
#  Source    7
 1  0  1  1  2106.7200  1.0000000E+00  1
#
 1.3999022E-01
 7
 0
 1.868278E-01
#  Source    8
 1  0  1  1  526.6800  1.0000000E+00  1
#
 3.4997554E-02
 8
 0
 1.868278E-01
#  Source    9
 1  0  2  1  3160.6512  1.0000000E+00  1
#
 1.5516129E-01
 9
 0
 1.868278E-01
#  Source    10
 1  0  2  1  790.1628  1.0000000E+00  1
#
 3.8790322E-02
 10
 0
 1.868278E-01
#  Source    11
 1  0  3  1  0.0002  1.0000000E+00  1
#
 2.3106062E-01
 11
 0
 1.500000E-04
#  Source    12
 1  0  3  1  1851.2592  1.0000000E+00  1
#
 0.0000000E+00
 12
 0
 1.500000E-04
#  Source    13
 1  0  1  1  702.2400  1.0000000E+00  1
#
 4.6663405E-02
```

```
 13
 0
 1.868278E-01
#  Source    14
 1  0  1  1  175.5600  1.0000000E+00  1
#
 1.1665851E-02
 14
 0
 1.868278E-01
#  Source    15
 1  0  2  1  1053.5504  1.0000000E+00  1
#
 5.1720429E-02
 15
 0
 1.868278E-01
#  Source    16
 1  0  2  1  263.3876  1.0000000E+00  1
#
 1.2930107E-02
 16
 0
 1.868278E-01
#  Source    17
 1  0  3  1  0.0001  1.0000000E+00  1
#
 7.7020207E-02
 17
 0
 5.000000E-05
#  Source    18
 1  0  3  1  617.0864  1.0000000E+00  1
#
 0.0000000E+00
 18
 0
 5.000000E-05
#
#  Description of blocks not considered before
#
#  Block i
#  NZ   NY    NX    NBLSP    MAT    IQFLOW
#  ZADIM  YADIM  XADIM  VOLBLK % one line per compartment if NBLSP = 1
#  IWINT                       % if IQFLOW = 1
#  NODWIN   NODWUT    BFLOW    % if IQFLOW = 1 and IWINT = 0
#
#  Porous concrete in 'inner cylinder' (bitumenised waste)
#  Block   19
 1  1  1  0  4  1
 3.8819E-04     9.6177E-05      3.0461E-05      1.9049E+02
 1
#  Block   20
 1  1  1  0  4  1
 1.2940E-04     3.2059E-05      1.0154E-05      5.7146E+02
 1
#  Block   21
 1  1  1  0  4  1
 3.8819E-04     9.6177E-05      3.0461E-05      1.9049E+02
 1
#  Porous concrete in 'outer cylinder' (cement conditioned waste)
#  Block   22
 1  1  1  0  4  1
 5.4227E-04     3.0888E-05      2.8910E-05      8.2432E+02
```

```
  1
#  Block   23
  1  1  1  0  4  1
  5.5153E-04     1.8076E-04      9.6366E-06      2.4730E+03
  1
#  Block   24
  1  1  1  0  4  1
  5.4227E-04     3.0888E-05      2.8910E-05      8.2432E+02
  1
# Walls of concrete moulds
#  Block   25
  1  1  1  0  5  0
  1.0000E+05     6.8051E-06      1.5563E-05      6.3904E+02
#  Block   26
  1  1  1  0  5  0
  1.0000E+05     2.2684E-06      5.1877E-06      1.9171E+03
#  Block   27
  1  1  1  0  5  0
  1.0000E+05     6.8051E-06      1.5563E-05      6.3904E+02
# Internal walls in 'inner cylinder' (bitumenised waste)
#  Block   28
  1  1  1  0  5  0
  1.0000E+05     1.0000E+05      6.7693E-05      1.4773E+02
#  Block   29
  1  1  1  0  5  0
  1.0000E+05     1.0000E+05      2.2564E-05      4.4318E+02
#  Block   30
  1  1  1  0  5  0
  1.0000E+05     1.0000E+05      6.7693E-05      1.4773E+02
# Internal walls in 'outer cylinder' (cement conditioned waste)
#  Block   31
  1  1  1  0  5  0
  1.0000E+05     1.0000E+05      1.5643E-05      6.3927E+02
#  Block   32
  1  1  1  0  5  0
  1.0000E+05     1.0000E+05      5.2143E-06      1.9178E+03
#  Block   33
  1  1  1  0  5  0
  1.0000E+05     1.0000E+05      1.5643E-05      6.3927E+02
# Walls between bitumenised waste and cement conditioned
# waste ('inner cylinder' and 'outer cylinder') (34-36)
#  Block   34
  1  1  1  0  5  0
  1.0000E+05     5.4645E-04      5.4645E-04      7.3200E+01
#  Block   35
  1  1  1  0  5  0
  1.0000E+05     1.8215E-04      1.8215E-04      2.1960E+02
#  Block   36
  1  1  1  0  5  0
  1.0000E+05     5.4645E-04      5.4645E-04      7.3200E+01
# Concrete silo walls (37-39)
#  Block   37
  1  5  1  0  5  0
  1.0000E+05     9.2957E-04      1.0000E+05      6.8849E+02
#  Block   38
  1  5  1  0  5  0
  1.0000E+05     3.0986E-04      1.0000E+05      2.0655E+03
#  Block   39
  1  5  1  0  5  0
  1.0000E+05     9.2957E-04      1.0000E+05      6.8849E+02
# Bentonite silo walls (40-42)
#  Block   40
  1  5  1  0  6  0
  1.0000E+05     1.2485E-03      1.0000E+05      1.2183E+03
```

```
#  Block   41
  1  5  1  0  6  0
  1.0000E+05     4.1617E-04      1.0000E+05      3.3303E+03
#  Block   42
  1  5  1  0  6  0
  1.0000E+05     1.2485E-03      1.0000E+05      1.2183E+03
# Gravel at the top (43-47)
#  Block   43
  1  1  1  0  7  1
  2.1342E-03     1.0000E+05      1.0000E+05      1.2158E+03
  1
#  Block   44
  1  1  1  0  7  1
  2.1342E-03     1.0000E+05      1.0000E+05      1.2158E+03
  1
#  Block   45
  1  1  1  0  7  1
  2.1342E-03     1.0000E+05      1.0000E+05      1.2158E+03
  1
#  Block   46
  1  1  1  0  7  1
  2.1342E-03     1.0000E+05      1.0000E+05      1.2158E+03
  1
#  Block   47
  1  1  1  0  7  1
  2.1342E-03     1.0000E+05      1.0000E+05      1.2158E+03
  1
# Sand/Bentonite at top (48)
#  Block   48
  5  1  1  0  8  1
  1.9874E-03     1.0000E+05      1.0000E+05      1.1322E+03
  0
  5              1            0.268
# Sand at top (49)
#  Block   49
  1  1  1  0  9  1
  1.3249E-04     9.2424E-04      1.6836E-04      7.5477E+01
  1
# Concrete silo top (50)
#  Block   50
  5  1  1  0  5  1
  1.6836E-03     1.0000E+05      1.0000E+05      5.9396E+02
  0
  5              1            0.23
# Concrete silo bottom (51)
#  Block   51
  5  1  1  0  5  1
  1.6836E-03     1.0000E+05      1.0000E+05      5.9396E+02
  0
  5              1            0.23
# Sand/Bentonite at bottom (52)
#  Block   52
  5  1  1  0  8  1
  2.5254E-03     1.0000E+05      1.0000E+05      1.0532E+03
  0
  5              1            0.23
# Fictitious blocks (53-54)
#  Block   53
  1  1  1  0  10  1
  1.0000E-05     1.0000E-05      1.0000E-05      1.0000E-02
  1
#  Block   54
  1  1  1  0  10  1
  1.0000E-05     1.0000E-05      1.0000E-05      1.0000E-02
```

```
  1
#
#  Codifying the connections
#
#  NSSCO    NSBCO    NBBCO
  9  18  39
#
#  Connection between sources
#  NABCO    ICSEQ    LSCFW    IRADD
#
#  QWATIN            % if LSCFW is not equal to 0
#
#  ISERNU            % if IRADD = 1
#
#  XRADD             % if IRADD = 1 and ISERNU = 1 one line per group
#
#  XRADD             % if IRADD = 1 and ISERNU = 0 one line per group
#
#  IBSA  IBSB  ISEQA  ISEQB   % if NABCO > 1 and ICSEQ = 1
#
#  IBSA  IBSB       % if ICSEQ = 0 NABCO*lines
#
#  WITHIN WASTE
#
#  1 Source-source 1 - 2
     1               0               1               1
     1.868278E-01
     1
     9.131667E-03
     1               2
#  2 Source-source 3 - 4
     1               0               1               1
     1.868278E-01
     1
     8.722704E-03
     3               4
#  3 Source-source 5 - 6
     1               0               1               1
     5.000000E-05
     1
     1.000000E+12
     5               6
#  4 Source-source 7 - 8
     1               0               1               1
     1.868278E-01
     1
     3.043889E-03
     7               8
#  5 Source-source 9 - 10
     1               0               1               1
     1.868278E-01
     1
     2.907568E-03
     9               10
#  6 Source-source 11 - 12
     1               0               1               1
     1.500000E-04
     1
     1.000000E+12
     11               12
#  7 Source-source 13 - 14
     1               0               1               1
     1.868278E-01
     1
```

```
     9.131667E-03
     13               14
#  8 Source-source 15 - 16
     1               0               1               1
     1.868278E-01
     1
     8.722704E-03
     15               16
#  9 Source-source 17 - 18
     1               0               1               1
     5.000000E-05
     1
     1.000000E+12
     17               18
#
#  Connection source - block
#
#  IBSOU  IBSB  ISEQC  NABCCO  IRZB  ICRB  IPLUG  IRADD
#
#  ICOMPB  ICSEQB   % if NABCCO > 1 and ISEQC =1
#
#  IDCB             % if ISEQC = 0. One value for each connection.
#
#  LSCFW  QWATIN    % if IFWATB(source term) = 1 and IQFLOW(block) = 1
#
#  ISERNU           % if IRADD =1
#
#  XRADD            % if IRADD = 1 and ISERNU = 1
#
#  XRADD            % if IRADD = 1 and ISERNU = 0. One line per group.
#
#
#  Between waste and conrete walls of concrete moulds
#  1 Source-block   2 - 25
     2  25  0  1  1  1  0  1
  1
  1
  0.00114222934111067
# Between cement waste and porous concrete
#  2 Source-block   4 - 22
     4  22  0  1  2  1  0  1
  1
  1  0.186827771355237
  1
  0.00109109676399092
#  Between bitumen waste - porous concrete
#  3 Source-block   6 - 19
     6  19  0  1  2  1  0  1
  1
  1  0.00005
  1
  6.55058132211069E-05
#  Between waste and conrete walls of concrete moulds
#  4 Source-block   8 - 26
     8  26  0  1  1  1  0  1
  1
  1
  0.00114222934111067
# Between cement waste and porous concrete
#  5 Source-block   10 - 23
     10  23  0  1  2  1  0  1
  1
  1  0.186827771355237
  1
```

```
  0.00109109676399092
#  Between bitumen waste - porous concrete
#  6 Source-block   12 - 20
     12  20  0  1  2  1  0  1
  1
  1  0.00015
  1
  6.55058132211069E-05
#  Between waste and conrete walls of concrete moulds
#  7 Source-block   14 - 27
     14  27  0  1  1  1  0  1
  1
  1
  0.00114222934111067
# Between cement waste and porous concrete
#  8 Source-block   16 - 24
     16  24  0  1  2  1  0  1
  1
  1  0.186827771355237
  1
  0.00109109676399092
#  Between bitumen waste - porous concrete
#  9 Source-block   18 - 21
     18  21  0  1  2  1  0  1
  1
  1  0.00005
  1
  6.55058132211069E-05
#  Between waste in concrete containers - porous concrete
#  10 Source-block   1 - 22
     1  22  0  1  1  0  0  1
  1
  -1  0.186827771355237
  1
  100000
#  11 Source-block   2 - 22
     2  22  0  1  1  0  0  1
  1
  1  0.186827771355237
  1
  100000
#  12 Source-block   7 - 23
     7  23  0  1  1  0  0  1
  1
  -1  0.186827771355237
  1
  100000
#  13 Source-block   8 - 23
     8  23  0  1  1  0  0  1
  1
  1  0.186827771355237
  1
  100000

#  14 Source-block   13 - 24
     13  24  0  1  1  0  0  1
  1
  -1  0.186827771355237
  1
  100000
#  15 Source-block   14 - 24
     14  24  0  1  1  0  0  1
  1
  1  0.186827771355237
```

```
  1
  100000
#  16 Source-block   3 - 22
    3  22  0  1  1  0  0  1
  1
  -1  0.186827771355237
  1
  100000
#  17 Source-block   9 - 23
    9  23  0  1  1  0  0  1
   1
  -1  0.186827771355237
  1
  100000
#  18 Source-block   15 - 24
    15  24  0  1  1  0  0  1
  1
  -1  0.186827771355237
  1
  100000
#  Connections between blocks not considered as sources
#
#  IBA  IBB  ISEQC  NABCCO  IRZA  IRZB  ICRA  ICRB  IPLUG  IRADD
#
#  IDCA    IDCB                   % if NABCCO = 1
#
#  ICOMPA  ICOMPB  ICSEQA  ICSEQB % if NABCCO > 1 and ISQC = 1
#
#  IDCA                           % if NABCCO > 1 and ISQC = 0
#
#  IDCB                           % if NABCCO > 1 and ISQC = 0
#
#  LSCFW  QWATIN                  % if IQFLOW(A) = 1 and IQFLOW(B) = 1
#
#  ISERNU                         % if IRADD = 1
#
#  XRADD             % if IRADD = 1 and ISERNU = 0. One line per group
#
# Within porous concrete in 'inner cylinder' (bitumenised waste)
#  1 Block-block   19 - 20
 19     20     0     1     2     2     0     0     0     1
    1           1
    -1        4.31722E-02
  1
  5.4240E-01
#  2 Block-block   20 - 21
 20     21     0     1     2     2     0     0     0     1
    1           1
    -1        4.31722E-02
  1
  5.4240E-01
# Between porous concrete and internal concrete walls in 'inner
cylinder' (bitumenised waste)
#  3 Block-block   19 - 28
 19     28     0     1     1     2     1     1     0     0
    1          1
#  4 Block-block   20 - 29
 20     29     0     1     1     2     1     1     0     0
    1           1
#  5 Block-block   21 - 30
 21     30     0     1     1     2     1     1     0     0
    1           1
# Between porous concrete and concrete walls between 'inner cylinder'
(bitumenised waste) and 'outer cylinder' (cement conditioned waste)
```

```
#  6 Block-block   19 - 34
 19     34     0     1     0     2     1     1     0     0
    1           1
#  7 Block-block   20 - 35
 20     35     0     1     0     2     1     1     0     0
    1           1
#  8 Block-block   21 - 36
 21     36     0     1     0     2     1     1     0     0
    1           1
# Between porous concrete and fictitious (concrete 'lid' on top of
silo)
#  9 Block-block   19 - 53
 19     53     0     1     0     0     0     0     0     1
    1           1
    1        4.31722E-02
  1
  3.5540E+00
# Between porous concrete and fictitious (concrete bottom of the silo)
#  10 Block-block   21 - 54
 21     54     0     1     0     0     0     0     0     1
    1           1
    -1        4.31722E-02
  1
  3.5540E+00
# Within porous concrete in 'outer cylinder' (cement conditioned
waste)
#  11 Block-block   22 - 23
 22     23     0     1     0     0     1     1     0     0
    1           1
    -1        1.86828E-01
#  12 Block-block   23 - 24
 23     24     0     1     0     0     1     1     0     0
    1           1
    -1        1.86828E-01
# Betwen porous concrete and concrete walls of conrete container
#  13 Block-block   22 - 25
 22     25     0     1     1     2     1     1     0     0
    1           1
#  14 Block-block   23 - 26
 23     26     0     1     2     2     1     1     0     0
    1           1
#  15 Block-block   24 - 27
 24     27     0     1     1     2     1     1     0     0
    1           1
# Between porous concrete and internal concrete walls in 'outer
cylinder' (cement conditioned waste)
#  16 Block-block   22 - 31
 22     31     0     1     1     2     1     1     0     0
    1           1
#  17 Block-block   23 - 32
 23     32     0     1     2     2     1     1     0     0
    1           1
#  18 Block-block   24 - 33
 24     33     0     1     1     2     1     1     0     0
    1           1
# Between porous concrete and concrete walls between 'inner cylinder'
(bitumenised waste) and 'outer cylinder' (cement conditioned waste)
#  19 Block-block   22 - 34
 22     34     0     1     0     1     1     1     0     0
    1           1
#  20 Block-block   23 - 35
 23     35     0     1     1     1     1     1     0     0
    1           1
#  21 Block-block   24 - 36
```

```
 24     36     0     1     0     1     1     1     0     0
    1           1
# Between porous concrete and outer concrete wall of silo
#  22 Block-block   22 - 37
 22     37     0     1     1     1     1     1     0     0
    1           1
#  23 Block-block   23 - 38
 23     38     0     1     2     1     1     1     0     0
    1           1
#  24 Block-block   24 - 39
 24     39     0     1     1     1     1     1     0     0
    1           1
# Between porous concrete and fictitious (concrete 'lid' on top of
silo)
#  25 Block-block   22 - 53
 22     53     0     1     0     0     0     0     0     1
    1           1
    1        1.86828E-01
  1
  4.3500E-01
# Between porous concrete and fictitious (concrete bottom of the silo)
#  26 Block-block   24 - 54
 24     54     0     1     0     0     0     0     0     1
    1           1
    -1        1.86828E-01
  1
  4.3500E-01
# Between outer concrete wall of silo and bentonite wall of silo
#  27 Block-block   37 - 40
 37     40     0     1     1     1     1     1     0     0
    5           1
#  28 Block-block   38 - 41
 38     41     0     1     1     1     1     1     0     0
    5           1
#  29 Block-block   39 - 42
 39     42     0     1     1     1     1     1     0     0
    5           1
# Within gravel in top of silo
#  30 Block-block   43 - 44
 43     44     0     1     0     0     1     1     0     0
    1           1
    -1        4.44000E-01
#  31 Block-block   44 - 45
 44     45     0     1     0     0     1     1     0     0
    1           1
    -1        4.00000E-01
#  32 Block-block   45 - 46
 45     46     0     1     0     0     1     1     0     0
    1           1
    -1        3.56000E-01
#  33 Block-block   46 - 47
 46     47     0     1     0     0     1     1     0     0
    1           1
    -1        3.12000E-01
# Between gravel in top of silo and sand/bentonite in top of silo
#  34 Block-block   47 - 48
 47     48     0     1     0     0     1     1     0     0
    1           1
    -1        2.68000E-01
# Between sand/bentonite in top of silo and sand in top of silo
#  35 Block-block   48 - 49
 48     49     0     1     0     0     1     1     0     0
    5           1
    -1        2.68000E-01
```

```
# Between sand in top of silo concrete 'lid' of silo
#  36 Block-block   49 - 50
 49     50     0     1     2     0     1     1     0     0
    1          1
    -1        2.30000E-01
# Between concrete in bottom of silo and sand/bentonite in bottom of
silo
#  37 Block-block   51 - 52
 51     52     0     1     0     0     1     1     0     0
    5          1
    -1        2.30000E-01
# Between concrete in top of silo and fictitious block
#  38 Block-block   50 - 53
 50     53     0     1     0     0     0     1     0     0
    5          1
    -1        2.30000E-01
# Between concrete in bottom of silo and fictitious block
#  39 Block-block   51 - 54
 51     54     0     1     0     0     0     1     0     0
    1          1
    1        2.30000E-01
#Data connecting the sinks with the system: one line per sink
# QEQ                IBS   ICS   IRZ  ICRS  ZAFRA
0.00351302855477305  40    5     1    1    0
0.0185983864664455   41    5     1    1    0
0.020251576374574    42    5     1    1    0
```

```
#  BMA CALCULATIONS
#  Problem Codification: BS1
#  Nuclide(s): C-14org
#
#  Problem Description:
#  PROPER VERSION INPUT DATA FORMAT
#
#  ITYPE    NGROUP    NSINKS    IWFLOW    NSOURC    NBSIZE    ISPSOL
   1        1         0         1         50        0         0
#
#  Flow stream conditions
#  NINFLW    NUTFLW      % if IWFLOW = 1
   21        26
#
#  Inflow conditions (one line per inflow)
#  QINFW         NBWIN    NBNWIN    % if IWFLOW = 1
   2.005571E-05  7        1
   3.775902E-05  9        1
   5.236769E-05  17       1
   3.226363E-05  19       1
   5.000000E-05  37       1
   2.855333E-02  126      1
   2.855333E-02  127      1
   2.855333E-02  128      1
   8.611880E-01  144      1
   1.099550E+00  145      1
   4.603700E-01  146      1
   2.961630E+00  147      1
   2.238840E+00  148      1
   8.086000E-02  154      1
   1.654200E-01  155      1
   4.641000E-02  156      1
   8.027000E-02  157      1
   4.559000E-02  158      1
   3.602733E-01  159      1
   3.602733E-01  160      1
   3.602733E-01  161      1
#
#  Outflow conditions (one line per inflow)
#  QUTFW         NBWOUT   NBNWOUT       % if IWFLOW = 1
   9.072333E-02  126      1
   9.072333E-02  127      1
   3.042833E-01  128      1
   1.070633E-01  129      1
   1.070633E-01  130      1
   1.431943E+00  131      1
   1.225267E-01  132      1
   1.225267E-01  133      1
   1.671747E+00  134      1
   5.164667E-02  135      1
   5.164667E-02  136      1
   7.183667E-01  137      1
   5.356667E-02  138      1
   5.356667E-02  139      1
   9.312967E-01  140      1
   4.536667E-02  141      1
   4.536667E-02  142      1
   5.948067E-01  143      1
   1.549200E-01  149      1
   1.697100E-01  150      1
   6.824000E-02  151      1
   7.149000E-02  152      1
   4.544000E-02  153      1
```

```
   6.097567E-01  159      1
   6.097567E-01  160      1
   8.832567E-01  161      1
#
# Number of blocks connections and materials
#  NBLOCK    NBCOUP    NMAT
   161       216       28
#
#  Data on materials (one line per material)
#  Material 1 = Waste (Concrete mould w. Cement in room 1-4)
#  Material 2 = Waste (Steel container w. Cement in room 1-4)
#  Material 3 = Waste (Steel drum w. Cement in room 1-4) (not used)
#  Material 4 = Waste (Steel container w. Bitumen in room 1-4)
#  Material 5 = Waste (Steel drum w. Bitumen in room 1-4)
#  Material 6 = Waste (Concrete mould w. Cement in room 5-9)
#  Material 7 = Waste (Steel container w. Cement in room 5-9)
#  Material 8 = Waste (Steel drum w. Cement in room 5-9) (not used)
#  Material 9 = Waste (Steel container w. Bitumen in room 5-9)
#  Material 10 = Waste (Steel drum w. Bitumen in room 5-9)
#  Material 11 = Waste (Concrete mould w. Cement in room 10-11)
#  Material 12 = Waste (Steel container w. Cement in room 10-11)
#  Material 13 = Waste (Steel drum w. Cement in room 10-11)
#  Material 14 = Waste (Steel container w. Bitumen in room 10-11) (not
used)
#  Material 15 = Waste (Steel drum w. Bitumen in room 10-11) (not
used)
#  Material 16 = Waste (Concrete mould w. Cement in room 12)
#  Material 17 = Waste (Steel container w. Cement in room 12)
#  Material 18 = Waste (Steel drum w. Cement in room 12)
#  Material 19 = Waste (Steel container w. Bitumen in room 12)
#  Material 20 = Waste (Steel drum w. Bitumen in room 12) (not used)
#  Material 21 = Waste (Concrete mould w. Cement in room 13-15)
#  Material 22 = Waste (Steel container w. Cement in room 13-15)
#  Material 23 = Waste (Steel drum w. Cement in room 13-15)
#  Material 24 = Waste (Steel container w. Bitumen in room 13-15) (not
used)
#  Material 25 = Waste (Steel drum w. Bitumen in room 13-15) (not
used)
#  Material 26 = Construction concrete
#  Material 27 = Water
#  Material 28 = Gravel
#
#  MAT        DENSM        PORM
   1          2250.0       0.339
   2          2250.0       0.270
   3          2250.0       1.000
   4          1030.0       0.096
   5          1030.0       0.185
   6          2250.0       0.333
   7          2250.0       0.288
   8          2250.0       1.000
   9          1030.0       0.096
   10         1030.0       0.182
   11         2250.0       0.327
   12         2250.0       0.280
   13         2250.0       0.268
   14         1030.0       1.000
   15         1030.0       1.000
   16         2250.0       0.323
   17         2250.0       0.280
   18         2250.0       0.257
   19         1030.0       0.096
   20         1030.0       1.000
   21         2250.0       0.324
```

```
   22         2250.0       0.467
   23         2250.0       0.258
   24         1030.0       1.000
   25         1030.0       1.000
   26         2529.4       0.150
   27         1000.0       1.000
   28         2700.0       0.300
#
#  Data on time series
#  TINIT     AGEO      RAT      TEND      NTERM      LREAD
   0.00      0.50      1.25     1000.00   90         0
#
#  Data on numerical parameters
#  EPS       EWT       NLOOP      MSPAR
   1.00E-06  1.00E-18  3          1
#
#  Data on group (one set of data per group common for all sources)
#
# Group No: 1
#  NNCH    ISPEC    ISPSOL
   1       1        0
#
# Nuclide: C-14org
#  TAU         CSOLUB      AINV
   5.7300E+03  1.35E+00    7.3428E-02
#
#  CIRF                          % if ISPEC = 1
#
#  MAT       DEFM       SKDM      % one line per material
   1         0.00315    0.000
   2         0.00315    0.000
   3         0.00315    0.000
   4         0.06307    0.000
   5         0.06307    0.000
   6         0.00315    0.000
   7         0.00315    0.000
   8         0.00315    0.000
   9         0.06307    0.000
  10         0.06307    0.000
  11         0.00315    0.000
  12         0.00315    0.000
  13         0.00315    0.000
  14         0.06307    0.000
  15         0.06307    0.000
  16         0.00315    0.000
  17         0.00315    0.000
  18         0.00315    0.000
  19         0.06307    0.000
  20         0.06307    0.000
  21         0.00315    0.000
  22         0.00315    0.000
  23         0.00315    0.000
  24         0.06307    0.000
  25         0.06307    0.000
  26         0.00032    0.000
  27         0.06307    0.000
  28         0.01892    0.000
#
#  Data on sources
#  NSBCHA    ISEQ    MAT    IFWATB    VOLSOU    FINVEN    JINVEN
#
#  IBLOCK    ISSEQ          % if ISEQ = 1
#
#  XXX                      % if JINVEN = 1. One line for each group.
```

```
#
#  IBSOUR                   % if ISEQ = 0
#
#  IWINT                    % if IFWATB = 1
#
#  WBFLOW                   % if IFWATB = 1 and IWINT = 0
#
#  Waste
#  Source    1
  1  0  1  0  7.9198E+02  1.0000000E+00  1
#
  1.9681102E-01
  1
#  Source    2
  1  0  1  0  1.9799E+02  1.0000000E+00  1
#
  4.9202755E-02
  2
#  Source    3
  1  0  2  0  1.4311E+02  1.0000000E+00  1
#
  2.4865513E-02
  3
#  Source    4
  1  0  2  0  3.5778E+01  1.0000000E+00  1
#
  6.2163783E-03
  4
#  Source    5
  1  0  3  0  1.0000E-04  1.0000000E+00  1
#
  0.0000000E+00
  5
#  Source    6
  1  0  3  0  1.0000E-04  1.0000000E+00  1
#
  0.0000000E+00
  6
#  Source    7
  1  0  4  1  2.0056E-05  1.0000000E+00  1
#
  3.6826632E-02
  7
  0
  2.00557103064067E-05
#  Source    8
  1  0  4  1  1.2688E+02  1.0000000E+00  1
#
  0.0000000E+00
  8
  0
  2.00557103064067E-05
#  Source    9
  1  0  5  1  3.7759E-05  1.0000000E+00  1
#
  6.9333749E-02
  9
  0
  3.77590210448915E-05
#  Source    10
  1  0  5  1  5.1890E+02  1.0000000E+00  1
#
  0.0000000E+00
  10
```

```
  0
  3.77590210448915E-05
#  Source    11
  1  0  6  0  1.0343E+03  1.0000000E+00  1
#
  2.2628720E-01
  11
#  Source    12
  1  0  6  0  2.5857E+02  1.0000000E+00  1
#
  5.6571800E-02
  12
#  Source    13
  1  0  7  0  7.3623E+01  1.0000000E+00  1
#
  2.2236580E-03
  13
#  Source    14
  1  0  7  0  1.8406E+01  1.0000000E+00  1
#
  5.5591451E-04
  14
#  Source    15
  1  0  8  0  1.0000E-04  1.0000000E+00  1
#
  0.0000000E+00
  15
#  Source    16
  1  0  8  0  1.0000E-04  1.0000000E+00  1
#
  0.0000000E+00
  16
#  Source    17
  1  0  9  1  5.2368E-05  1.0000000E+00  1
#
  9.6158429E-02
  17
  0
  5.23676880222841E-05
#  Source    18
  1  0  9  1  3.3130E+02  1.0000000E+00  1
#
  0.0000000E+00
  18
  0
  5.23676880222841E-05
#  Source    19
  1  0  10  1  3.2264E-05  1.0000000E+00  1
#
  5.9243025E-02
  19
  0
  3.22636330760221E-05
#  Source    20
  1  0  10  1  4.2974E+02  1.0000000E+00  1
#
  0.0000000E+00
  20
  0
  3.22636330760221E-05
#  Source    21
  1  0  11  0  1.9303E+02  1.0000000E+00  1
#
  3.1367550E-02
```

```
 21
#  Source    22
 1  0  11  0  4.8259E+01  1.0000000E+00  1
#
 7.8418875E-03
 22
#  Source    23
 1  0  12  0  2.3745E+02  1.0000000E+00  1
#
 1.6002049E-02
 23
#  Source    24
 1  0  12  0  5.9362E+01  1.0000000E+00  1
#
 4.0005124E-03
 24
#  Source    25
 1  0  13  0  8.6889E+01  1.0000000E+00  1
#
 0.0000000E+00
 25
#  Source    26
 1  0  13  0  2.1722E+01  1.0000000E+00  1
#
 0.0000000E+00
 26
#  Source    27
 1  0  14  0  1.0000E-04  1.0000000E+00  1
#
 0.0000000E+00
 27
#  Source    28
 1  0  14  0  1.0000E-04  1.0000000E+00  1
#
 0.0000000E+00
 28
#  Source    29
 1  0  15  0  1.0000E-04  1.0000000E+00  1
#
 0.0000000E+00
 29
#  Source    30
 1  0  15  0  1.0000E-04  1.0000000E+00  1
#
 0.0000000E+00
 30
#  Source    31
 1  0  16  0  3.2494E+01  1.0000000E+00  1
#
 1.1228460E-03
 31
#  Source    32
 1  0  16  0  8.1235E+00  1.0000000E+00  1
#
 2.8071150E-04
 32
#  Source    33
 1  0  17  0  6.6962E+01  1.0000000E+00  1
#
 4.8006148E-03
 33
#  Source    34
 1  0  17  0  1.6740E+01  1.0000000E+00  1
#
```

