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Engineering Design File

RESIDUAL RADIOACTIVE INVENTORY FOR FUEL REPROCESSING COMPLEX NON-TIME CRITICAL REMOVAL ACTION REPORT

Idaho Cleanup Project

CH2M ◆ WG Idaho, LLC is the Idaho Cleanup Project contractor for the U.S. Department of Energy

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This engineering design file (EDF) was prepared in support of the *CPP-601, CPP-602, CPP-627, and CPP-640 Fuel Reprocesing Complex Non-Time-Critical Removal Action Report* to provide a basis for performing a risk evaluation. This EDF updates EDF-8293, as well as adding new information obtained during the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) non-time critical removal action for the Fuel Reprocessing Complex. This inventory represents the residual radioactive material left from the decontamination and decommissioning of CPP-601, CPP-602, CPP- 627, and CPP-640, in addition to the contamination left beneath the buildings form historic CERCLA release sites CPP-80, CPP-117, CPP-118, CPP-119, CPP-120, CPP-121, CPP-122, and CPP-123. Former site CPP-86 was encompassed by CPP-117.

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Residual Radioactive Inventory for Fuel Reprocessing Complex Non-time Critical Removal Action Report

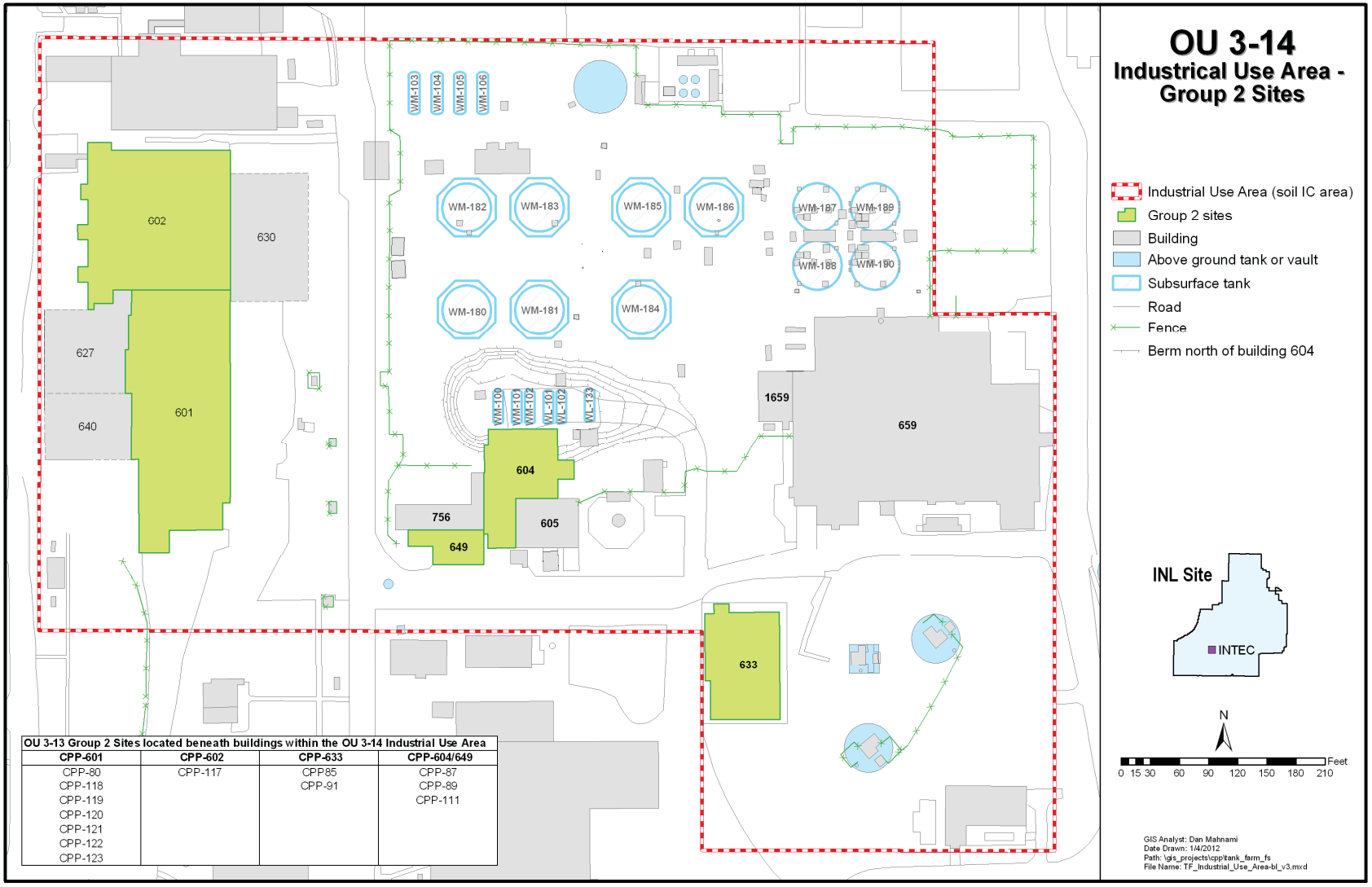
1. INTRODUCTION

The Idaho Nuclear Technology and Engineering Center Fuel Reprocessing Complex facilities CPP-601, CPP-602, CPP-627, and CPP-640 (see Figure 1) at the Idaho National Laboratory Site have undergone decontamination and decommissioning as non-time-critical removal actions under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

