FTF-WDIP-002
Revision 0

HIGHLY RADIOACTIVE RADIONUCLIDES (HRRs) INPUT PACKAGE

for the

Section 3116 Draft Basis Document for F-Tank Farm at the Savannah River Site

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ACRONYMS / ABBREVIATIONS

CFR	Code of Federal Regulations
DOE	United States Department of Energy
EPA	United States Environmental Protection Agency
FTF	F-Tank Farm
HRR	Highly Radioactive Radionuclides
MEP	Maximum Extent Practical
mrem	Millirem
NDAA	Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005
NRC	United States Nuclear Regulatory Commission
PA	Performance Assessment
SCDHEC	South Carolina Department of Health and Environmental Control
SRS	Savannah River Site

1.0 INPUT PACKAGE DESCRIPTION

Input package FTF-WDIP-002 provides information anticipated to be used in Section 5.1, *Highly Radioactive Radionuclides*, of the Draft F-Tank Farm (FTF) 3116 Basis Document. Development of FTF-WDIP-002 allows for early review of this information before the Draft FTF 3116 Basis Document is submitted to the Nuclear Regulatory Commission (NRC) for further consultation, and issued for public comment. This input package provides both the anticipated approach for identifying the highly radioactive radionuclides (HRRs) and wording representative of the information anticipated to be included in the Draft FTF 3116 Basis Document[1].

2.0 DRAFT FTF 3116 BASIS DOCUMENT APPROACH

The following describes the approach the Department of Energy (DOE) is considering for identification of HRRs for the FTF waste tanks and ancillary structures.

- As much as possible, the Draft FTF 3116 Basis Document will use the approach and the language provided in the *Basis for Section 3116 Determination for Salt Waste Disposal at the Savannah River Site* (DOE-WD-2005-001), and the *Basis for Section 3116 Determination for the Idaho Nuclear Technology and Engineering Center Tank Farm Facility* (DOE/NE-ID-11226), to identify HRRs.
- Also reviewed and considered to ensure any comments received from the NRC during consultation have been appropriately considered were the following documents:
  - CBU-PIT-2005-00131, *Response to Request for Additional Information on the Draft Section 3116 Determination for Salt Waste Disposal at the Savannah River Site, associated with the approved Basis for Section 3116 Determination for Salt Waste Disposal at the Savannah River Site* (DOE-WD-2005-001) and
  - ICP/EXT-06-01204, *Response to Request for Additional Information on the Draft Section 3116 Determination, Idaho Nuclear Technology and Engineering Center Tank Farm Facility* associated with *Basis for Section 3116 Determination for the Idaho Nuclear Technology and Engineering Center Tank Farm Facility* (DOE/NE-ID-11226).
- NUREG-1854 contains guidance for the NRC staff to consider during consultation on DOE 3116 Basis Documents; this guidance was considered in identifying the FTF potential HRRs. This guidance includes:
  - Ensuring that the list of radionuclides screened is comprehensive,
  - Evaluating to determine that the screening criteria is reasonable and conservative,
  - Ensuring that ingrowth of daughters is considered to ensure parent isotopes are not inappropriately screened,
  - Ensuring potential exposure of workers, members of the public, and inadvertent intruders are considered in the determination, and