```
 1.2001537E-03
 34
#  Source    35
 1  0  18  0  6.4678E+00  1.0000000E+00  1
#
 0.0000000E+00
 35
#  Source    36
 1  0  18  0  1.6169E+00  1.0000000E+00  1
#
 0.0000000E+00
 36
#  Source    37
 1  0  19  1  5.0000E-05  1.0000000E+00  1
#
 9.1810841E-02
 37
 0
 0.00005
#  Source    38
 1  0  19  1  3.1632E+02  1.0000000E+00  1
#
 0.0000000E+00
 38
 0
 0.00005
#  Source    39
 1  0  20  0  1.0000E-04  1.0000000E+00  1
#
 0.0000000E+00
 39
#  Source    40
 1  0  20  0  1.0000E-04  1.0000000E+00  1
#
 0.0000000E+00
 40
#  Source    41
 1  0  21  0  5.0936E+01  1.0000000E+00  1
#
 2.6199740E-03
 41
#  Source    42
 1  0  21  0  1.2734E+01  1.0000000E+00  1
#
 6.5499349E-04
 42
#  Source    43
 1  0  22  0  5.0967E+02  1.0000000E+00  1
#
 1.1201435E-02
 43
#  Source    44
 1  0  22  0  1.2742E+02  1.0000000E+00  1
#
 2.8003587E-03
 44
#  Source    45
 1  0  23  0  1.5817E+01  1.0000000E+00  1
#
 0.0000000E+00
 45
#  Source    46
 1  0  23  0  3.9542E+00  1.0000000E+00  1
#
```

```
  0.0000000E+00
  46
#  Source    47
  1  0  24  0  1.0000E-04  1.0000000E+00  1
#
  0.0000000E+00
  47
#  Source    48
  1  0  24  0  1.0000E-04  1.0000000E+00  1
#
  0.0000000E+00
  48
#  Source    49
  1  0  25  0  1.0000E-04  1.0000000E+00  1
#
  0.0000000E+00
  49
#  Source    50
  1  0  25  0  1.0000E-04  1.0000000E+00  1
#
  0.0000000E+00
  50
#
#  Description of blocks not considered before
#
#  Block i
#  NZ   NY   NX   NBLSP   MAT   IQFLOW
#
#  ZADIM  YADIM  XADIM  VOLBLK % one line per compartment if NBLSP = 1
#
#  IWINT                      % if IQFLOW = 1
#
#  NODWIN   NODWUT    BFLOW    % if IQFLOW = 1 and IWINT = 0
#
#  Walls of concrete containers
#  Block   51
  1  1  1  0  26  0
  1.0000E+05     1.0774E-05      1.0774E-05      7.3875E+02
#  Block   52
  1  1  1  0  26  0
  1.0000E+05     7.1788E-06      7.1788E-06      1.1087E+03
#  Block   53
  1  1  1  0  26  0
  1.0000E+05     3.4498E-05      3.4498E-05      2.3071E+02
#  Block   54
  1  1  1  0  26  0
  1.0000E+05     1.3526E-04      1.3526E-04      5.8843E+01
#  Block   55
  1  1  1  0  26  0
  1.0000E+05     9.1075E-05      9.1075E-05      8.7391E+01
# Water inside structure
#  Block   56
  1  1  1  0  27  1
  1.7126E-07     3.4698E-07      9.2621E-07      6.5313E+02
  1
#  Block   57
  1  1  1  0  27  1
  1.3701E-07     2.7758E-07      9.2621E-07      5.9769E+02
  1
#  Block   58
  1  1  1  0  27  1
  3.4252E-07     6.9395E-07      9.2621E-07      4.4430E+02
  1
#  Block   59
```

```
  1  1  1  0  27  1
  6.8504E-07     1.3879E-06      9.2621E-07      8.3770E+01
  1
#  Block   60
  1  1  1  0  27  1
  4.5623E-07     9.2433E-07      9.2621E-07      3.1590E+02
  1
# Short side of structure (passage)
#  Block   61
  1  1  1  0  26  1
  1.0000E+05     1.0000E+05      1.2349E-03      1.4396E+01
  0
  1              1             0.00257
#  Block   62
  1  1  1  0  26  1
  1.0000E+05     1.0000E+05      1.2349E-03      1.4396E+01
  0
  1              1             0.00257
#  Block   63
  1  1  1  0  26  1
  1.0000E+05     1.0000E+05      1.2349E-03      1.4396E+01
  0
  1              1             0.00257
#  Ceiling of structure
#  Block   64
  1  1  1  0  26  1
  5.4232E-04     4.9206E-04      8.3616E+00      2.0379E+02
  0
  1              1             0.00644
#  Block   65
  1  1  1  0  26  1
  5.4232E-04     4.9206E-04      8.3616E+00      2.0379E+02
  0
  1              1             0.00644
#  Block   66
  1  1  1  0  26  1
  5.4232E-04     4.9206E-04      8.3616E+00      2.0379E+02
  0
  1              1             0.00644
#  Block   67
  1  1  1  0  26  1
  4.3386E-04     3.9556E-04      1.0401E+01      2.5351E+02
  0
  1              1             0.0104
#  Block   68
  1  1  1  0  26  1
  4.3386E-04     3.9556E-04      1.0401E+01      2.5351E+02
  0
  1              1             0.0104
#  Block   69
  1  1  1  0  26  1
  4.3386E-04     3.9556E-04      1.0401E+01      2.5351E+02
  0
  1              1             0.0104
#  Block   70
  1  1  1  0  26  1
  1.0846E-03     9.8891E-04      4.1606E+00      1.0140E+02
  0
  1              1             0.00596
#  Block   71
  1  1  1  0  26  1
  1.0846E-03     9.8891E-04      4.1606E+00      1.0140E+02
  0
  1              1             0.00596
```

```
#  Block   72
  1  1  1  0  26  1
  1.0846E-03     9.8891E-04      4.1606E+00      1.0140E+02
  0
  1              1            0.00596
#  Block   73
  1  1  1  0  26  1
  2.1693E-03     1.9778E-03      2.0803E+00      5.0701E+01
  0
  1              1            0.01224
#  Block   74
  1  1  1  0  26  1
  2.1693E-03     1.9778E-03      2.0803E+00      5.0701E+01
  0
  1              1            0.01224
#  Block   75
  1  1  1  0  26  1
  2.1693E-03     1.9778E-03      2.0803E+00      5.0701E+01
  0
  1              1            0.01224
#  Block   76
  1  1  1  0  26  1
  1.4447E-03     1.2679E-03      3.2450E+00      7.9088E+01
  0
  1              1            0.0049
#  Block   77
  1  1  1  0  26  1
  1.4447E-03     1.2679E-03      3.2450E+00      7.9088E+01
  0
  1              1            0.0049
#  Block   78
  1  1  1  0  26  1
  1.4447E-03     1.2679E-03      3.2450E+00      7.9088E+01
  0
  1              1            0.0049
#  Bottom of structure
#  Block   79
  1  1  1  0  26  1
  4.2815E-04     3.8847E-04      1.0591E+01      1.6089E+02
  0
  1              1            0.00808
#  Block   80
  1  1  1  0  26  1
  3.4252E-04     3.1229E-04      1.3175E+01      2.0014E+02
  0
  1              1            0.01228
#  Block   81
  1  1  1  0  26  1
  8.5630E-04     7.8072E-04      5.2700E+00      8.0055E+01
  0
  1              1            0.00664
#  Block   82
  1  1  1  0  26  1
  1.7126E-03     1.5614E-03      2.6350E+00      4.0027E+01
  0
  1              1            0.05001
#  Block   83
  1  1  1  0  26  1
  1.1406E-03     1.0010E-03      4.1103E+00      6.2438E+01
  0
  1              1            0.03337
# Wall on left side of structure
#  Block   84
  1  1  1  0  26  1
```

```
  4.6264E-04     4.4246E-04      4.2411E+01      4.0179E+01
  0
  1              1            0.0018
#  Block   85
  1  1  1  0  26  1
  4.6264E-04     4.4246E-04      4.2411E+01      4.0179E+01
  0
  1              1            0.0018
#  Block   86
  1  1  1  0  26  1
  4.6264E-04     4.4246E-04      4.2411E+01      4.0179E+01
  0
  1              1            0.0018
#  Block   87
  1  1  1  0  26  1
  3.7011E-04     3.5569E-04      5.2757E+01      4.9981E+01
  0
  1              1            0.00288
#  Block   88
  1  1  1  0  26  1
  3.7011E-04     3.5569E-04      5.2757E+01      4.9981E+01
  0
  1              1            0.00288
#  Block   89
  1  1  1  0  26  1
  3.7011E-04     3.5569E-04      5.2757E+01      4.9981E+01
  0
  1              1            0.00288
#  Block   90
  1  1  1  0  26  1
  9.2527E-04     8.8923E-04      2.1103E+01      1.9992E+01
  0
  1              1            0.00131
#  Block   91
  1  1  1  0  26  1
  9.2527E-04     8.8923E-04      2.1103E+01      1.9992E+01
  0
  1              1            0.00131
#  Block   92
  1  1  1  0  26  1
  9.2527E-04     8.8923E-04      2.1103E+01      1.9992E+01
  0
  1              1            0.00131
#  Block   93
  1  1  1  0  26  1
  1.8505E-03     1.7785E-03      1.0551E+01      9.9961E+00
  0
  1              1            0.00262
#  Block   94
  1  1  1  0  26  1
  1.8505E-03     1.7785E-03      1.0551E+01      9.9961E+00
  0
  1              1            0.00262
#  Block   95
  1  1  1  0  26  1
  1.8505E-03     1.7785E-03      1.0551E+01      9.9961E+00
  0
  1              1            0.00262
#  Block   96
  1  1  1  0  26  1
  1.2324E-03     1.1401E-03      1.6459E+01      1.5593E+01
  0
  1              1            0.00141
#  Block   97
```

```
  1  1  1  0  26  1
  1.2324E-03     1.1401E-03      1.6459E+01      1.5593E+01
  0
  1              1            0.00141
#  Block   98
  1  1  1  0  26  1
  1.2324E-03     1.1401E-03      1.6459E+01      1.5593E+01
  0
  1              1            0.00141
# Wall on right side of structure
#  Block   99
  1  1  1  0  26  1
  4.6264E-04     4.4246E-04      4.2411E+01      4.0179E+01
  0
  1              1            0.00055
#  Block   100
  1  1  1  0  26  1
  4.6264E-04     4.4246E-04      4.2411E+01      4.0179E+01
  0
  1              1            0.00055
#  Block   101
  1  1  1  0  26  1
  4.6264E-04     4.4246E-04      4.2411E+01      4.0179E+01
  0
  1              1            0.00055
#  Block   102
  1  1  1  0  26  1
  3.7011E-04     3.5569E-04      5.2757E+01      4.9981E+01
  0
  1              1            0.00068
#  Block   103
  1  1  1  0  26  1
  3.7011E-04     3.5569E-04      5.2757E+01      4.9981E+01
  0
  1              1            0.00068
#  Block   104
  1  1  1  0  26  1
  3.7011E-04     3.5569E-04      5.2757E+01      4.9981E+01
  0
  1              1            0.00068
#  Block   105
  1  1  1  0  26  1
  9.2527E-04     8.8923E-04      2.1103E+01      1.9992E+01
  0
  1              1            0.00039
#  Block   106
  1  1  1  0  26  1
  9.2527E-04     8.8923E-04      2.1103E+01      1.9992E+01
  0
  1              1            0.00039
#  Block   107
  1  1  1  0  26  1
  9.2527E-04     8.8923E-04      2.1103E+01      1.9992E+01
  0
  1              1            0.00039
#  Block   108
  1  1  1  0  26  1
  1.8505E-03     1.7785E-03      1.0551E+01      9.9961E+00
  0
  1              1            0.00265
#  Block   109
  1  1  1  0  26  1
  1.8505E-03     1.7785E-03      1.0551E+01      9.9961E+00
  0
```

```
  1              1            0.00265
#  Block   110
  1  1  1  0  26  1
  1.8505E-03     1.7785E-03      1.0551E+01      9.9961E+00
  0
  1              1            0.00265
#  Block   111
  1  1  1  0  26  1
  1.2324E-03     1.1401E-03      1.6459E+01      1.5593E+01
  0
  1              1            0.00001
#  Block   112
  1  1  1  0  26  1
  1.2324E-03     1.1401E-03      1.6459E+01      1.5593E+01
  0
  1              1            0.00001
#  Block   113
  1  1  1  0  26  1
  1.2324E-03     1.1401E-03      1.6459E+01      1.5593E+01
  0
  1              1            0.00001
# Inner wall between room 4 and 5
#  Block   114
  1  1  1  0  26  1
  1.0000E+05     1.0000E+05      3.7048E-03      4.3187E+01
  0
  1              1            0.00217
# Inner wall between room 9 and 10
#  Block   115
  1  1  1  0  26  1
  1.0000E+05     1.0000E+05      3.7048E-03      4.3187E+01
  0
  1              1            0.00249
# Inner wall between room 11 and 12
#  Block   116
  1  1  1  0  26  1
  1.0000E+05     1.0000E+05      3.7048E-03      4.3187E+01
  0
  1              1            0.0035
# Inner wall between room 12 and 13
#  Block   117
  1  1  1  0  26  1
  1.0000E+05     1.0000E+05      3.7048E-03      4.3187E+01
  0
  1              1            0.029
# "Sink" 1 (inner wall between room 1 and 2, 2 and 3, 3 and 4)
#  Block   118
  1  1  1  0  26  0
  1.0000E+05     1.0000E+05      1.2349E-03      1.2956E+02
# "Sink" 2 (inner wall between room 5 and 6, 6 and 7, 7 and 8, 8 and
9)
#  Block   119
  1  1  1  0  26  0
  1.0000E+05     1.0000E+05      9.2621E-04      1.7275E+02
# "Sink" 3 (inner wall between room 10 and 11)
#  Block   120
  1  1  1  0  26  0
  1.0000E+05     1.0000E+05      3.7048E-03      4.3187E+01
# "Sink" 4 (no inner walls i.e. infinite small "sink")
#  Block   121
  1  1  1  0  26  0
  1.0000E+05     1.0000E+05      1.0000E+05      1.0000E-03
# "Sink" 5 (inner wall between room 13 and 14/15 14 and 15)
#  Block   122
```

```
  1  1  1  0  26  0
  1.0000E+05     1.0000E+05      3.7048E-03      4.3187E+01
# Short side of structure (loading zone)
#  Block   123
  1  1  1  0  26  1
  1.0000E+05     1.0000E+05      1.8524E-03      2.1593E+01
  0
  1              1            0.05607
#  Block   124
  1  1  1  0  26  1
  1.0000E+05     1.0000E+05      1.8524E-03      2.1593E+01
  0
  1              1            0.05607
#  Block   125
  1  1  1  0  26  1
  1.0000E+05     1.0000E+05      1.8524E-03      2.1593E+01
  0
  1              1            0.05607
# Gravel at the end of the tunnel (passage)
#  Block   126
  1  1  1  0  28  1
  1.5738E-02     6.1902E-03      2.1788E-03      2.0500E+02
  1
#  Block   127
  1  1  1  0  28  1
  1.0000E+05     6.1902E-03      2.1788E-03      2.0500E+02
  1
#  Block   128
  1  1  1  0  28  1
  1.0000E+05     6.1902E-03      2.1788E-03      2.0500E+02
  1
# Gravel on top of the structure
#  Block   129
  1  1  1  0  28  1
  2.6779E-03     2.6178E-02      9.7206E-01      1.7530E+03
  1
#  Block   130
  1  1  1  0  28  1
  2.6779E-03     2.6178E-02      9.7206E-01      1.7530E+03
  1
#  Block   131
  1  1  1  0  28  1
  2.6779E-03     2.6178E-02      9.7206E-01      1.7530E+03
  1
#  Block   132
  1  1  1  0  28  1
  2.1528E-03     2.1044E-02      1.2092E+00      2.1807E+03
  1
#  Block   133
  1  1  1  0  28  1
  2.1528E-03     2.1044E-02      1.2092E+00      2.1807E+03
  1
#  Block   134
  1  1  1  0  28  1
  2.1528E-03     2.1044E-02      1.2092E+00      2.1807E+03
  1
#  Block   135
  1  1  1  0  28  1
  5.3819E-03     5.2611E-02      4.8367E-01      8.7227E+02
  1
#  Block   136
  1  1  1  0  28  1
  5.3819E-03     5.2611E-02      4.8367E-01      8.7227E+02
  1
```

```
#  Block   137
  1  1  1  0  28  1
  5.3819E-03     5.2611E-02      4.8367E-01      8.7227E+02
  1
#  Block   138
  1  1  1  0  28  1
  1.0764E-02     1.0522E-01      2.4184E-01      4.3613E+02
  1
#  Block   139
  1  1  1  0  28  1
  1.0764E-02     1.0522E-01      2.4184E-01      4.3613E+02
  1
#  Block   140
  1  1  1  0  28  1
  1.0764E-02     1.0522E-01      2.4184E-01      4.3613E+02
  1
#  Block   141
  1  1  1  0  28  1
  6.9004E-03     6.7455E-02      3.7724E-01      6.8032E+02
  1
#  Block   142
  1  1  1  0  28  1
  6.9004E-03     6.7455E-02      3.7724E-01      6.8032E+02
  1
#  Block   143
  1  1  1  0  28  1
  6.9004E-03     6.7455E-02      3.7724E-01      6.8032E+02
  1
# Gravel in bottom of tunnel
#  Block   144
  1  1  1  0  28  1
  1.0100E-03     7.8534E-03      3.2402E+00      5.2591E+02
  1
#  Block   145
  1  1  1  0  28  1
  8.1195E-04     6.3133E-03      4.0306E+00      6.5420E+02
  1
#  Block   146
  1  1  1  0  28  1
  2.0299E-03     1.5783E-02      1.6122E+00      2.6168E+02
  1
#  Block   147
  1  1  1  0  28  1
  4.0597E-03     3.1567E-02      8.0612E-01      1.3084E+02
  1
#  Block   148
  1  1  1  0  28  1
  2.6026E-03     2.0237E-02      1.2575E+00      2.0409E+02
  1
# Gravel on left side of structure
#  Block   149
  1  1  1  0  28  1
  1.0270E-01     6.6535E-03      2.4222E+00      7.0351E+02
  1
#  Block   150
  1  1  1  0  28  1
  8.2559E-02     5.3487E-03      3.0131E+00      8.7513E+02
  1
#  Block   151
  1  1  1  0  28  1
  2.0640E-01     1.3372E-02      1.2052E+00      3.5005E+02
  1
#  Block   152
  1  1  1  0  28  1
```

```
  4.1279E-01     2.6744E-02      6.0261E-01      1.7503E+02
  1
#  Block   153
  1  1  1  0  28  1
  2.6463E-01     1.7145E-02      9.4000E-01      2.7302E+02
  1
# Gravel on right side of structure
#  Block   154
  1  1  1  0  28  1
  1.0270E-01     6.6535E-03      2.4222E+00      7.0351E+02
  1
#  Block   155
  1  1  1  0  28  1
  8.2559E-02     5.3487E-03      3.0131E+00      8.7513E+02
  1
#  Block   156
  1  1  1  0  28  1
  2.0640E-01     1.3372E-02      1.2052E+00      3.5005E+02
  1
#  Block   157
  1  1  1  0  28  1
  4.1279E-01     2.6744E-02      6.0261E-01      1.7503E+02
  1
#  Block   158
  1  1  1  0  28  1
  2.6463E-01     1.7145E-02      9.4000E-01      2.7302E+02
  1
# Gravel at the end of the tunnel (loading zone)
#  Block   159
  1  1  1  0  28  1
  1.4549E-01     5.7224E-02      2.0142E-02      1.8951E+03
  1
#  Block   160
  1  1  1  0  28  1
  1.0000E+05     5.7224E-02      2.0142E-02      1.8951E+03
  1
#  Block   161
  1  1  1  0  28  1
  1.0000E+05     5.7224E-02      2.0142E-02      1.8951E+03
  1
#  Codifying the connections
#
#  NSSCO    NSBCO    NBBCO
   25       25       166
#
#  Connection between sources
#  NABCO    ICSEQ    LSCFW    IRADD
#
#  QWATIN          % if LSCFW is not equal to 0
#
#  ISERNU          % if IRADD = 1
#
#  XRADD           % if IRADD = 1 and ISERNU = 0 one line per group
#
#  IBSA   IBSB   ISEQA   ISEQB   % if NABCO > 1 and ICSEQ = 1
#
#  IBSA    IBSB    % if ICSEQ = 0 NABCO*lines
#
#  WITHIN WASTE
#
#  1 Source-source 1 - 2
     1               0               0               1
     1
     1.185245E-02
```

```
     1               2
#  2 Source-source 3 - 4
     1               0               0               1
     1
     7.115983E-02
     3               4
#  3 Source-source 5 - 6
     1               0               0               1
     1
     2.000000E+12
     5               6
#  4 Source-source 7 - 8
     1               0               1               1
     2.005571E-05
     1
     1.000000E+12
     7               8
#  5 Source-source 9 - 10
     1               0               1               1
     3.775902E-05
     1
     1.000000E+12
     9               10
#  6 Source-source 11 - 12
     1               0               0               1
     1
     7.897481E-03
     11               12
#  7 Source-source 13 - 14
     1               0               0               1
     1
     1.079666E-01
     13               14
#  8 Source-source 15 - 16
     1               0               0               1
     1
     2.000000E+12
     15               16
#  9 Source-source 17 - 18
     1               0               1               1
     5.236769E-05
     1
     1.000000E+12
     17               18
#  10 Source-source 19 - 20
     1               0               1               1
     3.226363E-05
     1
     1.000000E+12
     19               20
#  11 Source-source 21 - 22
     1               0               0               1
     1
     3.795178E-02
     21               22
#  12 Source-source 23 - 24
     1               0               0               1
     1
     3.578323E-02
     23               24
#  13 Source-source 25 - 26
     1               0               0               1
     1
     1.487147E-02
```

```
     25              26
#  14 Source-source 27 - 28
     1               0               0               1
     1
     1.000000E+12
     27              28
#  15 Source-source 29 - 30
     1               0               0               1
     1
     1.000000E+12
     29              30
#  16 Source-source 31 - 32
     1               0               0               1
     1
     1.488010E-01
     31              32
#  17 Source-source 33 - 34
     1               0               0               1
     1
     1.277973E-01
     33              34
#  18 Source-source 35 - 36
     1               0               0               1
     1
     3.354343E-01
     35              36
#  19 Source-source 37 - 38
     1               0               1               1
     5.000000E-05
     1
     1.000000E+12
     37              38
#  20 Source-source 39 - 40
     1               0               0               1
     1
     1.000000E+12
     39              40
#  21 Source-source 41 - 42
     1               0               0               1
     1
     1.001927E-01
     41              42
#  22 Source-source 43 - 44
     1               0               0               1
     1
     2.236452E-02
     43              44
#  23 Source-source 45 - 46
     1               0               0               1
     1
     1.349233E-01
     45              46
#  24 Source-source 47 - 48
     1               0               0               1
     1
     1.000000E+12
     47              48
#  25 Source-source 49 - 50
     1               0               0               1
     1
     1.000000E+12
     49              50
#  Connection source - block
#
```

```
#  IBSOU  IBSB  ISEQC  NABCCO  IRZB  ICRB  IPLUG  IRADD
#
#  ICOMPB  ICSEQB   % if NABCCO > 1 and ISEQC =1
#
#  IDCB             % if ISEQC = 0. One value for each connection.
#
#  LSCFW  QWATIN    % if IFWATB(source term) = 1 and IQFLOW(block) = 1
#
#  ISERNU           % if IRADD =1
#
#  XRADD            % if IRADD = 1 and ISERNU = 1
#
#  XRADD            % if IRADD = 1 and ISERNU = 0. One line per group.
#
#
#  BETWEEN WASTE - CONCRETE WALLS OF CONCRETE CONTAINERS
#  1 Source-block   2 - 51
     2  51  0  1  1  1  0  1
#
  1
#
  1
  7.90732583E-04
#  2 Source-block   12 - 52
     12  52  0  1  1  1  0  1
#
  1
#
  1
  5.26878043E-04
#  3 Source-block   22 - 53
     22  53  0  1  1  1  0  1
#
  1
#
  1
  2.53194171E-03
#  4 Source-block   32 - 54
     32  54  0  1  1  1  0  1
#
  1
#
  1
  9.92721699E-03
#  5 Source-block   42 - 55
     42  55  0  1  1  1  0  1
#
  1
#
  1
  6.68432610E-03
#  BETWEEN WASTE - WATER
#  6 Source-block   4 - 56
     4  56  0  1  0  0  0  1
#
  1
#
  1
  4.74751081E-03
#  7 Source-block   6 - 56
     6  56  0  1  0  0  0  1
#
  1
#
```

```
  1
  1.00000000E+12
#  8 Source-block   8 - 56
     8  56  0  1  0  0  0  1
#
  1
  1            2.00557103064067E-05
  1
  2.94730830E-04
#  9 Source-block   10 - 56
     10  56  0  1  0  0  0  1
#
  1
  1            3.77590210448915E-05
  1
  2.56014226E-05
#  10 Source-block   14 - 57
     14  57  0  1  0  0  0  1
#
  1
#
  1
  7.20311984E-03
#  11 Source-block   16 - 57
     16  57  0  1  0  0  0  1
#
  1
#
  1
  1.00000000E+12
#  12 Source-block   18 - 57
     18  57  0  1  0  0  0  1
#
  1
  1            5.23676880222841E-05
  1
  1.12875637E-04
#  13 Source-block   20 - 57
     20  57  0  1  0  0  0  1
#
  1
  1            3.22636330760221E-05
  1
  3.74272453E-05
#  14 Source-block   24 - 58
     24  58  0  1  0  0  0  1
#
  1
#
  1
  2.38731972E-03
#  15 Source-block   26 - 58
     26  58  0  1  0  0  0  1
#
  1
#
  1
  1.09619884E-03
#  16 Source-block   28 - 58
     28  58  0  1  0  0  0  1
#
  1
#
  1
```

```
  1.00000000E+12
#  17 Source-block   30 - 58
     30  58  0  1  0  0  0  1
#
  1
#
  1
  1.00000000E+12
#  18 Source-block   34 - 59
     34  59  0  1  0  0  0  1
#
  1
#
  1
  8.52614186E-03
#  19 Source-block   36 - 59
     36  59  0  1  0  0  0  1
#
  1
#
  1
  2.47253739E-02
#  20 Source-block   38 - 59
     38  59  0  1  0  0  0  1
#
  1
  1            0.00005
  1
  1.18220723E-04
#  21 Source-block   40 - 59
     40  59  0  1  0  0  0  1
#
  1
#
  1
  1.00000000E+12
#  22 Source-block   44 - 60
     44  60  0  1  0  0  0  1
#
  1
#
  1
  1.49207482E-03
#  23 Source-block   46 - 60
     46  60  0  1  0  0  0  1
#
  1
#
  1
  9.94540179E-03
#  24 Source-block   48 - 60
     48  60  0  1  0  0  0  1
#
  1
#
  1
  1.00000000E+12
#  25 Source-block   50 - 60
     50  60  0  1  0  0  0  1
#
  1
#
  1
  1.00000000E+12
```

```
#  Connections between blocks not considered as sources
#
#  IBA  IBB  ISEQC  NABCCO  IRZA  IRZB  ICRA  ICRB  IPLUG  IRADD
#
#  IDCA     IDCB                   % if NABCCO = 1
#
#  ICOMPA  ICOMPB  ICSEQA  ICSEQB  % if NABCCO > 1 and ISQC = 1
#
#  IDCA                            % if NABCCO > 1 and ISQC = 0
#
#  IDCB                            % if NABCCO > 1 and ISQC = 0
#
#  LSCFW     QWATIN         % if IQFLOW(A) = 1 and IQFLOW(B) = 1
#
#  ISERNU                   % if IRADD = 1
#
#  XRADD       % if IRADD = 1 and ISERNU = 0. One line per group
#
#  BETWEEN WALLS OF CONCRETE CONTAINERS AND WATER
#  1 Block-block   51 - 56
   51  56  0  1  2  0  1  0  0  0
    1          1
#  2 Block-block   52 - 57
   52  57  0  1  2  0  1  0  0  0
    1          1
#  3 Block-block   53 - 58
   53  58  0  1  2  0  1  0  0  0
    1          1
#  4 Block-block   54 - 59
   54  59  0  1  2  0  1  0  0  0
    1          1
#  5 Block-block   55 - 60
   55  60  0  1  2  0  1  0  0  0
    1          1
#  BETWEEN WATER AND SHORT SIDE OF THE STRUCTURE (PASSAGE)
#  6 Block-block   56 - 61
   56  61  0  1  2  2  0  1  0  0
    1          1
    1        2.57000E-03
#  BETWEEN WATER AND CEILING OF THE STRUCTURE
#  7 Block-block   56 - 64
   56  64  0  1  0  0  0  1  0  0
    1          1
    1        6.44000E-03
#  8 Block-block   57 - 67
   57  67  0  1  0  0  0  1  0  0
    1          1
    1        1.04000E-02
#  9 Block-block   58 - 70
   58  70  0  1  0  0  0  1  0  0
    1          1
    1        5.96000E-03
#  10 Block-block   59 - 73
   59  73  0  1  0  0  0  1  0  0
    1          1
    1        1.22400E-02
#  11 Block-block   60 - 76
   60  76  0  1  0  0  0  1  0  0
    1          1
    1        4.90000E-03
#  BETWEEN WATER AND BOTTOM OF THE STRUCTURE
#  12 Block-block   56 - 79
   56  79  0  1  0  0  0  1  0  0
    1          1
```

