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NM5507

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
ANALYSIS/MODEL COVER SHEET
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1. QA: QA
Page: 1 of: 37

2. ☒ Analysis ☐ Engineering
☒ Performance Assessment
☐ Scientific

3. ☐ Model ☐ Conceptual Model Documentation
☐ Model Documentation
☐ Model Validation Documentation

4. Title:
Transfer Coefficient Analysis

5. Document Identifier (including Rev. No. and Change No., if applicable):
ANL-MGR-MD-000008 REV 00 /ICN 1

6. Total Attachments:
2

7. Attachment Numbers - No. of Pages in Each:
I-1

	Printed Name	Signature	Date
8. Originator	De (Wesley) Wu	D. Wu	1/24/2000
9. Checker	Kaylie E. Rasmuson	Kaylie E. Rasmuson	1/25/00
10. Lead/Supervisor	John F. Schmitt	John F. Schmitt	1/31/00
11. Responsible Manager	Larry D. Croft	Larry D. Croft	2/1/00

12. Remarks:

Editorial correction made on Revision Record Page 2 to the Document Identifier Number WW 4/7/00
KR 4/7/00

INFORMATION COPY
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OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
ANALYSIS/MODEL REVISION RECORD

Complete Only Applicable Items

1. Page: 2 of: 37

2. Analysis or Model Title:

Transfer Coefficient Analysis

3. Document Identifier (including Rev. No. and Change No., if applicable):

ANL-MMGR-MD-000008 / Rev. 00 / ICN 1

4. Revision/Change No.	5. Description of Revision/Change
Rev 00 / ICN 1	Changed to clarify selection criteria (page 4); move list of radionuclides from data input section (page 8) to criteria section (page 12); correct incorrectly selected values or incorrect comments in Tables 3 (page 19), 4 (page 20), 6 (Page 22), 7 (page 26), 8, (page 27), 9 (page 28), and 11 (page 31); and changed to electronic DIRS, which resulted in the removal of Attachment1 and changes in two references to match electronic DIRS (Liu 1998 to CRWMS 1998 and VA 1998 to DOE 1998).

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1. PURPOSE

This analysis and model report (AMR), *Transfer Coefficient Analysis*, is part of the efforts for the Biosphere Process Model Report, which supports the Site Recommendation Report, and the License Application. This AMR is developed under its document plan, TDP-MGR-MD-000006 (CRMWS M&O, 1999d).

The purpose of this AMR is to select values for transfer coefficients, including soil-to-plant transfer factors, animal feed transfer coefficients, and bioaccumulation factors for fresh water fish for GENII-S, a computer code for statistical and deterministic simulations of radiation doses to humans from radionulcides in the environment. GENII-S is qualified software under the Yucca Mountain Project (YMP) procedure for the calculation of the biosphere dose conversion factors (BDCFs) (CRWMS M&O 1998). The BDCFs will be used for the proposed repository radiation dose assessment.

The scope of the analysis includes consideration of the following eleven parameter categories: soil-to-plant transfer factors for leafy vegetables, for root vegetables, for fruit, and for grain, animal feed transfer coefficients for beef, for milk, for poultry, and for eggs, bioaccumulation factor for fresh water fish, soil/plant transfer scale factor, and animal uptake scale factor. The transfer factors, transfer coefficients and bioaccumulation factors are element-specific. Seventeen elements are included in this AMR. Parameter descriptions are given in Section 4.1.

Two sets of values for each parameter are to be selected and justified. One set is for a reasonable and conservative estimate (the reasonable case), and the other set is for high bounding values (the bounding case). Reasonable is defined as being reasonably expected to occur. Conservative is defined as a value that would result in a higher BDCF. A high bounding value is defined as a value based on extreme environmental conditions that would result in a high potential radiation dose.

The approach for the analysis is set as follows:

1. Perform a scientific literature search to evaluate the adequacy of the existing GENII-S parameters for the postclosure scenario of the proposed repository.
2. Identify potential parametric values that are relevant to the postclosure scenario, and compare them with GENII-S default values.
3. Select, justify and document the parameter values selected for use in the BDCFs calculation.
4. Summarize the recommended values of these parameters.

2. QUALITY ASSURANCE

This analysis has been determined to be Quality Affecting in accordance with Civilian Radioactive Waste Management System (CRWMS) Management and Operating (M&O) procedure QAP-2-0, *Conduct of Activities,* because the information will be used to support Performance Assessment and other quality-affecting activities. Therefore, this analysis is subject to the requirements of the *Quality Assurance Requirements and Description* document. This analysis is covered by the Activity Evaluation for *Scientific Investigation of Radiological Doses in the Biosphere* (CRWMS M&O, 1999a).

The primary implementing procedure for this work is Office of Civilian Radioactive Waste Management (OCRWM) procedure AP-3.10Q, *Analyses and Models*. To perform this work, several other procedures are invoked by AP-3.10Q. These include the following:

AP-2.13Q, *Technical Product Development Planning*
AP-2.14Q, *Review of Technical Products*
AP-3.4Q, *Level 3 Change Control*
AP-3.15Q, *Managing Document Inputs*
AP-6.1Q, *Controlled Documents*
AP-17.1Q, *Record Source Responsibilities for Inclusionary Records*
AP-SI.1Q, *Software Management*
AP-SIII.2Q, *Qualification of Unqualified Data and the Documentation of Rationale for Accepted Data*
AP-SIII.3Q, *Submittal and Incorporation of Data to the Technical Data Management System*
AP-SIII.4Q, *Development, Review, Online Placement, and Maintenance of Individual Reference Information Base Data Items*

Personnel performing work on this analysis will be trained and qualified according to OCRWM procedures AP-2.1Q, *Indoctrination and Training of Personnel* and AP-2.2Q, *Establishment and Verification of Required Education and Experience of Personnel*. Preparation of this analysis will not require the classification of items in accordance with CRWMS M&O procedure QAP-2-3, *Classification of Permanent Items*. This analysis is not a field activity. Therefore, a Determination of Importance Evaluation in accordance with CRWMS M&O procedure NLP-2-0 is not required.

3. COMPUTER SOFTWARE AND MODEL USAGE

This analysis is to develop food transfer factors and coefficients to be used in calculations of the BDCFs using GENIIS software. No models or software routines and macros are developed and used in this analysis. The only software used, is industry standard software, such as Microsoft Excel (spreadsheet) and Word (word processing). Spreadsheet software is used as an aid in calculations. Use of this software in this manner is exempt from the requirements in AP-SI.1Q, *Software Management.*

4. INPUTS

In this section, the parameters analyzed in this AMR are described. The input sources, including radionuclides of interest from the input transmittal and literature data from reviewed documents, are identified and summarized.

4.1 DATA AND PARAMETERS

4.1.1 Parameter description

The transfer coefficients are element-specific and food type dependent. Nine food types are considered in this AMR: leafy vegetables, root vegetables, fruit, grain, beef, milk, poultry, eggs and fresh water fish. This corresponds to the nine food types from the results of regional survey conducted during 1997 (DOE 1998, p.3-154). The transfer coefficients for beef are analyzed as one of the pathways included in GENII-S, even though a combination of beef and pork consumption rates was surveyed. More discussion is given in Section 6.3. The list of radionuclides and elements will be discussed in next section. In addition, two scale factors, soil/plant transfer and animal uptake, are also included in this AMR. Description of each parameter is summarized and shown in Table 1. Except for two scale factors, default values from the GENII-S software package can be located in two files, FTRANS.DAT (Leigh et al. 1993, p.5-65, and Rittmann 1993, p35-36) and BIOAC1.DAT (Leigh et al. 1993, p.5-62, and Napier et al. 1988b, p.5.769-5.770).

Most of these parameters are somewhat related to the local climate, soil, and other environmental conditions. Therefore, they should be ideally measured through site-specific studies. However, such site-specific data have not been collected, and collection of site-specific data is a very expensive and time-consuming task. Fortunately, many experimental and field studies for collecting related data have been conducted and published as generic values during the past several decades. Review and selection of available literature data can provide generic input data for the biosphere dose assessment. Since selected values for these parameters are not site-specific, the uncertainty associated with the parameter values could be very large. Variation of literature values for some parameters can be a few orders of magnitude.

4.1.2 Input sources

As the result of scientific literature search, there are so many published scientific papers and reports on these topics. In this AMR focus is on the summary articles and comprehensive dose assessment reports that included selection of input parameters. The important documents reviewed and data cited from are briefly discussed below. Information of each parameter cited from a document is given in the Attachment II of this report. Parameter values from these reference sources are compared and evaluated in Section 6. In addition, page numbers containing the parameter values are given in the comparison table for each parameter.

Table 1. Parameter Description

Item	Parameter Category	Description	Notes
1	Soil-to-plant transfer factor for leafy vegetables (Bq/kg-dry-plant) / (Bq/kg-dry soil)	This ratio is used to calculate the amount of radionuclide uptake from contaminated soil by leafy vegetables and forage. The ratio is based on dry soil weight to dry plant weight.	In FTRANS.DAT file
2	Soil-to-plant transfer factor for other vegetables (Bq/kg-dry-plant) / (Bq/kg-dry soil)	This ratio is used to calculate the amount of radionuclide uptake from contaminated soil by other vegetables. The ratio is based on dry soil weight to dry plant weight.	In FTRANS.DAT file
3	Soil-to-plant transfer factor for fruit (Bq/kg-dry-plant) / (Bq/kg-dry soil)	This ratio is used to calculate the amount of radionuclide uptake from contaminated soil by fruit. The ratio is based on dry soil weight to dry plant weight.	In FTRANS.DAT file
4	Soil-to-plant transfer factor for grain (Bq/kg-dry-plant) / (Bq/kg-dry soil)	This ratio is used to calculate the amount of radionuclide uptake from contaminated soil by grain. The ratio is based on dry soil weight to dry plant weight.	In FTRANS.DAT file
5	Soil/Plant transfer scale factor	It is a multiplier for soil-to-plant transfer factors in the statistical simulation to scale up and down the factors. This parameter can be assigned as a distribution	Input parameter
6	Feed transfer coefficient for beef (Bq/kg-beef) / (Bq/day-wet-feed)	This coefficient is used to calculate radionuclide concentration in beef due to the intake of contaminated feed and water by beef cattle. The coefficient is based on activity concentration of fresh weight beef to activity intake by the cattle each day.	In FTRANS.DAT file
7	Feed transfer coefficient for poultry (Bq/kg-poultry meat) / (Bq/day-wet-feed)	This coefficient is used to calculate radionuclide concentration in poultry due to the intake of contaminated feed and water by poultry. The coefficient is based on activity concentration in chicken meat to activity intake by the chicken each day.	In FTRANS.DAT file
8	Feed transfer coefficient for milk (Bq/L-milk) / (Bq/day-wet-feed)	This coefficient is used to calculate radionuclide concentration in milk due to the intake of contaminated feed and water by milk cow. The coefficient is based on activity concentration in milk to activity intake by cow each day.	In FTRANS.DAT file
9	Feed transfer coefficient for eggs (Bq/kg-eggs) / (Bq/day-wet-feed)	This coefficient is used to calculate radionuclide concentration in eggs due to the intake of contaminated feed and water by laying hen. The coefficient is based on activity concentration in eggs to activity intake by hen each day.	In FTRANS.DAT file
10	Animal uptake scale factor	It is a multiplier for animal feed transfer coefficients in the statistical simulation to scale up and down the coefficients. This parameter can be assigned as a distribution.	Input parameter
11	Bioaccumulation factor for fresh fish. (Bq/kg-fish) / (Bq/L water)	This factor is used to calculate radionuclide concentration in fresh fish due to the contaminated fishpond water used. The coefficient is based on the radionuclide concentration in fresh fish to the radionuclide concentration in the water.	In BIOAC1.DAT file