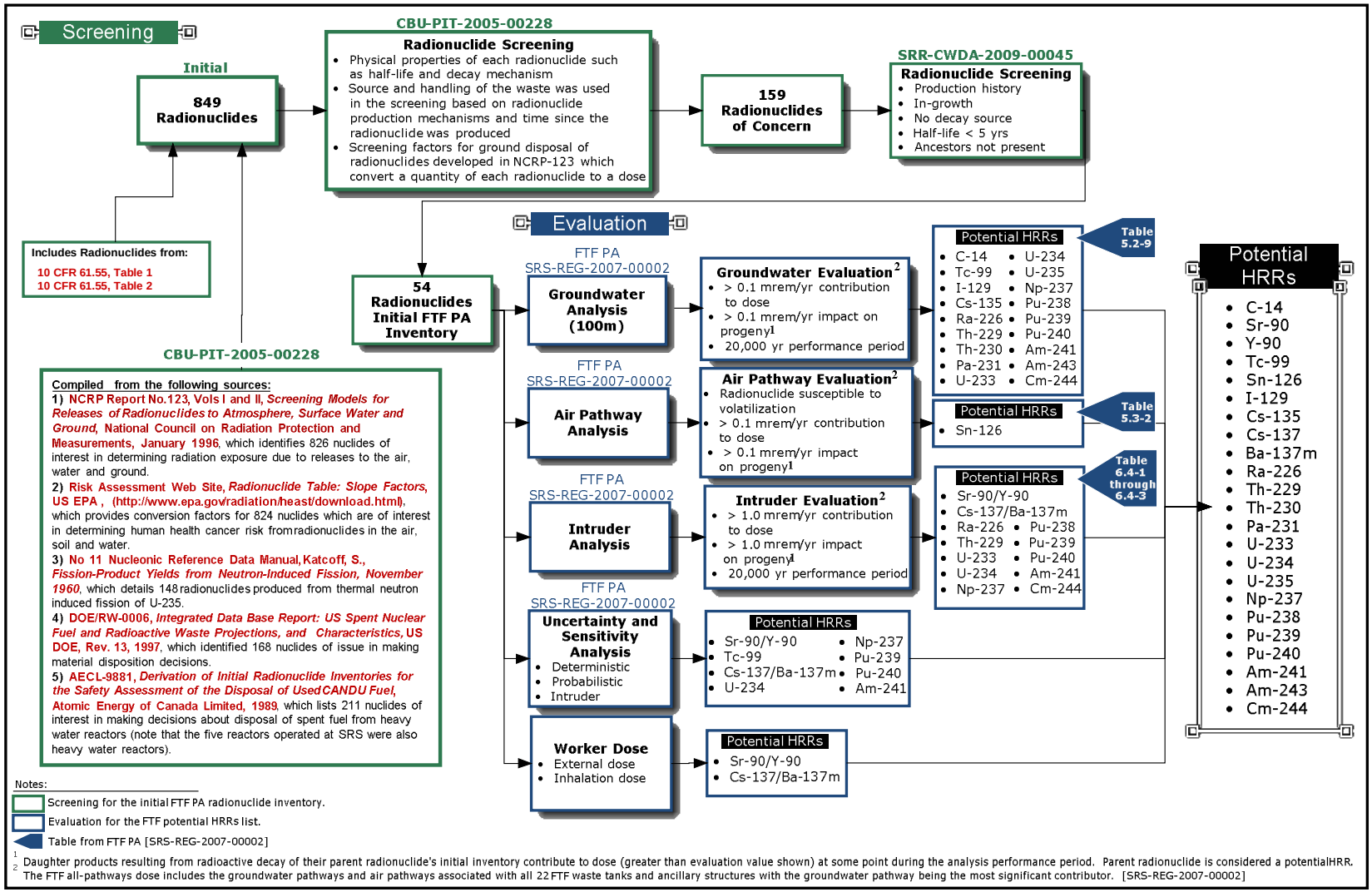
[1] The purpose of developing this input package and utilizing the scoping process parallel to development of the Draft FTF 3116 Basis Document is to expedite the identification of issues and assess the reasonability of DOE's approach in addressing the NDAA Section 3116 criteria, thereby allowing for more informed and efficient consultation with the NRC and a more informed draft for public comment. Changes in the described approaches and information presented in this input package may occur based on discussions during the scoping process.

  - Ensuring uncertainty in inventories is adequately represented.
- The FTF Performance Assessment (PA) is the primary tool used to assess long-term risk associated with FTF closure activities. Screening of radionuclides is performed to determine which radionuclides need to be included in the PA modeling. The modeling results are then evaluated to determine the potential HRRs based upon the individual risk significance of each radionuclide as indicated by the modeling results.
- The FTF PA included a detailed and conservative screening methodology to determine radionuclides that should be considered when assessing long-term risk associated with FTF closure.
  - The initial list of radionuclides considered was comprehensive, numbering 849, and included all radionuclides in Tables 1 and 2 of 10 Code of Federal Regulations (CFR) 61.55.
  - The FTF PA, Section 4.2.1, provides a detailed description of the screening process that was used to arrive at a total of 54 radionuclides that were considered in the initial FTF PA inventory.
  - The NRC has previously reviewed the screening criteria for FTF PA, Revision 0. Comments received were incorporated into Revision 1 of the FTF PA. The NRC is currently reviewing the screening criteria in FTF PA, Revision 1.
- A proposed methodology for determination of FTF HRRs has been developed. This methodology is shown in flowchart format in Figure 2.0-1 and is included to facilitate discussion in the scoping process. The methodology:
  - Is based on the work presented in FTF PA, Revision 1.
  - Considers potential impact to workers, members of the public and inadvertent intruders.
  - Considers ingrowth of daughter products (i.e., progeny), and
  - Considers uncertainty and sensitivity analyses.
  - Considers all radionuclides listed in Tables 1 and 2 of 10 CFR 61.55.
  - The Draft FTF 3116 Basis Document will also include all radionuclides which are important to meeting the performance objectives in 10 CFR Part 61, Subpart C.
- The proposed methodology for determination of FTF HRRs relies, in part, on the FTF PA all-pathways dose. The FTF all-pathways dose includes the groundwater pathways and air pathways associated with all 22 FTF waste tanks and ancillary structures with the groundwater pathway being the most significant contributor. [SRS-REG-2007-00002]
- The list of potential HRRs that was developed using the proposed methodology is conservative and is as follows: C-14, Sr-90 and its daughter Y-90, Tc-99, Sn-126, I-129, Cs-135, Cs-137 and its daughter Ba-137m, Ra-226, Th-229, Th-230, Pa-231, U-233, U-234, U-235, Np-237, Pu-238, Pu-239, Pu-240, Am-241, Am-243, and Cm-244[2].

[2] The potential list of HRRs is based, in part, on the results of FTF PA Revision 1. [SRS-REG-2007-00002] Revision 1 of the FTF PA is currently undergoing review by the NRC, South Carolina Department of Health and Environmental Control (SCDHEC), Environmental Protection Agency (EPA) and the public. Final interpretation of the FTF PA results by DOE will occur after the review process is complete. The list of potential HRRs contained in the Draft FTF 3116 Basis Document may differ from the potential HRR list contained in this input package as a result of the on-going review of FTF PA Revision 1 and discussions during the scoping process.

Based on the above outlined approach, the following section provides wording similar to that anticipated to be contained in the Draft FTF 3116 Basis Document. Although the wording will be revised as DOE further develops and refines the Draft FTF 3116 Basis Document, the information provided represents the level of information and general compliance arguments anticipated to be provided in the Draft FTF 3116 Basis Document.