```
    -1        8.08000E-03
#  13 Block-block   57 - 80
   57  80  0  1  0  0  0  1  0  0
    1          1
    -1        1.22800E-02
#  14 Block-block   58 - 81
   58  81  0  1  0  0  0  1  0  0
    1          1
    -1        6.64000E-03
#  15 Block-block   59 - 82
   59  82  0  1  0  0  0  1  0  0
    1          1
    -1        5.00100E-02
#  16 Block-block   60 - 83
   60  83  0  1  0  0  0  1  0  0
    1          1
    -1        3.33700E-02
#  BETWEEN WATER AND WALL ON THE LEFT SIDE OF THE STRUCTURE
#  17 Block-block   56 - 84
   56  84  0  1  1  0  0  1  0  0
    1          1
    1        1.80000E-03
#  18 Block-block   57 - 87
   57  87  0  1  1  0  0  1  0  0
    1          1
    1        2.88000E-03
#  19 Block-block   58 - 90
   58  90  0  1  1  0  0  1  0  0
    1          1
    1        1.31000E-03
#  20 Block-block   59 - 93
   59  93  0  1  1  0  0  1  0  0
    1          1
    1        2.62000E-03
#  21 Block-block   60 - 96
   60  96  0  1  1  0  0  1  0  0
    1          1
    1        1.41000E-03
#  BETWEEN WATER AND WALL ON THE RIGHT SIDE OF THE STRUCTURE
#  22 Block-block   56 - 99
   56  99  0  1  1  0  0  1  0  0
    1          1
    -1        5.50000E-04
#  23 Block-block   57 - 102
   57  102  0  1  1  0  0  1  0  0
    1          1
    -1        6.80000E-04
#  24 Block-block   58 - 105
   58  105  0  1  1  0  0  1  0  0
    1          1
    1        3.90000E-04
#  25 Block-block   59 - 108
   59  108  0  1  1  0  0  1  0  0
    1          1
    1        2.65000E-03
#  26 Block-block   60 - 111
   60  111  0  1  1  0  0  1  0  0
    1          1
    -1        1.00000E-05
#  BETWEEN WATER AND WALLS BETWEEN ROOM 4 AND 5 IN THE STRUCTURE
#  27 Block-block   56 - 114
   56  114  0  1  2  2  0  1  0  0
    1          1
    -1        2.17000E-03
```

```
#  28 Block-block   57 - 114
   57  114  0  1  2  2  0  1  0  0
    1          1
    1        2.17000E-03
#  BETWEEN WATER AND WALLS BETWEEN ROOM 9 AND 10 IN THE STRUCTURE
#  29 Block-block   57 - 115
   57  115  0  1  2  2  0  1  0  0
    1          1
    -1        2.49000E-03
#  30 Block-block   58 - 115
   58  115  0  1  2  2  0  1  0  0
    1          1
    1        2.49000E-03
#  BETWEEN WATER AND WALLS BETWEEN ROOM 11 AND 12 IN THE STRUCTURE
#  31 Block-block   58 - 116
   58  116  0  1  2  2  0  1  0  0
    1          1
    -1        3.50000E-03

#  32 Block-block   59 - 116
   59  116  0  1  2  2  0  1  0  0
    1          1
    1        3.50000E-03
#  BETWEEN WATER AND WALLS BETWEEN ROOM 12 AND 13 IN THE STRUCTURE
#  33 Block-block   59 - 117
   59  117  0  1  2  2  0  1  0  0
    1          1
    1        2.90000E-02
#  34 Block-block   60 - 117
   60  117  0  1  2  2  0  1  0  0
    1          1
    -1        2.90000E-02
#  BETWEEN WATER AND WALLS INSIDE ROOMS 1-4 IN THE STRUCTURE
#  35 Block-block   56 - 118
   56  118  0  1  2  2  0  1  0  0
    1          1
#  BETWEEN WATER AND WALLS INSIDE ROOMS 5-9 IN THE STRUCTURE
#  36 Block-block   57 - 119
   57  119  0  1  2  2  0  1  0  0
    1          1
#  BETWEEN WATER AND WALLS INSIDE ROOMS 10-11 IN THE STRUCTURE
#  37 Block-block   58 - 120
   58  120  0  1  2  2  0  1  0  0
    1          1
#  BETWEEN WATER AND WALLS INSIDE ROOM 12 IN THE STRUCTURE
#  38 Block-block   59 - 121
   59  121  0  1  2  2  0  1  0  0
    1          1
#  BETWEEN WATER AND WALLS INSIDE ROOMS 13-15 IN THE STRUCTURE
#  39 Block-block   60 - 122
   60  122  0  1  2  2  0  1  0  0
    1          1
#  BETWEEN WATER AND SHORT SIDE OF THE STRUCTURE (LOADING ZONE)
#  40 Block-block   60 - 123
   60  123  0  1  2  2  0  1  0  0
    1          1
    1        5.60700E-02
#  WITHIN SHORT SIDE OF THE STRUCTURE (PASSAGE)
#  41 Block-block   61 - 62
   61  62  0  1  2  2  1  1  0  0
    1          1
    1        2.57000E-03
#  42 Block-block   62 - 63
   62  63  0  1  2  2  1  1  0  0
```

```
    1          1
    1        2.57000E-03
#  BETWEEN SHORT SIDE OF THE STRUCTURE (PASSAGE)
# AND  GRAVEL AT THE SHORT SIDE OF THE STRUCTURE (PASSAGE)
#  43 Block-block   63 - 126
   63  126  0  1  2  1  1  1  0  0
    1          1
    1        2.57000E-03
# WITHIN CEILING OF THE STRUCTURE (TRANSVERSE TO THE MAIN AXIS OF
TUNNEL)
#  44 Block-block   64 - 65
   64  65  0  1  1  1  1  1  0  0
    1          1
    1        6.44000E-03
#  45 Block-block   65 - 66
   65  66  0  1  1  1  1  1  0  0
    1          1
    1        6.44000E-03
#  46 Block-block   67 - 68
   67  68  0  1  1  1  1  1  0  0
    1          1
    1        1.04000E-02
#  47 Block-block   68 - 69
   68  69  0  1  1  1  1  1  0  0
    1          1
    1        1.04000E-02
#  48 Block-block   70 - 71
   70  71  0  1  1  1  1  1  0  0
    1          1
    1        5.96000E-03
#  49 Block-block   71 - 72
   71  72  0  1  1  1  1  1  0  0
    1          1
    1        5.96000E-03
#  50 Block-block   73 - 74
   73  74  0  1  1  1  1  1  0  0
    1          1
    1        1.22400E-02
#  51 Block-block   74 - 75
   74  75  0  1  1  1  1  1  0  0
    1          1
    1        1.22400E-02
#  52 Block-block   76 - 77
   76  77  0  1  1  1  1  1  0  0
    1          1
    1        4.90000E-03
#  53 Block-block   77 - 78
   77  78  0  1  1  1  1  1  0  0
    1          1
    1        4.90000E-03
# WITHIN CEILING OF THE STRUCTURE (ALONG THE MAIN AXIS OF TUNNEL)
#  54 Block-block   64 - 67
#  55 Block-block   65 - 68
#  56 Block-block   66 - 69
#  57 Block-block   67 - 70
#  58 Block-block   68 - 71
#  59 Block-block   69 - 72
#  60 Block-block   70 - 73
#  61 Block-block   71 - 74
#  62 Block-block   72 - 75
#  63 Block-block   73 - 76
#  64 Block-block   74 - 77
#  65 Block-block   75 - 78
#  BETWEEN CEILING OF THE STRUCTURE AND GRAVEL ON TOP OF THE STRUCTURE
```

```
#  66 Block-block   66 - 129
   66  129  0  1  1  0  1  1  0  0
    1          1
    1        6.44000E-03
#  67 Block-block   69 - 132
   69  132  0  1  1  0  1  1  0  0
    1          1
    1        1.04000E-02
#  68 Block-block   72 - 135
   72  135  0  1  1  0  1  1  0  0
    1          1
    1        5.96000E-03
#  69 Block-block   75 - 138
   75  138  0  1  1  0  1  1  0  0
    1          1
    1        1.22400E-02
#  70 Block-block   78 - 141
   78  141  0  1  1  0  1  1  0  0
    1          1
    1        4.90000E-03
# WITHIN BOTTOM OF THE STRUCTURE
#  71 Block-block   79 - 80
#  72 Block-block   80 - 81
#  73 Block-block   81 - 82
#  74 Block-block   82 - 83
#  BETWEEN BOTTOM OF THE STRUCTURE AND GRAVEL IN BOTTOM OF THE
STRUCTURE
#  75 Block-block   79 - 144
   79  144  0  1  1  0  1  1  0  0
    1          1
    -1        8.08000E-03
#  76 Block-block   80 - 145
   80  145  0  1  1  0  1  1  0  0
    1          1
    -1        1.22800E-02
#  77 Block-block   81 - 146
   81  146  0  1  1  0  1  1  0  0
    1          1
    -1        6.64000E-03
#  78 Block-block   82 - 147
   82  147  0  1  1  0  1  1  0  0
    1          1
    -1        5.00100E-02
#  79 Block-block   83 - 148
   83  148  0  1  1  0  1  1  0  0
    1          1
    -1        3.33700E-02
# WITHIN LEFT WALL OF THE STRUCTURE (TRANSVERSE TO THE MAIN AXIS OF
TUNNEL)
#  80 Block-block   84 - 85
   84  85  0  1  1  1  1  1  0  0
    1          1
    1        1.80000E-03
#  81 Block-block   85 - 86
   85  86  0  1  1  1  1  1  0  0
    1          1
    1        1.80000E-03
#  82 Block-block   87 - 88
   87  88  0  1  1  1  1  1  0  0
    1          1
    1        2.88000E-03
#  83 Block-block   88 - 89
   88  89  0  1  1  1  1  1  0  0
    1          1
```

```
    1        2.88000E-03
#  84 Block-block   90 - 91
   90  91  0  1  1  1  1  1  0  0
    1          1
    1        1.31000E-03
#  85 Block-block   91 - 92
   91  92  0  1  1  1  1  1  0  0
    1          1
    1        1.31000E-03
#  86 Block-block   93 - 94
   93  94  0  1  1  1  1  1  0  0
    1          1
    1        2.62000E-03
#  87 Block-block   94 - 95
   94  95  0  1  1  1  1  1  0  0
    1          1
    1        2.62000E-03
#  88 Block-block   96 - 97
   96  97  0  1  1  1  1  1  0  0
    1          1
    1        1.41000E-03
#  89 Block-block   97 - 98
   97  98  0  1  1  1  1  1  0  0
    1          1
    1        1.41000E-03
# WITHIN LEFT WALL OF THE STRUCTURE (ALONG THE MAIN AXIS OF TUNNEL)
#  90 Block-block   84 - 87
#  91 Block-block   85 - 88
#  92 Block-block   86 - 89
#  93 Block-block   87 - 90
#  94 Block-block   88 - 91
#  95 Block-block   89 - 92
#  96 Block-block   90 - 93
#  97 Block-block   91 - 94
#  98 Block-block   92 - 95
#  99 Block-block   93 - 96
#  100 Block-block   94 - 97
#  101 Block-block   95 - 98
# BETWEEN LEFT WALL OF THE STRUCTURE AND GRAVEL ON LEFT SIDE OF THE
STRUCTURE
#  102 Block-block   86 - 149
   86  149  0  1  1  1  1  1  0  0
    1          1
    1        1.80000E-03
#  103 Block-block   89 - 150
   89  150  0  1  1  1  1  1  0  0
    1          1
    1        2.88000E-03
#  104 Block-block   92 - 151
   92  151  0  1  1  1  1  1  0  0
    1          1
    1        1.31000E-03
#  105 Block-block   95 - 152
   95  152  0  1  1  1  1  1  0  0
    1          1
    1        2.62000E-03
#  106 Block-block   98 - 153
   98  153  0  1  1  1  1  1  0  0
    1          1
    1        1.41000E-03
# WITHIN RIGHT WALL OF THE STRUCTURE (TRANSVERSE TO THE MAIN AXIS OF
TUNNEL)
#  107 Block-block   99 - 100
   99  100  0  1  1  1  1  1  0  0
```

```
    1           1
    -1        5.50000E-04
#  108 Block-block   100 - 101
   100  101  0  1  1  1  1  1  0  0
    1           1
    -1        5.50000E-04
#  109 Block-block   102 - 103
   102  103  0  1  1  1  1  1  0  0
    1           1
    -1        6.80000E-04
#  110 Block-block   103 - 104
   103  104  0  1  1  1  1  1  0  0
    1           1
    -1        6.80000E-04
#  111 Block-block   105 - 106
   105  106  0  1  1  1  1  1  0  0
    1           1
    1        3.90000E-04
#  112 Block-block   106 - 107
   106  107  0  1  1  1  1  1  0  0
    1           1
    1        3.90000E-04
#  113 Block-block   108 - 109
   108  109  0  1  1  1  1  1  0  0
    1           1
    1        2.65000E-03
#  114 Block-block   109 - 110
   109  110  0  1  1  1  1  1  0  0
    1           1
    1        2.65000E-03
#  115 Block-block   111 - 112
   111  112  0  1  1  1  1  1  0  0
    1           1
    -1        1.00000E-05
#  116 Block-block   112 - 113
   112  113  0  1  1  1  1  1  0  0
    1           1
    -1        1.00000E-05
# WITHIN RIGHT WALL OF THE STRUCTURE (ALONG THE MAIN AXIS OF TUNNEL)
#  117 Block-block   99 - 102
#  118 Block-block   100 - 103
#  119 Block-block   101 - 104
#  120 Block-block   102 - 105
#  121 Block-block   103 - 106
#  122 Block-block   104 - 107
#  123 Block-block   105 - 108
#  124 Block-block   106 - 109
#  125 Block-block   107 - 110
#  126 Block-block   108 - 111
#  127 Block-block   109 - 112
#  128 Block-block   110 - 113
#  BETWEEN RIGHT WALL OF THE STRUCTURE AND GRAVEL ON RIGHT SIDE OF THE
STRUCTURE
#  129 Block-block   101 - 154
   101  154  0  1  1  1  1  1  0  0
    1           1
    -1        5.50000E-04
#  130 Block-block   104 - 155
   104  155  0  1  1  1  1  1  0  0
    1           1
    -1        6.80000E-04
#  131 Block-block   107 - 156
   107  156  0  1  1  1  1  1  0  0
    1           1
```

```
    1        3.90000E-04
#  132 Block-block   110 - 157
   110  157  0  1  1  1  1  1  0  0
    1           1
    1        2.65000E-03
#  133 Block-block   113 - 158
   113  158  0  1  1  1  1  1  0  0
    1           1
    -1        1.00000E-05
#  WITHIN SHORT SIDE OF THE STRUCTURE (LOADING ZONE)
#  134 Block-block   123 - 124
   123  124  0  1  2  2  1  1  0  0
    1           1
    1        5.60700E-02
#  135 Block-block   124 - 125
   124  125  0  1  2  2  1  1  0  0
    1           1
    1        5.60700E-02
#  BETWEEN SHORT SIDE OF THE STRUCTURE (LOADING ZONE) AND
#  GRAVEL AT THE SHORT SIDE OF THE STRUCTURE (LOADING ZONE)
#  136 Block-block   125 - 159
   125  159  0  1  2  1  1  1  0  0
    1           1
    1        5.60700E-02
#  WITHIN GRAVEL AT THE SHORT SIDE OF THE STRUCTURE (LOADING ZONE)
#  137 Block-block   126 - 127
   126  127  0  1  2  2  1  1  0  0
    1           1
    1        3.37910E-01
#  138 Block-block   127 - 128
   127  128  0  1  2  2  1  1  0  0
    1           1
    1        2.75740E-01
#  BETWEEN GRAVEL AT THE SHORT SIDE OF THE STRUCTURE (PASSAGE)
# AND GRAVEL ON TOP OF STRUCTURE
#  139 Block-block   126 - 129
   126  129  0  1  0  2  1  1  0  0
    1           1
    -1        4.69933E-02
#  140 Block-block   126 - 130
   126  130  0  1  0  2  1  1  0  0
    1           1
    -1        4.69933E-02
#  141 Block-block   126 - 131
   126  131  0  1  0  2  1  1  0  0
    1           1
    -1        4.69933E-02
#  BETWEEN GRAVEL AT THE SHORT SIDE OF THE STRUCTURE (PASSAGE)
# AND GRAVEL IN BOTTOM OF STRUCTURE
#  142 Block-block   126 - 144
   126  144  0  1  0  2  1  1  0  0
    1           1
    -1        1.48180E-01
#  BETWEEN GRAVEL AT THE SHORT SIDE OF THE STRUCTURE (PASSAGE)
# AND GRAVEL ON LEFT SIDE OF STRUCTURE
#  143 Block-block   126 - 149
   126  149  0  1  0  2  1  1  0  0
    1           1
    -1        4.18900E-02
#  BETWEEN GRAVEL AT THE SHORT SIDE OF THE STRUCTURE (PASSAGE)
# AND GRAVEL ON RIGHT SIDE OF STRUCTURE
#  144 Block-block   126 - 154
   126  154  0  1  0  2  1  1  0  0
    1           1
```

```
    -1        6.64600E-02
# WITHIN GRAVEL ON TOP OF THE STRUCTURE (TRANSVERSE TO THE MAIN AXIS
OF TUNNEL)
#  145 Block-block   129 - 130
   129  130  0  1  0  0  1  1  0  0
    1           1
    1        1.10247E+00
#  146 Block-block   130 - 131
   130  131  0  1  0  0  1  1  0  0
    1           1
    1        1.21367E+00
#  147 Block-block   132 - 133
   132  133  0  1  0  0  1  1  0  0
    1           1
    1        1.51314E+00
#  148 Block-block   133 - 134
   133  134  0  1  0  0  1  1  0  0
    1           1
    1        1.53118E+00
#  149 Block-block   135 - 136
   135  136  0  1  0  0  1  1  0  0
    1           1
    1        8.12880E-01
#  150 Block-block   136 - 137
   136  137  0  1  0  0  1  1  0  0
    1           1
    1        7.39800E-01
#  151 Block-block   138 - 139
   138  139  0  1  0  0  1  1  0  0
    1           1
    1        1.43958E+00
#  152 Block-block   139 - 140
   139  140  0  1  0  0  1  1  0  0
    1           1
    1        1.15865E+00
#  153 Block-block   141 - 142
   141  142  0  1  0  0  1  1  0  0
    1           1
    1        6.94280E-01
#  154 Block-block   142 - 143
   142  143  0  1  0  0  1  1  0  0
    1           1
    1        6.21860E-01
# WITHIN GRAVEL ON TOP OF THE STRUCTURE (ALONG THE MAIN AXIS OF
TUNNEL)
#  155 Block-block   129 - 132
   129  132  0  1  2  2  1  1  0  0
    1           1
    -1        2.65263E-01
#  156 Block-block   130 - 133
   130  133  0  1  2  2  1  1  0  0
    1           1
    -1        2.65263E-01
#  157 Block-block   131 - 134
   131  134  0  1  2  2  1  1  0  0
    1           1
    -1        2.65263E-01
#  158 Block-block   132 - 135
   132  135  0  1  2  2  1  1  0  0
    1           1
    -1        4.05833E-01
#  159 Block-block   133 - 136
   133  136  0  1  2  2  1  1  0  0
    1           1
```

```
    -1        4.05833E-01
#  160 Block-block   134 - 137
   134  137  0  1  2  2  1  1  0  0
    1           1
    -1        4.05833E-01
#  161 Block-block   135 - 138
   135  138  0  1  2  2  1  1  0  0
    1           1
    -1        3.84400E-01
#  162 Block-block   136 - 139
   136  139  0  1  2  2  1  1  0  0
    1           1
    -1        3.84400E-01
#  163 Block-block   137 - 140
   137  140  0  1  2  2  1  1  0  0
    1           1
    -1        3.84400E-01
#  164 Block-block   138 - 141
   138  141  0  1  2  2  1  1  0  0
    1           1
    -1        1.57043E-01
#  165 Block-block   139 - 142
   139  142  0  1  2  2  1  1  0  0
    1           1
    -1        1.57043E-01
#  166 Block-block   140 - 143
   140  143  0  1  2  2  1  1  0  0
    1           1
    -1        1.57043E-01
# BETWEEN GRAVEL ON TOP OF THE STRUCTURE AND GRAVEL ON LEFT SIDE OF
THE STRUCTURE
#  167 Block-block   129 - 149
   129  149  0  1  1  0  1  1  0  0
    1           1
    -1        4.03150E-01
#  168 Block-block   132 - 150
   132  150  0  1  1  0  1  1  0  0
    1           1
    -1        6.14810E-01
#  169 Block-block   135 - 151
   135  151  0  1  1  0  1  1  0  0
    1           1
    -1        4.30680E-01
#  170 Block-block   138 - 152
   138  152  0  1  1  0  1  1  0  0
    1           1
    -1        9.63450E-01
#  171 Block-block   141 - 153
   141  153  0  1  1  0  1  1  0  0
    1           1
    -1        2.92440E-01
# BETWEEN GRAVEL ON TOP OF THE STRUCTURE AND GRAVEL ON RIGHT SIDE OF
THE STRUCTURE
#  172 Block-block   129 - 154
   129  154  0  1  1  0  1  1  0  0
    1           1
    -1        5.81670E-01
#  173 Block-block   132 - 155
   132  155  0  1  1  0  1  1  0  0
    1           1
    -1        8.69890E-01
#  174 Block-block   135 - 156
   135  156  0  1  1  0  1  1  0  0
    1           1
```