U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide (RG) 1.109 (NRC 1977) is the regulatory guide for calculation of annual doses to man from routine releases of reactor effluents for the purpose of evaluating compliance with 10 CFR 50, Appendix I. The document specifies the calculation methods for annual external exposure, inhalation, and ingestion doses due to liquid, noble gas, and particulate matter released from power reactor. Transfer factors for vegetation, transfer coefficients for beef and milk, and bioaccumulation factors for fresh water fish are included in this regulatory guide.

International Atomic Energy Agency (IAEA) Safety Series (SS) No. 57 (IAEA 1982) is the product of the international efforts on generic models and parameters for assessing the environmental transfer of radionuclides from routine releases. The ingestion pathways included in the IAEA report are similar to NRC RG 1.109, vegetation, beef, milk, and fresh water fish.

NUREG/CR-3160 (Mills et al. 1983) is the document for parameters and variables appearing in radiological assessment codes, such as PABLM, which was developed by B.A. Napier, W.E. Kennedy, and J.K. Soldat and documented in the report of PNL-3209 (Napier et al. 1980). This computer code became a part of GENII code developed in 1988 (Napier et al. 1988a, p.1.2). The ingestion food pathways considered in the document include poultry and eggs, besides four ingestion pathways in IAEA SS-57.

NUREG/CR-3332 (Till et al. 1983) is a textbook on environmental dose analysis for radiological assessment. Its Chapter 5, *Terrestrial and Aquatic Food Chain Pathways*, includes the calculation methods of radionuclide concentration in foodstuff, and many suggested values for the soil-to-plant transfer factor and animal transfer coefficients that are of interest in this AMR.

ORNL-5786 (Baes et al. 1984) is a review and analysis document of parameters for assessing the transport of environmentally released radionuclides through agriculture. It describes the specific information on the terrestrial environment computerized database, element-specific transport parameters, such as soil-to-plant transfer factor, animal feed to product transfer coefficients, and other parameters.

PNL-6584 (Napier et al. 1988b) is the three-volume document for GENII – the Hanford environmental radiation dosimetry software system. The software can be used to determine radiation dose to individual or population from a wide variety of potential exposure scenarios. The third volume of the document gives all default values in the data files.

NUREG/CR-5512-V1 (Kennedy et al. 1992) is the document that provides generic and site-specific estimates of radiation dose for exposures to residual radioactive contamination after the decommissioning of facilities licensed by the U.S. NRC. Although the document does not directly mention use of GENII model, the calculation methods, input parameters, and default values are very similar to those used in GENII software.

SAND91-0561 (Leigh et al. 1993) is the user's guide for GENII-S, *A Code for Statistical and Deterministic Simulations of Radiation Dose to Human from Radionuclides in the Environment.* The software, based on the GENII dose calculation methods, has the capability to perform

sensitivity and uncertainty analyses. It was used in the performance assessment for the Waste Isolation Pilot Plant Project for the U.S. Department of Energy. It will also be used for the biosphere dose assessment in Yucca Mountain Project. The document does not describe the dose calculation methods, but does describe the function of each input parameter, and some default data files. However, values in two data files that are analyzed in this AMR, FTRANS.DAT and BIOAC1.DAT are not completely shown in this user's guide. Therefore, two other documents, GENII manual Vol. 3, PNL-6584 (Napier et al. 1988b) and verification of 1993 version of GENII, WHC-SD-WM-TI-596 (Rittmann 1993), are cited for the default values of GENII-S.

ANL/EAIS/TM-103 (Wang et al. 1993) is a report for a compilation of radionuclide transfer factors for the plant, beef, milk, and aquatic food pathways and the suggested default values for the RESRAD code. It is a very comprehensive review document that included many important previous works in the area. It is one of the most important reviewed documents for this AMR.

IAEA Technical Reports Series (TRS) No. 364 (IAEA 1994) is a handbook of parameter values for prediction of radionuclide transfer in temperate environments. This handbook reflects the current efforts, in collaboration with the International Union of Radioecologists, for a convenient and authoritative reference for radionuclide transfer parameter values used in biosphere dose assessment models. It is a supplement to the previously published IAEA SS-57, as described earlier. All food transfer factors / coefficients needed in the GENII-S model can be found in the report, though the values do not cover for all elements of interest.

AECL-11474 (Sheppard 1995) is the report for application of the International Union of Radioecologists soil-to-plant database to Canadian settings. A statistical analysis was conducted for soil-to-plant transfer factors using the database. The estimated transfer factor values were suggested based on extrapolation. The distribution for transfer factors was also studied. It is very important input source for transfer factors in this AMR.

AECL-11494-4 (Zach et al. 1996) is the document for a biosphere model of the disposal of Canada's nuclear fuel waste by Atomic Energy of Canada Limited (ACEL). It describes a study of postclosure safety of in-room emplacement of used CANDU fuel in copper containers in permeable plutonic rock. A biosphere model, called BIOTRAC (BIOsphere Transport and Assessment Code), was developed and used for their Environmental Impact Statement postclosure assessment case study, AECL-10720 (Davis et al. 1993). Although there are many different biosphere characteristics between the Canada case and the Yucca Mountain case, it is still helpful to understand their parameter selection.

EPRI TR-107190 (Smith et al. 1996) is the document for biosphere modeling and dose assessment for Yucca Mountain prepared by the Electric Power Research Institute (EPRI). Using a different approach, the results are quite different from those obtained by the Center for Nuclear Regulatory Analysis CNWRA (LaPlante et al. 1997) and YMP (DOE 1998). However, the selections of the food transfer factors and coefficients still provide useful information.

CNWRA 97-009 (LaPlante et al. 1997) is the updated information and analyses to support selection of critical groups and reference biosphere for Yucca Mountain exposure scenarios. This is the latest work on the Yucca Mountain biosphere dose assessment from CNWRA, and

somewhat reflects the NRC position. The transfer factors and coefficients selected were mainly based on IAEA TRS-364 (IAEA 1994) report and GENII-S default values.

All above documents are based on either comprehensive calculation methods or completed dose assessment for special cases. Since some documents do not contain all pathways considered in the GENII-S model, a comparison made in Section 6 includes only applicable documents.

4.2 CRITERIA

The radionuclides of interest in both non-disrupted events and disruptive events were considered in this AMR. They are provided in *Status of Radionuclides Screening for the TSPA-SR* (CRWMS M&O, 1999b). The parameter selection criteria, as a part of the analysis, are listed in Section 6.

With the consideration of both scenarios, 21 radionuclides and corresponding 14 chemical elements need to be considered, as listed in Table 2. In addition, three more elements are also included in the analysis, because their corresponding radionuclides are decay progenies from primary radionuclides, which may be considered in the GENII-S model.

Table 2. List of Radionuclides and Elements of Interest

Radionuclide	Element	Z	Radionuclide	Element	Z
^{14}C	C	6	(^{225}Ra from ^{229}Th)	Ra	88
^{63}Ni	Ni	28	^{227}Ac	Ac	89
^{90}Sr	Sr	38	^{229}Th	Th	90
(^{90}Y from ^{90}Sr)	Y	39	^{231}Pa	Pa	91
^{93}Mo	Mo	42	^{232}U, ^{233}U, ^{234}U, ^{236}U, ^{238}U	U	92
^{99}Tc	Tc	43	^{237}Np	Np	93
^{129}I	I	53	^{238}Pu, ^{239}Pu, ^{240}Pu	Pu	94
^{137}Cs	Cs	55	^{241}Am, ^{243}Am,	Am	95
(^{223}Fr from ^{227}Ac)	Fr	87			

4.3 CODES AND STANDARDS

No codes or standards are used as a primary source of input in this analysis.

5. ASSUMPTIONS

No assumptions are used for the analysis.

6. ANALYSIS

In this section, literature data are studied for the applicability, and variation range to evaluate adequacy of the GENII-S default values for the parameters of interest. The selection criteria are established for use in the analysis. Each parameter group is discussed in detail under each subsection below. A comparison table is made for each parameter group between the available literature values.

6.1 SELECTION CRITERIA

From available literature sources, a range of food transfer factors and coefficients is quite large for some food types and elements. Selection of transfer coefficients for the reasonable case is based on following criteria, as the order of preference:

1. If one single value appears in at least half of the number of reviewed documents, this value is selected, because it is considered that this generic value is agreed by scientific community. A "More" is placed in the comment column for this case.

2. If one value appears in at least half of the recent published documents (published after GENII, 1988), this new value is selected, because it is considered that it reflects recent studies. A "Recent" is placed in the comment column for this case. The GENII-S default values were not considered recent, even though the reference (Rittmann 1993) was published after 1988, because the values in the 1993 revision were the same as those in the original version (Napier et al. 1988b) except for the addition of one element (Fr).

3. If no single agreed value from available literature data meets the above two criteria, the values are ranked from lowest to highest and the value with the middle rank is selected from all available data. If there is an even number of values, the one with a rank higher than the middle is chosen (e.g, the 4th is chosen if there are 6 values). A "Medium" is placed in the comment column for this case.

4. GENII-S default value (Rittmann 1993) is selected when only very limited literature data are available. A "Default" is placed in the comment column for this case.