Figure 2.0-1: FTF Potential HRRs



3.0 WASTE HAS HAD HIGHLY RADIOACTIVE RADIONUCLIDES REMOVED TO THE MAXIMUM EXTENT PRACTICAL

Section Purpose

The NDAA Section 3116(a) provides that certain waste resulting from reprocessing is not high-level waste if the Secretary, in consultation with the NRC, determines, among other things, that the waste has had highly radioactive radionuclides (HRRs) removed "to the maximum extent practical" (MEP). The purpose of this section is to demonstrate that DOE's strategy for removing the HRRs from the FTF waste tanks and ancillary structures meets this criterion.

Section Contents

Section 3.1 states the applicable criterion of NDAA Section 3116(a). Section 3.2 identifies the potential HRRs for the purpose of this Draft FTF 3116 Basis Document. Section 3.3 describes the removal processes used to remove HRRs to the maximum extent practical. Section 3.4 describes the basis for determining HRRs have been removed to the MEP.

Key Points

The list of potential HRRs for FTF describes the radionuclides that could reasonably be expected to exist in the FTF waste tanks and ancillary structures and that, using a risk-informed approach, contribute significantly to the radiological risk to workers, the public, and the environment, taking into account scientific and health physics principles, knowledge and expertise. The list of potential HRRs for FTF includes all radionuclides important to meeting the performance objectives in 10 CFR Part 61, Subpart C, and all radionuclides in Tables 1 and 2 of 10 CFR 61.55 were considered. Over 99% of the waste volume and radioactivity will be removed from the FTF tanks and ancillary structures prior to closure activities using mechanical, chemical or vacuum technologies that have previously been successfully demonstrated in similar waste removal activities at the Savannah River Site (SRS).

3.1 Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (NDAA) Criterion

NDAA Section 3116(a) provides in pertinent part:

> *[T]he term "high-level radioactive waste" does not include radioactive waste resulting from the reprocessing of spent nuclear fuel that the Secretary of Energy …, in consultation with the Nuclear Regulatory Commission …, determines— …*
>
> *(2) has had highly radioactive radionuclides removed to the maximum extent practical.*

3.2 Highly Radioactive Radionuclides

3.2.1 Methodology

Based on consultation with the NRC, DOE views "highly radioactive radionuclides" to be those radionuclides that, using a risk-informed approach, contribute most significantly to radiological risk to workers, the public, and the environment. Cesium-137 (including its

daughter, Ba-137m)[3], Sr-90 (including its daughter Y-90), C-14, Tc-99, Sn-126, I-129, Cs-135, Ra-226, Th-229, Th-230, Pa-231, U-233, U-234, U-235, Np-237, Pu-238, Pu-239, Pu-240, Am-241, Am-243, and Cm-244 are the potential HRRs in the FTF stabilized residuals, FTF waste tanks, and FTF ancillary structures at the closure of FTF that DOE has determined, on the basis of a risk-informed approach, contribute significantly to radiological risk to workers, the public, and the environment, taking into account scientific and health physics principles, knowledge, and expertise[4].

The list of potential HRRs, Table 3.2-1, was developed beginning with an initial listing of 849 radionuclides compiled from a variety of published resources. [CBU-PIT-2005-00228] DOE reviewed this initial list and identified those radionuclides from Tables 1 and 2 of 10 CFR 61.55,[5] as well as any additional radionuclides, that may be important in meeting performance objectives in 10 CFR Part 61, Subpart C because they contribute to the dose to the workers, the public, and/or the inadvertent intruder (for one or more reasonable intruder scenarios) in the FTF PA base case and sensitivity and uncertainty analyses. In DOE's view, this approach results in a risk-informed list of potential HRRs that includes: those short-lived radionuclides that may present risk because they produce radiation emissions that, without shielding or controls, may harm humans simply by proximity to humans without inhalation or ingestion; and those long-lived radionuclides that persist well into the future, may be mobile in the environment or may pose a risk to humans if inhaled or ingested.

[3] Cs-137, and its daughter Ba-137m, are typically considered as a single radionuclide for human health protection purposes because the half-life of Ba-137m is so short that it only exists when Cs-137 is present. The same is true for Sr-90 and its daughter Y-90. Accordingly, the discussions that follow in this Draft FTF 3116 Basis Document focus on Cs-137 or Sr-90 since approaches that are effective in removing Cs-137 and Sr-90 also remove Ba-137m and Y-90, respectively.

[4] Some of the radionuclides listed as highly radioactive radionuclides in this Draft FTF 3116 Basis Document may not be listed in other 3116 Basis Documents if such radionuclides are not present in the waste or do not contribute significantly to dose to the worker, the public, or the inadvertent intruder.