```
    -1        4.49320E-01
#  175 Block-block   138 - 157
   138  157  0  1  1  0  1  1  0  0
    1           1
    -1        7.44810E-01
#  176 Block-block   141 - 158
   141  158  0  1  1  0  1  1  0  0
    1           1
    -1        4.69360E-01
# WITHIN GRAVEL IN BOTTOM OF THE STRUCTURE (ALONG THE MAIN AXIS OF
TUNNEL)
#  177 Block-block   144 - 145
   144  145  0  1  2  2  1  1  0  0
    1           1
    -1        1.72350E-01
#  178 Block-block   145 - 146
   145  146  0  1  2  2  1  1  0  0
    1           1
    -1        3.55690E-01
#  179 Block-block   146 - 147
   146  147  0  1  2  2  1  1  0  0
    1           1
    -1        6.64060E-01
#  180 Block-block   147 - 148
   147  148  0  1  2  2  1  1  0  0
    1           1
    1        7.55000E-03
# BETWEEN GRAVEL IN BOTTOM OF THE STRUCTURE AND GRAVEL ON LEFT SIDE OF
THE STRUCTURE
#  181 Block-block   144 - 149
   144  149  0  1  1  0  1  1  0  0
    1           1
    1        4.55150E-01
#  182 Block-block   145 - 150
   145  150  0  1  1  0  1  1  0  0
    1           1
    1        6.66360E-01
#  183 Block-block   146 - 151
   146  151  0  1  1  0  1  1  0  0
    1           1
    1        3.98290E-01
#  184 Block-block   147 - 152
   147  152  0  1  1  0  1  1  0  0
    1           1
    1        1.46270E+00
#  185 Block-block   148 - 153
   148  153  0  1  1  0  1  1  0  0
    1           1
    1        3.62560E-01
# BETWEEN GRAVEL IN BOTTOM OF THE STRUCTURE AND GRAVEL ON RIGHT SIDE
OF THE STRUCTURE
#  186 Block-block   144 - 154
   144  154  0  1  1  0  1  1  0  0
    1           1
    1        4.22130E-01
#  187 Block-block   145 - 155
   145  155  0  1  1  0  1  1  0  0
    1           1
    1        6.04260E-01
#  188 Block-block   146 - 156
   146  156  0  1  1  0  1  1  0  0
    1           1
    1        3.63810E-01
#  189 Block-block   147 - 157
```

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   147  157  0  1  1  0  1  1  0  0
    1           1
    1        7.77490E-01
#  190 Block-block   148 - 158
   148  158  0  1  1  0  1  1  0  0
    1           1
    1        8.29070E-01
# WITHIN GRAVEL ON LEFT SIDE OF THE STRUCTURE (ALONG THE MAIN AXIS OF
TUNNEL)
#  191 Block-block   149 - 150
   149  150  0  1  2  2  1  1  0  0
    1           1
    -1        1.43020E-01
#  192 Block-block   150 - 151
   150  151  0  1  2  2  1  1  0  0
    1           1
    -1        2.58300E-01
#  193 Block-block   151 - 152
   151  152  0  1  2  2  1  1  0  0
    1           1
    -1        3.57620E-01
#  194 Block-block   152 - 153
   152  153  0  1  2  2  1  1  0  0
    1           1
    1        7.27600E-02
# WITHIN GRAVEL ON RIGHT SIDE OF THE STRUCTURE (ALONG THE MAIN AXIS OF
TUNNEL)
#  195 Block-block   154 - 155
   154  155  0  1  2  2  1  1  0  0
    1           1
    -1        1.45700E-01
#  196 Block-block   155 - 156
   155  156  0  1  2  2  1  1  0  0
    1           1
    -1        2.46590E-01
#  197 Block-block   156 - 157
   156  157  0  1  2  2  1  1  0  0
    1           1
    -1        2.85300E-01
#  198 Block-block   157 - 158
   157  158  0  1  2  2  1  1  0  0
    1           1
    -1        1.69700E-01
#  WITHIN GRAVEL AT THE SHORT SIDE OF THE STRUCTURE (LOADING ZONE)
#  199 Block-block   159 - 160
   159  160  0  1  2  2  1  1  0  0
    1           1
    1        7.72467E-01
#  200 Block-block   160 - 161
   160  161  0  1  2  2  1  1  0  0
    1           1
    1        5.22983E-01
#  BETWEEN GRAVEL AT THE SHORT SIDE OF THE STRUCTURE (LOADING ZONE)
# AND GRAVEL ON TOP OF STRUCTURE
#  201 Block-block   159 - 141
   159  141  0  1  0  2  1  1  0  0
    1           1
    1        1.29990E-01
#  202 Block-block   159 - 142
   159  142  0  1  0  2  1  1  0  0
    1           1
    1        1.29990E-01
#  203 Block-block   159 - 143
   159  143  0  1  0  2  1  1  0  0
```

```
    1          1
    1        1.29990E-01
#  BETWEEN GRAVEL AT THE SHORT SIDE OF THE STRUCTURE (LOADING ZONE)
# AND GRAVEL IN BOTTOM OF STRUCTURE
#  204 Block-block   159 - 148
   159  148  0  1  0  2  1  1  0  0
    1          1
    -1        1.02140E+00
#  BETWEEN GRAVEL AT THE SHORT SIDE OF THE STRUCTURE (LOADING ZONE)
# AND GRAVEL ON LEFT SIDE OF STRUCTURE
#  205 Block-block   159 - 153
   159  153  0  1  0  2  1  1  0  0
    1          1
    -1        9.88600E-02
#  BETWEEN GRAVEL AT THE SHORT SIDE OF THE STRUCTURE (LOADING ZONE)
# AND GRAVEL ON RIGHT SIDE OF STRUCTURE
#  206 Block-block   159 - 158
   159  158  0  1  0  2  1  1  0  0
    1          1
    -1        2.35590E-01
```

```
#  1BTF CALCULATIONS
#  Problem Codification: BS2
#  Nuclide(s): C-14 org
#
#  Problem Description:
# PROPER VERSION INPUT DATA FORMAT #
#
#  ITYPE  NGROUP  NSINKS  IWFLOW  NSOURC  NBSIZE  ISPSOL
   1      1       0       1       50      0       0
#
#  Flow stream conditions
#  NINFLW    NUTFLW      % if IWFLOW = 1
   36        11
#
#  Inflow conditions (one line per inflow)
#  QINFW                  NBWIN    NBNWIN    % if IWFLOW = 1
   0.0567066666666667     126      1
   0.0567066666666667     127      1
   0.120536666666667      128      1
   0.0629053333333333     129      1
   0.0629053333333333     130      1
   0.0629053333333333     131      1
   0.517870333333333      132      1
   0.517870333333333      133      1
   0.517870333333333      134      1
   0.510755333333334      135      1
   0.510763333333333      136      1
   0.510763333333333      137      1
   0.0292863333333333     138      1
   0.0292863333333333     139      1
   0.0292863333333333     140      1
   0.0315293333333333     141      1
   0.0315293333333333     142      1
   0.0315293333333333     143      1
   0.488112               144      1
   0.603498               145      1
   0.469099               146      1
   0.218313               147      1
   0.413202               148      1
   0.116626666666667      159      1
   0.116626666666667      160      1
   0.129276666666667      161      1
   0.091684               163      1
   0.131073               165      1
   0.027931               167      1
   0.028474               169      1
   0.052161               171      1
   0.067122               173      1
   0.020592               175      1
   0.144678               177      1
   0.042487               179      1
   0.054792               181      1
#
#  Outflow conditions (one line per inflow)
#  QUTFW                  NBWOUT   NBNWOUT     % if IWFLOW = 1
   0.00324                126      1
   0.00324                127      1
   0.00324                128      1
   0.189676               131      1
   3.695231               134      1
   2.35931                137      1
   0.097219               140      1
   0.295508               143      1
```

```
   0.0866966666666667     159      1
   0.0866966666666667     160      1
   0.0866966666666667     161      1
#
# Number of blocks connections and materials
#  NBLOCK    NBCOUP    NMAT
   195       289       9
#
#  Data on materials (one line per material)
#  Material 1 = Waste tankar
#  Material 2 = Construction concrete
#  Material 3 = Water
#  Material 4 = Gravel
#  Material 5 = Porous concrete
#  Material 6 = Waste drums
#  Material 7 = Waste "Berglofslador"
#  Material 8 = Concrete moulds including waste
#  Material 9 = Cement between inner and outer drums
#  MAT        DENSM        PORM
   1          2250.0       0.633
   2          2529.4       0.150
   3          1000.0       1.000
   4          2700.0       0.300
   5          2625.0       0.200
   6          2250.0       0.095
   7          2250.0       0.098
   8          2250.0       0.248
   9          2250.0       0.200
#
#  Data on time series
#  TINIT     AGEO      RAT      TEND      NTERM     LREAD
   0.00      0.50      1.23     1000.00   90        0
#
#  Data on numerical parameters
#  EPS       EWT       NLOOP      MSPAR
   1.00E-06  1.00E-18  3          1
#
#  Data on group (one set of data per group common for all sources)
#
# Group No: 1
#  NNCH    ISPEC    ISPSOL
   1       1        0
#
# Nuclide: C-14 org
#  TAU        CSOLUB      AINV
   5.7300E+03 1.00E+10    7.7519E-02
#
#  CIRF                                % if ISPEC = 1
#
#  MAT       DEFM       SKDM             % one line per material
   1         0.06307    0.000
   2         0.00032    0.000
   3         0.06307    0.000
   4         0.01892    0.000
   5         0.00315    0.000
   6         0.06307    0.000
   7         0.06307    0.000
   8         0.00032    0.000
   9         0.00315    0.000
#
#  Data on sources
#  NSBCHA  ISEQ  MAT  IFWATB  VOLSOU  FINVEN  JINVEN
#
#  IBLOCK    ISSEQ         % if ISEQ = 1
```

```
#
#  XXX                     % if JINVEN = 1. One line for each group.
#
#  IBSOUR                  % if ISEQ = 0
#
#  IWINT                   % if IFWATB = 1
#
#  WBFLOW                  % if IFWATB = 1 and IWINT = 0
#
#
#  Waste
#  Source    1
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  1
#  Source    2
  1  0  1  1  336.0000  1.0000000E+00  1
#
  1.0174918E-02
  2
  0
  5.591650E-01
#  Source    3
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  3
#  Source    4
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  4
#  Source    5
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  5
#  Source    6
  1  0  6  1  680.2950  1.0000000E+00  1
#
  0.0000000E+00
  6
  0
  5.591650E-01
#  Source    7
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  7
#  Source    8
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  8
#  Source    9
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  9
#  Source    10
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  10
```

```
#  Source    11
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  11
#  Source    12
  1  0  1  1  570.0000  1.0000000E+00  1
#
  4.1078860E-03
  12
  0
  5.858700E-01
#  Source    13
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  13
#  Source    14
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  14
#  Source    15
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  15
#  Source    16
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  16
#  Source    17
  1  0  7  1  4.9211  1.0000000E+00  1
#
  8.5549378E-02
  17
  0
  5.858700E-01
#  Source    18
  1  0  7  1  4.9211  1.0000000E+00  1
#
  8.5549378E-02
  18
  0
  5.858700E-01
#  Source    19
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  19
#  Source    20
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  20
#  Source    21
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  21
#  Source    22
  1  0  1  1  570.0000  1.0000000E+00  1
#
```

```
  4.1078860E-03
  22
  0
  6.387300E-01
#  Source    23
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  23
#  Source    24
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
#  24
#  Source    25
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  25
#  Source    26
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00

  26
#  Source    27
  1  0  7  1  4.9211  1.0000000E+00  1
#
  8.5549378E-02
  27
  0
  6.387300E-01
#  Source    28
  1  0  7  1  4.9211  1.0000000E+00  1
#
  8.5549378E-02
  28
  0
  6.387300E-01
#  Source    29
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  29
#  Source    30
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  30
#  Source    31
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  31
#  Source    32
  1  0  1  1  612.0000  1.0000000E+00  1
#
  4.4502098E-03
  32
  0
  5.420300E-01
#  Source    33
  1  0  1  0  0.0010  1.0000000E+00  1
#
```

```
  0.0000000E+00
  33
#  Source    34
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  34
#  Source    35
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  35
#  Source    36
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  36
#  Source    37
  1  0  7  1  5.2105  1.0000000E+00  1
#
  9.0581694E-02
  37
  0
  5.420300E-01
#  Source    38
  1  0  7  1  5.2105  1.0000000E+00  1
#
  9.0581694E-02
  38
  0
  5.420300E-01
#  Source    39
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  39
#  Source    40
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  40
#  Source    41
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  41
#  Source    42
  1  0  1  1  1518.0000  1.0000000E+00  1
#
  1.0954363E-02
  42
  0
  7.311550E-01
#  Source    43
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  43
#  Source    44
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  44
#  Source    45
```

```
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  45
#  Source    46
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  46
#  Source    47
  1  0  7  1  12.7368  1.0000000E+00  1
#
  2.2142192E-01
  47
  0
  7.311550E-01
#  Source    48
  1  0  7  1  12.7368  1.0000000E+00  1
#
  2.2142192E-01
  48
  0
  7.311550E-01
#  Source    49
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  49
#  Source    50
  1  0  1  0  0.0010  1.0000000E+00  1
#
  0.0000000E+00
  50
#  Description of blocks not considered before
#
#  Block i
#  NZ   NY    NX    NBLSP    MAT    IQFLOW
#
#  ZADIM  YADIM  XADIM  VOLBLK % one line per compartment if NBLSP = 1
#
#  IWINT                        % if IQFLOW = 1
#
#  NODWIN   NODWUT    BFLOW    % if IQFLOW = 1 and IWINT = 0
#
#  Walls of concrete tanks  51-55 and 118-122
#  Block   51
  1  1  1  0  2  1
  1.0000E+05     2.4351E-04      1.8013E-04      1.1200E+02
  0
  1              1            0.559165
#
#  Block   52
  1  1  1  0  2  1
  1.0000E+05     1.4354E-04      1.0618E-04      1.9000E+02
  0
  1              1            0.58587
#
#  Block   53
  1  1  1  0  2  1
  1.0000E+05     1.4354E-04      1.0618E-04      1.9000E+02
  0
  1              1            0.63873
#
#  Block   54
```

```
  1  1  1  0  2  1
  1.0000E+05     1.3369E-04      9.8896E-05      2.0400E+02
  0
  1              1            0.54203
#
#  Block   55
  1  1  1  0  2  1
  1.0000E+05     5.3899E-05      3.9871E-05      5.0600E+02
  0
  1              1            0.731155
# Kringgjutningsbetong
#  Block   56
  1  1  1  0  5  1
  4.3447E-06     1.4402E-04      3.7185E-05      5.5072E+02
  1
#
#  Block   57
  1  1  1  0  5  1
  2.1793E-04     6.0585E-04      3.6026E-05      2.0819E+02
  1
#
#  Block   58
  1  1  1  0  5  1
  2.1793E-04     6.0585E-04      3.6026E-05      2.0819E+02
  1
#
#  Block   59
  1  1  1  0  5  1
  2.0117E-04     5.5925E-04      3.3553E-05      2.2554E+02
  1
#
#  Block   60
  1  1  1  0  5  1
  8.1725E-05     2.2719E-04      1.3527E-05      5.5519E+02
  1
# Short side of structure (passage)
#  Block   61
  1  1  1  0  2  1
  1.0000E+05     3.3307E-03      3.1010E-03      2.0155E+01
  0
  1              1            0.0812
#
#  Block   62
  1  1  1  0  2  1
  1.0000E+05     3.1010E-03      3.1010E-03      2.0155E+01
  0
  1              1            0.0812
# Fiktivt block 63
#  Block   63
  1  1  1  0  3  1
  1.0000E-05     1.0000E-05      1.0000E-05      1.0000E-02
  0
  1              1            0.0812
#  Ceiling
#  Block   64
  1  1  1  0  2  1
  2.4244E+00     2.2051E-04      2.2308E-04      7.9693E+01
  0
  1              1            0.47797
#
#  Block   65
  1  1  1  0  2  1
  2.4244E+00     2.2051E-04      1.0000E+05      7.9693E+01
  0
```

```
  1              1            0.47797
#
#  Block   66
  1  1  1  0  2  1
  2.4244E+00     2.2051E-04      1.0000E+05      7.9693E+01
  0
  1              1            0.47797
#
#  Block   67
  1  1  1  0  2  1
  3.1027E+00     1.1419E-03      1.1419E-03      6.2272E+01
  0
  1              1            0.44204
#
#  Block   68
  1  1  1  0  2  1
  3.1027E+00     1.1419E-03      1.0000E+05      6.2272E+01
  0
  1              1            0.44204
#
#  Block   69
  1  1  1  0  2  1
  3.1027E+00     1.1419E-03      1.0000E+05      6.2272E+01
  0
  1              1            0.44204
#
#  Block   70
  1  1  1  0  2  1
  3.1027E+00     1.1419E-03      1.1419E-03      6.2272E+01
  0
  1              1            0.36708
#
#  Block   71
  1  1  1  0  2  1
  3.1027E+00     1.1419E-03      1.0000E+05      6.2272E+01
  0
  1              1            0.36708
#
#  Block   72
  1  1  1  0  2  1
  3.1027E+00     1.1419E-03      1.0000E+05      6.2272E+01
  0
  1              1            0.36708
#
#  Block   73
  1  1  1  0  2  1
  2.8640E+00     1.0541E-03      1.0541E-03      6.7461E+01
  0
  1              1            0.24072
#
#  Block   74
  1  1  1  0  2  1
  2.8640E+00     1.0541E-03      1.0000E+05      6.7461E+01
  0
  1              1            0.24072
#
#  Block   75
  1  1  1  0  2  1
  2.8640E+00     1.0541E-03      1.0000E+05      6.7461E+01
  0
  1              1            0.24072
#
#  Block   76
  1  1  1  0  2  1
```

```
  1.1635E+00     4.2350E-04      4.2823E-04      1.6606E+02
  0
  1              1            0.36594
#
#  Block   77
  1  1  1  0  2  1
  1.1635E+00     4.2350E-04      1.0000E+05      1.6606E+02
  0
  1              1            0.36594
#
#  Block   78
  1  1  1  0  2  1
  1.1635E+00     4.2350E-04      1.0000E+05      1.6606E+02
  0
  1              1            0.36594
#  Bottom of structure 79-83 and 182-191
#  Block   79
  1  1  1  0  2  1
  2.2989E-02     2.0851E-04      2.2308E-04      8.5260E+01
  1
#
#  Block   80
  1  1  1  0  2  1
  5.9524E-02     5.3990E-04      5.7097E-04      3.2928E+01
  1
#
#  Block   81
  1  1  1  0  2  1
  5.9524E-02     5.3990E-04      5.7097E-04      3.2928E+01
  1
#
#  Block   82
  1  1  1  0  2  1
  5.4945E-02     4.9837E-04      5.2705E-04      3.5672E+01
  1
#
#  Block   83
  1  1  1  0  2  1
  2.2075E-02     2.0023E-04      2.1411E-04      8.8788E+01
  1
# Fictitious block 84-113
#  Block   84
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.08172
#
#  Block   85
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.08172
#
#  Block   86
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.08172
#
#  Block   87
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.04921
```

```
#
#  Block   88
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.04921
#
#  Block   89
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.04921
#
#  Block   90
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.02749
#
#  Block   91
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.02749
#
#  Block   92
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.02749
#
#  Block   93
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.02734
#
#  Block   94
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.02734
#
#  Block   95
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.02734
#
#  Block   96
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.04747
#
#  Block   97
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.04747
#
#  Block   98
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
```

```
  0
  1              1             0.04747
# Fictitious block (Wall on right side of structure) 99-113
#  Block   99
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#
#  Block   100
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#
#  Block   101
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#
#  Block   102
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#
#  Block   103
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#
#  Block   104
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#
#  Block   105
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#
#  Block   106
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#
#  Block   107
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#
#  Block   108
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#
#  Block   109
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#
#  Block   110
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#
#  Block   111
```

```
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#
#  Block   112
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#
#  Block   113
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
# Fictiotious block 114-117
#  Block   114
  1  1  1  0  3  1
  1.0000E+05     1.0000E+05      1.0000E+05      1.0000E-02
  0
  1              1            0.00536
#
#  Block   115
  1  1  1  0  3  1
  1.0000E+05     1.0000E+05      1.0000E+05      1.0000E-02
  0
  1              1            0.13847
#
#  Block   116
  1  1  1  0  3  1
  1.0000E+05     1.0000E+05      1.0000E+05      1.0000E-02
  0
  1              1            0.27165
#
#  Block   117
  1  1  1  0  3  1
  1.0000E+05     1.0000E+05      1.0000E+05      1.0000E-02
  0
  1              1            0.30131
# Walls of conrete tanks 118-122
#  Block   118
  1  1  1  0  2  1
  1.0000E+05     2.4351E-04      1.8013E-04      1.1200E+02
  0
  1              1            0.559165
#
#  Block   119
  1  1  1  0  2  1
  1.0000E+05     1.4354E-04      1.0618E-04      1.9000E+02
  0
  1              1            0.58587
#
#  Block   120
  1  1  1  0  2  1
  1.0000E+05     1.4354E-04      1.0618E-04      1.9000E+02
  0
  1              1            0.63873
#
#  Block   121
  1  1  1  0  2  1
  1.0000E+05     1.3369E-04      9.8896E-05      2.0400E+02
  0
  1              1            0.54203
#
#  Block   122
  1  1  1  0  2  1
```

```
  1.0000E+05     5.3899E-05      3.9871E-05      5.0600E+02
  0
  1              1            0.731155
# Short side of structure (loading zone)
#  Block   123
  1  1  1  0  2  1
  1.0000E+05     3.5971E-03      3.1010E-03      2.0155E+01
  0
  1              1            0.36522
#
#  Block   124
  1  1  1  0  2  1
  1.0000E+05     3.1010E-03      3.1010E-03      2.0155E+01
  0
  1              1            0.36522
# Fictitious block 125
#  Block   125
  1  1  1  0  3  1
  1.0000E+05     1.0000E+05      1.0000E+05      1.0000E-02
  0
  1              1            0.36522
# Gravel at the end of the tunnel (passage) 126-128
#  Block   126
  1  1  1  0  4  1
  1.4506E-01     1.6538E-02      1.0829E-02      1.6417E+02
  1
#
#  Block   127
  1  1  1  0  4  1
  1.0000E+05     1.0000E+05      1.0829E-02      1.6417E+02
  1
#
#  Block   128
  1  1  1  0  4  1
  1.0000E+05     1.0000E+05      1.0829E-02      1.6417E+02
  1
# Gravel on top of the structure 129-143
#  Block   129
  1  1  1  0  4  1
  9.7785E-04     1.0781E-01      4.7325E+00      3.9984E+02
  1
#
#  Block   130
  1  1  1  0  4  1
  9.7785E-04     1.0000E+05      4.7325E+00      3.9984E+02
  1
#
#  Block   131
  1  1  1  0  4  1
  9.7785E-04     1.0000E+05      4.7325E+00      3.9984E+02
  1
#
#  Block   132
  1  1  1  0  4  1
  2.5319E-03     2.7914E-01      1.8277E+00      1.5442E+02
  1
#
#  Block   133
  1  1  1  0  4  1
  2.5319E-03     1.0000E+05      1.8277E+00      1.5442E+02
  1
#
#  Block   134
  1  1  1  0  4  1
```

```
  2.5319E-03     1.0000E+05      1.8277E+00      1.5442E+02
  1
#
#  Block   135
  1  1  1  0  4  1
  2.5319E-03     2.7914E-01      1.8277E+00      1.5442E+02
  1
#
#  Block   136
  1  1  1  0  4  1
  2.5319E-03     1.0000E+05      1.8277E+00      1.5442E+02
  1
#
#  Block   137
  1  1  1  0  4  1
  2.5319E-03     1.0000E+05      1.8277E+00      1.5442E+02
  1
#
#  Block   138
  1  1  1  0  4  1
  2.3372E-03     2.5767E-01      1.9801E+00      1.6729E+02
  1
#
#  Block   139
  1  1  1  0  4  1
  2.3372E-03     1.0000E+05      1.9801E+00      1.6729E+02
  1
#
#  Block   140
  1  1  1  0  4  1
  2.3372E-03     1.0000E+05      1.9801E+00      1.6729E+02
  1
#
#  Block   141
  1  1  1  0  4  1
  9.3899E-04     1.0352E-01      4.9284E+00      4.1638E+02
  1
#
#  Block   142
  1  1  1  0  4  1
  9.3899E-04     1.0000E+05      4.9284E+00      4.1638E+02
  1
#
#  Block   143
  1  1  1  0  4  1
  9.3899E-04     1.0000E+05      4.9284E+00      4.1638E+02
  1
# Gravel in bottom of tunnel 144-148
#  Block   144
  1  1  1  0  4  1
  4.6915E-04     1.0000E+05      9.7506E+00      1.9184E+02
  1
#
#  Block   145
  1  1  1  0  4  1
  1.2148E-03     1.0000E+05      3.8095E+00      7.4088E+01
  1
#
#  Block   146
  1  1  1  0  4  1
  1.2148E-03     1.0000E+05      3.8095E+00      7.4088E+01
  1
#
#  Block   147
```

```
  1  1  1  0  4  1
  1.1213E-03     1.0000E+05      4.1270E+00      8.0262E+01
  1
#
#  Block   148
  1  1  1  0  4  1
  4.5051E-04     1.0000E+05      1.0159E+01      1.9977E+02
  1
# Concrete on left side 149-153 and 162-171
#  Block   149
  1  1  1  0  5  1
  1.0000E+00     5.2847E-04      5.5603E+01      3.3640E+01
  1
#
#  Block   150
  1  1  1  0  5  1
  2.5893E+00     1.3684E-03      2.1724E+01      1.2992E+01
  1
#
#  Block   151
  1  1  1  0  5  1
  2.5893E+00     1.3684E-03      2.1724E+01      1.2992E+01
  1
#
#  Block   152
  1  1  1  0  5  1
  2.3901E+00     1.2631E-03      2.3534E+01      1.4075E+01
  1
#
#  Block   153
  1  1  1  0  5  1
  9.6026E-01     5.0747E-04      5.7931E+01      3.5032E+01
  1
# Concrete on right side 154-158 and 172-181
#  Block   154
  1  1  1  0  5  1
  1.0000E+00     5.2847E-04      5.5603E+01      3.3640E+01
  1
#
#  Block   155
  1  1  1  0  5  1
  2.5893E+00     1.3684E-03      2.1724E+01      1.2992E+01
  1
#
#  Block   156
  1  1  1  0  5  1
  2.5893E+00     1.3684E-03      2.1724E+01      1.2992E+01
  1
#
#  Block   157
  1  1  1  0  5  1
  2.3901E+00     1.2631E-03      2.3534E+01      1.4075E+01
  1
#
#  Block   158
  1  1  1  0  5  1
  9.6026E-01     5.0747E-04      5.7931E+01      3.5032E+01
  1
# Gravel at the end of the tunnel (loading zone) 159-161
#  Block   159
  1  1  1  0  4  1
  5.5848E-01     6.3673E-02      4.1692E-02      6.3204E+02
  1
#
```

```
#  Block   160
  1  1  1  0  4  1
  1.0000E+05     1.0000E+05      4.1692E-02      6.3204E+02
  1
#
#  Block   161
  1  1  1  0  4  1
  1.0000E+05     1.0000E+05      4.1692E-02      6.3204E+02
  1
# Concrete on left side 149-153 and 162-171
#  Block   162
  1  1  1  0  5  1
  1.0000E+05     5.2847E-04      5.5603E+01      3.3640E+01
  1
#
#  Block   163
  1  1  1  0  5  1
  1.0000E+05     5.2847E-04      5.5603E+01      3.3640E+01
  1
#
#  Block   164
  1  1  1  0  5  1
  1.0000E+05     1.3684E-03      2.1724E+01      1.2992E+01
  1
#
#  Block   165
  1  1  1  0  5  1
  1.0000E+05     1.3684E-03      2.1724E+01      1.2992E+01
  1
#
#  Block   166
  1  1  1  0  5  1
  1.0000E+05     1.3684E-03      2.1724E+01      1.2992E+01
  1
#
#  Block   167
  1  1  1  0  5  1
  1.0000E+05     1.3684E-03      2.1724E+01      1.2992E+01
  1
#
#  Block   168
  1  1  1  0  5  1
  1.0000E+05     1.2631E-03      2.3534E+01      1.4075E+01
  1
#
#  Block   169
  1  1  1  0  5  1
  1.0000E+05     1.2631E-03      2.3534E+01      1.4075E+01
  1
#
#  Block   170
  1  1  1  0  5  1
  1.0000E+05     5.0747E-04      5.7931E+01      3.5032E+01
  1
#
#  Block   171
  1  1  1  0  5  1
  1.0000E+05     5.0747E-04      5.7931E+01      3.5032E+01
  1
# Concrete on right side 154-158 and 172-181
#  Block   172
  1  1  1  0  5  1
  1.0000E+05     5.2847E-04      5.5603E+01      3.3640E+01
  1
```

```
#
#  Block   173
  1  1  1  0  5  1
  1.0000E+05     5.2847E-04      5.5603E+01      3.3640E+01
  1
#
#  Block   174
  1  1  1  0  5  1
  1.0000E+05     1.3684E-03      2.1724E+01      1.2992E+01
  1
#
#  Block   175
  1  1  1  0  5  1
  1.0000E+05     1.3684E-03      2.1724E+01      1.2992E+01
  1
#
#  Block   176
  1  1  1  0  5  1
  1.0000E+05     1.3684E-03      2.1724E+01      1.2992E+01
  1
#
#  Block   177
  1  1  1  0  5  1
  1.0000E+05     1.3684E-03      2.1724E+01      1.2992E+01
  1
#
#  Block   178
  1  1  1  0  5  1
  1.0000E+05     1.2631E-03      2.3534E+01      1.4075E+01
  1
#
#  Block   179
  1  1  1  0  5  1
  1.0000E+05     1.2631E-03      2.3534E+01      1.4075E+01
  1
#
#  Block   180
  1  1  1  0  5  1
  1.0000E+05     5.0747E-04      5.7931E+01      3.5032E+01
  1
#
#  Block   181
  1  1  1  0  5  1
  1.0000E+05     5.0747E-04      5.7931E+01      3.5032E+01
  1
#  Bottom of structure 79-83 and 182-191
#  Block   182
  1  1  1  0  2  1
  1.1494E-02     2.0851E-04      2.2194E+01      8.5260E+01
  0
  1              1            0.46813
#
#  Block   183
  1  1  1  0  2  1
  1.1494E-02     2.0851E-04      2.2194E+01      8.5260E+01
  0
  1              1            0.46813
#
#  Block   184
  1  1  1  0  2  1
  2.9762E-02     5.3990E-04      8.5714E+00      3.2928E+01
  0
  1              1            0.570663
#
```

```
#  Block   185
  1  1  1  0  2  1
  2.9762E-02     5.3990E-04      8.5714E+00      3.2928E+01
  0
  1              1            0.570663
#
#  Block   186
  1  1  1  0  2  1
  2.9762E-02     5.3990E-04      8.5714E+00      3.2928E+01
  0
  1              1            0.458716
#
#  Block   187
  1  1  1  0  2  1
  2.9762E-02     5.3990E-04      8.5714E+00      3.2928E+01
  0
  1              1            0.458716
#
#  Block   188
  1  1  1  0  2  1
  2.7473E-02     4.9837E-04      9.2857E+00      3.5672E+01
  0
  1              1            0.232102
#
#  Block   189
  1  1  1  0  2  1
  2.7473E-02     4.9837E-04      9.2857E+00      3.5672E+01
  0
  1              1            0.232102
#
#  Block   190
  1  1  1  0  2  1
  1.1038E-02     2.0023E-04      2.3112E+01      8.8788E+01
  0
  1              1            0.380536
#
#  Block   191
  1  1  1  0  2  1
  1.1038E-02     2.0246E-04      2.3112E+01      8.8788E+01
  0
  1              1            0.380536
# Cement between inner and outer drums
#  Block   192
  1  1  1  0  9  1
  1.0000E+05     9.8219E-06      1.6006E-05      3.9321E+02
  0
  1              1            0.559165
#
#  Block   193
  1  1  1  0  9  1
  1.0000E+05     9.8219E-06      1.6006E-05      3.9321E+02
  0
  1              1            0.559165
# Walls of concrete moulds
#  Block   194
  1  1  1  0  8  1
  1.0000E+05     1.0000E+05      6.4300E-04      1.8662E+02
  0
  1              1            0.559165
#
#  Block   195
  1  1  1  0  8  1
  1.0000E+05     1.0000E+05      6.4300E-04      1.8662E+02
  0
```

```
  1              1            0.559165
#
#  Codifying the connections
#
#  NSSCO    NSBCO    NBBCO
   4        20       265
#
#  Connection between sources
#  NABCO    ICSEQ    LSCFW    IRADD
#
#  QWATIN             % if LSCFW is not equal to 0
#
#  ISERNU             % if IRADD = 1
#
#  XRADD              % if IRADD = 1 and ISERNU = 1 one line per group
#
#  XRADD              % if IRADD = 1 and ISERNU = 0 one line per group
#
#  IBSA  IBSB  ISEQA  ISEQB      % if NABCO > 1 and ICSEQ = 1
#
#  IBSA    IBSB                  % if ICSEQ = 0 NABCO*lines
#
#  WITHIN WASTE
#
#  1 Source-source 17 - 18
     1               0               1               1
     5.858700E-01
     1
     1.000000E-03
     17               18
#
#  2 Source-source 27 - 28
     1               0               1               1
     6.387300E-01
     1
     1.000000E-03
     27               28
#
#  3 Source-source 37 - 38
     1               0               1               1
     5.420300E-01
     1
     1.000000E-03
     37               38
#
#  4 Source-source 47 - 48
     1               0               1               1
     7.311550E-01
     1
     1.000000E-03

     47               48
#
#  Connection source - block
#
#  IBSOU    IBSB    ISEQC    NABCCO    IRZB    ICRB    IPLUG    IRADD
#
#  ICOMPB  ICSEQB   % if NABCCO > 1 and ISEQC =1
#
#  IDCB             % if ISEQC = 0. One value for each connection.
#
#  LSCFW  QWATIN    % if IFWATB(source term) = 1 and IQFLOW(block) = 1
#
#  ISERNU           % if IRADD =1
```

```
#
#  XRADD            % if IRADD = 1 and ISERNU = 1
#
#  XRADD            % if IRADD = 1 and ISERNU = 0. One line per group.
#
#
#  BETWEEN WASTE - CONCRETE WALLS OF CONCRETE TANKS
#  1 Source-block   2 - 51
    2  51  0  1  1  1  0  0
#
  1
  1  0.559165
#  2 Source-block   2 - 118
    2  118  0  1  1  1  0  0
#
  1
  -1  0.559165
#  BETWEEN WASTE - CEMENT BETWEEN DRUM IN DRUM
#  3 Source-block   6 - 192
    6  192  0  1  2  1  0  0
#
  1
  1  0.559165
#  4 Source-block   6 - 193
    6  193  0  1  2  1  0  0
#
  1
  -1  0.559165
#  5 Source-block   12 - 52
    12  52  0  1  1  1  0  0
#
  1
  1  0.58587
#  6 Source-block   12 - 119
    12  119  0  1  1  1  0  0
#
  1
  -1  0.58587
#  BETWEEN WASTE IN 'BERGLOFSLADOR' - CEMENT AROUND WASTE PACKAGES
#  7 Source-block   17 - 57
    17  57  0  1  1  1  0  0
#
  1
  -1  0.58587
#  8 Source-block   18 - 57
    18  57  0  1  1  1  0  0
#
  1
  1  0.58587
#  9 Source-block   22 - 53
    22  53  0  1  1  1  0  0
#
  1
  1  0.63873
#  10 Source-block   22 - 120
    22  120  0  1  1  1  0  0
#
  1
  -1  0.63873
#  11 Source-block   27 - 58
    27  58  0  1  1  1  0  0
#
  1
  -1  0.63873
```

```
# 12 Source-block   28 - 58
     28  58  0  1  1  1  0  0
#
  1
  1  0.63873
#  13 Source-block   32 - 54
     32  54  0  1  1  1  0  0
#
  1
  1  0.54203
#  14 Source-block   32 - 121
     32  121  0  1  1  1  0  0
#
  1
  -1  0.54203
#  15 Source-block   37 - 59
     37  59  0  1  1  1  0  0
#
  1
  -1  0.54203
#  16 Source-block   38 - 59
     38  59  0  1  1  1  0  0
#
  1
  1  0.54203
#  17 Source-block   42 - 55
     42  55  0  1  1  1  0  0
#
  1