In addition, two values are considered the same for selection criteria 1 and 2 when their one-digit rounded off value is the same. For example, 1.6E-2 and 2.2E-2 are considered the same, since both can be rounded off to 2E-2. The highest (i.e., most conservative) value of those rounded is chosen (e.g,. 2.2E-2 in the above example).

Values for the bounding case are selected by consideration of the values for the reasonable case and the scale factors, which is discussed in the following sections.

6.2 SOIL-TO-PLANT TRANSFER FACTORS

Soil-to-plant transfer factor, or concentration ratio (CR) in some documents, is defined as a ratio of radioactivity concentration in the edible part of plant (Bq/kg) to the radioactivity concentration in soil (Bq/kg). Some authors use a fresh weight concentration in plant, while

others use a dry weight concentration. The difference between them is dry-to-wet ratio. Since a dry based ratio is used in GENII-S model, transfer factors reviewed and compared in this analysis focus on dry based ratio.

There are four types of plant food ingestion pathways considered in GENII-S software: leafy vegetables, root vegetables, fruits, and grain. In addition, each type of food transfer factor needs to be considered for 17 elements as shown in Table 2. Thus, 68 parameter values are evaluated, compared, and selected in this section.

As GENII-S uses a special carbon-14 model, a transfer factor is not used for carbon. Even though other values are shown in some documents, "0" will be selected as it appears in the FTRANS.DAT file. A "N/A" is shown in the comment column of comparison tables, indicating the data selection does not apply to section criteria in Section 6.1.

Each food group usually contains many specific plant foods. Thus, transfer factors for each group have an obviously large range. The site-specific information on vegetable types planted and consumed by the critical group is unknown. Furthermore, transfer factors of these vegetables grown in the location have not been measured. Therefore, generic values are reviewed and selected from available literature.

Although most documents reviewed provide separated transfer factors for various plant foods, some authors combined transfer factors for root vegetables, fruit and grain as one factor (Baes et al. 1984; and Wang et al. 1993). On the other hand, some documents provide transfer factors for a specific food, instead of food group required by GENII-S, such as IAEA TRS-364 (IAEA 1994). In this case, the value selected for comparison is based on a combined value for the group, such as mixed green vegetables for leafy vegetables, and root crops for root vegetables. Otherwise, a range is given in the comparison table. For some elements, such as Sr and Cs, several values are given under different soil conditions. A value corresponding to sandy soil is selected.

Sheppard (1995) conducted statistical analysis for soil-to-plant transfer factor database compiled by the International Union of Radioecologists. Sheppard suggested a set of estimated transfer factor values based on extrapolation among elements. For each element, eight types of plant food (cereal, forage, root, grass, pod, tuber, vegie, and other) and three clay contents (5%, 15%, and 40%) are tabulated (Sheppard 1995, p.55). From the table, cereal column is selected for grain, root column is selected for root vegetables, and vegie column is selected for leafy vegetables. A 15% clay content is selected because it is conservative and reflects soil conditions in the location where the critical group lives. Site-specific soil measurements show that the maximum clay content in North Amargosa valley is less than 12% (CRWMS 1999c, p.9). For element Tc, 5% clay data are used due to data availability.

6.2.1 Leafy vegetables

Leafy vegetables include various green vegetables, such as lettuce, cabbage, broccoli, spinach, and many more. Transfer factors for leafy vegetables were studied and published in many

scientific articles. Some comprehensive reviews were made (Baes et al. 1984, Wang et al. 1993, IAEA 1994, and Sheppard 1995).

Eight documents are reviewed for transfer factors for leafy vegetables. A comparison of the transfer factor from various sources is made and shown in Table 3. Since there is no combined transfer factor for leafy vegetable available for element Tc in IAEA TRS-364 (IAEA 1994, p.18 & 20), a range is shown in the comparison table (Table 3). For some elements, Ni and I from IAEA TRS-364 (IAEA 1994, p.20), and Tc from AECL-11474 (Sheppard 1995, p.57), transfer factors for leafy vegetables are not available. The transfer factors for grass are listed in the comparison table, because transfer factors for leafy vegetables are also used for animal products.

The selected values are also shown in Table 3. The selection of the transfer factor for the reasonable case is based on the criteria discussed in Section 6.1. A simple justification is provided in the last column of the table. The result of the selection indicates that most of the GENII-S default values of transfer factors for leafy vegetables are modified.

6.2.2 Root vegetables

Like leafy vegetables, root vegetables include many types of plant food. Transfer factors for root vegetables have a large range. Transfer factors for root vegetables were studied and published in many scientific articles. Some comprehensive reviews were made (Baes et al. 1984, Wang et al. 1993, IAEA 1994, and Sheppard 1995).

Eight documents are reviewed for transfer factors for root vegetables. A comparison of transfer factors for root vegetables from various sources is made and shown in Table 4. Some documents used other vegetables, instead of root vegetables (LaPlante et al. 1997). For some elements, there are no combined transfer factors for root vegetables available in the document of IAEA TRS-364 (IAEA 1994, p.17). Thus, ranges are shown in the comparison table (Table 4). Till et al. (1983) listed two categories of root vegetables, the first one for radish, carrot, turnip, and beet, and the second for potato, and sweet potato. In this AMR, only the first one was used for comparison, unless it is not available, then the second one is used in the table. This selection is based on the first group of root vegetables most likely being planted in the farmer's garden.

The selected values are also shown in Table 4. The selection of transfer factors for the reasonable case is based on the criteria in Section 6.1. A simple justification is provided in the last column of the table. The result of selection indicates that only a few GENII-S default values of transfer factors for root vegetables are selected in the analysis.

6.2.3 Fruit

Transfer factors for fruit have not been studied in detail. There is not much published data available. Many data used in radiological dose assessments were directly taken from transfer factors for root vegetables, as suggested by Baes et al (1984) and Wang et al (1993). Other

documents provide only very limited values for some elements, such as NUREG/CR-3332 (Till et al. 1983) and IAEA TRS-364 (IAEA 1994).

A comparison of the transfer factors for fruit from various sources is made and shown in Table 5. The selected values are also shown in the table. The selection of the reasonable case is based on the criteria in Section 6.1. A simple justification is provided in the last column of the table. The result of selection indicates that only a few GENII-S default values of transfer factors for fruit are selected in the analysis, even though the selection was based on one single agreed value (Criteria 1) for most elements.

6.2.4 Grain

Transfer factors for grain have been studied and published in some scientific articles (IAEA 1994, Sheppard 1995). But some authors combined transfer factors for root vegetables, fruit and grain as one (Baes et al. 1984, and Wang et al. 1993).

Eight documents are reviewed for transfer factors for grain. A comparison of the transfer factors for grain from various sources is made and shown in Table 6. Till et al. (1983) listed two categories of grain, the first one for wheat, oat and barley, and the second for dry corn and rice. In this AMR, only the first one is used for comparison, unless it is not available. Then the second one is used in the table. This choice is based on the fact that rice is not a suitable crop being planted in Nevada.

The selection of the reasonable case is based on the criteria discussed in Section 6.1. The selected values are also shown in the table. A simple justification is provided in the last column of the table. The result of selection indicates that most of GENII-S default values for transfer factors for grain have to be modified, although the selection was based on one single agreed value (Criteria 1) for most elements.

6.2.5 Soil-to-plant transfer scale factor

Soil-to-plant transfer scale factor is used as a multiplier for the soil-to-plant transfer factors that are discussed in previous subsections. The scale factor is used for statistical simulation so that transfer factors, fixed values in the FTRANS.DAT file, can be scale up and down with a specified distribution. It is designed so that one scale factor fits for all four types of plant food and elements considered.

Since the transfer scale factor is a special parameter designed for GENII-S code, there are not many documents that address its value and distribution. However, some literatures describe the variation of the transfer factor with a range. For example, a 95% confident range is given in IAEA TRS-364 (IAEA 1994, p.17 – p.25). The range depends on the elements, food types, and soil conditions. A ratio of more than 100 can be found from the high value to low value for many elements, such as Ni, Sr, Tc, I, Cs, Ra, Th, U, Np, Pu and Am. With this 95% range, a

geometric standard deviation (GSD) can be calculated as 3.2 if a lognormal distribution is assumed.

Sheppard (1995) studied the International Union of Radioecologists soil-to-plant database, including more than twenty elements with several hundred data for some elements. It was reported that transfer factors tend to have a lognormal distribution (Sheppard 1995, p.2). With consideration for the food types, for example, a range of GSD for Cs-137 is from 3.1 to 4.2 (Sheppard 1995, p.12). A similar range can be found for some other elements in the study.

In the biosphere dose assessment for Total System Performance Assessment – Viability Assessment (TSPA-VA), a GSD of 2.0 was taken from CNRWA 97-009 (LaPlante et al. 1997, p.2-14). As GENII-S requires 0.1 and 99.9 percentile values for a lognormal distribution (Leigh et al. 1993, p.5-33), the range was calculated to be 0.117 to 8.51 (DOE 1998, p. 3-156).

From above reviewed documents, a GSD of 3.2 is a reasonable range for transfer factors. Therefore, it is recommended that the transfer scale factor be a lognormal distribution with a GSD of 3.2. For a lognormal distribution, the 0.1 and 99.9 percentile values can be calculated as 0.027 and 36.4. This large range should cover the uncertainty of soil-to-plant transfer factors.

6.2.6 Transfer factors for the bounding case

The high bounding values are obtained by multiplying the reasonable values given in Table 3 to Table 6 by 10. This selection is based on the fact that most elements of interest have an uncertainty factor of 10, or a high 95% confidence value is 10 times higher than the expected value, as shown in IAEA TRS-364 (IAEA 1994, p.17 – p.25). This factor of ten can also be calculated from a GSD of 3.2 with a 95-percentile value for soil-to-plant transfer scale factor.