[5] Although Tables 1 and 2 in 10 CFR 61.55 specify concentration limits for certain radionuclides in the form of activated metal, DOE includes such radionuclides, if present in sufficient quantities that could potentially contribute significantly to the radiological dose to the workers, public and/or the inadvertent intruder, in the list of "highly radioactive radionuclides" as it exists in the waste, without regard to whether such radionuclides are in the form of activated metal. Consistent with Table 1, DOE excludes alpha-emitting transuranic nuclides with half-lives of 5 years or less from the list of "highly radioactive radionuclides". All of the radionuclides in Tables 1 and 2 are considered with respect to section 6 of the Draft FTF Basis Document (concerning 3116(a)(3)(A) of the NDAA) and, where relevant, section 7 of the Draft FTF Basis Document (concerning 3116(a)(3)(A)(i) of the NDAA). However, radionuclides with half-lives of 5 years or less, as well as those radionuclides in Tables 1 and 2 in 10 CFR 61.55 which are determined, through screening, to not contribute significantly to the radiological dose to the workers, public and/or the inadvertent intruder, are not discussed in section 5 of the Draft FTF Basis Document concerning "removal to the maximum extent practical".

Table 3.2-1: Potential FTF HRRs[6]

Radionuclide	Radionuclide Half-Life (yr)	Potential Long-Term Radiological Hazards	Potential Short-Term Radiological Hazards
C-14 [a]	5.70E+03	X	
Sr-90 [b, c, d]	2.89E+01		X
Y-90 [b, c, d]	7.31E-03		X
Tc-99 [a, c]	2.11E+05	X	
Sn-126 [e]	2.30E+05	X	
I-129 [a]	1.57E+07	X	
Cs-135 [a]	2.36E+06	X	
Cs-137 [b, c, d]	3.00E+01		X
Ba-137m [b, c, d]	4.85E-06		X
Ra-226 [a,b]	1.60E+03	X	
Th-229 [a,b]	7.88E+03	X	
Th-230 [a]	7.54E+04	X	
Pa-231 [a]	3.27E+04	X	
U-233 [a, b]	1.59E+05	X	
U-234 [a, b, c]	2.46E+05	X	
U-235 [a]	7.04E+08	X	
Np-237 [a, b, c]	2.14E+06	X	
Pu-238 [a, b]	8.77E+01	X	
Pu-239 [a, b, c]	2.41E+04	X	
Pu-240 [a, b, c]	6.56E+03	X	
Am-241 [a, b, c]	4.32E+02	X	
Am-243 [a]	7.37E+03	X	
Cm-244 [a, b]	1.81E+01	X	

a Potential HRRs based on groundwater analyses results from the FTF Performance Assessment (PA). [SRS-REG-2007-00002]

b Potential HRRs based on intruder analysis results from the FTF PA. [SRS-REG-2007-00002]

c Potential HRRs based on uncertainty and sensitivity run results from the FTF PA. [SRS-REG-2007-00002]

d Potential HRRs based on potential contribution to worker dose.

e Potential HRRs based on air pathways analysis results from the FTF PA. [SRS-REG-2007-0002]

[6] The list of potential HRRs is based, in part, on the results of FTF PA Revision 1. [SRS-REG-2007-00002] Revision 1 of the FTF PA is currently undergoing review by the NRC, SCDHEC, EPA and the public. Final interpretation of the FTF PA results by DOE will occur after the review process is complete. The list of potential HRRs contained in the Draft FTF 3116 Basis Document may differ from the potential HRR list contained in this input package as a result of the on-going review of FTF PA Revision 1 and discussions during the scoping process.

The short-lived fission products Cs-137 and Sr-90 and their equilibrium daughter products, Ba-137m and Y-90, are by far the predominant sources of radioactivity present in the FTF waste today. Based on process and sample knowledge, as reflected in the current Waste Characterization System database, approximately 97% of the current radioactivity in the FTF waste is associated with these two radionuclides and their daughters. Moreover, Cs-137, Sr-90, and their daughters are present in sufficient concentrations in the FTF waste that without shielding and controls they produce radiation emissions that would present risk to humans simply due to their proximity without direct inhalation or ingestion. Accordingly, they are of potential acute hazard to occupational workers, the public, and the environment.

Although the remainder of the radionuclides listed as potential HRRs in this Draft FTF Basis Document do not require distance and shielding to protect workers and the public, these radionuclides contain the majority of long-lived isotopes that may pose the greatest risk in the future to human health because of their long life and because they present human health risk if directly inhaled or ingested. These radionuclides combined account for less than 1% of the radionuclide inventory in the FTF waste today.

3.2.2 Performance Assessment Radionuclides

As explained above, DOE has included in the list of potential HRRs those radionuclides that may be important to meeting the performance objectives of 10 CFR 61, Subpart C because they contribute to the dose to workers, the public, and/or the inadvertent intruder based on the FTF PA, which includes sensitivity and uncertainty analyses. [SRS-REG-2007-00002] The DOE used the following approach in the FTF PA to focus on those radionuclides that contribute to the dose for various pathways.

For the purpose of determining which radionuclides should be evaluated in the FTF PA, an initial radionuclide screening process was developed and performed, evaluating an initial list of 849 radionuclides compiled from a variety of published resources. This initial screening process considered the following information:

- Physical properties of each radionuclide such as half-life and decay mechanism,
- Waste source and handling based on radionuclide production mechanisms and time since the radionuclide was produced, and
- Screening factors for radionuclide ground disposal developed in NCRP-123 which convert a quantity of each radionuclide to a dose.

This initial screening reduced the radionuclide list from 849 down to 159 radionuclides. [CBU-PIT-2005-00228]

Additional screening of the 159 radionuclides was performed to identify the radionuclides, from this list of 159, to be considered in the initial FTF inventory for the PA. The screening criteria included the following:

- Radionuclides were screened out if there were no ancestors present from the specific decay chain or no decay source for the radionuclide.
- Evaluation of FTF waste production history information for the potential for a specific radionuclide. This criterion screened out radionuclides not present within the FTF waste.