  1  0.731155
#  18 Source-block   42 - 122
     42  122  0  1  1  1  0  0
#
  1
  -1  0.731155
#  19 Source-block   47 - 60
     47  60  0  1  1  1  0  0
#
  1
  -1  0.731155
#  20 Source-block   48 - 60
     48  60  0  1  1  1  0  0
#
  1
  1  0.731155
#  Connections between blocks not considered as sources
#
#  IBA IBB ISEQC NABCCO IRZA IRZB ICRA ICRB IPLUG IRADD
#
#  IDCA    IDCB                   % if NABCCO = 1
#
#  ICOMPA  ICOMPB  ICSEQA  ICSEQB % if NABCCO > 1 and ISQC = 1
#
#  IDCA                           % if NABCCO > 1 and ISQC = 0
#
#  IDCB                           % if NABCCO > 1 and ISQC = 0
#
#  LSCFW  QWATIN                  % if IQFLOW(A) = 1 and IQFLOW(B) = 1
#
#  ISERNU                         % if IRADD = 1
#
#  XRADD             % if IRADD = 1 and ISERNU = 0. One line per group
#
#  BETWEEN WALLS OF CONCRETE TANKS AND BACKFILL CONCRETE
```

```
#  1 Block-block   51 - 56
   51  56  0  1  2  2  1  1  0  0
    1           1
    1        5.59165E-01
#  2 Block-block   52 - 57
   52  57  0  1  2  2  1  1  0  0
    1           1
    1        5.85870E-01
#  3 Block-block   53 - 58
   53  58  0  1  2  2  1  1  0  0
    1           1
    1        6.38730E-01
#  4 Block-block   54 - 59
   54  59  0  1  2  2  1  1  0  0
    1           1
    1        5.42030E-01
#  5 Block-block   55 - 60
   55  60  0  1  2  2  1  1  0  0
    1           1
    1        7.31155E-01
#  6 Block-block   56 - 118
   56 118  0  1  2  2  1  1  0  0
    1           1
    1        5.59165E-01
#  7 Block-block   57 - 119
   57 119  0  1  2  2  1  1  0  0
    1           1
    1        5.85870E-01
#  8 Block-block   58 - 120
   58 120  0  1  2  2  1  1  0  0
    1           1
    1        6.38730E-01
#  9 Block-block   59 - 121
   59 121  0  1  2  2  1  1  0  0
    1           1
    1        5.42030E-01
#  10 Block-block   60 - 122
   60 122  0  1  2  2  1  1  0  0
    1           1
    1        7.31155E-01
#  BETWEEN CONCRETE BACKFILL AND WALL BETWEEN WASTE AND GRAVEL
BACKFILL (PASSAGE)
#  11 Block-block   56 - 61
   56 61  0  1  0  1  1  1  0  0
    1           1
    1        8.12000E-02
#  BETWEEN CONCRETE BACKFILL AND CONCRETE BLOCKS ABOVE THE WASTE
#  12 Block-block   56 - 64
   56 64  0  1  0  2  1  1  0  0
    1           1
    1        4.77970E-01
#  13 Block-block   57 - 67
   57 67  0  1  0  2  1  1  0  0
    1           1
    1        4.42040E-01
#  14 Block-block   58 - 70
   58 70  0  1  0  2  1  1  0  0
    1           1
    1        3.67080E-01
#  15 Block-block   59 - 73
   59 73  0  1  0  2  1  1  0  0
    1           1
    1        2.40720E-01
#  16 Block-block   60 - 76
```

```
   60 76  0  1  0  2  1  1  0  0
    1           1
    1        3.65940E-01
#  BETWEEN CONCRETE BACKFILL AND CONCRETE BELOW THE WASTE
#  17 Block-block   56 - 79
   56 79  0  1  0  2  1  1  0  0
    1           1
    -1        4.10580E-01
#  18 Block-block   57 - 80
   57 80  0  1  0  2  1  1  0  0
    1           1
    -1        5.13890E-01
#  19 Block-block   58 - 81
   58 81  0  1  0  2  1  1  0  0
    1           1
    -1        4.11690E-01
#  20 Block-block   59 - 82
   59 82  0  1  0  2  1  1  0  0
    1           1
    -1        2.03310E-01
#  21 Block-block   60 - 83
   60 83  0  1  0  2  1  1  0  0
    1           1
    -1        3.32250E-01
#  BETWEEN CONCRETE BACKFILL AND FICTITIOUS BLOCK
#  22 Block-block   56 - 84
   56 84  0  1  1  2  1  0  0  0
    1           1
    -1        8.17200E-02
#  23 Block-block   57 - 87
   57 87  0  1  1  2  1  0  0  0
    1           1
    -1        4.92100E-02
#  24 Block-block   58 - 90
   58 90  0  1  1  2  1  0  0  0
    1           1
    -1        2.74900E-02
#  25 Block-block   59 - 93
   59 93  0  1  1  2  1  0  0  0
    1           1
    -1        2.73400E-02
#  26 Block-block   60 - 96
   60 96  0  1  1  2  1  0  0  0
    1           1
    -1        4.74700E-02
#  BETWEEN CONCRETE BACKFILL AND FICTITIOUS BLOCK
#  27 Block-block   56 - 99
   56 99  0  1  1  2  1  0  0  0
    1           1
    -1        6.15000E-02
#  28 Block-block   57 - 102
   57 102  0  1  1  2  1  0  0  0
    1           1
    -1        2.27700E-02
#  29 Block-block   58 - 105
   58 105  0  1  1  2  1  0  0  0
    1           1
    -1        6.10800E-02
#  30 Block-block   59 - 108
   59 108  0  1  1  2  1  0  0  0
    1           1
    -1        3.97300E-02
#  31 Block-block   60 - 111
   60 111  0  1  1  2  1  0  0  0
```

```
    1           1
    -1        5.01200E-02
#  BETWEEN CONCRETE BACKFILL AND FICTITIOUS BLOCK
#  32 Block-block   56 - 114
   56 114  0  1  2  2  0  0  0  1
    1           1
     -1        5.36000E-03
  1
  1.1843E-01
#  33 Block-block   57 - 114
   57 114  0  1  2  2  0  0  0  1
    1           1
    1        5.36000E-03
  1
  1.6607E-01
#  BETWEEN CONCRETE BACKFILL AND FICTITIOUS BLOCK
#  34 Block-block   57 - 115
   57 115  0  1  2  2  0  0  0  1
    1           1
    1        1.38470E-01
  1
  1.6607E-01
#  35 Block-block   58 - 115
   58 115  0  1  2  2  0  0  0  1
    1           1
    -1        1.38470E-01
  1
  1.6607E-01
#  BETWEEN CONCRETE BACKFILL AND FICTITIOUS BLOCK
#  36 Block-block   58 - 116
   58 116  0  1  2  2  0  0  0  1
    1           1
    1        2.71650E-01
  1
  1.6607E-01
#  37 Block-block   59 - 116
   59 116  0  1  2  2  0  0  0  1
    1           1
    -1        2.71650E-01
  1
  1.6607E-01
#  BETWEEN CONCRETE BACKFILL AND FICTITIOUS BLOCK
#  38 Block-block   59 - 117
   59 117  0  1  2  2  0  0  0  1
    1           1
    1        3.01310E-01
  1
  1.6607E-01
#  39 Block-block   60 - 117
   60 117  0  1  2  2  0  0  0  1
    1           1
    -1        3.01310E-01
  1
  1.6607E-01
#
#  BETWEEN CONCRETE BACKFILL AND WALL BETWEEN WASTE AND GRAVEL
BACKFILL (LOADING ZONE)
#  40 Block-block   60 - 123
   60 123  0  1  2  1  1  1  0  0
    1           1
    1        3.65220E-01
# WITHIN WALL BETWEEN CONCRETE BACKFILL AND GRAVEL BACKFILL (PASSAGE)
#  41 Block-block   61 - 62
   61 62  0  1  2  2  1  1  0  0
```

```
    1           1
    1        8.12000E-02

# BETWEN WALL BETWEEN CONCRETE BACKFILL AND GRAVEL BACKFILL (PASSAGE)
AND FICTITIOUS BLOCK
#  42 Block-block   62 - 63
   62 63  0  1  2  2  1  0  0  0
    1           1

    1        8.12000E-02
#  BETWEEN FICTITIOUS BLOCK AND  GRAVEL BACKFILL (PASSAGE)
#  43 Block-block   63 - 126
   63 126  0  1  2  2  0  1  0  0
    1           1
    1        8.12000E-02
# WITHIN CONCRETE ABOVE THE WASTE  (TRANSVERSE THE MAIN AXIS OF
TUNNEL)
#  44 Block-block   64 - 65
   64 65  0  1  1  1  1  1  0  0
    1           1
    1        4.77970E-01
#  45 Block-block   65 - 66
   65 66  0  1  1  1  1  1  0  0
    1           1
    1        4.77970E-01
#  46 Block-block   67 - 68
   67 68  0  1  1  1  1  1  0  0
    1           1
    1        4.42040E-01
#  47 Block-block   68 - 69
   68 69  0  1  1  1  1  1  0  0
    1           1
    1        4.42040E-01
#  48 Block-block   70 - 71
   70 71  0  1  1  1  1  1  0  0
    1           1
    1        3.67080E-01
#  49 Block-block   71 - 72
   71 72  0  1  1  1  1  1  0  0
    1           1
    1        3.67080E-01
#  50 Block-block   73 - 74
   73 74  0  1  1  1  1  1  0  0
    1           1
    1        2.40720E-01
#  51 Block-block   74 - 75
   74 75  0  1  1  1  1  1  0  0
    1           1
    1        2.40720E-01
#  52 Block-block   76 - 77
   76 77  0  1  1  1  1  1  0  0
    1           1
    1        3.65940E-01
#  53 Block-block   77 - 78
   77 78  0  1  1  1  1  1  0  0
    1           1
    1        3.65940E-01
# WITHIN CONCRETE ABOVE THE WASTE (ALONG THE MAIN AXIS OF TUNNEL)
#  54 Block-block   64 - 67
#  55 Block-block   65 - 68
#  56 Block-block   66 - 69
#  57 Block-block   67 - 70
#  58 Block-block   68 - 71
#  59 Block-block   69 - 72
```

```
#  60 Block-block   70 - 73
#  61 Block-block   71 - 74
#  62 Block-block   72 - 75
#  63 Block-block   73 - 76
#  64 Block-block   74 - 77
#  65 Block-block   75 - 78
#  BETWEEN CONCRETE ABOVE THE WASTE AND GRAVEL IN TOP OF TUNNEL
#  66 Block-block   66 - 129
   66 129  0  1  1  0  1  1  0  0
    1           1
    1        4.77970E-01
#  67 Block-block   69 - 132
   69 132  0  1  1  0  1  1  0  0
    1           1
    1        4.42040E-01
#  68 Block-block   72 - 135
   72 135  0  1  1  0  1  1  0  0
    1           1
    1        3.67080E-01
#  69 Block-block   75 - 138
   75 138  0  1  1  0  1  1  0  0
    1           1
    1        2.40720E-01
#  70 Block-block   78 - 141
   78 141  0  1  1  0  1  1  0  0
    1           1
    1        3.65940E-01
# WITHIN CONCRETE BELOW THE WASTE  (TRANSVERSE THE MAIN AXIS OF
TUNNEL)
#  71 Block-block   79 - 182
   79 182  0  1  1  1  1  1  0  0
    1           1
    -1        4.68130E-01
#  72 Block-block   182 - 183
   182  183  0  1  1  1  1  1  0  0
    1           1
    -1        4.68130E-01
#  73 Block-block   80 - 184
   80 184  0  1  1  1  1  1  0  0
    1           1
    -1        5.70663E-01
#  74 Block-block   184 - 185
   184  185  0  1  1  1  1  1  0  0
    1           1
    -1        5.70663E-01
#  75 Block-block   81 - 186
   81 186  0  1  1  1  1  1  0  0
    1           1
    -1        4.58716E-01
#  76 Block-block   186 - 187
   186  187  0  1  1  1  1  1  0  0
    1           1
    -1        4.58716E-01
#  77 Block-block   82 - 188
   82 188  0  1  1  1  1  1  0  0
    1           1
    -1        2.32102E-01
#  78 Block-block   188 - 189
   188  189  0  1  1  1  1  1  0  0
    1           1
    -1        2.32102E-01
#  79 Block-block   83 - 190
   83 190  0  1  1  1  1  1  0  0
    1           1
```

```
    -1        3.80536E-01
#  80 Block-block   190 - 191
   190  191  0  1  1  1  1  1  0  0
    1           1
    -1        3.80536E-01
# WITHIN CONCRETE BELOW THE WASTE (ALONG THE MAIN AXIS OF TUNNEL)
#  81 Block-block   79 - 80
#  82 Block-block   80 - 81
#  83 Block-block   81 - 82
#  84 Block-block   82 - 83
# BETWEEN CONCRETE IN BOTTOM OF THE TUNNEL AND CONCRETE BACKFILL ON
LEFT SIDE OF THE TUNNEL
#  85 Block-block   79 - 149
   79 149  0  1  0  0  1  1  0  0
    1           1
    1        9.36967E-03
#  86 Block-block   79 - 162
   79 162  0  1  0  0  1  1  0  0
    1           1
    1        9.36967E-03
#  87 Block-block   79 - 163
   79 163  0  1  0  0  1  1  0  0
    1           1
    1        9.36967E-03
#  88 Block-block   80 - 150
   80 150  0  1  0  0  1  1  0  0
    1           1
    1        8.47567E-03
#  89 Block-block   80 - 164
   80 164  0  1  0  0  1  1  0  0
    1           1
    1        8.47567E-03
#  90 Block-block   80 - 165
   80 165  0  1  0  0  1  1  0  0
    1           1
    1        8.47567E-03
#  91 Block-block   81 - 151
   81 151  0  1  0  0  1  1  0  0
    1           1
    1        7.35400E-03
#  92 Block-block   81 - 166
   81 166  0  1  0  0  1  1  0  0
    1           1
    1        7.35400E-03
#  93 Block-block   81 - 167
   81 167  0  1  0  0  1  1  0  0
    1           1
    1        7.35400E-03
#  94 Block-block   82 - 152
   82 152  0  1  0  0  1  1  0  0
    1           1
    1        4.70733E-03
#  95 Block-block   82 - 168
   82 168  0  1  0  0  1  1  0  0
    1           1
    1        4.70733E-03
#  96 Block-block   82 - 169
   82 169  0  1  0  0  1  1  0  0
    1           1
    1        4.70733E-03
#  97 Block-block   83 - 153
   83 153  0  1  0  0  1  1  0  0
    1           1
    1        7.91500E-03
```

```
#  98 Block-block   83 - 170
   83 170  0  1  0  0  1  1  0  0
    1           1
    1        7.91500E-03
#  99 Block-block   83 - 171
   83 171  0  1  0  0  1  1  0  0
    1           1
    1        7.91500E-03
# BETWEEN CONCRETE IN BOTTOM OF THE TUNNEL AND CONCRETE BACKFILL ON
RIGHT SIDE OF THE TUNNEL
#  100 Block-block   79 - 154
   79 154  0  1  0  0  1  1  0  0
    1           1
    1        9.81367E-03
#  101 Block-block   79 - 172
   79 172  0  1  0  0  1  1  0  0
    1           1
    1        9.81367E-03
#  102 Block-block   79 - 173
   79 173  0  1  0  0  1  1  0  0
    1           1
    1        9.81367E-03
#  103 Block-block   80 - 155
   80 155  0  1  0  0  1  1  0  0
    1           1
    1        1.04487E-02
#  104 Block-block   80 - 174
   80 174  0  1  0  0  1  1  0  0
    1           1
    1        1.04487E-02
#  105 Block-block   80 - 175
   80 175  0  1  0  0  1  1  0  0
    1           1
    1        1.04487E-02
#  106 Block-block   81 - 156
   81 156  0  1  0  0  1  1  0  0
    1           1
    1        8.32133E-03
#  107 Block-block   81 - 176
   81 176  0  1  0  0  1  1  0  0
    1           1
    1        8.32133E-03
#  108 Block-block   81 - 177
   81 177  0  1  0  0  1  1  0  0
    1           1
    1        8.32133E-03
#  109 Block-block   82 - 157
   82 157  0  1  0  0  1  1  0  0
    1           1
    1        4.89000E-03
#  110 Block-block   82 - 178
   82 178  0  1  0  0  1  1  0  0
    1           1
    1        4.89000E-03
#  111 Block-block   82 - 179
   82 179  0  1  0  0  1  1  0  0
    1           1
    1        4.89000E-03
#  112 Block-block   83 - 158
   83 158  0  1  0  0  1  1  0  0
    1           1
    1        8.18033E-03
#  113 Block-block   83 - 180
   83 180  0  1  0  0  1  1  0  0
```

```
    1          1
    1        8.18033E-03
#  114 Block-block   83 - 181
   83 181  0  1  0  0  1  1  0  0
    1          1
    1        8.18033E-03
#  BETWEEN CONCRETE BELOW THE WASTE AND GRAVEL IN BOTTOM OF THE TUNNEL
#  115 Block-block   183 - 144
   183  144  0  1  1  0  1  1  0  0
    1          1
    -1        4.68130E-01
#  116 Block-block   185 - 145
   185  145  0  1  1  0  1  1  0  0
    1          1
    -1        5.70663E-01
#  117 Block-block   187 - 146
   187  146  0  1  1  0  1  1  0  0
    1          1
    -1        4.58716E-01
#  118 Block-block   189 - 147
   189  147  0  1  1  0  1  1  0  0
    1          1
    -1        2.32102E-01
#  119 Block-block   191 - 148
   191  148  0  1  1  0  1  1  0  0
    1          1
    -1        3.80536E-01
# WITHIN FICTITIOUS BLOCK (TRANSVERSE TO THE MAIN AXIS OF TUNNEL)
#  120 Block-block   84 - 85
   84 85  0  1  2  2  0  0  0  0
    1          1
    -1        8.17200E-02
#  121 Block-block   85 - 86
   85 86  0  1  2  2  0  0  0  0
    1          1
    -1        8.17200E-02
#  122 Block-block   87 - 88
   87 88  0  1  2  2  0  0  0  0
    1          1
    -1        4.92100E-02
#  123 Block-block   88 - 89
   88 89  0  1  2  2  0  0  0  0
    1          1
    -1        4.92100E-02
#  124 Block-block   90 - 91
   90 91  0  1  2  2  0  0  0  0
    1          1
    -1        2.74900E-02
#  125 Block-block   91 - 92
   91 92  0  1  2  2  0  0  0  0
    1          1
    -1        2.74900E-02
#  126 Block-block   93 - 94
   93 94  0  1  2  2  0  0  0  0
    1          1
    -1        2.73400E-02
#  127 Block-block   94 - 95
   94 95  0  1  2  2  0  0  0  0
    1          1
    -1        2.73400E-02
#  128 Block-block   96 - 97
   96 97  0  1  2  2  0  0  0  0
    1          1
    -1        4.74700E-02
```

```
#  129 Block-block   97 - 98
   97 98  0  1  2  2  0  0  0  0
    1          1
    -1        4.74700E-02
# WITHIN FICTITIOUS BLOCK (ALONG THE MAIN AXIS OF TUNNEL)
#  130 Block-block   84 - 87
#  131 Block-block   85 - 88
#  132 Block-block   86 - 89
#  133 Block-block   87 - 90
#  134 Block-block   88 - 91
#  135 Block-block   89 - 92
#  136 Block-block   90 - 93
#  137 Block-block   91 - 94
#  138 Block-block   92 - 95
#  139 Block-block   93 - 96
#  140 Block-block   94 - 97
#  141 Block-block   95 - 98
# BETWEEN FICTITIOUS BLOCK AND CONCRETE BACKFILL ON LEFT SIDE OF THE
WASTE
#  142 Block-block   86 - 149
   86 149  0  1  2  1  0  1  0  0
    1          1
    -1        8.17200E-02
#  143 Block-block   89 - 150
   89 150  0  1  2  1  0  1  0  0
    1          1
    -1        4.92100E-02
#  144 Block-block   92 - 151
   92 151  0  1  2  1  0  1  0  0
    1          1
    -1        2.74900E-02
#  145 Block-block   95 - 152
   95 152  0  1  2  1  0  1  0  0
    1          1
    -1        2.73400E-02
#  146 Block-block   98 - 153
   98 153  0  1  2  1  0  1  0  0
    1          1
    -1        4.74700E-02
# WITHIN FICTITIOUS BLOCK (TRANSVERSE TO THE MAIN AXIS OF TUNNEL)
#  147 Block-block   99 - 100
   99 100  0  1  2  2  0  0  0  0
    1          1
    -1        6.15000E-02
#  148 Block-block   100 - 101
   100  101  0  1  2  2  0  0  0  0
    1          1
    -1        6.15000E-02
#  149 Block-block   102 - 103
   102  103  0  1  2  2  0  0  0  0
    1          1
    -1        2.27700E-02
#  150 Block-block   103 - 104
   103  104  0  1  2  2  0  0  0  0
    1          1
    -1        2.27700E-02
#  151 Block-block   105 - 106
   105  106  0  1  2  2  0  0  0  0
    1          1
    -1        6.10800E-02
#  152 Block-block   106 - 107
   106  107  0  1  2  2  0  0  0  0
    1          1
    -1        6.10800E-02
```

```
#  153 Block-block   108 - 109
   108  109  0  1  2  2  0  0  0  0
    1          1
    -1        3.97300E-02
#  154 Block-block   109 - 110
   109  110  0  1  2  2  0  0  0  0
    1          1
    -1        3.97300E-02
#  155 Block-block   111 - 112
   111  112  0  1  2  2  0  0  0  0
    1          1
    -1        5.01200E-02
#  156 Block-block   112 - 113
   112  113  0  1  2  2  0  0  0  0
    1          1
    -1        5.01200E-02
# WITHIN FICTITIOUS BLOCK (ALONG THE MAIN AXIS OF TUNNEL)
#  157 Block-block   99 - 102
#  158 Block-block   100 - 103
#  159 Block-block   101 - 104
#  160 Block-block   102 - 105
#  161 Block-block   103 - 106
#  162 Block-block   104 - 107
#  163 Block-block   105 - 108
#  164 Block-block   106 - 109
#  165 Block-block   107 - 110
#  166 Block-block   108 - 111
#  167 Block-block   109 - 112
#  168 Block-block   110 - 113
# BETWEEN FICTITIOUS BLOCK AND CONCRETE BACKFILL ON RIGHT SIDE OF THE
WASTE
#  169 Block-block   101 - 154
   101  154  0  1  2  1  0  1  0  0
    1          1
    -1        6.15000E-02
#  170 Block-block   104 - 155
   104  155  0  1  2  1  0  1  0  0
    1          1
    -1        2.27700E-02
#  171 Block-block   107 - 156
   107  156  0  1  2  1  0  1  0  0
    1          1
    -1        6.10800E-02
#  172 Block-block   110 - 157
   110  157  0  1  2  1  0  1  0  0
    1          1
    -1        3.97300E-02
#  173 Block-block   113 - 158
   113  158  0  1  2  1  0  1  0  0
    1          1
    -1        5.01200E-02
# WITHIN WALL BETWEEN CONCRETE BACKFILL AND GRAVEL BACKFILL (LOADING
ZONE)
#  174 Block-block   123 - 124
   123  124  0  1  2  2  1  1  0  0
    1          1
    1        3.65220E-01
# BETWEN WALL BETWEEN CONCRETE BACKFILL AND GRAVEL BACKFILL (LOADING
ZONE) AND FICTITIOUS BLOCK
#  175 Block-block   124 - 125
   124  125  0  1  2  2  1  0  0  0
    1          1
    1        3.65220E-01
#  BETWEEN FICTITIOUS BLOCK AND  GRAVEL BACKFILL (LOADING ZONE)
```

```
#  176 Block-block   125 - 159
   125  159  0  1  2  2  0  1  0  0
    1          1
    1        3.65220E-01
#  WITHIN GRAVEL BACKFILL (PASSAGE)
#  177 Block-block   126 - 127
   126  127  0  1  2  2  1  1  0  0
    1          1
    -1        1.70763E-01
#  178 Block-block   127 - 128
   127  128  0  1  2  2  1  1  0  0
    1          1
    -1        1.17297E-01
#  BETWEEN GRAVEL BACKFILL (PASSAGE) AND GRAVEL IN TOP OF TUNNEL
#  179 Block-block   126 - 129
   126  129  0  1  0  2  1  1  0  0
    1          1
    1        1.19407E-01
#  180 Block-block   126 - 130
   126  130  0  1  0  2  1  1  0  0
    1          1
    1        1.19407E-01
#  181 Block-block   126 - 131
   126  131  0  1  0  2  1  1  0  0
    1          1
    1        1.19407E-01
#  BETWEEN GRAVEL BACKFILL (PASSAGE) AND GRAVEL IN BOTTOM OF TUNNEL
#  182 Block-block   126 - 144
   126  144  0  1  1  2  1  1  0  0
    1          1
    -1        4.54920E-02
#  BETWEEN GRAVEL BACKFILL (PASSAGE) AND CONCRETE BACKFILL ON LEFT
SIDE OF STRUCTURE
#  183 Block-block   126 - 149
   126  149  0  1  0  2  1  1  0  0
    1          1
    -1        1.30900E-03
#  184 Block-block   126 - 162
   126  162  0  1  0  2  1  1  0  0
    1          1
    -1        1.30900E-03
#  185 Block-block   126 - 163
   126  163  0  1  0  2  1  1  0  0
    1          1
    -1        1.30900E-03
#  BETWEEN GRAVEL BACKFILL (PASSAGE) AND CONCRETE BACKFILL ON RIGHT
SIDE OF STRUCTURE
#  186 Block-block   126 - 154
   126  154  0  1  0  2  1  1  0  0
    1          1
    -1        1.12367E-03
#  187 Block-block   126 - 172
   126  172  0  1  0  2  1  1  0  0
    1          1
    0        1.12367E-03
#  188 Block-block   126 - 173
   126  173  0  1  0  2  1  1  0  0
    1          1
    -1        1.12367E-03
# WITHIN GRAVEL IN TOP OF THE TUNNEL (TRANSVERSE TO THE MAIN AXIS OF
TUNNEL)
#  189 Block-block   129 - 130
   129  130  0  1  0  0  1  1  0  0
    1          1
```

```
    1        4.27465E-01
#  190 Block-block   130 - 131
   130  131  0  1  0  0  1  1  0  0
    1           1
    1        3.08571E-01
#  191 Block-block   132 - 133
   132  133  0  1  0  0  1  1  0  0
    1           1
    1        1.61543E+00
#  192 Block-block   133 - 134
   133  134  0  1  0  0  1  1  0  0
    1           1
    1        2.65533E+00
#  193 Block-block   135 - 136
   135  136  0  1  0  0  1  1  0  0
    1           1
    1        1.11748E+00
#  194 Block-block   136 - 137
   136  137  0  1  0  0  1  1  0  0
    1           1
    1        1.73840E+00
#  195 Block-block   138 - 139
   138  139  0  1  0  0  1  1  0  0
    1           1
    1        2.15620E-01
#  196 Block-block   139 - 140
   139  140  0  1  0  0  1  1  0  0
    1           1
    1        1.56419E-01
#  197 Block-block   141 - 142
   141  142  0  1  0  0  1  1  0  0
    1           1
    1        3.77816E-01
#  198 Block-block   142 - 143
   142  143  0  1  0  0  1  1  0  0
    1           1
    1        3.36662E-01
# WITHIN GRAVEL IN TOP OF THE TUNNEL (ALONG THE MAIN AXIS OF TUNNEL)
#  199 Block-block   129 - 132
   129  132  0  1  2  2  1  1  0  0
    1           1
    1        3.01207E-01
#  200 Block-block   130 - 133
   130  133  0  1  2  2  1  1  0  0
    1           1
    1        3.01207E-01
#  201 Block-block   131 - 134
   131  134  0  1  2  2  1  1  0  0
    1           1
    1        3.01207E-01
#  202 Block-block   132 - 135
   132  135  0  1  2  2  1  1  0  0
    1           1
    -1        2.20823E-01
#  203 Block-block   133 - 136
   133  136  0  1  2  2  1  1  0  0
    1           1
    -1        2.20823E-01
#  204 Block-block   134 - 137
   134  137  0  1  2  2  1  1  0  0
    1           1
    -1        2.20823E-01
#  205 Block-block   135 - 138
   135  138  0  1  2  2  1  1  0  0
```

```
    1           1
    -1        3.30973E-01
#  206 Block-block   136 - 139
   136  139  0  1  2  2  1  1  0  0
    1           1
    -1        3.30973E-01
#  207 Block-block   137 - 140
   137  140  0  1  2  2  1  1  0  0
    1           1
    -1        3.30973E-01
#  208 Block-block   138 - 141
   138  141  0  1  2  2  1  1  0  0
    1           1
    -1        2.42487E-01
#  209 Block-block   139 - 142
   139  142  0  1  2  2  1  1  0  0
    1           1
    -1        2.42487E-01
#  210 Block-block   140 - 143
   140  143  0  1  2  2  1  1  0  0
    1           1
    -1        2.42487E-01
# BETWEEN GRAVEL IN TOP OF THE TUNNEL AND CONCRETE ON LEFT SIDE OF THE
TUNNEL
#  211 Block-block   129 - 149
   129  149  0  1  1  0  1  1  0  0
    1           1
    -1        1.18610E-02
#  212 Block-block   129 - 162
   129  162  0  1  1  0  1  1  0  0
    1           1
    -1        1.18610E-02
#  213 Block-block   129 - 163
   129  163  0  1  1  0  1  1  0  0
    1           1
    -1        1.18610E-02
#  214 Block-block   132 - 150
   132  150  0  1  1  0  1  1  0  0
    1           1
    -1        3.49733E-02
#  215 Block-block   132 - 164
   132  164  0  1  1  0  1  1  0  0
    1           1
    -1        3.49733E-02
#  216 Block-block   132 - 165
   132  165  0  1  1  0  1  1  0  0
    1           1
    -1        3.49733E-02
#  217 Block-block   135 - 151
   135  151  0  1  1  0  1  1  0  0
    1           1
    -1        7.61000E-03
#  218 Block-block   135 - 166
   135  166  0  1  1  0  1  1  0  0
    1           1
    -1        7.61000E-03
#  219 Block-block   135 - 167
   135  167  0  1  1  0  1  1  0  0
    1           1
    -1        7.61000E-03
#  220 Block-block   138 - 152
   138  152  0  1  1  0  1  1  0  0
    1           1
    -1        5.21967E-03
```

```
#  221 Block-block   138 - 168
   138  168  0  1  1  0  1  1  0  0
    1           1
    -1        5.21967E-03
#  222 Block-block   138 - 169
   138  169  0  1  1  0  1  1  0  0
    1           1
    -1        5.21967E-03
#  223 Block-block   141 - 153
   141  153  0  1  1  0  1  1  0  0
    1           1
    -1        8.65800E-03
#  224 Block-block   141 - 170
   141  170  0  1  1  0  1  1  0  0
    1           1
    -1        8.65800E-03
#  225 Block-block   141 - 171
   141  171  0  1  1  0  1  1  0  0
    1           1
    -1        8.65800E-03
# BETWEEN GRAVEL IN TOP OF THE TUNNEL AND CONCRETE ON RIGHT SIDE OF
THE TUNNEL
#  226 Block-block   129 - 154
   129  154  0  1  1  0  1  1  0  0
    1           1
    -1        1.09367E-02
#  227 Block-block   129 - 172
   129  172  0  1  1  0  1  1  0  0
    1           1
    -1        1.09367E-02
#  228 Block-block   129 - 173
   129  173  0  1  1  0  1  1  0  0
    1           1
    -1        1.09367E-02
#  229 Block-block   132 - 155
   132  155  0  1  1  0  1  1  0  0
    1           1
    -1        9.52433E-03
#  230 Block-block   132 - 174
   132  174  0  1  1  0  1  1  0  0
    1           1
    -1        9.52433E-03
#  231 Block-block   132 - 175
   132  175  0  1  1  0  1  1  0  0
    1           1
    -1        9.52433E-03
#  232 Block-block   135 - 156
   135  156  0  1  1  0  1  1  0  0
    1           1
    -1        3.55533E-02
#  233 Block-block   135 - 176
   135  176  0  1  1  0  1  1  0  0
    1           1
    -1        3.55533E-02
#  234 Block-block   135 - 177
   135  177  0  1  1  0  1  1  0  0
    1           1
    -1        3.55533E-02
#  235 Block-block   138 - 157
   138  157  0  1  1  0  1  1  0  0
    1           1
    -1        6.14600E-03
#  236 Block-block   138 - 178
   138  178  0  1  1  0  1  1  0  0
```

```
    1           1
    -1        6.14600E-03
#  237 Block-block   138 - 179
   138  179  0  1  1  0  1  1  0  0
    1           1
    -1        6.14600E-03
#  238 Block-block   141 - 158
   141  158  0  1  1  0  1  1  0  0
    1           1
    -1        9.01833E-03
#  239 Block-block   141 - 180
   141  180  0  1  1  0  1  1  0  0
    1           1
    -1        9.01833E-03
#  240 Block-block   141 - 181
   141  181  0  1  1  0  1  1  0  0
    1           1
    -1        9.01833E-03
# WITHIN GRAVEL IN BOTTOM OF THE TUNNEL (ALONG THE MAIN AXIS OF
TUNNEL)
#  241 Block-block   144 - 145
   144  145  0  1  2  2  1  1  0  0
    1           1
    -1        2.55100E-02
#  242 Block-block   145 - 146
   145  146  0  1  2  2  1  1  0  0
    1           1
    1        7.32800E-03
#  243 Block-block   146 - 147
   146  147  0  1  2  2  1  1  0  0
    1           1
    1        1.77070E-02
#  244 Block-block   147 - 148
   147  148  0  1  2  2  1  1  0  0
    1           1
    1        3.90800E-03
# WITHIN CONCRETE BACKFILL ON LEFT SIDE OF THE TUNNEL (ALONG THE MAIN
AXIS OF TUNNEL)
#  245 Block-block   149 - 150
   149  150  0  1  2  2  1  1  0  0
    1           1
    -1        4.79333E-04
#  246 Block-block   150 - 151
   150  151  0  1  2  2  1  1  0  0
    1           1
    1        3.09333E-04
#  247 Block-block   151 - 152
   151  152  0  1  2  2  1  1  0  0
    1           1
    1        2.01000E-04
#  248 Block-block   152 - 153
   152  153  0  1  2  2  1  1  0  0
    1           1
    1        6.76667E-05
#  249 Block-block   162 - 164
   162  164  0  1  2  2  1  1  0  0
    1           1
    -1        4.79333E-04
#  250 Block-block   163 - 165
   163  165  0  1  2  2  1  1  0  0
    1           1
    -1        4.79333E-04
#  251 Block-block   164 - 166
   164  166  0  1  2  2  1  1  0  0
```

```
    1          1
    1        3.09333E-04
#  252 Block-block   165 - 167
   165  167  0  1  2  2  1  1  0  0
    1          1
    1        3.09333E-04
#  253 Block-block   166 - 168
   166  168  0  1  2  2  1  1  0  0
    1          1
    1        2.01000E-04
#  254 Block-block   167 - 169
   167  169  0  1  2  2  1  1  0  0
    1          1
    1        2.01000E-04
#  255 Block-block   168 - 170
   168  170  0  1  2  2  1  1  0  0
    1          1
    1        6.76667E-05
#  256 Block-block   169 - 171
   169  171  0  1  2  2  1  1  0  0
    1          1
    1        6.76667E-05
# WITHIN CONCRETE BACKFILL ON LEFT SIDE OF THE TUNNEL (TRANSVERSE TO
THE MAIN AXIS OF TUNNEL)
#  257 Block-block   149 - 162
   149  162  0  1  1  1  1  1  0  0
    1          1
    -1        8.50420E-02
#  258 Block-block   162 - 163
   162  163  0  1  1  1  1  1  0  0
    1          1
    -1        8.83630E-02
#  259 Block-block   150 - 164
   150  164  0  1  1  1  1  1  0  0
    1          1
    -1        7.65003E-02
#  260 Block-block   164 - 165
   164  165  0  1  1  1  1  1  0  0
    1          1
    -1        1.03787E-01
#  261 Block-block   151 - 166
   151  166  0  1  1  1  1  1  0  0
    1          1
    -1        2.76357E-02
#  262 Block-block   166 - 167
   166  167  0  1  1  1  1  1  0  0
    1          1
    -1        2.77833E-02
#  263 Block-block   152 - 168
   152  168  0  1  1  1  1  1  0  0
    1          1
    -1        2.77160E-02
#  264 Block-block   168 - 169
   168  169  0  1  1  1  1  1  0  0
    1          1
    -1        2.80950E-02
#  265 Block-block   153 - 170
   153  170  0  1  1  1  1  1  0  0
    1          1
    -1        4.90357E-02
#  266 Block-block   170 - 171
   170  171  0  1  1  1  1  1  0  0
    1          1
    -1        5.05983E-02
```

```
# WITHIN CONCRETE BACKFILL ON RIGHT SIDE OF THE TUNNEL (ALONG THE MAIN
AXIS OF TUNNEL)
#  267 Block-block   154 - 155
   154  155  0  1  2  2  1  1  0  0
    1          1
    -1        3.74000E-04
#  268 Block-block   155 - 156
   155  156  0  1  2  2  1  1  0  0
    1          1
    -1        1.75333E-04
#  269 Block-block   156 - 157
   156  157  0  1  2  2  1  1  0  0
    1          1
    1        4.59333E-04
#  270 Block-block   157 - 158
   157  158  0  1  2  2  1  1  0  0
    1          1
    1        1.21333E-04
#  271 Block-block   172 - 174
   172  174  0  1  2  2  1  1  0  0
    1          1
    -1        3.74000E-04
#  272 Block-block   173 - 175
   173  175  0  1  2  2  1  1  0  0
    1          1
    -1        3.74000E-04
#  273 Block-block   174 - 176
   174  176  0  1  2  2  1  1  0  0
    1          1
    -1        1.75333E-04
#  274 Block-block   175 - 177
   175  177  0  1  2  2  1  1  0  0
    1          1
    -1        1.75333E-04
#  275 Block-block   176 - 178
   176  178  0  1  2  2  1  1  0  0
    1          1
    1        4.59333E-04
#  276 Block-block   177 - 179
   177  179  0  1  2  2  1  1  0  0
    1          1
    1        4.59333E-04
#  277 Block-block   178 - 180
   178  180  0  1  2  2  1  1  0  0
    1          1
    1        1.21333E-04
#  278 Block-block   179 - 181
   179  181  0  1  2  2  1  1  0  0
    1          1
    1        1.21333E-04
# WITHIN CONCRETE BACKFILL ON RIGHT SIDE OF THE TUNNEL (TRANSVERSE TO
THE MAIN AXIS OF TUNNEL)
#  279 Block-block   154 - 172
   154  172  0  1  1  1  1  1  0  0
    1          1
    -1        6.33767E-02
#  280 Block-block   172 - 173
   172  173  0  1  1  1  1  1  0  0
    1          1
    -1        6.52493E-02
#  281 Block-block   155 - 174
   155  174  0  1  1  1  1  1  0  0
    1          1
```

```
    -1        2.20433E-02
#  282 Block-block   174 - 175
   174  175  0  1  1  1  1  1  0  0
    1           1
    -1        2.13177E-02
#  283 Block-block   156 - 176
   156  176  0  1  1  1  1  1  0  0
    1           1
    -1        8.89447E-02
#  284 Block-block   176 - 177
   176  177  0  1  1  1  1  1  0  0
    1           1
    -1        1.16811E-01
#  285 Block-block   157 - 178
   157  178  0  1  1  1  1  1  0  0
    1           1
    -1        4.06510E-02
#  286 Block-block   178 - 179
   178  179  0  1  1  1  1  1  0  0
    1           1
    -1        4.15690E-02
#  287 Block-block   158 - 180
   158  180  0  1  1  1  1  1  0  0
    1           1
    -1        5.16787E-02
#  288 Block-block   180 - 181
   180  181  0  1  1  1  1  1  0  0
    1           1
    -1        5.32353E-02
#  WITHIN GRAVEL IN LOADING ZONE
#  289 Block-block   159 - 160
   159  160  0  1  2  2  1  1  0  0
    1           1
    -1        7.25100E-02
#  290 Block-block   160 - 161
   160  161  0  1  2  2  1  1  0  0
    1           1
    -1        4.25800E-02
#  BETWEEN GRAVEL IN LOADING ZONE AND GRAVEL IN TOP OF TUNNEL
#  291 Block-block   159 - 141
   159  141  0  1  0  2  1  1  0  0
    1           1
    1        1.69803E-01
#  292 Block-block   159 - 142
   159  142  0  1  0  2  1  1  0  0