This engineering design file (EDF) summarizes the remaining radioactive inventory for CPP-601, CPP-602, CPP-627, and CPP-640. It also summarizes the inventory for the CERCLA sites beneath CPP-601 and CPP-602, which include the CERCLA sites CPP-80, CPP-117, CPP-118, CPP-119, CPP-120, CPP-121, CPP-122, and CPP-123. Former site CPP-86 was encompassed by CPP-117. This EDF primarily combines several documents to providing a single radiological source term for the supporting EDF, "Groundwater Risk Assessment for CPP-601, CPP-602, CPP-627, and CPP-640 Fuel Reprocessing Complex Non-Time-Critical Removal Action" (EDF-10195). This groundwater risk assessment documents that the end state for these facilities does not present an unacceptable risk. This risk assessment will be used to support the development of the *Final Removal Action Report for CPP-601, CPP-602, CPP-627, CPP-630, and CPP-640* (DOE-ID 2012).

The following sections document the information sources for each facility pertaining to residual radioactive inventory, as well as any minor corrections to the information that was combined to develop this final source term. Figure 2 presents a flowchart of the development process of the residual radioactive inventory. Radionuclides present at less than 1 μCi total and comprising less than 0.01% of the total are considered negligible and are unnecessary for purposes of this EDF and may be omitted to simplify calculations and presentation.

Section 2 provides background information from EDF-8293, Rev. 2, on how the original source term was developed. Sections 3 through 6 discuss how that source term was modified during the non-time critical removal actions. Section 7 summarizes the changes and presents the final source term to be evaluated in a risk assessment. Section 8 compares the 2012 source term to the 2008 source term.



OU 3-13 Group 2 Sites located beneath buildings within the OU 3-14 Industrial Use Area			
CPP-601	CPP-602	CPP-633	CPP-604/649
CPP-80 CPP-118 CPP-119 CPP-120 CPP-121 CPP-122 CPP-123	CPP-117	CPP85 CPP-91	CPP-87 CPP-89 CPP-111

Figure 1. Fuel Reprocessing Complex facilities CPP-601, CPP-602, CPP-627, and CPP-640 CERCLA Operable Unit 3-13 Group 2 sites.