- In general, radionuclides present due to ingrowth from a decay series were screened out, however, production history was used to retain those radionuclides present at a greater proportion than from the decay series. This criterion eliminated radionuclides that are present only due to the decay of their parent radionuclide. The inventory of these radionuclides can be controlled by removing the parent radionuclide(s) to the "maximum extent practical".
- Radionuclides with less than a five year half-life were screened out. This criterion reflects that active institutional control will be maintained over the site for 100 years after facility closure. The inventories of these radionuclides will be significantly diminished due to the amount of radioactive decay that will occur during the 100 year institutional control period.

Based on these screening criteria, an additional 105 radionuclides were screened out, thus reducing the FTF PA modeling initial inventory radionuclide number to 54. For each of the waste tanks and ancillary structures, an initial inventory value for these 54 radionuclides was developed and was used as input into the FTF PA modeling. The results of the FTF PA analyses were then evaluated using the methodology described below to determine which of the 54 radionuclides would be considered potential HRRs for FTF. [SRR-CWDA-2009-00045, SRS-REG-2007-00002]

3.2.3 Potential HRRs Based on 100 Meter Groundwater Analysis

Some radionuclides have been included on the potential HRR list based on an evaluation of the FTF 100 meter groundwater dose, using the groundwater dose results calculated in the FTF PA. For the FTF PA, the 100 meter point is the point of maximum exposure at or outside of the FTF 100 meter buffer zone. [SRS-REG-2007-00002] The groundwater analysis in the FTF PA utilized the initial inventory of 54 radionuclides resulting from the screening analysis described in the previous section as input for the FTF PA model. The model used to perform the groundwater analysis did account for radioactive decay and ingrowth throughout the performance period. The results of the groundwater analysis were then evaluated to determine the potential HRRs.

The first step in the groundwater evaluation was to review the resulting doses from the FTF PA groundwater analysis and determine all radionuclides that contributed to the public groundwater dose at greater than or equal to 0.1 millirem (mrem)/yr at any time within 20,000[7] years. Based on this evaluation criterion, C-14, Tc-99, I-129, Cs-135, Ra-226, Th-229, Pa-231, U-233, U-234, Np-237, Pu-239 and Pu-240 were included on the groundwater evaluation list. At the time of closure, the initial inventory for several of these radionuclides, Ra-226, Th-229 and Pa-231 is not high enough by itself to cause a dose contribution of

[7] DOE is considering a 20,000 year evaluation period for determination of HRRs due to the expected tank liner failures beyond the 10,000 year performance period and resultant peak doses. This tank liner failure analysis is specific to the SRS FTF tanks.

greater than 0.1 mrem/yr, however, ingrowth of these radionuclides after closure does result in these radionuclides exceeding this evaluation criterion[8]. The final evaluation step was to review the resulting doses from the FTF PA groundwater analysis and determine any additional radionuclides that, although their contribution to dose at any time over the 20,000 year period never exceeded 0.1 mrem/yr, had a greater than 0.1 mrem/yr impact on progeny[9]. The additional radionuclides based on this criterion include Th-230 (for Np-237), U-235 (for Pa-231), Pu-238 (for Ra-226), Am-241 (for Np-237), Am-243 (for Pu-239), and Cm-244 (for Pu-240).

The criterion of 0.1 mrem/yr was considered sufficiently low, compared to the 25 mrem/yr all-pathways dose limit, to capture all risk significant radionuclides and eliminate radionuclides with negligible impact to public groundwater dose. The FTF PA evaluates the consequences of closure activities during the performance period (i.e., 10,000 years) after closure. The DOE has evaluated for periods beyond 10,000 years in the FTF PA to further inform closure decisions. To ensure that a conservative approach is taken in selection of the potential HRRs, the calculation of groundwater dose for 20,000 years was used to evaluate the peak dose outside the performance period. Based on the evaluation criteria described above, C-14, Tc-99, I-129, Cs-135, Ra-226, Th-229, Th-230, Pa-231, U-233, U-234, U-235, Np-237, Pu-238, Pu-239, Pu-240, Am-241, Am-243, and Cm-244 contributed, either from initial inventory or through progeny, greater than or equal to 0.1 mrem/yr to the FTF public groundwater doses. For the purpose of this Draft FTF 3116 Basis Document, these radionuclides were included in the potential HRR list.

3.2.4 Potential HRRs Based on Air Pathway Analysis

Some radionuclides have been included on the potential HRR list based on an evaluation of the FTF 100 meter dose from airborne radionuclides, using the air pathway dose results calculated in the FTF PA[10]. In the FTF PA, radionuclides contained in the initial inventory that are susceptible to volatilization were considered in the air pathways analysis. These radionuclides included H-3, C-14, Cl-36, Se-79, Tc-99, Sb-125, Sn-126, and I-129. For the FTF PA, the 100 meter point is the point of maximum exposure at or outside of the FTF 100 meter buffer zone. [SRS-REG-2007-00002]

The first step in the air pathways evaluation was to review the resulting doses from the FTF PA air pathways analysis and determine all radionuclides that contributed to the air pathways

[8] Even though the initial inventory of these radionuclides at the time of closure is anticipated to be at levels which would not contribute greater than 0.1 mrem/yr to the groundwater pathways dose, DOE has decided to consider these radionuclides as potential HRRs. The anticipated concentrations of these radionuclides in the residuals at the completion of waste removal activities is expected to be below analytical detection limits and therefore characterization of these radionuclides at the time of closure may not be possible. Reduction of the future inventory of these radionuclides is accomplished through removal of the parent radionuclide during the waste removal process.