    1           1
    1        1.69803E-01
#  293 Block-block   159 - 143
   159  143  0  1  0  2  1  1  0  0
    1           1
    1        1.69803E-01
# BETWEEN GRAVEL IN LOADING ZONE AND GRAVEL IN BOTTOM OF TUNNEL
#  294 Block-block   159 - 148
   159  148  0  1  0  2  1  1  0  0
    1           1
    -1        3.65700E-02
#  BETWEEN GRAVEL IN LOADING ZONE AND CONCRETE BACKFILL ON LEFT SIDE
OF TUNNEL
#  295 Block-block   159 - 153
   159  153  0  1  0  2  1  1  0  0
    1           1
    -1        8.87333E-04
#  296 Block-block   159 - 170
   159  170  0  1  0  2  1  1  0  0
```

```
    1           1
    -1        8.87333E-04
#  297 Block-block   159 - 171
   159  171  0  1  0  2  1  1  0  0
    1           1
    -1        8.87333E-04
#  BETWEEN GRAVEL IN LOADING ZONE AND CONCRETE BACKFILL ON RIGHT SIDE
OF TUNNEL
#  298 Block-block   159 - 158
   159  158  0  1  0  2  1  1  0  0
    1           1
    -1        8.40000E-04
#  299 Block-block   159 - 180
   159  180  0  1  0  2  1  1  0  0
    1           1
    -1        8.40000E-04
#  300 Block-block   159 - 181
   159  181  0  1  0  2  1  1  0  0
    1           1
    -1        8.40000E-04
# BETWEEN CONCRETE BACKFILL AND CEMENT BETWEEN DRUM IN DRUM WITH ASHES
#  301 Block-block   56 - 192
   56  192  0  1  0  1  1  1  0  0
    1           1
    -1        5.59165E-01
#  302 Block-block   56 - 193
   56  193  0  1  0  1  1  1  0  0
    1           1
    1        5.59165E-01
# BETWEEN CONCRETE BACKFILL AND CONCRETE CONTAINER WITHOUT ACTIVITY
(ACTIVITY MOVED TO BMA)
#  303 Block-block   56 - 194
   56  194  0  1  2  2  1  1  0  0
    1           1
    1        5.59165E-01
#  304 Block-block   56 - 195
   56  195  0  1  2  2  1  1  0  0
    1           1
    -1        5.59165E-01
# WITHIN CONCRETE CONTAINER WITHOUT ACTIVITY (ACTIVITY MOVED TO BMA)
#  305 Block-block   194 - 195
   194  195  0  1  2  2  0  0  0  0
    1           1
    1        5.59165E-01
```

```
#  2BTF CALCULATIONS
#  Problem Codification: BS2
#  Nuclide(s): C-14 org
#
#  Problem Description:
#  PROPER VERSION INPUT DATA FORMAT
#
#  ITYPE    NGROUP    NSINKS    IWFLOW    NSOURC    NBSIZE    ISPSOL
   1        1         0         1         50        0         0
#
#
#  Flow stream conditions
#  NINFLW    NUTFLW            % if IWFLOW = 1
   36        13
#
#  Inflow conditions (one line per inflow)
#  QINFW               NBWIN    NBNWIN     % if IWFLOW = 1
   0.0312433333333333  126      1
   0.0312433333333333  127      1
   0.0718833333333333  128      1
   0.07635             129      1
   0.07635             130      1
   0.07635             131      1
   0.119846666666667   132      1
   0.119846666666667   133      1
   0.119846666666667   134      1
   0.569643666666666   135      1
   0.569666666666667   136      1
   0.569666666666667   137      1
   0.0342963333333333  138      1
   0.0342963333333333  139      1
   0.0342963333333333  140      1
   0.024688            141      1
   0.024688            142      1
   0.024688            143      1
   0.665689            144      1
   0.277931            145      1
   0.732123            146      1
   0.21793             147      1
   0.267952            148      1
   0.182563333333333   159      1
   0.182563333333333   160      1
   0.207363333333333   161      1
   0.112734            163      1
   0.17645             165      1
   0.051952            167      1
   0.032214            169      1
   0.036187            171      1
   0.097839            173      1
   0.033147            175      1
   0.142149            177      1
   0.043713            179      1
   0.043463            181      1
#
#  Outflow conditions (one line per inflow)
#  QUTFW               NBWOUT   NBNWOUT    % if IWFLOW = 1
   0.00503333333333333 126      1
   0.00503333333333333 127      1
   0.00503333333333333 128      1
   0.30393             131      1
   0.02274             134      1
   0.132756666666667   135      1
   0.132756666666667   136      1
```

```
   5.06469666666667    137      1
   0.068019            140      1
   0.143864            143      1
   0.07633             159      1
   0.07633             160      1
   0.07633             161      1
#
# Number of blocks connections and materials
#  NBLOCK    NBCOUP    NMAT
   191       270       5
#
#
#  Data on materials (one line per material)
#  Material 1 = Waste
#  Material 2 = Construction concrete
#  Material 3 = Water
#  Material 4 = Gravel
#  Material 5 = Porous concrete
#  MAT        DENSM        PORM
   1          2250.0       0.633
   2          2529.4       0.150
   3          1000.0       1.000
   4          2700.0       0.300
   5          2625.0       0.200
#
#  Data on time series
#  TINIT     AGEO      RAT      TEND      NTERM      LREAD
   0.00      0.50      1.23     1000.00   90         0
#
#
#  Data on numerical parameters
#  EPS      EWT      NLOOP      MSPAR
   1.00E-06 1.00E-18 3          1
#
#
#  Data on group (one set of data per group common for all sources)
#
# Group No: 1
#  NNCH    ISPEC    ISPSOL
   1       1        0
#
# Nuclide: C-14 org
#  TAU        CSOLUB      AINV
   5.7300E+03 1.00E+10    1.2784E-02
#
#  CIRF                              % if ISPEC = 1
#
#
#  MAT       DEFM       SKDM         % one line per material
   1         0.06307    0.000
   2         0.00032    0.000
   3         0.06307    0.000
   4         0.01892    0.000
   5         0.00315    0.000
#
#
#  Data on sources
#  NSBCHA    ISEQ    MAT    IFWATB    VOLSOU    FINVEN    JINVEN
#
#  IBLOCK    ISSEQ           % if ISEQ = 1
#
#  XXXX                      % if JINVEN = 1. One line for each group.
#
#  IBSOUR                    % if ISEQ = 0
```

```
#
#  IWINT                     % if IFWATB = 1
#
#  WBFLOW                    % if IFWATB = 1 and IWINT = 0
#
#  Waste
#  Source    1
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  1
#  Source    2
  1  0  1  1  2064.0000  1.0000000E+00  1
#
  4.3000000E-01
  2
  0
  8.183800E-01
#  Source    3
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  3
#  Source    4
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  4
#  Source    5
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  5
#  Source    6
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  6
#  Source    7
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  7
#  Source    8
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  8
#  Source    9
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  9
#  Source    10
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  10
#  Source    11
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  11
#  Source    12
```

```
  1  0  1  1  576.0000  1.0000000E+00  1
#
  1.2000000E-01
  12
  0
  4.089400E-01
#  Source    13
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  13
#  Source    14
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  14
#  Source    15
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  15
#  Source    16
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  16
#  Source    17
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  17
#  Source    18
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  18
#  Source    19
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  19
#  Source    20
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  20
#  Source    21
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  21
#  Source    22
  1  0  1  1  576.0000  1.0000000E+00  1
#
  1.2000000E-01
  22
  0
  6.729000E-01
#  Source    23
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  23
#  Source    24
```

```
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  24
#  Source    25
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  25
#  Source    26
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  26
#  Source    27
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  27
#  Source    28
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  28
#  Source    29
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  29
#  Source    30
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  30
#  Source    31
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  31
#  Source    32
  1  0  1  1  624.0000  1.0000000E+00  1
#
  1.3000000E-01
  32
  0
  5.264500E-01
#  Source    33
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  33
#  Source    34
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  34
#  Source    35
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  35
#  Source    36
  1  0  1  0  0.0001  1.0000000E+00  1
#
```

```
  0.0000000E+00
  36
#  Source    37
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  37
#  Source    38
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  38
#  Source    39
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  39
#  Source    40
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  40
#  Source    41
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  41
#  Source    42
  1  0  1  1  960.0000  1.0000000E+00  1
#
  2.0000000E-01
  42
  0
  5.437200E-01
#  Source    43
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  43
#  Source    44
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  44
#  Source    45
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  45
#  Source    46
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  46
#  Source    47
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  47
#  Source    48
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  48
```

```
#  Source    49
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  49
#  Source    50
  1  0  1  0  0.0001  1.0000000E+00  1
#
  0.0000000E+00
  50
#  Description of blocks not considered before
#
#  Block i
#  NZ   NY    NX    NBLSP    MAT    IQFLOW
#
#  ZADIM  YADIM  XADIM  VOLBLK % one line per compartment if NBLSP = 1
#
#  IWINT                       % if IQFLOW = 1
#
#  NODWIN   NODWUT    BFLOW    % if IQFLOW = 1 and IWINT = 0
#
#  Walls of concrete tanks  51-55 and 118-122
#  Block   51
  1  1  1  0  2  1
  1.0000E+05     3.9641E-05      2.9324E-05      6.8800E+02
  0
  1              1            0.81838
#  Block   52
  1  1  1  0  2  1
  1.0000E+05     1.4205E-04      1.0508E-04      1.9200E+02
  0
  1              1            0.40894
#  Block   53
  1  1  1  0  2  1
  1.0000E+05     1.4205E-04      1.0508E-04      1.9200E+02
  0
  1              1            0.6729
#  Block   54
  1  1  1  0  2  1
  1.0000E+05     1.3112E-04      9.6994E-05      2.0800E+02
  0
  1              1            0.52645
#  Block   55
  1  1  1  0  2  1
  1.0000E+05     8.5227E-05      6.3046E-05      3.2000E+02
  0
  1              1            0.54372
# Porous concrete
#  Block   56
  1  1  1  0  5  1
  8.6897E-05     2.4157E-04      1.4215E-05      7.4390E+02
  1
#  Block   57
  1  1  1  0  5  1
  3.1138E-04     8.6564E-04      5.0937E-05      2.0760E+02
  1
#  Block   58
  1  1  1  0  5  1
  3.1138E-04     8.6564E-04      5.0937E-05      2.0760E+02
  1
#  Block   59
  1  1  1  0  5  1
  2.8743E-04     7.9905E-04      4.7019E-05      2.2490E+02
  1
```

```
#  Block   60
  1  1  1  0  5  1
  1.8683E-04     5.1938E-04      3.0562E-05      3.4600E+02
  1
# Short side of structure (passage)
#  Block   61
  1  1  1  0  2  1
  1.0000E+05     3.5971E-03      3.1010E-03      2.0155E+01
  0
  1              1            0.17863
#  Block   62
  1  1  1  0  2  1
  1.0000E+05     3.1010E-03      3.1010E-03      2.0155E+01
  0
  1              1            0.17863
# Fictitious block 63
#  Block   63
  1  1  1  0  2  1
  1.0000E-05     1.0000E-05      1.0000E-05      1.0000E-02
  0
  1              1            0.17863
#  Ceiling
#  Block   64
  1  1  1  0  2  1
  8.6586E-01     3.1606E-04      3.1868E-04      2.2314E+02
  0
  1              1            0.63975
#  Block   65
  1  1  1  0  2  1
  8.6586E-01     3.1606E-04      1.0000E+05      2.2314E+02
  0
  1              1            0.63975
#  Block   66
  1  1  1  0  2  1
  8.6586E-01     3.1606E-04      1.0000E+05      2.2314E+02
  0
  1              1            0.63975
#  Block   67
  1  1  1  0  2  1
  3.1027E+00     1.1419E-03      1.1419E-03      6.2272E+01
  0
  1              1            0.31853
#  Block   68
  1  1  1  0  2  1
  3.1027E+00     1.1419E-03      1.0000E+05      6.2272E+01
  0
  1              1            0.31853
#  Block   69
  1  1  1  0  2  1
  3.1027E+00     1.1419E-03      1.0000E+05      6.2272E+01
  0
  1              1            0.31853
#  Block   70
  1  1  1  0  2  1
  3.1027E+00     1.1419E-03      1.1419E-03      6.2272E+01
  0
  1              1            0.4312
#  Block   71
  1  1  1  0  2  1
  3.1027E+00     1.1419E-03      1.0000E+05      6.2272E+01
  0
  1              1            0.4312
#  Block   72
  1  1  1  0  2  1
```

```
  3.1027E+00     1.1419E-03      1.0000E+05      6.2272E+01
  0
  1              1            0.4312
#  Block   73
  1  1  1  0  2  1
  2.8640E+00     1.0541E-03      1.0541E-03      6.7461E+01
  0
  1              1            0.25631
#  Block   74
  1  1  1  0  2  1
  2.8640E+00     1.0541E-03      1.0000E+05      6.7461E+01
  0
  1              1            0.25631
#  Block   75
  1  1  1  0  2  1
  2.8640E+00     1.0541E-03      1.0000E+05      6.7461E+01
  0
  1              1            0.25631
#  Block   76
  1  1  1  0  2  1
  1.8616E+00     6.7315E-04      6.8517E-04      1.0379E+02
  0
  1              1            0.22832
#  Block   77
  1  1  1  0  2  1
  1.8616E+00     6.7315E-04      1.0000E+05      1.0379E+02
  0
  1              1            0.22832
#  Block   78
  1  1  1  0  2  1
  1.8616E+00     6.7315E-04      1.0000E+05      1.0379E+02
  0
  1              1            0.22832
#  Bottom of structure 79-83 and 182-191
#  Block   79
  1  1  1  0  2  1
  8.2372E-03     1.4943E-04      1.5934E-04      1.1897E+02
  1
#  Block   80
  1  1  1  0  2  1
  2.9762E-02     5.3990E-04      5.7097E-04      3.2928E+01
  1
#  Block   81
  1  1  1  0  2  1
  2.9762E-02     5.3990E-04      5.7097E-04      3.2928E+01
  1
#  Block   82
  1  1  1  0  2  1
  2.7473E-02     4.9837E-04      5.2705E-04      3.5672E+01
  1
#  Block   83
  1  1  1  0  2  1
  1.7544E-02     3.1826E-04      3.4258E-04      5.5860E+01
  1
# Fiktiva block 84-113
#  Block   84
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.10248
#  Block   85
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
```

```
  1              1            0.10248
#  Block   86
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.10248
#  Block   87
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.11733
#  Block   88
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.11733
#  Block   89
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.11733
#  Block   90
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.0106
#  Block   91
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.0106
#  Block   92
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.0106
#  Block   93
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.03144
#  Block   94
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.03144
#  Block   95
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.03144
#  Block   96
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.03189
#  Block   97
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  0
  1              1            0.03189
#  Block   98
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
```

```
  0
  1              1             0.03189
# Fictitious blocks (Wall on right side of structure) 99-113
#  Block   99
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#  Block   100
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#  Block   101
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#  Block   102
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#  Block   103
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#  Block   104
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#  Block   105
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#  Block   106
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#  Block   107
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#  Block   108
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#  Block   109
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#  Block   110
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#  Block   111
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#  Block   112
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
#  Block   113
  1  1  1  0  3  1
  1.0000E-05     1.0000E+05      1.0000E-05      1.0000E-02
  1
# Fictitious block 114-117
```

```
#  Block   114
  1  1  1  0  3  1
  1.0000E+05     1.0000E+05      1.0000E+05      1.0000E-02
  0
  1              1             0.07433
#  Block   115
  1  1  1  0  3  1
  1.0000E+05     1.0000E+05      1.0000E+05      1.0000E-02
  0
  1              1             0.01608
#  Block   116
  1  1  1  0  3  1
  1.0000E+05     1.0000E+05      1.0000E+05      1.0000E-02
  0
  1              1             0.2417
#  Block   117
  1  1  1  0  3  1
  1.0000E+05     1.0000E+05      1.0000E+05      1.0000E-02
  0
  1              1             0.27014
# Walls of conrete tanks 118-122
#  Block   118
  1  1  1  0  2  1
  1.0000E+05     3.9641E-05      2.9324E-05      6.8800E+02
  0
  1              1             0.81838
#  Block   119
  1  1  1  0  2  1
  1.0000E+05     1.4205E-04      1.0508E-04      1.9200E+02
  0
  1              1             0.40894
#  Block   120
  1  1  1  0  2  1
  1.0000E+05     1.4205E-04      1.0508E-04      1.9200E+02
  0
  1              1             0.6729
#  Block   121
  1  1  1  0  2  1
  1.0000E+05     1.3112E-04      9.6994E-05      2.0800E+02
  0
  1              1             0.52645
#  Block   122
  1  1  1  0  2  1
  1.0000E+05     8.5227E-05      6.3046E-05      3.2000E+02
  0
  1              1             0.54372
# Short side of structure (loading zone)
#  Block   123
  1  1  1  0  2  1
  1.0000E+05     3.5971E-03      3.1010E-03      2.0155E+01
  0
  1              1             0.3154
#  Block   124
  1  1  1  0  2  1
  1.0000E+05     3.1010E-03      3.1010E-03      2.0155E+01
  0
  1              1             0.3154
# Fictitious block 125
#  Block   125
  1  1  1  0  2  1
  1.0000E+05     1.0000E+05      1.0000E+05      1.0000E-02
  0
  1              1             0.3154
# Gravel at the end of the tunnel (passage) 126-128
```

```
#  Block   126
  1  1  1  0  4  1
  1.4506E-01     1.6538E-02      1.0829E-02      1.6417E+02
  1
#  Block   127
  1  1  1  0  4  1
  1.0000E+05     1.0000E+05      1.0829E-02      1.6417E+02
  1
#  Block   128
  1  1  1  0  4  1
  1.0000E+05     1.0000E+05      1.0829E-02      1.6417E+02
  1
# Gravel on top of the structure 129-143
#  Block   129
  1  1  1  0  4  1
  7.0076E-04     7.7259E-02      6.6038E+00      5.5793E+02
  1
#  Block   130
  1  1  1  0  4  1
  7.0076E-04     1.0000E+05      6.6038E+00      5.5793E+02
  1
#  Block   131
  1  1  1  0  4  1
  7.0076E-04     1.0000E+05      6.6038E+00      5.5793E+02
  1
#  Block   132
  1  1  1  0  4  1
  2.5319E-03     2.7914E-01      1.8277E+00      1.5442E+02
  1
#  Block   133
  1  1  1  0  4  1
  2.5319E-03     1.0000E+05      1.8277E+00      1.5442E+02
  1
#  Block   134
  1  1  1  0  4  1
  2.5319E-03     1.0000E+05      1.8277E+00      1.5442E+02
  1
#  Block   135
  1  1  1  0  4  1
  2.5319E-03     2.7914E-01      1.8277E+00      1.5442E+02
  1
#  Block   136
  1  1  1  0  4  1
  2.5319E-03     1.0000E+05      1.8277E+00      1.5442E+02
  1
#  Block   137
  1  1  1  0  4  1
  2.5319E-03     1.0000E+05      1.8277E+00      1.5442E+02
  1
#  Block   138
  1  1  1  0  4  1
  2.3372E-03     2.5767E-01      1.9801E+00      1.6729E+02
  1
#  Block   139
  1  1  1  0  4  1
  2.3372E-03     1.0000E+05      1.9801E+00      1.6729E+02
  1
#  Block   140
  1  1  1  0  4  1
  2.3372E-03     1.0000E+05      1.9801E+00      1.6729E+02
  1
#  Block   141
  1  1  1  0  4  1
  1.4925E-03     1.6455E-01      3.1006E+00      2.6196E+02
```

```
  1
#  Block   142
  1  1  1  0  4  1
  1.4925E-03     1.0000E+05      3.1006E+00      2.6196E+02
  1
#  Block   143
  1  1  1  0  4  1
  1.4925E-03     1.0000E+05      3.1006E+00      2.6196E+02
  1
# Gravel in bottom of tunnel 144-148
#  Block   144
  1  1  1  0  4  1
  3.3621E-04     1.0000E+05      1.3651E+01      2.6769E+02
  1
#  Block   145
  1  1  1  0  4  1
  1.2148E-03     1.0000E+05      3.8095E+00      7.4088E+01
  1
#  Block   146
  1  1  1  0  4  1
  1.2148E-03     1.0000E+05      3.8095E+00      7.4088E+01
  1
#  Block   147
  1  1  1  0  4  1
  1.1213E-03     1.0000E+05      4.1270E+00      8.0262E+01
  1
#  Block   148
  1  1  1  0  4  1
  7.1608E-04     1.0000E+05      6.3492E+00      1.2569E+02
  1
# Concrete on left side 149-153 and 162-171
#  Block   149
  1  1  1  0  5  1
  7.1664E-01     3.7872E-04      7.7845E+01      4.6941E+01
  1
#  Block   150
  1  1  1  0  5  1
  2.5893E+00     1.3684E-03      2.1724E+01      1.2992E+01
  1
#  Block   151
  1  1  1  0  5  1
  2.5893E+00     1.3684E-03      2.1724E+01      1.2992E+01
  1
#  Block   152
  1  1  1  0  5  1
  2.3901E+00     1.2631E-03      2.3534E+01      1.4075E+01
  1
#  Block   153
  1  1  1  0  5  1
  1.5263E+00     8.0661E-04      3.6207E+01      2.2040E+01
  1
# Concrete on right side 154-158 and 172-181
#  Block   154
  1  1  1  0  5  1
  7.1664E-01     3.7872E-04      7.7845E+01      4.6941E+01
  1
#  Block   155
  1  1  1  0  5  1
  2.5893E+00     1.3684E-03      2.1724E+01      1.2992E+01
  1
#  Block   156
  1  1  1  0  5  1
  2.5893E+00     1.3684E-03      2.1724E+01      1.2992E+01
  1
```

```
#  Block   157
  1  1  1  0  5  1
  2.3901E+00     1.2631E-03      2.3534E+01      1.4075E+01
  1
#  Block   158
  1  1  1  0  5  1
  1.5263E+00     8.0661E-04      3.6207E+01      2.2040E+01
  1
# Gravel at the end of the tunnel (loading zone) 159-161
#  Block   159
  1  1  1  0  4  1
  5.4397E-01     6.2019E-02      4.0609E-02      6.1563E+02
  1
#  Block   160
  1  1  1  0  4  1
  1.0000E+05     1.0000E+05      4.0609E-02      6.1563E+02
  1
#  Block   161
  1  1  1  0  4  1
  1.0000E+05     1.0000E+05      4.0609E-02      6.1563E+02
  1
# Concrete on left side 149-153 and 162-171
#  Block   162
  1  1  1  0  5  1
  1.0000E+05     3.7872E-04      7.7845E+01      4.6941E+01
  1
#  Block   163
  1  1  1  0  5  1
  1.0000E+05     3.7872E-04      7.7845E+01      4.6941E+01
  1
#  Block   164
  1  1  1  0  5  1
  1.0000E+05     1.3684E-03      2.1724E+01      1.2992E+01
  1
#  Block   165
  1  1  1  0  5  1
  1.0000E+05     1.3684E-03      2.1724E+01      1.2992E+01
  1
#  Block   166
  1  1  1  0  5  1
  1.0000E+05     1.3684E-03      2.1724E+01      1.2992E+01
  1
#  Block   167
  1  1  1  0  5  1
  1.0000E+05     1.3684E-03      2.1724E+01      1.2992E+01
  1
#  Block   168
  1  1  1  0  5  1
  1.0000E+05     1.2631E-03      2.3534E+01      1.4075E+01
  1
#  Block   169
  1  1  1  0  5  1
  1.0000E+05     1.2631E-03      2.3534E+01      1.4075E+01
  1
#  Block   170
  1  1  1  0  5  1
  1.0000E+05     8.0661E-04      3.6207E+01      2.2040E+01
  1
#  Block   171
  1  1  1  0  5  1
  1.0000E+05     8.0661E-04      3.6207E+01      2.2040E+01
  1
# Concrete on right side 154-158 and 172-181
#  Block   172
```

```
  1  1  1  0  5  1
  1.0000E+05     3.7872E-04      7.7845E+01      4.6941E+01
  1
#  Block   173
  1  1  1  0  5  1
  1.0000E+05     3.7872E-04      7.7845E+01      4.6941E+01
  1
#  Block   174
  1  1  1  0  5  1
  1.0000E+05     1.3684E-03      2.1724E+01      1.2992E+01
  1
#  Block   175
  1  1  1  0  5  1
  1.0000E+05     1.3684E-03      2.1724E+01      1.2992E+01
  1
#  Block   176
  1  1  1  0  5  1
  1.0000E+05     1.3684E-03      2.1724E+01      1.2992E+01
  1
#  Block   177
  1  1  1  0  5  1
  1.0000E+05     1.3684E-03      2.1724E+01      1.2992E+01
  1
#  Block   178
  1  1  1  0  5  1
  1.0000E+05     1.2631E-03      2.3534E+01      1.4075E+01
  1
#  Block   179
  1  1  1  0  5  1
  1.0000E+05     1.2631E-03      2.3534E+01      1.4075E+01
  1
#  Block   180
  1  1  1  0  5  1
  1.0000E+05     8.0661E-04      3.6207E+01      2.2040E+01
  1
#  Block   181
  1  1  1  0  5  1
  1.0000E+05     8.0661E-04      3.6207E+01      2.2040E+01
  1
#  Bottom of structure 79-83 and 182-191
#  Block   182
  1  1  1  0  2  1
  8.2372E-03     1.4943E-04      3.0969E+01      1.1897E+02
  0
  1              1            0.631108
#  Block   183
  1  1  1  0  2  1
  8.2372E-03     1.4943E-04      3.0969E+01      1.1897E+02
  0
  1              1            0.631108
#  Block   184
  1  1  1  0  2  1
  2.9762E-02     5.3990E-04      8.5714E+00      3.2928E+01
  0
  1              1            0.293864
#  Block   185
  1  1  1  0  2  1
  2.9762E-02     5.3990E-04      8.5714E+00      3.2928E+01
  0
  1              1            0.293864
#  Block   186
  1  1  1  0  2  1
  2.9762E-02     5.3990E-04      8.5714E+00      3.2928E+01
  0
```

```
  1              1            0.6763
#  Block   187
  1  1  1  0  2  1
  2.9762E-02     5.3990E-04      8.5714E+00      3.2928E+01
  0
  1              1            0.6763
#  Block   188
  1  1  1  0  2  1
  2.7473E-02     4.9837E-04      9.2857E+00      3.5672E+01
  0
  1              1            0.242692
#  Block   189
  1  1  1  0  2  1
  2.7473E-02     4.9837E-04      9.2857E+00      3.5672E+01
  0
  1              1            0.242692
#  Block   190
  1  1  1  0  2  1
  1.7544E-02     3.1826E-04      1.4541E+01      5.5860E+01
  0
  1              1            0.232857
#  Block   191
  1  1  1  0  2  1
  1.7544E-02     3.2394E-04      1.4541E+01      5.5860E+01
  0
  1              1            0.232857
#  Codifying the connections
#
#  NSSCO    NSBCO    NBBCO
   0        10       260
#
#  Connection source - block
#
#  IBSOU  IBSB  ISEQC  NABCCO  IRZB  ICRB  IPLUG  IRADD
#
#  ICOMPB  ICSEQB  % if NABCCO > 1 and ISEQC =1
#
#  IDCB            % if ISEQC = 0. One value for each connection.
#
#  LSCFW  QWATIN   % if IFWATB(source term) = 1 and IQFLOW(block) = 1
#
#  ISERNU          % if IRADD =1
#
#  XRADD           % if IRADD = 1 and ISERNU = 1
#
#  XRADD           % if IRADD = 1 and ISERNU = 0. One line per group.
#
#
#  BETWEEN WASTE - CONCRETE WALLS OF CONCRETE CONTAINERS
#  1 Source-block   2 - 51
     2  51  0  1  1  1  0  0
  1
  1  0.81838
#  2 Source-block   2 - 118
     2  118  0  1  1  1  0  0
  1
  -1  0.81838
#  3 Source-block   12 - 52
     12  52  0  1  1  1  0  0
  1
  1  0.40894
#  4 Source-block   12 - 119
     12  119  0  1  1  1  0  0
  1
```

```
  -1  0.40894
#  5 Source-block   22 - 53
     22  53  0  1  1  1  0  0
  1
  1  0.6729
#  6 Source-block   22 - 120
     22  120  0  1  1  1  0  0
  1
  -1  0.6729
#  7 Source-block   32 - 54
     32  54  0  1  1  1  0  0
  1
  1  0.52645
#  8 Source-block   32 - 121
     32  121  0  1  1  1  0  0
  1
  -1  0.52645
#  9 Source-block   42 - 55
     42  55  0  1  1  1  0  0
  1
  1  0.54372
#  10 Source-block   42 - 122
     42  122  0  1  1  1  0  0
  1
  -1  0.54372
#  Connections between blocks not considered as sources
#
#  IBA  IBB  ISEQC  NABCCO  IRZA  IRZB  ICRA  ICRB  IPLUG  IRADD
#
#  IDCA     IDCB                        % if NABCCO = 1
#
#  ICOMPA  ICOMPB  ICSEQA  ICSEQB      % if NABCCO > 1 and ISQC = 1
#
#  IDCA                                % if NABCCO > 1 and ISQC = 0
#
#  IDCB                                % if NABCCO > 1 and ISQC = 0
#
#  LSCFW     QWATIN               % if IQFLOW(A) = 1 and IQFLOW(B) = 1
#
#  ISERNU                         % if IRADD = 1
#
#  XRADD             % if IRADD = 1 and ISERNU = 0. One line per group
#
#  BETWEEN WALLS OF CONCRETE CONTAINERS AND BACKFILL CONCRETE
#  1 Block-block   51 - 56
   51  56  0  1  2  2  1  1  0  0
    1           1
    1        8.18380E-01
#  2 Block-block   52 - 57
   52  57  0  1  2  2  1  1  0  0
    1           1
    1        4.08940E-01
#  3 Block-block   53 - 58
   53  58  0  1  2  2  1  1  0  0
    1           1
    1        6.72900E-01
#  4 Block-block   54 - 59
   54  59  0  1  2  2  1  1  0  0
    1           1
    1        5.26450E-01
#  5 Block-block   55 - 60
   55  60  0  1  2  2  1  1  0  0
    1           1
    1        5.43720E-01
```

```
#  6 Block-block   56 - 118
   56  118  0  1  2  2  1  1  0  0
    1          1
    1        8.18380E-01
#  7 Block-block   57 - 119
   57  119  0  1  2  2  1  1  0  0
    1          1
    1        4.08940E-01
#  8 Block-block   58 - 120
   58  120  0  1  2  2  1  1  0  0
    1          1
    1        6.72900E-01
#  9 Block-block   59 - 121
   59  121  0  1  2  2  1  1  0  0
    1          1
    1        5.26450E-01
#  10 Block-block   60 - 122
   60  122  0  1  2  2  1  1  0  0
    1          1
    1        5.43720E-01
# BETWEEN CONCRETE BACKFILL AND WALL BETWEEN WASTE AND GRAVEL BACKFILL
(PASSAGE)
#  11 Block-block   56 - 61
   56  61  0  1  0  1  1  1  0  0
    1          1
    1        1.78630E-01
# BETWEEN CONCRETE BACKFILL AND CONCRETE BLOCKS ABOVE THE WASTE
#  12 Block-block   56 - 64
   56  64  0  1  0  2  1  1  0  0
    1          1
    1        6.39750E-01
#  13 Block-block   57 - 67
   57  67  0  1  0  2  1  1  0  0
    1          1
    1        3.18530E-01
#  14 Block-block   58 - 70
   58  70  0  1  0  2  1  1  0  0
    1          1
    1        4.31200E-01
#  15 Block-block   59 - 73
   59  73  0  1  0  2  1  1  0  0
    1          1
    1        2.56310E-01
#  16 Block-block   60 - 76
   60  76  0  1  0  2  1  1  0  0
    1          1
    1        2.28320E-01
# BETWEEN CONCRETE BACKFILL AND CONCRETE BELOW THE WASTE
#  17 Block-block   56 - 79
   56  79  0  1  0  2  1  1  0  0
    1          1
    -1        5.52740E-01
#  18 Block-block   57 - 80
   57  80  0  1  0  2  1  1  0  0
    1          1
    -1        2.59470E-01
#  19 Block-block   58 - 81
   58  81  0  1  0  2  1  1  0  0
    1          1
    -1        5.93020E-01
#  20 Block-block   59 - 82
   59  82  0  1  0  2  1  1  0  0
    1          1
    -1        2.12730E-01
```

```
#  21 Block-block   60 - 83
   60  83  0  1  0  2  1  1  0  0
    1          1
   -1        2.03880E-01
# BETWEEN CONCRETE BACKFILL AND FICTITIOUS BLOCK
#  22 Block-block   56 - 84
   56  84  0  1  1  2  1  0  0  0
    1          1
   -1        1.02480E-01
#  23 Block-block   57 - 87
   57  87  0  1  1  2  1  0  0  0
    1          1
   -1        1.17330E-01
#  24 Block-block   58 - 90
   58  90  0  1  1  2  1  0  0  0
    1          1
   -1        1.06000E-02
#  25 Block-block   59 - 93
   59  93  0  1  1  2  1  0  0  0
    1          1
   -1        3.14400E-02
#  26 Block-block   60 - 96
   60  96  0  1  1  2  1  0  0  0
    1          1
   -1        3.18900E-02
# BETWEEN CONCRETE BACKFILL AND FICTITIOUS BLOCK
#  27 Block-block   56 - 99
   56  99  0  1  1  2  1  0  0  0
    1          1
   -1        8.88300E-02
#  28 Block-block   57 - 102
   57  102  0  1  1  2  1  0  0  0
    1          1
   -1        3.21400E-02
#  29 Block-block   58 - 105
   58  105  0  1  1  2  1  0  0  0
    1          1
   -1        5.32000E-02
#  30 Block-block   59 - 108
   59  108  0  1  1  2  1  0  0  0
    1          1
   -1        4.05800E-02
#  31 Block-block   60 - 111
   60  111  0  1  1  2  1  0  0  0
    1          1
   -1        3.78100E-02
# BETWEEN CONCRETE BACKFILL AND FICTITIOUS BLOCK
#  32 Block-block   56 - 114
   56  114  0  1  2  2  0  0  0  1
    1          1
   -1        7.43300E-02
  1
  1.6607E-01
#  33 Block-block   57 - 114
   57  114  0  1  2  2  0  0  0  1
    1          1
    1       7.43300E-02
  1
  1.6607E-01
#  BETWEEN CONCRETE BACKFILL AND FICTITIOUS BLOCK
#  34 Block-block   57 - 115
   57  115  0  1  2  2  0  0  0  1
    1          1
    1       1.60800E-02
```

```
  1
  1.6607E-01
#  35 Block-block   58 - 115
   58  115  0  1  2  2  0  0  0  1
    1           1
    -1         1.60800E-02
  1
  1.6607E-01
#  BETWEEN CONCRETE BACKFILL AND FICTITIOUS BLOCK
#  36 Block-block   58 - 116
   58  116  0  1  2  2  0  0  0  1
    1           1
    1        2.41700E-01
  1
  1.6607E-01
#  37 Block-block   59 - 116
   59  116  0  1  2  2  0  0  0  1
    1           1
    -1         2.41700E-01
  1
  1.6607E-01
#  BETWEEN CONCRETE BACKFILL AND FICTITIOUS BLOCK
#  38 Block-block   59 - 117
   59  117  0  1  2  2  0  0  0  1
    1           1
    1        2.70140E-01
  1
  1.6607E-01

#  39 Block-block   60 - 117
   60  117  0  1  2  2  0  0  0  1
    1           1
    -1         2.70140E-01
  1
  1.6607E-01
#  BETWEEN CONCRETE BACKFILL AND WALL BETWEEN WASTE AND GRAVEL
BACKFILL (LOADING ZONE)
#  40 Block-block   60 - 123
   60  123  0  1  2  1  1  1  0  0
    1           1
    1        3.15400E-01
#  WITHIN WALL BETWEEN CONCRETE BACKFILL AND GRAVEL BACKFILL (PASSAGE)
#  41 Block-block   61 - 62
   61  62  0  1  2  2  1  1  0  0
    1           1
    1        1.78630E-01