Table 3. Transfer Factors for Leafy Vegetables from Various Sources and the Selected Values

		1	2	3	4	5
Element	**Z**	**WHC-SD-WM-TI-596 (Rittmann 1993, p.35-36)**	**NUREG/CR-3332 (Till et al. 1983, p.5-50-5-51)**	**ORNL-5786 (Baes et al. 1984, p.10)**	**NUREG/CR-5512 (Kennedy et al. 1992, p.6.25-6.27)**	**ANL/EAIS/TM-103 (Wang et al. 1993, p.25-26)**
C	6	0.0E+00	-	-	7.0E-01	7.0E-01
Ni	28	1.0E-01	-	6.0E-02	2.8E-01	2.8E-01
Sr	38	2.0E+00	2.2E+00	2.5E+00	1.6E+00	1.6E+00
Y	39	1.0E-02	-	1.5E-02	1.5E-02	1.5E-02
Mo	42	1.0E+00	-	2.5E-01	2.5E-01	2.5E-01
Tc	43	4.0E+01	-	9.5E+00	4.4E+01	4.0E+01
I	53	4.0E-01	7.0E-02	1.5E-01	3.4E-03	1.5E-01
Cs	55	2.0E-02	2.2E-02	8.0E-02	1.3E-01	1.3E-01
Fr	87	2.0E-02	-	3.0E-02	-	-
Ra	88	1.0E-01	4.4E-01	1.5E-02	7.5E-02	7.5E-02
Ac	89	1.0E-02	-	3.5E-03	3.5E-03	3.5E-03
Th	90	4.0E-03	-	8.5E-04	6.6E-03	4.0E-03
Pa	91	5.0E-02	-	2.5E-03	2.5E-03	2.5E-03
U	92	4.0E-03	-	8.5E-03	1.7E-02	8.5E-03
Np	93	1.0E+00	-	1.0E-01	1.3E-02	1.3E-02
Pu	94	4.0E-04	1.8E-04	4.5E-04	3.9E-04	3.9E-04
Am	95	2.0E-03	5.0E-02	5.5E-03	5.8E-04	2.0E-03

		6	7	8		
Element	**Z**	**IAEA TRS-364 (IAEA 1994, p.17-25)**	**AECL-11474 (Sheppard 1995, p.55-57)**	**CNWRA 97-009 (LaPlante et al. 1997, p.2-13)**	**Selected Values**	**Comment**
C	6	-	-	-	**0.0E+00**	N/A
Ni	28	1.8E-01	4.1E-01	1.8E-01	**1.8E-01**	Medium
Sr	38	3.0E+00	2.0E+00	1.1E+00	**2.0E+00**	More
Y	39	1.0E-02	-	-	**1.5E-02**	More
Mo	42	8.0E-01	-	8.0E-01	**2.5E-01**	More
Tc	43	1.2E1 – 2.6E3	8.9E+00	7.6E+01	**4.0E+01**	Medium
I	53	3.4E-03	5.4E-03	3.4E-03	**3.4E-03**	Recent
Cs	55	4.6E-01	1.3E-01	1.1E-01	**1.3E-01**	More
Fr	87	-	-	-	**2.0E-02**	Default
Ra	88	4.9E-02	2.8E-02	8.0E-02	**8.0E-02**	Recent
Ac	89	-	-	3.5E-03	**3.5E-03**	More
Th	90	1.8E-03	9.0E-03	1.1E-02	**4.0E-03**	Medium
Pa	91	-	-	2.5E-03	**2.5E-03**	More
U	92	8.3E-03	2.2E-02	2.3E-02	**8.5E-03**	Medium
Np	93	3.7E-02	2.5E-02	6.9E-02	**3.7E-02**	Medium
Pu	94	7.3E-05	2.9E-04	3.4E-04	**3.9E-04**	Medium
Am	95	6.6E-04	1.2E-03	1.2E-03	**2.0E-03**	Medium

Table 4. Transfer Factors for Root Vegetables from Various Sources and the Selected Values

		1	2	3	4	5
Element	**Z**	**WHC-SD-WM-TI-596 (Rittmann 1993, p.35-36)**	**NUREG/CR-3332 (Till et al. 1983, p.5-50-5-51)**	**ORNL-5786 (Baes et al. 1984, p.11)**	**NUREG/CR-5512 (Kennedy et al. 1992, p.6.25-6.27)**	**ANL/EAIS/TM-103 (Wang et al. 1993, p.25)**
C	6	0.0E+00	-	-	7.0E-01	7.0E-01
Ni	28	1.0E-01	-	6.0E-02	6.0E-02	6.0E-02
Sr	38	2.0E+00	1.8E+00	2.5E-01	8.1E-01	3.7E-01
Y	39	1.0E-02	-	6.0E-03	6.0E-03	6.0E-03
Mo	42	1.0E+00	-	6.0E-02	6.0E-02	6.0E-02
Tc	43	4.0E+01	-	1.5E+00	1.1E+00	1.5E+00
I	53	4.0E-01	3.0E-02	5.0E-02	5.0E-02	5.0E-02
Cs	55	2.0E-02	3.7E-02	3.0E-02	4.9E-02	9.8E-02
Fr	87	2.0E-02	-	8.0E-03	-	-
Ra	88	1.0E-01	1.7E-01	1.5E-03	3.2E-03	3.5E-03
Ac	89	1.0E-02	-	3.5E-04	3.5E-04	3.5E-04
Th	90	4.0E-03	3.0E-04	8.5E-05	1.2E-04	2.1E-04
Pa	91	5.0E-02	-	2.5E-04	2.5E-04	2.5E-04
U	92	4.0E-03	3.0E-04	4.0E-03	1.4E-02	6.4E-03
Np	93	1.0E+00	-	1.0E-02	9.4E-03	1.7E-02
Pu	94	4.0E-04	3.7E-04	4.5E-05	2.0E-04	1.9E-04
Am	95	2.0E-03	-	2.5E-04	4.1E-04	4.1E-04

		6	7	8		
Element	**Z**	**IAEA TRS-364 (IAEA 1994, p.17)**	**AECL-11474 (Sheppard 1995, p.55)**	**CNWRA 97-009 (LaPlante et al. 1997, p.2-13)**	**Selected Values**	**Comment**
C	6	-	-	-	**0.0E+00**	N/A
Ni	28	-	2.5E-01	3.0E-02	**6.0E-02**	More
Sr	38	1.4E+00	1.2E+00	8.6E-01	**1.2E+00**	Medium
Y	39	1.0E-02	-	-	**6.0E-03**	More
Mo	42	8.0E-01	-	8.0E-01	**6.0E-02**	More
Tc	43	2.4E-1 – 7.9E+1	6.6E+00	1.1E+01	**6.6E+00**	Medium
I	53	2.0E-02	3.3E-03	2.0E-02	**5.0E-02**	Medium
Cs	55	1.1E-02	7.7E-02	7.2E-02	**4.9E-02**	Medium
Fr	87	-	-	-	**2.0E-02**	Default
Ra	88	1.1E-3 – 2.1E-2	1.7E-02	1.3E-02	**1.3E-02**	Medium
Ac	89	-	-	3.5E-03	**3.5E-04**	More
Th	90	5.6E-5 – 3.9E-2	5.5E-03	3.1E-04	**3.0E-04**	Medium
Pa	91	-	-	2.5E-03	**2.5E-04**	More
U	92	1.4E-02	1.3E-02	1.1E-02	**1.4E-02**	More
Np	93	6.7E-3 – 3.5E-2	1.5E-02	2.7E-02	**1.7E-02**	Medium
Pu	94	8.7E-5 – 4.4E-3	1.8E-04	2.3E-04	**2.0E-04**	More
Am	95	1.6E-4 – 2.2E-3	7.0E-04	4.7E-04	**4.7E-04**	Medium

Table 5. Transfer Factors for Fruit from Various Sources and the Selected Values

		1	2	3	4	5
Element	**Z**	**WHC-SD-WM-TI-596 (Rittmann 1993, p.35-36)**	**NUREG/CR-3332 (Till et al. 1983, p.5-50-5-51)**	**ORNL-5786 (Baes et al. 1984, p.11)**	**NUREG/CR-5512 (Kennedy et al. 1992, p.6.25-6.27)**	**ANL/EAIS/TM-103 (Wang et al. 1993, p.25-26)**
C	6	0.0E+00	-	-	7.0E-01	7.0E-01
Ni	28	1.0E-01	-	6.0E-02	6.0E-02	6.0E-02
Sr	38	2.0E+00	2.4E-01	2.5E-01	1.7E-01	3.7E-01
Y	39	1.0E-02	-	6.0E-03	6.0E-03	6.0E-03
Mo	42	1.0E+00	-	6.0E-02	6.0E-02	6.0E-02
Tc	43	4.0E+01	-	1.5E+00	1.5E+00	1.5E+00
I	53	4.0E-01	-	5.0E-02	5.0E-02	5.0E-02
Cs	55	2.0E-02	2.6E-02	3.0E-02	2.2E-01	9.8E-02
Fr	87	2.0E-02	-	8.0E-03	-	-
Ra	88	1.0E-01	3.5E-03	1.5E-03	6.1E-03	3.5E-03
Ac	89	3.0E-03	-	3.5E-04	3.5E-04	3.5E-04
Th	90	4.0E-03	-	8.5E-05	8.5E-05	2.1E-04
Pa	91	5.0E-02	-	2.5E-04	2.5E-04	2.5E-04
U	92	4.0E-03	1.7E-03	4.0E-03	4.0E-03	6.4E-03
Np	93	1.0E+00	-	1.0E-02	1.0E-02	1.7E-02
Pu	94	4.0E-04	-	4.5E-05	4.5E-05	1.9E-04
Am	95	2.0E-03	-	2.5E-04	2.5E-04	4.1E-04

		6	7		
Element	**Z**	**IAEA TRS-364 (IAEA 1994, p.17-25)**	**CNWRA 97-009 (LaPlante et al. 1997, p.2-13)**	**Selected Values**	**Comment**
C	6	-	-	**0.0E+00**	N/A
Ni	28	-	3.0E-02	**6.0E-02**	More
Sr	38	2.0E-01	2.0E-01	**2.0E-01**	More
Y	39	1.0E-02	-	**6.0E-03**	More
Mo	42	8.0E-01	8.0E-01	**6.0E-02**	More
Tc	43	-	1.1E+01	**1.5E+00**	More
I	53	2.0E-02	2.0E-02	**5.0E-02**	More
Cs	55	2.2E-01	7.2E-02	**2.2E-01**	Recent
Fr	87	-	-	**2.0E-02**	Default
Ra	88	6.1E-03	1.3E-02	**6.1E-03**	Recent
Ac	89	-	3.5E-03	**3.5E-04**	More
Th	90	-	3.1E-04	**2.1E-04**	Medium
Pa	91	-	2.5E-03	**2.5E-04**	More
U	92	-	1.1E-02	**4.0E-03**	More
Np	93	-	2.7E-02	**1.7E-02**	Medium
Pu	94	-	2.3E-04	**1.9E-04**	Medium
Am	95	-	4.7E-04	**4.1E-04**	Medium