[9] Daughter products resulting from radioactive decay of their parent radionuclide's initial inventory contribute greater than 0.1 mrem/yr to dose at some point during the 20,000 year period. Reduction of the future inventory of the daughter products is accomplished through removal of the parent radionuclide during the waste removal process.

[10] The DOE considers the methodology used to perform the air pathways analysis in the FTF PA to be conservative based on the assumptions used. The DOE is evaluating the methodology being used to perform the air pathways analysis for the SRS tank farms and, if any changes are made, will address impacts to the FTF PA through the consultation process. As a result, the potential HRRs listed in the Draft FTF 3116 Basis Document, based on the air pathways analysis screening, may differ from those shown in this input package.

dose at greater than or equal to 0.1 mrem/yr. For the FTF PA analysis, Sn-126 was the only radionuclide that met this criterion. The final evaluation step was to review the resulting doses from the FTF PA air pathways analysis and determine any additional radionuclides that, although their contribution to dose never exceeded 0.1 mrem/yr, had a greater than 0.1 mrem/yr impact on progeny[11]. Considering Sn-126 was the only radionuclide to exceed the 0.1 mrem/yr criterion, and was not present due to ingrowth, no additional radionuclides were added based on this evaluation criterion.

The contribution to dose considered not just the dose associated with the individual radionuclide being evaluated, but also the dose associated with the daughter products of the individual radionuclide. The criterion of 0.1 mrem/yr was considered sufficiently low, compared to the 25 mrem/yr all-pathways dose limit, to capture all risk significant radionuclides and eliminate radionuclides with negligible impact to the air pathways dose. The FTF PA evaluates the consequences of closure activities during the performance period (i.e., 10,000 years) after closure. The results of the FTF PA air pathways analysis showed that maximum dose would occur at the end of the 100 year institutional control period. Based on the evaluation criteria described above, Sn-126 was the only radionuclide that contributed greater than or equal to 0.1 mrem/yr to the FTF air pathways dose. For the purpose of this Draft FTF 3116 Basis Document, Sn-126 was included in the potential HRR list.

3.2.5 Potential HRRs Based on Intruder Pathway Analysis

Some radionuclides have been included on the potential HRR list based on an evaluation of the FTF inadvertent intruder dose, using the intruder dose results calculated in the FTF PA. [SRS-REG-2007-00002] The intruder analysis utilized the initial inventory of 54 radionuclides resulting from the screening analysis described previously as input for the FTF PA model. The model used to perform the intruder analysis did account for radioactive decay and ingrowth throughout the performance period. The results of the intruder analysis were then used to determine the potential HRRs.

The first step in the intruder evaluation was to review the resulting doses from the FTF PA intruder analysis and determine all radionuclides that contributed to the intruder dose at a contribution of greater than or equal to 1.0 mrem/yr at any time within 20,000 years. Based on this evaluation criterion, Sr-90, Y-90, Cs-137, Ba-137m, Ra-226, Th-229, U-233, U-234, Np-237, Pu-239 and Pu-240 were included on the initial intruder evaluation list. At the time of closure, the initial inventory for two of these radionuclides, Ra-226 and Th-229, is not high enough by itself to cause a dose contribution of greater than 1.0 mrem/yr, however,

[11] Daughter products resulting from radioactive decay of their parent radionuclide's initial inventory contribute greater than 0.1 mrem/yr to dose at some point during the 20,000 year period. Reduction of the future inventory of the daughter products is accomplished through removal of the parent radionuclide during the waste removal process.

ingrowth of these radionuclides after closure does result in these radionuclides exceeding this evaluation criterion[12]. The final evaluation step was to review the resulting doses from the FTF PA intruder analysis and determine any additional radionuclides that, although their contribution to dose at any time over the 20,000[13] year period never exceeded 1.0 mrem/yr, had a greater than 1.0 mrem/yr impact on progeny[14]. The additional radionuclides based on this criterion include Pu-238 (for Ra-226), Am-241 (for Np-237) and Cm-244 (for Pu-240).

The criterion of 1.0 mrem/yr was considered sufficiently low, compared to the 500 mrem/yr peak intruder dose standard, to capture all risk significant radionuclides and eliminate radionuclides with negligible impact to inadvertent intruder dose. The FTF PA evaluates the consequences of closure activities during the performance period (i.e., 10,000 years) after closure. The DOE has evaluated for periods beyond 10,000 years in the FTF PA to further inform closure decisions. To ensure that a conservative approach is taken in selection of the potential HRRs, the calculation of inadvertent intruder dose for 20,000 years was used. This time period allows for both the chronic and acute intruder doses to be considered. Based on the evaluation criteria described above, Sr-90, Y-90, Cs-137, Ba-137m, Ra-226, Th-229, U-233, U-234, Np-237, Pu-238, Pu-239, Pu-240, Am-241, and Cm-244 contributed, either from initial inventory or through progeny, greater than or equal to 1.0 mrem/yr to the FTF hypothetical inadvertent intruder doses. For the purpose of this FTF Draft 3116 Basis Document, these radionuclides were included in the potential HRR list.