#  BETWEN WALL BETWEEN CONCRETE BACKFILL AND GRAVEL BACKFILL (PASSAGE)
AND FICTITIOUS BLOCK
#  42 Block-block   62 - 63
   62  63  0  1  2  2  1  0  0  0
    1           1
    1        1.78630E-01
#  BETWEEN FICTITIOUS BLOCK AND  GRAVEL BACKFILL (PASSAGE)
#  43 Block-block   63 - 126
   63  126  0  1  2  2  0  1  0  0
    1           1
    1        1.78630E-01
#  WITHIN CONCRETE ABOVE THE WASTE  (TRANSVERSE THE MAIN AXIS OF
TUNNEL)
#  44 Block-block   64 - 65
   64  65  0  1  1  1  1  1  0  0
    1           1
    1        6.39750E-01
#  45 Block-block   65 - 66
```

```
   65  66  0  1  1  1  1  1  0  0
    1           1
    1        6.39750E-01
#  46 Block-block   67 - 68
   67  68  0  1  1  1  1  1  0  0
    1           1
    1        3.18530E-01
#  47 Block-block   68 - 69
   68  69  0  1  1  1  1  1  0  0
    1           1
    1        3.18530E-01
#  48 Block-block   70 - 71
   70  71  0  1  1  1  1  1  0  0
    1           1
    1        4.31200E-01
#  49 Block-block   71 - 72
   71  72  0  1  1  1  1  1  0  0
    1           1
    1        4.31200E-01
#  50 Block-block   73 - 74
   73  74  0  1  1  1  1  1  0  0
    1           1
    1        2.56310E-01
#  51 Block-block   74 - 75
   74  75  0  1  1  1  1  1  0  0
    1           1
    1        2.56310E-01
#  52 Block-block   76 - 77
   76  77  0  1  1  1  1  1  0  0
    1           1
    1        2.28320E-01
#  53 Block-block   77 - 78
   77  78  0  1  1  1  1  1  0  0
    1           1
    1        2.28320E-01
#  WITHIN CONCRETE ABOVE THE WASTE (ALONG THE MAIN AXIS OF TUNNEL)
#  54 Block-block   64 - 67
#  55 Block-block   65 - 68
#  56 Block-block   66 - 69
#  57 Block-block   67 - 70
#  58 Block-block   68 - 71
#  59 Block-block   69 - 72
#  60 Block-block   70 - 73
#  61 Block-block   71 - 74
#  62 Block-block   72 - 75
#  63 Block-block   73 - 76
#  64 Block-block   74 - 77
#  65 Block-block   75 - 78
#  BETWEEN CONCRETE ABOVE THE WASTE AND GRAVEL IN TOP OF TUNNEL
#  66 Block-block   66 - 129
   66  129  0  1  1  0  1  1  0  0
    1           1
    1        6.39750E-01
#  67 Block-block   69 - 132
   69  132  0  1  1  0  1  1  0  0
    1           1
    1        3.18530E-01
#  68 Block-block   72 - 135
   72  135  0  1  1  0  1  1  0  0
    1           1
    1        4.31200E-01
#  69 Block-block   75 - 138
   75  138  0  1  1  0  1  1  0  0
    1           1
```

```
    1        2.56310E-01
#  70 Block-block   78 - 141
   78  141  0  1  1  0  1  1  0  0
    1           1
    1        2.28320E-01
#  WITHIN CONCRETE BELOW THE WASTE  (TRANSVERSE THE MAIN AXIS OF
TUNNEL)
#  71 Block-block   79 - 182
   79  182  0  1  1  1  1  1  0  0
    1           1
    -1        6.31108E-01
#  72 Block-block   182 - 183
   182  183  0  1  1  1  1  1  0  0
    1           1
    -1        6.31108E-01
#  73 Block-block   80 - 184
   80  184  0  1  1  1  1  1  0  0
    1           1
    -1        2.93864E-01
#  74 Block-block   184 - 185
   184  185  0  1  1  1  1  1  0  0
    1           1
    -1        2.93864E-01
#  75 Block-block   81 - 186
   81  186  0  1  1  1  1  1  0  0
    1           1
    -1        6.76300E-01
#  76 Block-block   186 - 187
   186  187  0  1  1  1  1  1  0  0
    1           1
    -1        6.76300E-01
#  77 Block-block   82 - 188
   82  188  0  1  1  1  1  1  0  0
    1           1
    -1        2.42692E-01
#  78 Block-block   188 - 189
   188  189  0  1  1  1  1  1  0  0
    1           1
    -1        2.42692E-01
#  79 Block-block   83 - 190
   83  190  0  1  1  1  1  1  0  0
    1           1
    -1        2.32857E-01
#  80 Block-block   190 - 191
   190  191  0  1  1  1  1  1  0  0
    1           1
    -1        2.32857E-01
#  WITHIN CONCRETE BELOW THE WASTE (ALONG THE MAIN AXIS OF TUNNEL)
#  81 Block-block   79 - 80
#  82 Block-block   80 - 81
#  83 Block-block   81 - 82
#  84 Block-block   82 - 83
# BETWEEN CONCRETE IN BOTTOM OF THE TUNNEL AND CONCRETE BACKFILL ON
LEFT SIDE OF THE TUNNEL
#  85 Block-block   79 - 149
   79  149  0  1  0  0  1  1  0  0
    1           1
    1        1.31610E-02
#  86 Block-block   79 - 162
   79  162  0  1  0  0  1  1  0  0
    1           1
    1        1.31610E-02
#  87 Block-block   79 - 163
   79  163  0  1  0  0  1  1  0  0
```

```
    1           1
    1        1.31610E-02
#  88 Block-block   80 - 150
   80  150  0  1  0  0  1  1  0  0
    1           1
    1        5.59567E-03
#  89 Block-block   80 - 164
   80  164  0  1  0  0  1  1  0  0
    1           1
    1        5.59567E-03
#  90 Block-block   80 - 165
   80  165  0  1  0  0  1  1  0  0
    1           1
    1        5.59567E-03
#  91 Block-block   81 - 151
   81  151  0  1  0  0  1  1  0  0
    1           1
    1        1.88363E-02
#  92 Block-block   81 - 166
   81  166  0  1  0  0  1  1  0  0
    1           1
    1        1.88363E-02
#  93 Block-block   81 - 167
   81  167  0  1  0  0  1  1  0  0
    1           1
    1        1.88363E-02
#  94 Block-block   82 - 152
   82  152  0  1  0  0  1  1  0  0
    1           1
    1        5.16500E-03
#  95 Block-block   82 - 168
   82  168  0  1  0  0  1  1  0  0
    1           1
    1        5.16500E-03
#  96 Block-block   82 - 169
   82  169  0  1  0  0  1  1  0  0
    1           1
    1        5.16500E-03
#  97 Block-block   83 - 153
   83  153  0  1  0  0  1  1  0  0
    1           1
    1        4.87267E-03
#  98 Block-block   83 - 170
   83  170  0  1  0  0  1  1  0  0
    1           1
    1        4.87267E-03
#  99 Block-block   83 - 171
   83  171  0  1  0  0  1  1  0  0
    1           1
    1        4.87267E-03
#  BETWEEN CONCRETE IN BOTTOM OF THE TUNNEL AND CONCRETE BACKFILL ON
RIGHT SIDE OF THE TUNNEL
#  100 Block-block   79 - 154
   79  154  0  1  0  0  1  1  0  0
    1           1
    1        1.29617E-02
#  101 Block-block   79 - 172
   79  172  0  1  0  0  1  1  0  0
    1           1
    1        1.29617E-02
#  102 Block-block   79 - 173
   79  173  0  1  0  0  1  1  0  0
    1           1
    1        1.29617E-02
```

```
#  103 Block-block   80 - 155
   80  155  0  1  0  0  1  1  0  0
    1           1
    1        5.86900E-03
#  104 Block-block   80 - 174
   80  174  0  1  0  0  1  1  0  0
    1           1
    1        5.86900E-03
#  105 Block-block   80 - 175
   80  175  0  1  0  0  1  1  0  0
    1           1
    1        5.86900E-03
#  106 Block-block   81 - 156
   81  156  0  1  0  0  1  1  0  0
    1           1
    1        8.92367E-03
#  107 Block-block   81 - 176
   81  176  0  1  0  0  1  1  0  0
    1           1
    1        8.92367E-03
#  108 Block-block   81 - 177
   81  177  0  1  0  0  1  1  0  0
    1           1
    1        8.92367E-03
#  109 Block-block   82 - 157
   82  157  0  1  0  0  1  1  0  0
    1           1
    1        4.82233E-03
#  110 Block-block   82 - 178
   82  178  0  1  0  0  1  1  0  0
    1           1
    1        4.82233E-03
#  111 Block-block   82 - 179
   82  179  0  1  0  0  1  1  0  0
    1           1
    1        4.82233E-03
#  112 Block-block   83 - 158
   83  158  0  1  0  0  1  1  0  0
    1           1
    1        4.78633E-03
#  113 Block-block   83 - 180
   83  180  0  1  0  0  1  1  0  0
    1           1
    1        4.78633E-03
#  114 Block-block   83 - 181
   83  181  0  1  0  0  1  1  0  0
    1           1
    1        4.78633E-03
#  BETWEEN CONCRETE BELOW THE WASTE AND GRAVEL IN BOTTOM OF THE TUNNEL
#  115 Block-block   183 - 144
   183  144  0  1  1  0  1  1  0  0
    1           1
    -1        6.31108E-01
#  116 Block-block   185 - 145
   185  145  0  1  1  0  1  1  0  0
    1           1
    -1        2.93864E-01
#  117 Block-block   187 - 146
   187  146  0  1  1  0  1  1  0  0
    1           1
    -1        6.76300E-01
#  118 Block-block   189 - 147
   189  147  0  1  1  0  1  1  0  0
    1           1
```

```
    -1        2.42692E-01
#  119 Block-block   191 - 148
   191  148  0  1  1  0  1  1  0  0
    1           1
    -1        2.32857E-01
#  WITHIN FICTITIOUS BLOCK (TRANSVERSE TO THE MAIN AXIS OF TUNNEL)
#  120 Block-block   84 - 85
   84  85  0  1  2  2  0  0  0  0
    1           1
    -1        1.02480E-01
#  121 Block-block   85 - 86
   85  86  0  1  2  2  0  0  0  0
    1           1
    -1        1.02480E-01
#  122 Block-block   87 - 88
   87  88  0  1  2  2  0  0  0  0
    1           1
    -1        1.17330E-01
#  123 Block-block   88 - 89
   88  89  0  1  2  2  0  0  0  0
    1           1
    -1        1.17330E-01
#  124 Block-block   90 - 91
   90  91  0  1  2  2  0  0  0  0
    1           1
    -1        1.06000E-02
#  125 Block-block   91 - 92
   91  92  0  1  2  2  0  0  0  0
    1           1
    -1        1.06000E-02
#  126 Block-block   93 - 94
   93  94  0  1  2  2  0  0  0  0
    1           1
    -1        3.14400E-02
#  127 Block-block   94 - 95
   94  95  0  1  2  2  0  0  0  0
    1           1
    -1        3.14400E-02
#  128 Block-block   96 - 97
   96  97  0  1  2  2  0  0  0  0
    1           1
    -1        3.18900E-02
#  129 Block-block   97 - 98
   97  98  0  1  2  2  0  0  0  0
    1           1
    -1        3.18900E-02
#  WITHIN FICTITIOUS BLOCK (ALONG THE MAIN AXIS OF TUNNEL)
#  130 Block-block   84 - 87
#  131 Block-block   85 - 88
#  132 Block-block   86 - 89
#  133 Block-block   87 - 90
#  134 Block-block   88 - 91
#  135 Block-block   89 - 92
#  136 Block-block   90 - 93
#  137 Block-block   91 - 94
#  138 Block-block   92 - 95
#  139 Block-block   93 - 96
#  140 Block-block   94 - 97
#  141 Block-block   95 - 98
# BETWEEN FICTITIOUS BLOCK AND CONCRETE BACKFILL ON LEFT SIDE OF THE
WASTE
#  142 Block-block   86 - 149
   86  149  0  1  2  1  0  1  0  0
    1           1
```

```
    -1        1.02480E-01
#  143 Block-block   89 - 150
   89  150  0  1  2  1  0  1  0  0
    1           1
    -1        1.17330E-01
#  144 Block-block   92 - 151
   92  151  0  1  2  1  0  1  0  0
    1           1
    -1        1.06000E-02
#  145 Block-block   95 - 152
   95  152  0  1  2  1  0  1  0  0
    1           1
    -1        3.14400E-02
#  146 Block-block   98 - 153
   98  153  0  1  2  1  0  1  0  0
    1           1
    -1        3.18900E-02
#  WITHIN FICTITIOUS BLOCK (TRANSVERSE TO THE MAIN AXIS OF TUNNEL)
#  147 Block-block   99 - 100
   99  100  0  1  2  2  0  0  0  0
    1           1
    -1        8.88300E-02
#  148 Block-block   100 - 101
   100  101  0  1  2  2  0  0  0  0
    1           1
    -1        8.88300E-02
#  149 Block-block   102 - 103
   102  103  0  1  2  2  0  0  0  0
    1           1
    -1        3.21400E-02
#  150 Block-block   103 - 104
   103  104  0  1  2  2  0  0  0  0
    1           1
    -1        3.21400E-02
#  151 Block-block   105 - 106
   105  106  0  1  2  2  0  0  0  0
    1           1
    -1        5.32000E-02
#  152 Block-block   106 - 107
   106  107  0  1  2  2  0  0  0  0
    1           1
    -1        5.32000E-02
#  153 Block-block   108 - 109
   108  109  0  1  2  2  0  0  0  0
    1           1
    -1        4.05800E-02
#  154 Block-block   109 - 110
   109  110  0  1  2  2  0  0  0  0
    1           1
    -1        4.05800E-02
#  155 Block-block   111 - 112
   111  112  0  1  2  2  0  0  0  0
    1           1
    -1        3.78100E-02
#  156 Block-block   112 - 113
   112  113  0  1  2  2  0  0  0  0
    1           1
    -1        3.78100E-02
#  WITHIN FICTITIOUS BLOCK (ALONG THE MAIN AXIS OF TUNNEL)
#  157 Block-block   99 - 102
#  158 Block-block   100 - 103
#  159 Block-block   101 - 104
#  160 Block-block   102 - 105
#  161 Block-block   103 - 106
```

```
#  162 Block-block   104 - 107
#  163 Block-block   105 - 108
#  164 Block-block   106 - 109
#  165 Block-block   107 - 110
#  166 Block-block   108 - 111
#  167 Block-block   109 - 112
#  168 Block-block   110 - 113
# BETWEEN FICTITIOUS BLOCK AND CONCRETE BACKFILL ON RIGHT SIDE OF THE
WASTE
#  169 Block-block   101 - 154
   101  154  0  1  2  1  0  1  0  0
    1           1
    -1        8.88300E-02
#  170 Block-block   104 - 155
   104  155  0  1  2  1  0  1  0  0
    1           1
    -1        3.21400E-02
#  171 Block-block   107 - 156
   107  156  0  1  2  1  0  1  0  0
    1           1
    -1        5.32000E-02
#  172 Block-block   110 - 157
   110  157  0  1  2  1  0  1  0  0
    1           1
    -1        4.05800E-02
#  173 Block-block   113 - 158
   113  158  0  1  2  1  0  1  0  0
    1           1
    -1        3.78100E-02
#  WITHIN WALL BETWEEN CONCRETE BACKFILL AND GRAVEL BACKFILL (LOADING
ZONE)
#  174 Block-block   123 - 124
   123  124  0  1  2  2  1  1  0  0
    1           1
    1        3.15400E-01
#  BETWEN WALL BETWEEN CONCRETE BACKFILL AND GRAVEL BACKFILL (LOADING
ZONE) AND FICTITIOUS BLOCK
#  175 Block-block   124 - 125
   124  125  0  1  2  2  1  0  0  0
    1           1
    1        3.15400E-01
#  BETWEEN FICTITIOUS BLOCK AND  GRAVEL BACKFILL (LOADING ZONE)
#  176 Block-block   125 - 159
   125  159  0  1  2  2  0  1  0  0
    1           1
    1        3.15400E-01
#  WITHIN GRAVEL BACKFILL (PASSAGE)
#  177 Block-block   126 - 127
   126  127  0  1  2  2  1  1  0  0
    1           1
    -1        9.30500E-02
#  178 Block-block   127 - 128
   127  128  0  1  2  2  1  1  0  0
    1           1
    -1        6.68400E-02
#  BETWEEN GRAVEL BACKFILL (PASSAGE) AND GRAVEL IN TOP OF TUNNEL
#  179 Block-block   126 - 129
   126  129  0  1  0  2  1  1  0  0
    1           1
    1        1.15893E-01
#  180 Block-block   126 - 130
   126  130  0  1  0  2  1  1  0  0
    1           1
    1        1.15893E-01
```

```
#  181 Block-block   126 - 131
   126  131  0  1  0  2  1  1  0  0
    1          1
    1        1.15893E-01
#  BETWEEN GRAVEL BACKFILL (PASSAGE) AND GRAVEL IN BOTTOM OF TUNNEL
#  182 Block-block   126 - 144
   126  144  0  1  1  2  1  1  0  0
    1          1
    -1        4.30820E-02
#  BETWEEN GRAVEL BACKFILL (PASSAGE) AND CONCRETE BACKFILL ON LEFT
SIDE OF STRUCTURE
#  183 Block-block   126 - 149
   126  149  0  1  0  2  1  1  0  0
    1          1
    -1        1.10400E-03
#  184 Block-block   126 - 162
   126  162  0  1  0  2  1  1  0  0
    1          1
    -1        1.10400E-03
#  185 Block-block   126 - 163
   126  163  0  1  0  2  1  1  0  0
    1          1
    -1        1.10400E-03
#  BETWEEN GRAVEL BACKFILL (PASSAGE) AND CONCRETE BACKFILL ON RIGHT
SIDE OF STRUCTURE
#  186 Block-block   126 - 154
   126  154  0  1  0  2  1  1  0  0
    1          1
    -1        1.13067E-03
#  187 Block-block   126 - 172
   126  172  0  1  0  2  1  1  0  0
    1          1
    0        1.13067E-03
#  188 Block-block   126 - 173
   126  173  0  1  0  2  1  1  0  0
    1          1
    -1        1.13067E-03
#  WITHIN GRAVEL IN TOP OF THE TUNNEL (TRANSVERSE TO THE MAIN AXIS OF
TUNNEL)
#  189 Block-block   129 - 130
   129  130  0  1  0  0  1  1  0  0
    1          1
    1        5.89643E-01
#  190 Block-block   130 - 131
   130  131  0  1  0  0  1  1  0  0
    1          1
    1        4.46787E-01
#  191 Block-block   132 - 133
   132  133  0  1  0  0  1  1  0  0
    1          1
    1        2.82580E-01
#  192 Block-block   133 - 134
   133  134  0  1  0  0  1  1  0  0
    1          1
    1        1.52660E-01
#  193 Block-block   135 - 136
   135  136  0  1  0  0  1  1  0  0
    1          1
    1        2.07099E+00
#  194 Block-block   136 - 137
   136  137  0  1  0  0  1  1  0  0
    1          1
    1        3.50146E+00
#  195 Block-block   138 - 139
```

```
   138  139  0  1  0  0  1  1  0  0
    1          1
    1        2.17500E-01
#  196 Block-block   139 - 140
   139  140  0  1  0  0  1  1  0  0
    1          1
    1        1.42759E-01
#  197 Block-block   141 - 142
   141  142  0  1  0  0  1  1  0  0
    1          1
    1        2.22601E-01
#  198 Block-block   142 - 143
   142  143  0  1  0  0  1  1  0  0
    1          1
    1        1.83233E-01
#  WITHIN GRAVEL IN TOP OF THE TUNNEL (ALONG THE MAIN AXIS OF TUNNEL)
#  199 Block-block   129 - 132
   129  132  0  1  2  2  1  1  0  0
    1          1
    1        3.35100E-01
#  200 Block-block   130 - 133
   130  133  0  1  2  2  1  1  0  0
    1          1
    1        3.35100E-01
#  201 Block-block   131 - 134
   131  134  0  1  2  2  1  1  0  0
    1          1
    1        3.35100E-01
#  202 Block-block   132 - 135
   132  135  0  1  2  2  1  1  0  0
    1          1
    1        5.84867E-01
#  203 Block-block   133 - 136
   133  136  0  1  2  2  1  1  0  0
    1          1
    1        5.84867E-01
#  204 Block-block   134 - 137
   134  137  0  1  2  2  1  1  0  0
    1          1
    1        5.84867E-01
#  205 Block-block   135 - 138
   135  138  0  1  2  2  1  1  0  0
    1          1
    -1        4.08700E-01
#  206 Block-block   136 - 139
   136  139  0  1  2  2  1  1  0  0
    1          1
    -1        4.08700E-01
#  207 Block-block   137 - 140
   137  140  0  1  2  2  1  1  0  0
    1          1
    -1        4.08700E-01
#  208 Block-block   138 - 141
   138  141  0  1  2  2  1  1  0  0
    1          1
    -1        2.99663E-01
#  209 Block-block   139 - 142
   139  142  0  1  2  2  1  1  0  0
    1          1
    -1        2.99663E-01
#  210 Block-block   140 - 143
   140  143  0  1  2  2  1  1  0  0
    1          1
    -1        2.99663E-01
```

```
#  BETWEEN GRAVEL IN TOP OF THE TUNNEL AND CONCRETE ON LEFT SIDE OF
THE TUNNEL
#  211 Block-block   129 - 149
   129  149  0  1  1  0  1  1  0  0
    1          1
    -1        1.59743E-02
#  212 Block-block   129 - 162
   129  162  0  1  1  0  1  1  0  0
    1          1
    -1        1.59743E-02
#  213 Block-block   129 - 163
   129  163  0  1  1  0  1  1  0  0
    1          1
    -1        1.59743E-02
#  214 Block-block   132 - 150
   132  150  0  1  1  0  1  1  0  0
    1          1
    -1        2.47607E-02
#  215 Block-block   132 - 164
   132  164  0  1  1  0  1  1  0  0
    1          1
    -1        2.47607E-02
#  216 Block-block   132 - 165
   132  165  0  1  1  0  1  1  0  0
    1          1
    -1        2.47607E-02
#  217 Block-block   135 - 151
   135  151  0  1  1  0  1  1  0  0
    1          1
    -1        3.21630E-02
#  218 Block-block   135 - 166
   135  166  0  1  1  0  1  1  0  0
    1          1
    -1        3.21630E-02
#  219 Block-block   135 - 167
   135  167  0  1  1  0  1  1  0  0
    1          1
    -1        3.21630E-02
#  220 Block-block   138 - 152
   138  152  0  1  1  0  1  1  0  0
    1          1
    -1        5.77700E-03
#  221 Block-block   138 - 168
   138  168  0  1  1  0  1  1  0  0
    1          1
    -1        5.77700E-03
#  222 Block-block   138 - 169
   138  169  0  1  1  0  1  1  0  0
    1          1
    -1        5.77700E-03
#  223 Block-block   141 - 153
   141  153  0  1  1  0  1  1  0  0
    1          1
    -1        5.45700E-03
#  224 Block-block   141 - 170
   141  170  0  1  1  0  1  1  0  0
    1          1
    -1        5.45700E-03
#  225 Block-block   141 - 171
   141  171  0  1  1  0  1  1  0  0
    1          1
    -1        5.45700E-03
#  BETWEEN GRAVEL IN TOP OF THE TUNNEL AND CONCRETE ON RIGHT SIDE OF
THE TUNNEL
```

```
#  226 Block-block   129 - 154
   129  154  0  1  1  0  1  1  0  0
    1          1
    -1        1.49423E-02
#  227 Block-block   129 - 172
   129  172  0  1  1  0  1  1  0  0
    1          1
    -1        1.49423E-02
#  228 Block-block   129 - 173
   129  173  0  1  1  0  1  1  0  0
    1          1
    -1        1.49423E-02
#  229 Block-block   132 - 155
   132  155  0  1  1  0  1  1  0  0
    1          1
    -1        6.56233E-03
#  230 Block-block   132 - 174
   132  174  0  1  1  0  1  1  0  0
    1          1
    -1        6.56233E-03
#  231 Block-block   132 - 175
   132  175  0  1  1  0  1  1  0  0
    1          1
    -1        6.56233E-03
#  232 Block-block   135 - 156
   135  156  0  1  1  0  1  1  0  0
    1          1
    -1        3.76067E-02
#  233 Block-block   135 - 176
   135  176  0  1  1  0  1  1  0  0
    1          1
    -1        3.76067E-02
#  234 Block-block   135 - 177
   135  177  0  1  1  0  1  1  0  0
    1          1
    -1        3.76067E-02
#  235 Block-block   138 - 157
   138  157  0  1  1  0  1  1  0  0
    1          1
    -1        6.20100E-03
#  236 Block-block   138 - 178
   138  178  0  1  1  0  1  1  0  0
    1          1
    -1        6.20100E-03
#  237 Block-block   138 - 179
   138  179  0  1  1  0  1  1  0  0
    1          1
    -1        6.20100E-03
#  238 Block-block   141 - 158
   141  158  0  1  1  0  1  1  0  0
    1          1
    -1        5.75933E-03
#  239 Block-block   141 - 180
   141  180  0  1  1  0  1  1  0  0
    1          1
    -1        5.75933E-03
#  240 Block-block   141 - 181
   141  181  0  1  1  0  1  1  0  0
    1          1
    -1        5.75933E-03
#  WITHIN GRAVEL IN BOTTOM OF THE TUNNEL (ALONG THE MAIN AXIS OF
TUNNEL)
#  241 Block-block   144 - 145
   144  145  0  1  2  2  1  1  0  0
```

```
    1           1
    -1        8.50300E-03
#  242 Block-block   145 - 146
   145  146  0  1  2  2  1  1  0  0
    1           1
    -1        2.44320E-02
#  243 Block-block   146 - 147
   146  147  0  1  2  2  1  1  0  0
    1           1
    1        3.13910E-02
#  244 Block-block   147 - 148
   147  148  0  1  2  2  1  1  0  0
    1           1
    1        6.61900E-03
#  WITHIN CONCRETE BACKFILL ON LEFT SIDE OF THE TUNNEL (ALONG THE MAIN
AXIS OF TUNNEL)
#  245 Block-block   149 - 150
   149  150  0  1  2  2  1  1  0  0
    1           1
    -1        4.99333E-04
#  246 Block-block   150 - 151
   150  151  0  1  2  2  1  1  0  0
    1           1
    1        4.20000E-05
#  247 Block-block   151 - 152
   151  152  0  1  2  2  1  1  0  0
    1           1
    1        4.98667E-04
#  248 Block-block   152 - 153
   152  153  0  1  2  2  1  1  0  0
    1           1
    1        1.43333E-04
#  249 Block-block   162 - 164
   162  164  0  1  2  2  1  1  0  0
    1           1
    -1        4.99333E-04
#  250 Block-block   163 - 165
   163  165  0  1  2  2  1  1  0  0
    1           1
    -1        4.99333E-04
#  251 Block-block   164 - 166
   164  166  0  1  2  2  1  1  0  0
    1           1
    1        4.20000E-05
#  252 Block-block   165 - 167
   165  167  0  1  2  2  1  1  0  0
    1           1
    1        4.20000E-05
#  253 Block-block   166 - 168
   166  168  0  1  2  2  1  1  0  0
    1           1
    1        4.98667E-04
#  254 Block-block   167 - 169
   167  169  0  1  2  2  1  1  0  0
    1           1
    1        4.98667E-04
#  255 Block-block   168 - 170
   168  170  0  1  2  2  1  1  0  0
    1           1
    1        1.43333E-04
#  256 Block-block   169 - 171
   169  171  0  1  2  2  1  1  0  0
    1           1
    1        1.43333E-04
```

```
#  WITHIN CONCRETE BACKFILL ON LEFT SIDE OF THE TUNNEL (TRANSVERSE TO
THE MAIN AXIS OF TUNNEL)
#  257 Block-block   149 - 162
   149  162  0  1  1  1  1  1  0  0
    1           1
    -1        1.05898E-01
#  258 Block-block   162 - 163
   162  163  0  1  1  1  1  1  0  0
    1           1
    -1        1.09316E-01
#  259 Block-block   150 - 164
   150  164  0  1  1  1  1  1  0  0
    1           1
    -1        1.37036E-01
#  260 Block-block   164 - 165
   164  165  0  1  1  1  1  1  0  0
    1           1
    -1        1.56744E-01
#  261 Block-block   151 - 166
   151  166  0  1  1  1  1  1  0  0
    1           1
    -1        2.43853E-02
#  262 Block-block   166 - 167
   166  167  0  1  1  1  1  1  0  0
    1           1
    -1        3.81687E-02
#  263 Block-block   152 - 168
   152  168  0  1  1  1  1  1  0  0
    1           1
    -1        3.17007E-02
#  264 Block-block   168 - 169
   168  169  0  1  1  1  1  1  0  0
    1           1
    -1        3.19573E-02
#  265 Block-block   153 - 170
   153  170  0  1  1  1  1  1  0  0
    1           1
    -1        3.33217E-02
#  266 Block-block   170 - 171
   170  171  0  1  1  1  1  1  0  0
    1           1
    -1        3.47543E-02
#  WITHIN CONCRETE BACKFILL ON RIGHT SIDE OF THE TUNNEL (ALONG THE
MAIN AXIS OF TUNNEL)
#  267 Block-block   154 - 155
   154  155  0  1  2  2  1  1  0  0
    1           1
    -1        1.07667E-04
#  268 Block-block   155 - 156
   155  156  0  1  2  2  1  1  0  0
    1           1
    -1        4.66667E-04
#  269 Block-block   156 - 157
   156  157  0  1  2  2  1  1  0  0
    1           1
    1        5.00333E-04
#  270 Block-block   157 - 158
   157  158  0  1  2  2  1  1  0  0
    1           1
    1        1.66667E-04
#  271 Block-block   172 - 174
   172  174  0  1  2  2  1  1  0  0
    1           1
    -1        1.07667E-04
```

```
#  272 Block-block   173 - 175
   173  175  0  1  2  2  1  1  0  0
    1          1
    -1        1.07667E-04
#  273 Block-block   174 - 176
   174  176  0  1  2  2  1  1  0  0
    1          1
    -1        4.66667E-04
#  274 Block-block   175 - 177
   175  177  0  1  2  2  1  1  0  0
    1          1
    -1        4.66667E-04
#  275 Block-block   176 - 178
   176  178  0  1  2  2  1  1  0  0
    1          1
    1        5.00333E-04
#  276 Block-block   177 - 179
   177  179  0  1  2  2  1  1  0  0
    1          1
    1        5.00333E-04
#  277 Block-block   178 - 180
   178  180  0  1  2  2  1  1  0  0
    1          1
    1        1.66667E-04
#  278 Block-block   179 - 181
   179  181  0  1  2  2  1  1  0  0
    1          1
    1        1.66667E-04
#  WITHIN CONCRETE BACKFILL ON RIGHT SIDE OF THE TUNNEL (TRANSVERSE TO
THE MAIN AXIS OF TUNNEL)
#  279 Block-block   154 - 172
   154  172  0  1  1  1  1  1  0  0
    1          1
    -1        9.18317E-02
#  280 Block-block   172 - 173
   172  173  0  1  1  1  1  1  0  0
    1          1
    -1        9.48353E-02
#  281 Block-block   155 - 174
   155  174  0  1  1  1  1  1  0  0
    1          1
    -1        3.24783E-02
#  282 Block-block   174 - 175
   174  175  0  1  1  1  1  1  0  0
    1          1
    -1        3.28127E-02
#  283 Block-block   156 - 176
   156  176  0  1  1  1  1  1  0  0
    1          1
    -1        8.28490E-02
#  284 Block-block   176 - 177
   176  177  0  1  1  1  1  1  0  0
    1          1
    -1        1.12499E-01
#  285 Block-block   157 - 178
   157  178  0  1  1  1  1  1  0  0
    1          1
    -1        4.16230E-02
#  286 Block-block   178 - 179
   178  179  0  1  1  1  1  1  0  0
    1          1
    -1        4.26680E-02
#  287 Block-block   158 - 180
   158  180  0  1  1  1  1  1  0  0
```

```
    1          1
    -1        3.96943E-02
#  288 Block-block   180 - 181
   180  181  0  1  1  1  1  1  0  0
    1          1
    -1        4.15787E-02
#  WITHIN GRAVEL IN LOADING ZONE
#  289 Block-block   159 - 160
   159  160  0  1  2  2  1  1  0  0
    1          1
    -1        2.37257E-01
#  290 Block-block   160 - 161
   160  161  0  1  2  2  1  1  0  0
    1          1
    -1        1.31023E-01
#  BETWEEN GRAVEL IN LOADING ZONE AND GRAVEL IN TOP OF TUNNEL
#  291 Block-block   159 - 141
   159  141  0  1  0  2  1  1  0  0
    1          1
    1        2.35607E-01
#  292 Block-block   159 - 142
   159  142  0  1  0  2  1  1  0  0
    1          1
    1        2.35607E-01
#  293 Block-block   159 - 143
   159  143  0  1  0  2  1  1  0  0
    1          1
    1        2.35607E-01
#  BETWEEN GRAVEL IN LOADING ZONE AND GRAVEL IN BOTTOM OF TUNNEL
#  294 Block-block   159 - 148
   159  148  0  1  0  2  1  1  0  0
    1          1
    -1        4.17120E-02
#  BETWEEN GRAVEL IN LOADING ZONE AND CONCRETE BACKFILL ON LEFT SIDE
OF TUNNEL
#  295 Block-block   159 - 153
   159  153  0  1  0  2  1  1  0  0
    1          1
    -1        9.91667E-04
#  296 Block-block   159 - 170
   159  170  0  1  0  2  1  1  0  0
    1          1
    -1        9.91667E-04
#  297 Block-block   159 - 171
   159  171  0  1  0  2  1  1  0  0
    1          1
    -1        9.91667E-04
#  BETWEEN GRAVEL IN LOADING ZONE AND CONCRETE BACKFILL ON RIGHT SIDE
OF TUNNEL
#  298 Block-block   159 - 158
   159  158  0  1  0  2  1  1  0  0
    1          1
    -1        1.07800E-03
#  299 Block-block   159 - 180
   159  180  0  1  0  2  1  1  0  0
    1          1
    -1        1.07800E-03
#  300 Block-block   159 - 181
   159  181  0  1  0  2  1  1  0  0
    1          1
    -1        1.07800E-03
```

```
#  BLA CALCULATIONS
#  Problem Codification: BS1
#  Nuclide(s): C-14 org
#
#  Problem Description:
#  PROPER VERSION INPUT DATA FORMAT
#
#  ITYPE    NGROUP    NSINKS    IWFLOW    NSOURC    NBSIZE    ISPSOL
   1        1         0         1         5         0         0
#
#  Flow stream conditions
#  NINFLW    NUTFLW               % if IWFLOW = 1
   7         7
#
#  Inflow conditions (one line per inflow
#  QINFW    NBWIN    NBNWIN       % if IWFLOW = 1
   1.34563  1        1
   1.01519  2        1
   9.4796   3        1
   0.66294  4        1
   0.15947  5        1
   0.1139   6        1
   0.60853  7        1
#
#  Outflow conditions (one line per inflow)
#  QUTFW    NBWOUT    NBNWOUT     % if IWFLOW = 1
   0.7824   1         1
   0.4314   2         1
   11.33948 3         1
   0.2742   4         1
   0.1351   5         1
   0.05295  6         1
   0.36973  7         1
#
# Number of blocks connections and materials
#  NBLOCK    NBCOUP    NMAT
   7         6         2
#
#  Data on materials (one line per material)
#  Material 1 = Waste
#  Material 2 = Water
#  MAT        DENSM        PORM
   1          1000.0       0.632
   2          1000.0       1.000
#
#  Data on time series
#  TINIT     AGEO      RAT      TEND      NTERM      LREAD
   0.00      0.50      1.23     1000.00   90         0
#
#  Data on numerical parameters
#  EPS       EWT      NLOOP      MSPAR
   1.00E-06  1.00E-18 3          1
#
#  Data on group (one set of data per group common for all sources)
#
# Group No: 1
#  NNCH    ISPEC    ISPSOL
   1       1        0
#
# Nuclide: C-14 org
#  TAU        CSOLUB      AINV
   5.7300E+03 1.00E+10    1.4159E-05
#
```

```
#  CIRF                               % if ISPEC = 1
#
#  MAT       DEFM       SKDM       % one line per material
   1         0.06307    0.000
   2         0.06307    0.000

#  Data on sources
#  NSBCHA  ISEQ  MAT  IFWATB  VOLSOU  FINVEN  JINVEN
#
#  IBLOCK    ISSEQ          % if ISEQ = 1
#
#  XXX                      % if JINVEN = 1. One line for each group.
#
#  IBSOUR                   % if ISEQ = 0
#
#  IWINT                    % if IFWATB = 1
#
#  WBFLOW                   % if IFWATB = 1 and IWINT = 0
#
#  Waste
#  Source    1
  1  0  1  1  10069.5150  1.0000000E+00  1
#
  4.0707965E-01
  1
  1
#
#  Source    2
  1  0  1  1  6129.2700  1.0000000E+00  1
#
  2.4778761E-01
  2
  1
#
#  Source    3
  1  0  1  1  3064.6350  1.0000000E+00  1
#
  1.2389381E-01
  3
  1
#
#  Source    4
  1  0  1  1  3502.4400  1.0000000E+00  1
#
  1.4159292E-01
  4
  1
#
#  Source    5
  1  0  1  1  1970.1225  1.0000000E+00  1
#
  7.9646018E-02
  5
  1
#
#  Description of blocks not considered before
#
#  Block i
#  NZ   NY    NX    NBLSP    MAT    IQFLOW
#
#  ZADIM  YADIM  XADIM  VOLBLK % one line per compartment if NBLSP = 1
#
#  IWINT                        % if IQFLOW = 1
#
```

```
#  NODWIN   NODWUT    BFLOW    % if IQFLOW = 1 and IWINT = 0
#
#  Loading zone at S.1.
#  Block   6
  1  1  1  0  2  1
  1.0000E+00     1.0000E+00      1.0000E+00      6.9000E+02
  1
#
#  Loading zone at S.9.
#  Block   7
  1  1  1  0  2  1
  1.0000E+00     1.0000E+00      1.0000E+00      2.1740E+03
  1
#
#  Codifying the connections
#
#  NSSCO    NSBCO    NBBCO
  4  2  0
#
#  Connection between sources
#  NABCO    ICSEQ    LSCFW    IRADD
#
#  QWATIN            % if LSCFW is not equal to 0
#
#  ISERNU            % if IRADD = 1
#
#  XRADD             % if IRADD = 1 and ISERNU = 1 one line per group
#
#  XRADD             % if IRADD = 1 and ISERNU = 0 one line per group
#
#  IBSA  IBSB  ISEQA  ISEQB    % if NABCO > 1 and ICSEQ = 1
#
#  IBSA    IBSB                % if ICSEQ = 0 NABCO*lines
#
#  WITHIN WASTE
#
#  1 Source-source 1 - 2
    1               0               1               0
    6.242200E-01
#
    1               2
#
#  2 Source-source 2 - 3
    1               0               1               0
    1.207930E+00
#
    2               3
#
#  3 Source-source 3 - 4
    1               0               -1               0
    6.519100E-01
#
    3               4
#
#  4 Source-source 4 - 5
    1               0               -1               0
    2.631600E-01
#
    4               5
#
#  Connection source - block
#
#  IBSOU    IBSB    ISEQC    NABCCO    IRZB    ICRB    IPLUG    IRADD
#
```

```
#  ICOMPB  ICSEQB    % if NABCCO > 1 and ISEQC =1
#
#  IDCB              % if ISEQC = 0. One value for each connection.
#
#  LSCFW  QWATIN  % if IFWATB(source term) = 1 and IQFLOW(block) = 1
#
#  ISERNU         % if IRADD =1
#
#  XRADD          % if IRADD = 1 and ISERNU = 1
#
#  XRADD          % if IRADD = 1 and ISERNU = 0. One line per group.
#
#
#  BETWEEN WASTE - LOADING ZONES
#  1 Source-block   1 - 6
    1  6  0  1  2  0  0  0
#
  1
  -1  0.06094
#  2 Source-block   5 - 7
    5  7  0  1  2  0  0  0
#
  1
  -1  0.23879
```