Table 6. Transfer Factors for Grain from Various Sources and the Selected Values

		1	2	3	4	5
Element	**Z**	**WHC-SD-WM-TI-596 (Rittmann 1993, p.35-36)**	**NUREG/CR-3332 (Till et al. 1983, p.5-50-5-51)**	**ORNL-5786 (Baes et al. 1984, p.11)**	**NUREG/CR-5512 (Kennedy et al. 1992, p.6.25-6.27)**	**ANL/EAIS/TM-103 (Wang et al. 1993, p.25-26)**
C	6	0.0E+00	-	-	7.0E-01	7.0E-01
Ni	28	5.0E-02	-	6.0E-02	3.0E-02	6.0E-02
Sr	38	2.0E-01	2.2E-01	2.5E-01	1.3E-01	3.7E-01
Y	39	1.0E-03	-	6.0E-03	6.0E-03	6.0E-03
Mo	42	1.0E-01	-	6.0E-02	6.0E-02	6.0E-02
Tc	43	4.0E+01	-	1.5E+00	7.3E-01	1.5E+00
I	53	4.0E-01	-	5.0E-02	5.0E-02	5.0E-02
Cs	55	1.0E-02	1.9E-02	3.0E-02	2.6E-02	9.8E-02
Fr	87	1.0E-02	-	8.0E-03	-	-
Ra	88	1.0E-02	5.8E-02	1.5E-03	1.2E-03	3.5E-03
Ac	89	3.0E-04	-	3.5E-04	3.5E-04	3.5E-04
Th	90	4.0E-04	2.0E-03	8.5E-05	3.4E-05	2.1E-04
Pa	91	2.0E-02	-	2.5E-04	2.5E-04	2.5E-04
U	92	2.0E-04	1.6E-04	4.0E-03	1.3E-03	6.4E-03
Np	93	1.0E-01	5.1E-04	1.0E-02	2.7E-03	1.7E-02
Pu	94	4.0E-05	1.5E-06	4.5E-05	2.6E-05	1.9E-04
Am	95	2.0E-04	2.8E-05	2.5E-04	5.9E-05	4.1E-04

		6	7	8		
Element	**Z**	**IAEA TRS-364 (IAEA 1994, p.17-25)**	**AECL-11474 (Sheppard 1995, p.55-57)**	**CNWRA 97-009 (LaPlante et al. 1997, p.2-13)**	**Selected Values**	**Comment**
C	6	-	-	-	**0.0E+00**	N/A
Ni	28	3.0E-02	3.1E-02	3.0E-02	**3.0E-02**	More
Sr	38	2.1E-01	1.5E-01	1.2E-01	**2.0E-01**	More
Y	39	1.0E-02	-	-	**6.0E-03**	More
Mo	42	8.0E-01	-	8.0E-01	**6.0E-02**	More
Tc	43	7.3E-01	8.3E-01	7.3E-01	**7.3E-01**	Recent
I	53	2.0E-02	4.2E-04	2.0E-02	**5.0E-02**	Medium
Cs	55	2.6E-02	1.0E-02	1.0E-02	**2.6E-02**	Medium
Fr	87	-	-	-	**1.0E-02**	Default
Ra	88	1.2E-03	2.1E-03	1.2E-03	**1.2E-03**	Recent
Ac	89	-	-	3.5E-03	**3.5E-04**	More
Th	90	3.4E-05	6.9E-04	3.4E-05	**3.4E-05**	Recent
Pa	91	-	-	2.5E-03	**2.5E-04**	More
U	92	1.3E-03	1.7E-03	1.3E-03	**1.3E-03**	Recent
Np	93	2.7E-03	1.9E-03	2.7E-03	**2.7E-03**	Recent
Pu	94	8.6E-06	2.0E-05	8.6E-06	**2.6E-05**	Medium
Am	95	2.2E-05	9.0E-05	2.2E-05	**9.0E-05**	Medium

6.3 TRANSFER COEFFICIENTS FOR ANIMAL PRODUCTS

The transfer coefficient is defined as a ratio of radionulcide concentration in animal product (Bq/kg or Bq/L) to animal daily radionuclide intake (Bq/day). Thus it is in units of day/kg or day/L. There are four types of animal product ingestion pathways considered in the GENII-S software including beef, poultry, milk, and eggs. Each type of animal product has its own transfer coefficient.

Since transfer coefficients depend on chemical elements, the parameter needs to be considered for 17 elements as shown in Table 2. Thus, 68 parameter values are evaluated, compared, and selected in this section. Similar to transfer factors discussed in Section 6.2, GENII-S uses a special carbon-14 model for animal products. Even though other values show in some documents, "0" is selected as it appears in the FTRANS.DAT file. A "N/A" is shown in the comment column of comparison tables, indicating the data selection does not apply to section criteria in Section 6.1.

6.3.1 Beef

Beef ingestion is one of the most important pathways for radionuclide transport into human body. The transfer coefficients for beef were studied and published in many scientific articles. Many comprehensive reviews were made (Baes et al. 1984, and Wang et al. 1993). In some documents the word "meat" is used, instead of "beef". The food consumption rate for beef in Yucca Mountain biosphere survey (DOE 1998, p.3-156) includes pork. As the fraction is unknown, it is assumed that transfer coefficients for beef are suitable for pork. Therefore, this analysis focuses only on transfer coefficients for beef.

Twelve documents are reviewed for transfer coefficients for beef. Two values for Tc, 1E-4 d/kg from Tc-95m study and 1E-6 d/kg from Tc-99m study, are given in IAEA TRS-364. A high value is selected for the comparison as a conservative approach. A comparison of transfer coefficients for beef from various sources is made and shown in Table 7. The selected values are also shown in the table. The selection is based on the criteria discussed in Section 6.1. A simple justification is provided in the last column of the table.

The results of the selections indicate that there are not many elements having a single agreed value from literature data. Most parameter values are selected based on data from recently published documents. The ranges of available data shown in Table 7 are very large, from one to four orders of magnitude.

6.3.2 Poultry

There are not many studies on transfer coefficients for poultry. In addition, many radiological dose assessments do not include poultry ingestion pathway. Although some dose assessments include poultry ingestion pathway, the values may be based on very rough estimates. For instance, transfer coefficients for poultry and eggs in AECL work were taken from available data

plus some rough estimates, such as 100 times the transfer coefficients for beef (Davis 1993, p.237).

Six documents that include the poultry ingestion pathway are reviewed. A comparison of transfer coefficients for poultry from various sources is made and shown in Table 8. The selected values are also shown in the table. The selection is based on the criteria in Section 6.1. A simple justification is provided in the last column of the table.

The results of the selections indicate that GENII-S default values for transfer coefficients for poultry are the best choice for most elements of interest. In addition, the selection criteria of a single agreed value apply for most elements.

6.3.3 Milk

Milk ingestion is one of the most important pathways for radionulcide transport into human body. The transfer coefficients for milk were studied and published in many scientific articles. Many comprehensive reviews were made (Ng et al. 1977, Baes et al. 1984, and Wang et al. 1993). However, the parameter values from Ng's report (1977, p.94) are not included in the comparison table, because he was one of the authors for IAEA SS-57 (IAEA 1982), which used the same set of transfer coefficients for milk.

Twelve documents are reviewed for transfer coefficients for milk in this analysis. Two values for Tc, 1.4E-4 d/L from Tc-95m study and 2.3E-5 d/L from Tc-99m study are given in IAEA TRS-364. A high value is selected for the comparison as a conservative approach. A comparison of transfer coefficients for milk from various sources is made and shown in Table 9. The selected values are also shown in the table. The selection is based on the criteria in Section 6.1. A simple justification is provided in the last column of the table.

The results of the selections indicate that there are many elements having a single agreed value for milk transfer coefficient. Thus most parameter values are selected based on one single agreed value (Criteria 1) discussed in Section 6.1. The range of available data shown in Table 9 is relatively small. Only a few elements have a range larger than one order of magnitude.

6.3.4 Eggs

Like transfer coefficients for poultry, there are not many studies on transfer coefficients for eggs. It is also true that many dose assessments do not include the eggs ingestion pathway. Some documents simply use the same set of values for transfer coefficients for poultry and for eggs (Davis et al. 1993, p.235). Seven documents, one more for poultry discussed in subsection 6.3.2, provide transfer coefficients for eggs in the reviewed documents.

A comparison of the transfer coefficients for eggs from various sources is made and shown in Table 10. The selected values are also shown in the table. The selection is based on the criteria in Section 6.1. A simple justification is provided in the last column of the table.

The results of the selections indicate that GENII-S default values for transfer coefficients for eggs are the best choice for most elements. In addition, most parameter values are selected based on data from the single agreed value (Criteria 1) discussed in Section 6.1. Only a few values are selected differently from the default values, but the difference between selected value and the default value is relatively small.

6.3.5 Animal uptake scale factor

Animal uptake scale factor is used as a multiplier for the transfer coefficients for animal products that are discussed in previous subsections. The scale factor is used for statistical simulation so that the transfer coefficient, a fixed value in FTRANS.DAT file, can be scale up and down with a specified distribution. It is designed so that one scale factor fits for all four types of animal products and elements considered.

Like the soil-to-plant transfer scale factor, the animal uptake scale factor is a special parameter designed for the GENII-S software. A lognormal distribution was suggested by many authors (LaPlante et al. 1997, Davis et al. 1993). A GSD of 3.2 was used for all four types of animal products in AECL postclosure assessment (Davis et al. 1993, p.236-238). In the biosphere dose assessment for TSPA-VA, a GSD of 2.0 was taken from CNRWA 97-009 (LaPlante et al. 1997, p.2-14).

The ranges for transfer coefficients for beef, milk, poultry and eggs in IAEA TRS-364 are given from the same order to three orders of magnitude. For most of them, the range is in one order of magnitude. Therefore, a lognormal distribution with a GSD of 2.0 is suitable to animal uptake scale. For a lognormal distribution, the 0.1 and 99.9 percentile values can be calculated as 0.117 and 8.51. This large range should cover the uncertainty of animal food transfer coefficients.

6.3.6 Transfer coefficients for the bounding case

The high bounding values for transfer coefficients are obtained by multiplying the reasonable values given in Table 7 to Table 10 by 4. This selection is based on the available data that most elements of interest have a range less than an order of magnitude shown in IAEA TRS-364 (IAEA 1994, p.35, p.37, p.40, and p.41). This factor of four can also be calculated from a GSD of 2.0 with a 95-percentile value for the animal uptake scale factor.