3.2.6 Potential HRRs Based on Uncertainty and Sensitivity Analyses

Some radionuclides have been included on the potential HRR list based on an evaluation of the uncertainty and sensitivity analyses included in the FTF PA. [SRS-REG-2007-00002] The FTF PA uncertainty and sensitivity analyses were reviewed to identify those radionuclides shown to have the most influence on the model results.

The purpose of the uncertainty and sensitivity analyses was to consider the effects of uncertainties in the conceptual models used and sensitivities in the parameters used in the mathematical models. While the uncertainty and sensitivity analyses were primarily performed using a probabilistic model, some additional single parameter sensitivity analyses were performed through deterministic modeling. The probabilistic model allows for variability of multiple parameters simultaneously, so concurrent effect of changes in the model can be analyzed. The deterministic model single parameter analysis provides a method to evaluate the importance of the uncertainty around a single parameter of concern.

[12]Even though the initial inventory of these radionuclides at the time of closure is anticipated to be at levels which would not contribute greater than 1.0 mrem/yr to the intruder dose, DOE has decided to consider these radionuclides as potential HRRs. The anticipated concentrations of these radionuclides in the residuals at the completion of waste removal activities is expected to be below analytical detection limits and therefore characterization of these radionuclides at the time of closure may not be possible. Reduction of the future inventory of these radionuclides is accomplished through removal of the parent radionuclide during the waste removal process.

[13] DOE is considering a 20,000 year evaluation period for determination of HRRs due to the expected tank liner failures beyond the 10,000 year performance period and resultant peak doses. This tank liner failure analysis is specific to the SRS FTF tanks.

[14]Daughter products resulting from radioactive decay of their parent radionuclide's initial inventory contribute greater than 1.0 mrem/yr to dose at some point during the 20,000 year period. Reduction of the future inventory of the daughter products is accomplished through removal of the parent radionuclide during the waste removal process.

Using both probabilistic and deterministic models for sensitivity analysis versus a single approach provides additional information concerning which parameters are of most importance to the FTF PA model. [SRS-REG-2007-00002]

The FTF PA considers the uncertainties and sensitivities associated with the projected dose results to a Member of the Public through Uncertainty Analysis of the FTF Probabilistic Model, through Sensitivity Analysis using the FTF Probabilistic Model and through Sensitivity Analysis using the FTF Deterministic Model. Based on an evaluation of the FTF PA results for these different analyses, Tc-99, U-234, Np-237, Pu-239, Pu-240 and Am-241 were included in the potential HRR list. The FTF PA also considered the effects on the Intruder Analysis of uncertainties in the conceptual models used, and sensitivities in the parameters used in the mathematical models. Sr-90, Y-90, Tc-99, Cs-137, Ba-137m, Pu-239, and Am-241 were included in the potential HRR list based on an evaluation of the results for the FTF PA inadvertent intruder uncertainty and sensitivity analyses.

Based on the FTF PA uncertainty and sensitivity analyses, Sr-90, Y-90, Tc-99, Cs-137, Ba-137m, U-234, Np-237, Pu-239, Pu-240, and Am-241 were included in the potential HRR list.

3.2.7 Potential HRRs Summary

The results of the HRR evaluation are summarized in Table 3.2-1[15]. The table provides the results of the evaluation for each of the 54 radionuclides contained in the initial FTF PA inventory. Radionuclides were considered potential HRRs if one or more of the evaluation criteria were met. Based on these evaluations C-14, Sr-90, Y-90, Tc-99, Sn-126, I-129, Cs-135, Cs-137, Ba-137m, Ra-226, Th-229, Th-230, Pa-231, U-233, U-234, U-235, Np-237, Pu-238, Pu-239, Pu-240, Am-241, Am-243, and Cm-244 are considered the potential HRRs in the FTF stabilized residuals, FTF waste tanks, and FTF ancillary structures at the closure of FTF.

3.3 Removal of Highly Radioactive Radionuclides to the Maximum Extent Practical

(Removal to the Maximum Extent Practical Input Package, FTF-WDIP-003)

3.4 Conclusion of Waste Removal Activities

(Removal to the Maximum Extent Practical Input Package, FTF-WDIP-003)

[15] The list of potential HRRs is based, in part, on the results of FTF PA Revision 1. [SRS-REG-2007-00002] Revision 1 of the FTF PA is currently undergoing review by the NRC, SCDHEC, EPA and the public. Final interpretation of the FTF PA results by DOE will occur after the review process is complete. The list of potential HRRs contained in the Draft FTF 3116 Basis Document may differ from the potential HRR list contained in this input package as a result of the on-going review of FTF PA Revision 1 and discussions during the scoping process.