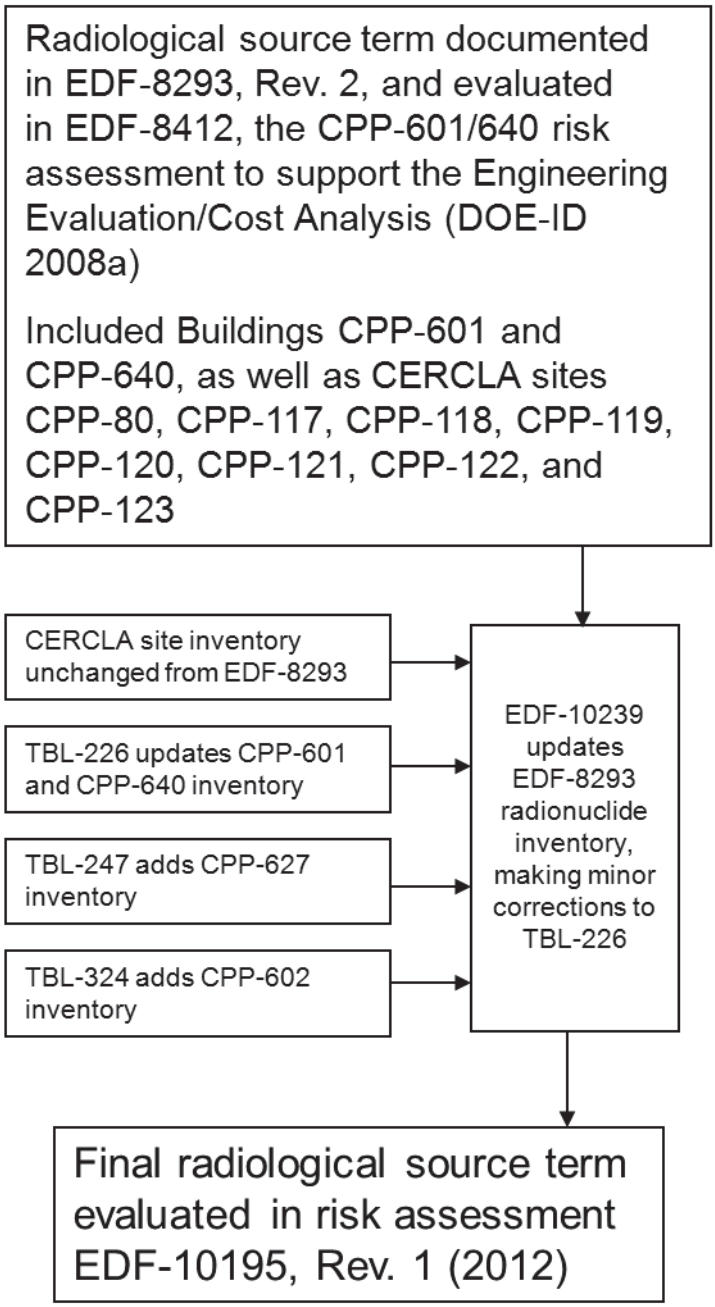


Figure 2. Flowchart for development of revised residual radionuclide source term.

2. DEVELOPMENT OF ORIGINAL RADIOACITVE SOURCE TERM

The information presented in this section is excerpted from EDF-8293, Rev. 2, to provide a background on how the radiological source term was developed. The information from EDF-8293, Rev. 2, was not changed, except references to figures and tables that were not included this EDF were deleted.

2.1 Facility Radiological Characterization

Radiological isotopes for CPP-601/640 are well understood, based on detailed knowledge of the reprocessing operations and historical and current sampling and analysis of the process systems and facility areas (e.g., process system components, tank liquids and heel sludge, and smear and air sample filters). Several methods were employed to develop a bounding estimate of the radioactive material inventory for CPP-601/640. Some characterization information was available from historical documents and reports. Some historical theoretical modeling data for process solutions for the typical fuel types processed at the Fuel Reprocessing Complex also were used. Physical and destructive sampling also were used to provide empirical data for source term development. Radiological surveys and radiochemical analysis information from process system components; liquids, sludge, and solids; scans and smears of building surfaces; dose rate surveys; and in situ gamma spectroscopy were used to develop applicable source terms.

2.2 Holistic Dose-to-Curie Characterization

The holistic dose-to-curie method was applied to estimate the radioactive material inventory remaining in process cells in their entirety. This methodology inherently takes into account radioactivity from process systems, as well as interior structures of the process cells. Additionally, dose-rate measurements generally are considered bounding on account of the survey techniques to which technicians are trained. Technicians typically scan an object or area and document the highest reading. Empirical dose rate survey data from the process cells were statistically analyzed to ensure the dose rates fit a normal or log-normal distribution, thus demonstrating the data are statistically representative. An aggregate average gamma dose rate was determined for the process cell. Process vessels and piping were analyzed to determine an aggregate attenuation factor. This factor was applied to the average dose rate for the process cell to correct for the estimated collective attenuation from objects in the process cell (i.e., to obtain an average unshielded dose rate). A MicroShield model was designed to approximate the geometry and conserve the volume of the process cell. In some cases, for complex geometries, more than one aggregate average unshielded dose rate and model were used, and the results were summed (e.g., N-Cell and F-Cell). The appropriate source term was applied to the model, and activity levels were adjusted up or down to achieve the attenuation-corrected unshielded average dose rate in the center of the model, thus yielding the estimated radioactive material inventory in the process cells.