Table 7. Transfer Coefficients for Beef from Various Sources and the Selected Values (day/kg)

		1	2	3	4	5	6	7
Element	**Z**	**WHC-SD-WM-TI-596 (Rittmann 1993, p.35-36)**	**NRC RG 1.109 (NRC 1977, p.37)**	**IAEA SS-57 (IAEA 1982, p.70)**	**NUREG/CR-3332 (Till et al. 1983, p.5-87)**	**NUREG/CR-3160 (Mills et al. 1983, p.145)**	**ORNL-5786 (Baes et al. 1984, p.51)**	**NUREG/CR-5512 (Kennedy et al. 1992, p.6.29-6.30)**
C	6	0.0E+00	3.1E-02	-	-	0.0E+00	-	-
Ni	28	2.0E-03	5.3E-02	5E-03	2.0E-03	1.0E-03	6.0E-03	6.0E-03
Sr	38	8.0E-04	6.0E-04	6E-04	8.1E-04	3.0E-04	3.0E-04	3.0E-04
Y	39	1.0E-03	4.6E-03	2E-03	1.0E-03	5.0E-03	3.0E-04	3.0E-04
Mo	42	1.2E-03	8.0E-03	-	6.8E-03	1.0E-02	6.0E-03	6.0E-03
Tc	43	9.9E-04	4.0E-01	1E-02	8.7E-03	9.9E-04	8.5E-03	8.5E-03
I	53	2.0E-03	2.9E-03	1E-02	7.2E-03	2.0E-02	7.0E-03	7.0E-03
Cs	55	3.0E-02	4.0E-03	2E-02	2.0E-03	3.0E-02	2.0E-02	2.0E-02
Fr	87	3.0E-02	-	-	-	-	2.5E-03	-
Ra	88	9.0E-04	-	5E-04	5.1E-04	9.9E-04	2.5E-04	2.5E-04
Ac	89	4.0E-04	-	2E-05	-	5.0E-03	2.5E-05	2.5E-05
Th	90	5.0E-03	-	1E-04	2.0E-04	5.0E-03	6.0E-06	6.0E-06
Pa	91	5.0E-03	-	1E-03	-	5.0E-03	1.0E-05	1.0E-05
U	92	2.0E-04	-	3E-02	3.4E-04	5.0E-03	2.0E-04	2.0E-04
Np	93	1.0E-03	2.0E-04	1E-03	-	5.0E-03	5.5E-05	5.5E-05
Pu	94	2.0E-06	-	1E-05	1.0E-06	5.0E-03	5.0E-07	5.0E-07
Am	95	2.0E-05	-	2E-05	3.6E-06	5.0E-03	3.5E-06	3.5E-06

		8	9	10	11	12		
Element	**Z**	**ANL/EAIS/TM-103 (Wang et al. 1993, p.27-29)**	**AECL-10720 (Davis et al. 1993, p.233-234)**	**IAEA TRS-364 (IAEA 1994, p.37)**	**EPRI TR-10790 (Smith et al. 1996, p.5-27)**	**CNWRA 97-009 (LaPlante et al.1997, p.2-13)**	**Selected Values**	**Comment**
C	6	3.1E-02	6.4E-02	-	-	-	**0.0E+00**	N/A
Ni	28	5.0E-03	2.0E-03	5E-03	-	5E-03	**5.0E-03**	Recent
Sr	38	8.0E-03	8.1E-04	8E-03	-	8E-03	**8.0E-03**	Recent
Y	39	2.0E-03	3.0E-04	1E-03	-	-	**1.0E-03**	Medium
Mo	42	1.0E-03	6.8E-03	1E-03	-	1E-03	**1.0E-03**	Recent
Tc	43	1.0E-04	8.5E-03	1E-04	6.0E-03	1E-04	**1.0E-04**	Recent
I	53	7.0E-03	7.0E-03	4E-02	3.0E-03	4E-02	**7.0E-03**	Recent
Cs	55	3.0E-02	2.6E-02	5E-02	5.0E-02	5E-02	**5.0E-02**	Recent
Fr	87	-	-	-	-	-	**3.0E-02**	Default
Ra	88	1.0E-03	9.0E-04	9E-04	1.3E-03	9E-04	**9.0E-04**	Recent
Ac	89	2.5E-05	2.5E-05	-	1.6E-03	2.5E-05	**2.5E-05**	More
Th	90	1.0E-04	6.0E-06	-	2.7E-03	6.0E-06	**6.0E-06**	Recent
Pa	91	5.0E-03	1.0E-05	-	5.0E-05	1.0E-05	**1.0E-05**	Recent
U	92	3.4E-04	2.0E-04	3E-04	6.9E-04	3E-04	**3.0E-04**	Recent
Np	93	1.0E-03	5.5E-05	1E-03	1.2E-04	1E-03	**1.0E-03**	Recent
Pu	94	1.0E-04	2.0E-06	1E-05	2.0E-04	1E-05	**1.0E-05**	Medium
Am	95	5.0E-05	3.5E-06	4E-05	4.0E-04	4E-05	**2.0E-05**	Medium

Table 8. Transfer Coefficients for Poultry from Various Sources and the Selected Values (day/kg)

		1	2	3	4
Element	**Z**	**WHC-SD-WM-TI-596 (Rittmann 1993, p.35-36)**	**NUREG/CR-3160 (Mills et al. 1983, p.145)**	**NUREG/CR-5512 (Kennedy et al. 1992, p.6.29-6.30)**	**AECL-10720 (Davis et al. 1993, p.233-234)**
C	6	0.0E+00	0.0E+00	-	6.4E+00
Ni	28	1.0E-03	1.0E-03	1.0E-03	2.0E-01
Sr	38	3.5E-02	9.0E-04	3.5E-02	3.0E-01
Y	39	1.0E-02	5.0E-04	1.0E-02	3.0E-02
Mo	42	1.9E-01	2.0E-03	1.9E-01	5.0E-01
Tc	43	3.0E-02	9.9E-04	3.0E-02	1.9E+00
I	53	1.8E-02	4.0E-03	1.8E-02	2.8E+00
Cs	55	4.4E+00	4.5E+00	4.4E+00	4.4E+00
Fr	87	4.4E+00	-	-	-
Ra	88	9.9E-04	9.9E-04	3.0E-02	9.0E-02
Ac	89	4.0E-03	4.0E-03	4.0E-03	2.5E-03
Th	90	4.0E-03	4.0E-03	4.0E-03	6.0E-04
Pa	91	4.0E-03	4.0E-03	4.0E-03	1.0E-03
U	92	1.2E+00	1.2E-03	1.2E+00	1.2E+00
Np	93	4.0E-03	4.0E-03	4.0E-03	5.5E-03
Pu	94	1.5E-04	4.0E-03	1.5E-04	7.6E-03
Am	95	2.0E-04	4.0E-03	2.0E-04	8.5E-03

		5	6		
Element	**Z**	**IAEA TRS-364 (IAEA 1994, p.40)**	**EPRI TR-10790 (Smith et al. 1996, p.5-29)**	**Selected Values**	**Comment**
C	6	-	-	**0.0E+00**	N/A
Ni	28	-	-	**1.0E-03**	More
Sr	38	8E-02	-	**3.5E-02**	Medium
Y	39	1E-02	-	**1.0E-02**	More
Mo	42	1E+00	-	**1.9E-01**	Medium
Tc	43	3E-02	1.2E+00	**3.0E-02**	More
I	53	1E-02	2.0E-01	**1.8E-02**	Medium
Cs	55	1E+01	1.2E+01	**4.4E+00**	More
Fr	87	-	-	**4.4E+00**	Default
Ra	88	-	4.8E-01	**3.0E-02**	Medium
Ac	89	-	6.6E-03	**4.0E-03**	More
Th	90	-	1.8E-01	**4.0E-03**	More
Pa	91	-	4.1E-03	**4.0E-03**	More
U	92	1E+00	1.0E-01	**1.2E+00**	More
Np	93	-	1.7E-03	**4.0E-03**	More
Pu	94	3E-03	1.0E-01	**4.0E-03**	Medium
Am	95	6E-03	1.0E-01	**6.0E-03**	Medium

Table 9. Transfer Coefficients for Milk from Various Sources and the Selected Values (day/L)

		1	2	3	4	5	6	7
Element	**Z**	**WHC-SD-WM-TI-596 (Rittmann 1993, p.35-36)**	**NRC RG 1.109 (NRC 1977, p.37)**	**IAEA SS-57 (IAEA 1982, p.66)**	**NUREG/CR-3332 (Till et al. 1983, p.5-86)**	**NUREG/CR-3160 (Mills et al. 1983, p.145)**	**ORNL-5786 (Baes et al. 1984, p.50)**	**NUREG/CR-5512 (Kennedy et al. 1992, p.6.29-6.30)**
C	6	0.0E+00	1.2E-02	-	1.5E-02	0.0E+00	-	-
Ni	28	1.0E-03	6.7E-03	1E-02	1.0E-02	3.4E-03	1.0E-03	1.0E-03
Sr	38	1.3E-03	8.0E-04	1E-03	1.4E-03	1.5E-03	1.5E-03	1.5E-03
Y	39	5.0E-06	1.0E-05	2E-05	2.0E-05	5.0E-06	2.0E-05	2.0E-05
Mo	42	1.7E-03	7.5E-03	-	1.4E-03	4.0E-03	1.5E-03	1.5E-03
Tc	43	3.0E-04	2.5E-02	1E-02	9.9E-03	1.2E-02	1.0E-02	1.0E-02
I	53	1.2E-02	6.0E-03	1E-02	9.9E-03	1.0E-02	1.0E-02	1.0E-02
Cs	55	7.0E-03	1.2E-02	8E-03	7.1E-03	5.0E-03	7.0E-03	7.0E-03
Fr	87	7.0E-03	-	-	-	-	2.0E-02	-
Ra	88	2.0E-04	-	6E-04	4.5E-04	2.0E-04	4.5E-04	4.5E-04
Ac	89	2.0E-05	-	2E-05	2.0E-05	2.5E-06	2.0E-05	2.0E-05
Th	90	2.5E-06	-	5E-06	5.0E-06	2.5E-06	5.0E-06	5.0E-06
Pa	91	2.5E-06	-	5E-06	5.0E-06	2.5E-06	5.0E-06	5.0E-06
U	92	6.0E-04	-	6E-04	6.1E-04	6.0E-04	6.0E-04	6.0E-04
Np	93	1.0E-05	5.0E-06	5E-06	5.0E-06	2.5E-06	5.0E-06	5.0E-06
Pu	94	1.0E-07	-	1E-07	2.7E-09	2.5E-08	1.0E-07	1.0E-07
Am	95	3.0E-07	-	4E-07	2.0E-05	2.5E-06	4.0E-07	4.0E-07