Table 3.2-1: Radionuclides Contained in FTF PA Initial Inventory

Radionuclide with Initial Inventory	Half-Life (yr)	Evaluation Results[a]							
		Groundwater Analysis		Air Pathway Analysis		Intruder Analysis		Uncertainty & Sensitivity Analysis	Contribution to Worker Dose
		Dose > 0.1 mrem/yr	Impact on Progeny > 0.1 mrem/yr	Dose > 0.1 mrem/yr	Impact on Progeny > 0.1 mrem/yr	Dose > 1.0 mrem/yr	Impact on Progeny > 1.0 mrem/yr		
H-3	1.23E+01	x	x	x	x	x	x	x	x
C-14	**5.70E+03**	✓	x	x	x	x	x	x	x
Al-26	7.17E+05	x	x	x	x	x	x	x	x
Cl-36	3.01E+05	x	x	x	x	x	x	x	x
K-40	1.25E+09	x	x	x	x	x	x	x	x
Ni-59	7.60E+04	x	x	x	x	x	x	x	x
Ni-63	1.00E+02	x	x	x	x	x	x	x	x
Co-60	1.93E+03	x	x	x	x	x	x	x	x
Se-79	2.95E+05	x	x	x	x	x	x	x	x
Sr-90	**2.89E+01**	x	x	x	x	✓	x	✓	✓
Y-90	**7.31E-03**	x	x	x	x	✓	x	✓	✓
Zr-93	1.53E+06	x	x	x	x	x	x	x	x
Nb-93m	1.61E+01	x	x	x	x	x	x	x	x
Nb-94	2.03E+04	x	x	x	x	x	x	x	x
Tc-99	**2.11E+05**	✓	x	x	x	x	x	✓	x
Pd-107	6.50E+06	x	x	x	x	x	x	x	x
Sn-126	**2.30E+05**	x	x	✓	x	x	x	x	x
Sb-126	1.24E+01	x	x	x	x	x	x	x	x
Sb-126m	1.92E+01	x	x	x	x	x	x	x	x
I-129	**1.57E+07**	✓	x	x	x	x	x	x	x
Cs-135	**2.36E+06**	✓	x	x	x	x	x	x	x
Cs-137	**3.00E+01**	x	x	x	x	✓	x	✓	✓
Ba-137m	**4.85E-06**	x	x	x	x	✓	x	✓	✓
Sm-151	**9.00E+00**	x	x	x	x	**x**	x	**x**	**x**
Eu-152	1.35E+01	x	x	x	x	x	x	x	x
Eu-154	8.59E+00	x	x	x	x	x	x	x	x
Pt-193	5.00E+01	x	x	x	x	x	x	x	x
Ra-226	**1.60E+03**	✓	x	x	x	✓	x	x	x
Ac-227	2.17E+01	x	x	x	x	x	x	x	x

✓ Included on the potential HRR list based on specific evaluation criterion.

x Does not meet specific evaluation criterion.

[a] Radionuclides considered potential HRRs if one or more evaluation criteria are met.

Note: Potential HRRs for this Draft FTF 3116 Basis Document are highlighted.

[SRS-REG-2007-00002]

Table 3.2-1: Radionuclides Contained in FTF PA Initial Inventory (Continued)

Radionuclide with Initial Inventory	Half-Life (yr)	Evaluation Results[a]							
		Groundwater Analysis		Air Pathway Analysis		Intruder Analysis		Uncertainty & Sensitivity Analysis	Contribution to Worker Dose
		Dose > 0.1 mrem/yr	Impact on Progeny > 0.1 mrem/yr	Dose > 0.1 mrem/yr	Impact on Progeny > 0.1 mrem/yr	Dose > 1.0 mrem/yr	Impact on Progeny > 1.0 mrem/yr		
Th-229	**7.88E+03**	✓	x	x	x	✓	x	x	x
Th-230	**7.54E+04**	x	✓	x	x	x	x	x	x
Pa-231	**3.27E+04**	✓	x	x	x	x	x	x	x
U-232	6.89E+01	x	x	x	x	x	x	x	x
U-233	**1.59E+05**	✓	x	x	x	✓	x	x	x
U-234	**2.46E+05**	✓	x	x	x	✓	x	✓	x
U-235	**7.04E+08**	x	✓	x	x	x	x	x	x
U-236	2.34E+00	x	x	x	x	x	x	x	x
U-238	4.47E+00	x	x	x	x	x	x	x	x
Np-237	**2.14E+06**	✓	x	x	x	✓	x	✓	x
Pu-238	**8.77E+01**	x	✓	x	x	x	✓	x	x
Pu-239	**2.41E+04**	✓	x	x	x	✓	x	✓	x
Pu-240	**6.56E+03**	✓	x	x	x	✓	x	✓	x
Pu-241	1.43E+01	x	x	x	x	x	x	x	x
Pu-242	3.75E+05	x	x	x	x	x	x	x	x
Pu-244	8.00E+07	x	x	x	x	x	x	x	x
Am-241	**4.32E+02**	x	✓	x	x	x	✓	✓	x
Am-242m	1.41E+02	x	x	x	x	x	x	x	x
Am-243	**7.37E+03**	x	✓	x	x	x	x	x	x
Cm-243	2.91E+01	x	x	x	x	x	x	x	x
Cm-244	**1.81E+01**	x	✓	x	x	x	✓	x	x
Cm-245	8.50E+03	x	x	x	x	x	x	x	x
Cm-247	1.56E+07	x	x	x	x	x	x	x	x
Cm-248	3.48E+05	x	x	x	x	x	x	x	x
Cf-249	3.51E+02	x	x	x	x	x	x	x	x

✓ Included on the potential HRR list based on specific evaluation criterion.
x Does not meet specific evaluation criterion.
[a] Radionuclides considered potential HRRs if one or more evaluation criteria are met.
Note: Potential HRRs for this Draft FTF 3116 Basis Document are highlighted.
[SRS-REG-2007-00002]

4.0 REFERENCES

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