Appendix D: Biosphere models

Schematic figures of the biosphere models.

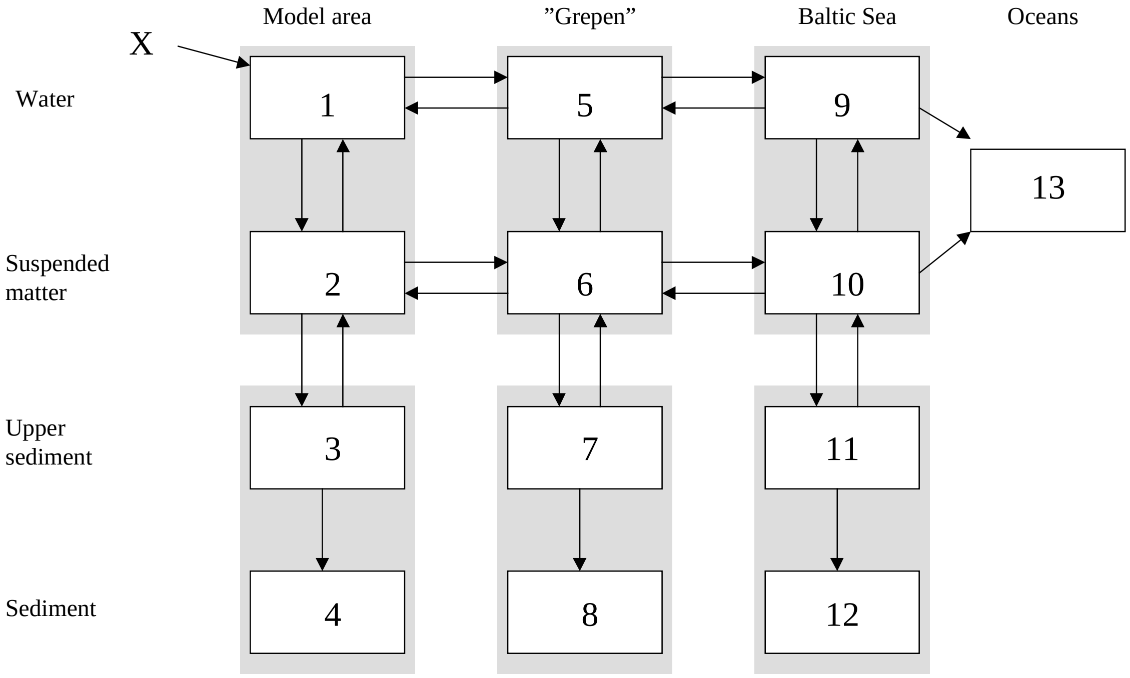

Figure D-1 Structure of the coastal model. The cross marks the source of radionuclides.

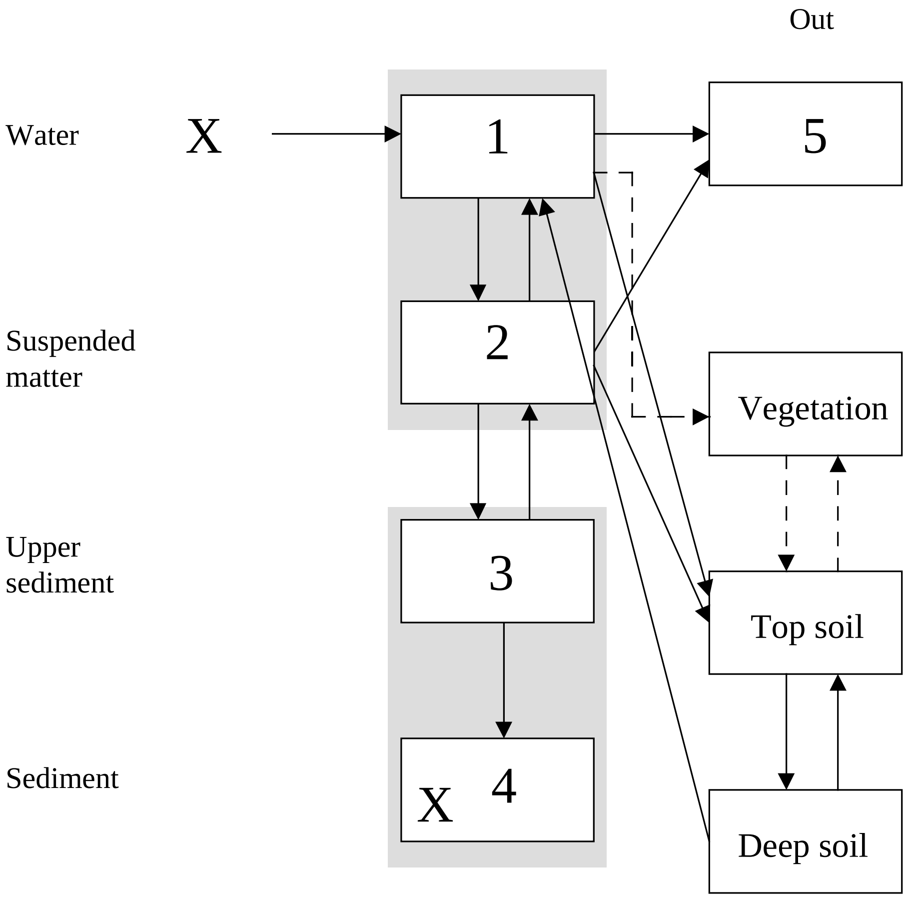

Figure D-2 Structure of the lake model. The cross marks the source of radionuclides.

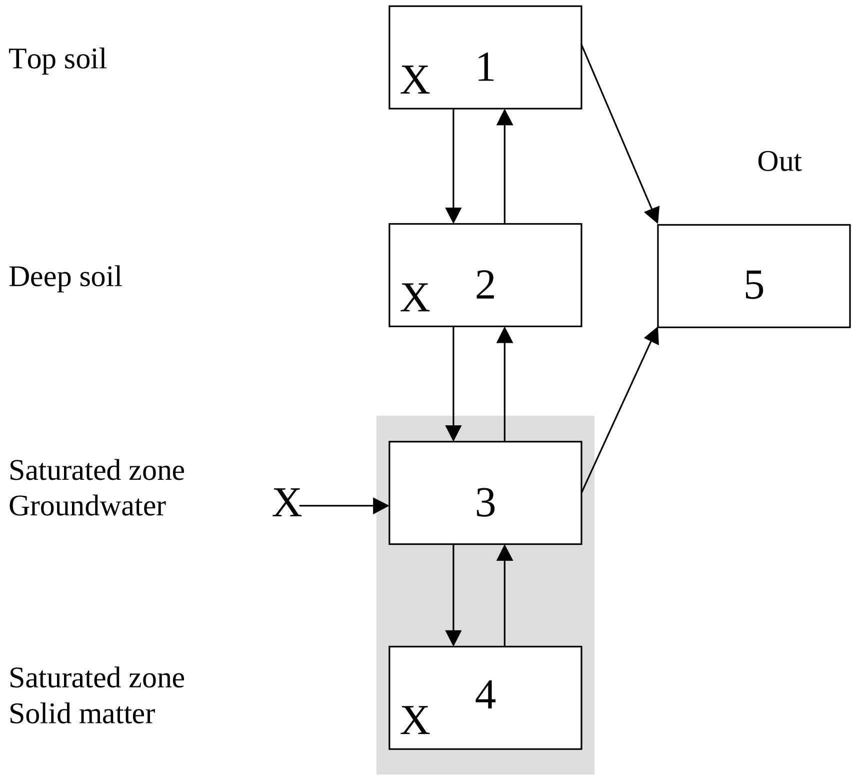

Figure D-3 Structure of the agricultural land model. The crosses mark the source of radionuclides.

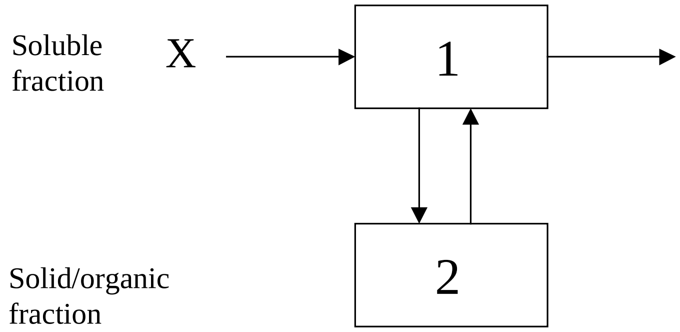

Figure D-4 Structure of the mire model. The cross marks the source of radionuclides.

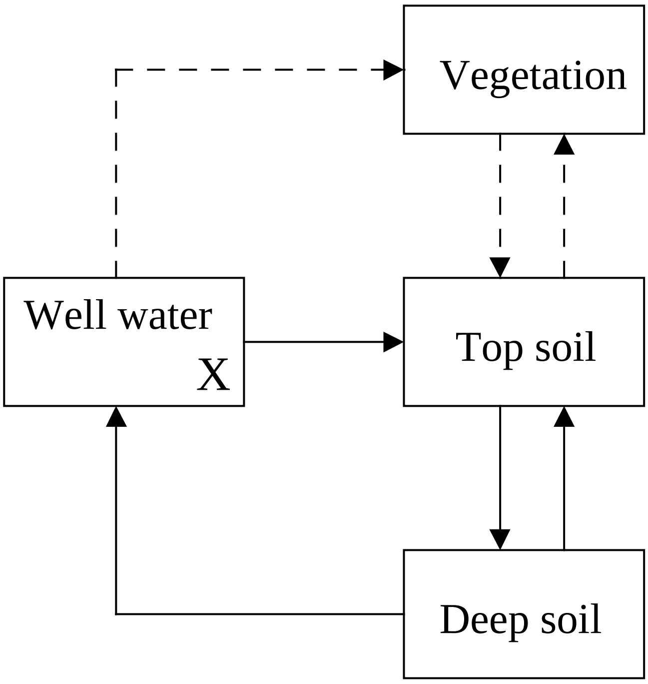

Figure D-5 Structure of the well model. The cross marks the source of radionuclides.