		8	9	10	11	12		
Element	**Z**	**ANL/EAIS/TM-103 (Wang et al. 1993, p.30-32)**	**AECL-10720 (Davis et al. 1993, p.233-234)**	**IAEA TRS-364 (IAEA 1994, p.35)**	**EPRI TR-10790 (Smith et al. 1996, p.5-27)**	**CNWRA 97-009 (LaPlante et al.1997, p.2-13)**	**Selected Values**	**Comment**
C	6	1.2E-02	1.5E-02	-	-	-	**0.0E+00**	N/A
Ni	28	2.0E-02	1.0E-03	1.6E-02	-	1.6E-02	**2.0E-02**	Recent
Sr	38	2.0E-03	1.4E-03	2.8E-03	-	3.0E-03	**1.5E-03**	More
Y	39	2.0E-05	2.0E-05	-	-	-	**2.0E-05**	More
Mo	42	1.7E-03	1.4E-03	1.7E-03	-	2.0E-03	**1.5E-03**	More
Tc	43	1.0E-03	9.9E-04	1.4E-04	7.5E-03	1.4E-04	**9.9E-03**	Medium
I	53	1.0E-02	9.9E-03	1.0E-02	3.0E-03	1.0E-02	**1.0E-02**	More
Cs	55	8.0E-03	7.1E-03	7.9E-03	8.0E-03	7.9E-03	**8.0E-03**	Recent
Fr	87	-	-	-	-	-	**7.0E-03**	Default
Ra	88	1.0E-03	4.0E-04	1.3E-03	1.3E-03	1.3E-03	**1.3E-03**	Recent
Ac	89	2.0E-05	2.0E-05	-	4.0E-07	2.0E-05	**2.0E-05**	More
Th	90	5.0E-06	5.0E-06	-	5.0E-06	5.0E-06	**5.0E-06**	More
Pa	91	5.0E-06	5.0E-06	-	5.0E-06	5.0E-06	**5.0E-06**	More
U	92	6.0E-04	3.7E-04	4.0E-04	4.0E-04	4.0E-04	**6.0E-04**	More
Np	93	5.0E-06	5.0E-06	5.0E-06	5.0E-06	5.0E-06	**5.0E-06**	More
Pu	94	1.0E-06	1.0E-07	1.1E-06	5.0E-06	1.1E-06	**1.1E-06**	Recent
Am	95	2.0E-06	4.1E-07	1.5E-06	5.0E-06	1.5E-06	**2.0E-06**	Recent

Table 10. Transfer Coefficients for Eggs from Various Sources and the Selected Values (day/kg)

		1	2	3	4	5
Element	**Z**	**WHC-SD-WM-TI-596 (Rittmann 1993, p.35-36)**	**NUREG/CR-3160 (Mills et al. 1983, p.145-146)**	**NUREG/CR-5512 (Kennedy et al. 1992, p.6.29-6.30)**	**AECL-10720 (Davis et al. 1993, p.233-234)**	**IAEA TRS-364 (IAEA 1994, p.41)**
C	6	0.0E+00	0.0E+00	-	6.4E+00	-
Ni	28	1.0E-01	1.0E-01	1.0E-01	2.0E-01	-
Sr	38	3.0E-01	4.0E-01	3.0E-01	3.0E-01	2E-01
Y	39	2.0E-03	5.0E-04	2.0E-03	3.0E-02	2E-03
Mo	42	7.8E-01	4.0E-01	7.8E-01	5.0E-01	9E-01
Tc	43	3.0E+00	9.9E-04	3.0E+00	1.9E+00	3E+00
I	53	2.8E+00	1.6E+00	2.8E+00	2.8E+00	3E+00
Cs	55	4.9E-01	5.0E-01	4.9E-01	4.4E+00	4E-01
Fr	87	4.9E-01	-	-	-	-
Ra	88	2.0E-05	2.0E-05	2.0E-05	9.0E-02	-
Ac	89	2.0E-03	2.0E-03	2.0E-03	2.5E-03	-
Th	90	2.0E-03	2.0E-03	2.0E-03	6.0E-04	-
Pa	91	2.0E-03	2.0E-03	2.0E-03	1.0E-03	-
U	92	9.9E-01	3.4E-01	9.9E-01	1.2E+00	1E+00
Np	93	2.0E-03	2.0E-03	2.0E-03	5.5E-03	-
Pu	94	8.0E-03	2.0E-03	8.0E-03	7.6E-03	5E-04
Am	95	9.0E-03	2.0E-03	9.0E-03	8.5E-03	4E-03

		6	7		
Element	**Z**	**EPRI TR-10790 (Smith et al. 1996, p.5-29)**	**CNWRA 97-009 (LaPlante et al.1997, p.2-13)**	**Selected Values**	**Comment**
C	6	-	-	**0.0E+00**	N/A
Ni	28	-	1.0E-01	**1.0E-01**	More
Sr	38	-	2E-01	**3.0E-01**	More
Y	39	-	-	**2.0E-03**	More
Mo	42	-	9E-01	**9.0E-01**	Recent
Tc	43	1.2E+00	3E+00	**3.0E+00**	More
I	53	1.6E+00	3E+00	**3.0E+00**	More
Cs	55	4.0E-01	4E-01	**4.0E-01**	Recent
Fr	87	-	-	**4.9E-01**	Default
Ra	88	2.5E-01	2.0E-05	**2.0E-05**	More
Ac	89	1.6E-02	2.0E-03	**2.0E-03**	More
Th	90	1.8E-01	2.0E-03	**2.0E-03**	More
Pa	91	4.1E-03	2.0E-03	**2.0E-03**	More
U	92	1.0E-01	1E+00	**1.0E+00**	More
Np	93	1.7E-02	2.0E-03	**2.0E-03**	More
Pu	94	8.0E-03	5E-04	**8.0E-03**	More
Am	95	3.9E-03	4E-03	**4.0E-03**	Recent

6.4 BIOACCUMULATION FACTORS FOR AQUATIC FOOD

The bioaccumulation factor is defined as a ratio of the radionuclide concentration in fresh water fish (Bq/kg) to the radionuclide concentration in the water (Bq/L). It is in units of L/kg. The parameter is designed as element-specific. Thus, this parameter needs to be considered for 17 elements discussed in Table 2. The default values from the GENII-S software package are located in the BIOAC1.DAT file. In this file, eight aquatic foods are included: fish, crustacea, molluscs, and plants for both fresh water and salt water. Since fresh water fish is the only aquatic food pathway identified for Amargosa Valley, the evaluation of bioaccumulation factors are given for fresh water fish only.

6.4.1 Fresh water fish

Ingestion of fresh water fish is not an important dose pathway to human for postclosure dose assessment. This pathway was not included in several recent biosphere studies for Yucca Mountain (Smith et al. 1996, LaPlante et al. 1997, DOE 1998).

Nine documents are reviewed for bioaccumulation factors for fresh water fish in this analysis. A comparison of GENII-S default values and other available data is made and shown in Table 11. The selected values are also shown in the table. The selection is based on the criteria discussed in Section 6.1. A simple justification is provided in the last column of the table.

The results of the selections indicate that the parameter values are selected based on one single agreed value (Criteria 1) for most elements. However, GENII-S default values are not among the values selected for most elements.

There is no scale factor for the bioaccumulation factor in GENII-S. Therefore, selection of the scale factor is not needed.

6.4.2 Bioaccumulation factors for the bounding case

Since there is no scale factor for bioaccumulation factor, the high bounding value for bioaccumulation factor is selected as the maximum value of available data for each element shown in Table 11.

Table 11. Bioaccumulation Factors for Fresh Water Fish from Various Sources and the Selected Values (L/kg)

		1	2	3	4	5	6
Element	**Z**	**PNL-6584 V.3 (Napier et al. 1988b, p.5.769-5.770)**	**NRC RG 1.109 (NRC 1977, p.13)**	**IAEA SS-57 (IAEA 1982, p.72)**	**NUREG/CR-3332 (Till et al. 1983, p.5-98-5.103)**	**NUREG/CR-3160 (Mills et al. 1983, p.148)**	**NUREG/CR-5512 (Kennedy et al. 1992, p.6.32-6.33)**
C	6	9.0E+03	4.6E+03	-	-	4.6E+03	4.6E+03
Ni	28	1.0E+02	1.0E+02	1.0E+02	-	1.0E+02	1.0E+02
Sr	38	5.0E+01	3.0E+01	6E+01	2.8E+01	3.0E+01	5.0E+01
Y	39	2.5E+01	2.5E+01	3E+01	-	2.5E+01	2.5E+01
Mo	42	1.0E+01	1.0E+01	-	1.0E+01	1.0E+01	1.0E+01
Tc	43	1.5E+01	1.5E+01	2.0E+01	7.8E+01	1.5E+01	1.5E+01
I	53	5.0E+01	1.5E+01	4.0E+01	4.4E+01	1.5E+01	5.0E+02
Cs	55	1.5E+04	2.0E+03	2.0E+03	5.6E+03	2.0E+03	2.0E+03
Fr	87	-	-	-	-	-	-
Ra	88	5.0E+01	-	5.0E+01	5.2E+02	5.0E+01	7.0E+01
Ac	89	3.3E+02	-	-	-	2.5E+01	2.5E+01
Th	90	1.0E+02	-	3.0E+01	8.0E+01	3.0E+01	1.0E+02
Pa	91	3.0E+01	-	1.0E+01	-	1.1E+01	1.1E+01
U	92	5.0E+01	-	1.0E+01	7.5E+00	2.0E+00	5.0E+01
Np	93	2.5E+03	1.0E+01	1.0E+01	-	1.0E+01	2.5E+02
Pu	94	2.5E+02	-	4.0E+00	8.0E+00	3.5E+00	2.5E+02
Am	95	1.0E+02	-	3.0E+01	-	2.5E+01	2.5E+02

		7	8	9		
Element	**Z**	**ANL/EAIS/TM-103 (Wang et al. 1993, p.33-35)**	**AECL-10720 (Davis et al. 1993, p.233-234)**	**IAEA TRS-364 (IAEA 1994, p.45)**	**Selected Values**	**Comment**
C	6	5.0E+04	5.0E+04	5E+04	**5.0E+04**	Recent
Ni	28	1.0E+02	1.0E+02	1E+02	**1.0E+02**	More
Sr	38	6.0E+01	1.0E+02	6E+01	**6.0E+01**	Recent
Y	39	3.0E+01	1.0E+02	3E+01	**3.0E+01**	More
Mo	42	1.0E+01	1.0E+01	1E+01	**1.0E+01**	More
Tc	43	2.0E+01	1.5E+01	2E+01	**2.0E+01**	More
I	53	4.0E+01	5.0E+01	4E+01	**4.0E+01**	Recent
Cs	55	2.0E+03	1.0E+04	2E+03	**2.0E+03**	More
Fr	87	-	-	-	-	Default
Ra	88	5.0E+01	5.0E+01	5E+01	**5.0E+01**	More
Ac	89	1.5E+01	2.5E+01	-	**2.5E+01**	More
Th	90	1.0E+02	1.0E+03	1E+02	**1.0E+02**	More
Pa	91	1.0E+01	1.1E+01	1E+01	**1.1E+01**	More
U	92	1.0E+01	5.0E+01	1E+01	**1.0E+01**	Medium
Np	93	3.0E+01	2.5E+03	3E+01	**3.0E+01**	Recent
Pu	94	3.0E+01	2.5E+02	3E+01	**3.0E+01**	Medium
Am	95	3.0E+01	1.0E+02	3E+01	**3.0E+01**	More

7. CONCLUSIONS

As a result of the literature search and comparison of available data with the GENII-S default values, the selected reasonable transfer parameter values are summarized in the Table 12. The selected scale factor distribution and values are summarized in Table 13. The selected bounding transfer parameter values are summarized in Table 14. It is suggested that the selected values replace the default values in either FTRANS.DAT or BIOAC1.DAT for relevant elements and food types. However, any selected values in this analysis should be updated whenever more suitable site-specific data becomes available.

Table 12. Recommendation of Transfer Parameter Values for the Reasonable Case

Element	Z	Soil-to-Plant Transfer Factors				Animal Feed Transfer Coefficients				Bioacc. Factor
		Leafy	Root	Fruit	Grain	Beef (d/kg)	Poultry (d/kg)	Milk (d/L)	Eggs (d/kg)	Fish (L/kg)
C	6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.0E+04
Ni	28	**1.8E-01**	6.0E-02	6.0E-02	3.0E-02	5.0E-03	1.0E-03	**2.0E-02**	1.0E-01	1.0E+02
Sr	38	2.0E+00	1.2E+00	2.0E-01	2.0E-01	8.0E-03	**3.5E-02**	1.5E-03	3.0E-01	6.0E+01
Y	39	1.5E-02	6.0E-03	6.0E-03	6.0E-03	1.0E-03	1.0E-02	2.0E-05	2.0E-03	3.0E+01
Mo	42	2.5E-01	6.0E-02	6.0E-02	6.0E-02	1.0E-03	1.9E-01	1.5E-03	9.0E-01	1.0E+01
Tc	43	4.0E+01	**6.6E+00**	1.5E+00	7.3E-01	1.0E-04	3.0E-02	**9.9E-03**	3.0E+00	2.0E+01
I	53	3.4E-03	5.0E-02	5.0E-02	5.0E-02	7.0E-03	1.8E-02	1.0E-02	3.0E+00	4.0E+01
Cs	55	1.3E-01	4.9E-02	2.2E-01	2.6E-02	5.0E-02	4.4E+00	8.0E-03	4.0E-01	2.0E+03
Fr	87	2.0E-02	2.0E-02	2.0E-02	1.0E-02	3.0E-02	4.4E+00	7.0E-03	4.9E-01	-
Ra	88	8.0E-02	1.3E-02	6.1E-03	1.2E-03	9.0E-04	3.0E-02	1.3E-03	2.0E-05	5.0E+01
Ac	89	3.5E-03	3.5E-04	3.5E-04	3.5E-04	2.5E-05	4.0E-03	2.0E-05	2.0E-03	2.5E+01
Th	90	4.0E-03	3.0E-04	2.1E-04	3.4E-05	**6.0E-06**	4.0E-03	5.0E-06	2.0E-03	1.0E+02
Pa	91	2.5E-03	2.5E-04	2.5E-04	2.5E-04	**1.0E-05**	4.0E-03	5.0E-06	2.0E-03	1.1E+01
U	92	8.5E-03	1.4E-02	4.0E-03	1.3E-03	3.0E-04	1.2E+00	6.0E-04	1.0E+00	1.0E+01
Np	93	3.7E-02	1.7E-02	1.7E-02	2.7E-03	1.0E-03	4.0E-03	5.0E-06	2.0E-03	3.0E+01
Pu	94	**3.9E-04**	2.0E-04	1.9E-04	2.6E-05	1.0E-05	**4.0E-03**	1.1E-06	8.0E-03	3.0E+01
Am	95	2.0E-03	4.7E-04	4.1E-04	9.0E-05	2.0E-05	6.0E-03	2.0E-06	4.0E-03	3.0E+01

Table 13. Recommendation of Scale Factor Distribution and Values

Parameter	Distribution	0.1% Value	50% Value	99.9% Value	Comment
Soil-to-plant transfer scale factor	Lognormal distribution	0.0275	1.0	36.4	From AECL-11474 and IAEA TRS-364
Animal uptake scale factor	Lognormal distribution	0.117	1.0	8.51	From CNWRA 97-009

Table 14. Recommendation of Transfer Parameter Values for the Bounding Case

Element	Z	Soil-to-Plant Transfer Factors				Animal Feed Transfer Coefficients				Bioacc. Factor
		Leafy	Root	Fruit	Grain	Beef (d/kg)	Poultry (d/kg)	Milk (d/L)	Eggs (d/kg)	Fish (L/kg)
C	6	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.0E+04
Ni	28	**1.8E+00**	6.0E-01	6.0E-01	3.0E-01	2.0E-02	4.0E-03	**8.0E-02**	4.0E-01	1.0E+02
Sr	38	2.0E+01	1.2E+01	2.0E+00	2.0E+00	3.2E-02	**1.4E-01**	6.0E-03	1.2E+00	1.0E+02
Y	39	1.5E-01	6.0E-02	6.0E-02	6.0E-02	4.0E-03	4.0E-02	8.0E-05	8.0E-03	1.0E+02
Mo	42	2.5E+00	6.0E-01	6.0E-01	6.0E-01	4.0E-03	7.6E-01	6.0E-03	3.6E+00	1.0E+01
Tc	43	4.0E+02	**6.6E+01**	1.5E+01	7.3E+00	4.0E-04	1.2E-01	4.0E-02	1.2E+01	7.8E+01
I	53	3.4E-02	5.0E-01	5.0E-01	5.0E-01	2.8E-02	7.2E-02	4.0E-02	1.2E+01	5.0E+02
Cs	55	1.3E+00	4.9E-01	2.2E+00	2.6E-01	2.0E-01	1.8E+01	3.2E-02	1.6E+00	1.5E+04
Fr	87	2.0E-01	2.0E-01	2.0E-01	1.0E-01	1.2E-01	1.8E+01	2.8E-02	2.0E+00	-
Ra	88	8.0E-01	1.3E-01	6.1E-02	1.2E-02	3.6E-03	1.2E-01	5.2E-03	8.0E-05	5.2E+02
Ac	89	3.5E-02	3.5E-03	3.5E-03	3.5E-03	1.0E-04	1.6E-02	8.0E-05	8.0E-03	3.3E+02
Th	90	4.0E-02	3.0E-03	2.1E-03	3.4E-04	**2.4E-05**	1.6E-02	2.0E-05	8.0E-03	1.0E+03
Pa	91	2.5E-02	2.5E-03	2.5E-03	2.5E-03	**4.0E-05**	1.6E-02	2.0E-05	8.0E-03	3.0E+01
U	92	8.5E-02	1.4E-01	4.0E-02	1.3E-02	1.2E-03	4.8E+00	2.4E-03	4.0E+00	5.0E+01
Np	93	3.7E-01	1.7E-01	1.7E-01	2.7E-02	4.0E-03	1.6E-02	2.0E-05	8.0E-03	2.5E+03
Pu	94	**3.9E-03**	2.0E-03	1.9E-03	2.6E-04	4.0E-05	**1.6E-02**	4.4E-06	3.2E-02	2.5E+02
Am	95	2.0E-02	4.7E-03	4.1E-03	9.0E-04	8.0E-05	2.4E-02	8.0E-06	1.6E-02	2.5E+02

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8.2 PROCEDURES

AP-2.1Q, *Indoctrination and Training of Personnel (Rev.0)*

AP-2.2Q, *Establishment and Verification of Required Education and Experience of Personnel (Rev.0)*

AP-2.13Q, *Technical Product Development Planning (Rev.0)*

AP-2.14Q, *Review of Technical Products (Rev.0)*

AP-3.4Q, *Level 3 Change Control (Rev.0)*

AP-3.10Q, *Analyses and Models (Rev.1)*

AP-3.15Q, *Managing Document Inputs (Rev.0)*

AP-6.1Q, *Controlled Documents (Rev.3)*

AP-17.1Q, *Record Source Responsibilities for Inclusionary Records (Rev.1)*

AP-SI.1Q, *Software Management (Rev.1)*

AP-SIII.2Q, *Qualification of Unqualified Data and the Documentation of Rationale for Accepted Data (Rev.0)*

AP-SIII.3Q, *Submittal and Incorporation of Data to the Technical Data Management System (Rev.0)*

QAP-2-0, *Conduct of Activities (Rev.5)*

QAP-2-3, *Classification of Permanent Items (Rev.10)*

NLP-2-0, *Determination of importance Evaluations (Rev.5)*

ATTACHMENT 1. ACRONYMS

AECL	Atomic Energy of Canada Limited
AMR	analysis and model report
BDCF	Biosphere Dose Conversion Factor
CNWRA	Center for Nuclear Waste Regulatory Analyses
CRWMS	Civilian Radioactive Waste Management System
EPRI	Electric Power Research Institute
GSD	geometric standard deviation
IAEA	International Atomic Energy Agency
M&O	Management and Operating
NRC	Nuclear Regulatory Commission
OCRWM	Office of Civilian Radioactive Waste Management
RG	Regulatory Guide
SS	Safety Series
TBV	to be verified
TRS	Technical Report Series
TSPA-VA	Total System Performance Assessment – Viability Assessment
YMP	Yucca Mountain Project