This method was determined to be invalid for characterization of CPP-640, Cells-1, -2, -3, and -4, which processed the low burn-up Rover fuels. In low burn-up fuels, an unacceptable error is introduced due to the relatively low mixed fission product (i.e., gamma tag) activity in relation to the uranium and actinide activity.

The holistic dose-to-curie method was applied to the following process cells and service corridor to estimate the individual cell radioactive material inventory:

- CPP-601 Process Cells A, B, C, D, E , F, G, H, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z, and service corridor
- CPP-640 Process Cell-5.

2.3 Traditional Dose-to-Curie Characterization

The traditional dose-to-curie method was applied to estimate the radioactive material inventory remaining in the CPP-640 HW-100 and HW-101 tank heels. The combined heel volume of the tanks was conservatively estimated at 50 L, based on past visual observation. Observation in April 2007 indicated no appreciable tank heel in HW-100 and less than 50 L in HW-101. Conservatively, the previous estimated heel volume of 50 L was used. The on-contact dose-rate measurement from the HW-101 tank was higher than for the HW-100 tank; therefore, to add another level of conservatism, the HW-101 tank dose rates were averaged to determine the mean on-contact dose rate. Additionally, the dose-rate measurements generally are considered bounding, as previously described in Section 2.2, on account of survey techniques used. A MicroShield model was designed to approximate the geometry and conserve the volume of the 50-L tank heel. The appropriate source term, tank wall, and heel-attenuation parameters were applied to the model and activity levels adjusted up or down to achieve the attenuation-corrected unshielded mean dose rate in the center of the model, thus yielding the estimated radioactive material inventory remaining in the tank heels.

2.4 Activity-Over-Surface-Area Characterization

The activity-over-surface-area method was applied to estimate the radioactive material inventory remaining in areas where fixed and removable contamination are the predominant sources of radioactivity (i.e., insignificant or no process system equipment). Analytical isotopic data were used to determine a representative and conservative isotopic-activity-concentration-per-unit surface area. Typically, the isotopic data were obtained from radiochemical analysis of smears or from analytical data from other material or media. Because the analytical data typically represented the isotopic concentrations of removable contamination, a conservative correction factor of 10 was applied to the resulting values to account for fixed contamination that is likely present. Next, the interior surface area of each area was calculated and multiplied by the individual isotopic activity concentrations. Another conservative correction factor of 50% was added to account for possibly contaminated external surfaces of equipment in the areas (e.g., electrical cabinets, conduit, structural walls, and nonradioactive systems). Individual isotopic activities were summed to determine the estimate of total residual radioactive material in an area. This method also is considered conservative and bounding because the activity is applied to the entire surface area when, in reality, surface areas of the entire facility are not contaminated.

The activity-over-surface-area method was applied to the following process cells and areas to estimate the individual cell or area radioactive material inventory:

- CPP-640 Process Cells 1, 2, 3, and 4
- CPP-601 process makeup area, operating and sample corridors, access corridor, ventilation tunnels, and waste trench.

2.5 Activity Scaled to Existing Source-Term Characterization

All process equipment has been removed from CPP-640 Cell-3, except two burners (i.e., VES-100 and VES-104), which contain residual uranium. VES-100 contains approximately 1.332E-03 Ci of U-235, and VES-104 contains approximately 4.583E-03 Ci of U-235. Both vessels have been filled with grout. A vacuum vessel (i.e., VES-106) also remains in Cell-3 and contains approximately 4.324E-04 Ci of U-235 embedded in sintered metal filters, which have not been grouted. Cell-3 and the Mechanical Handling Cave were last used in August 1984.

CPP-640 Cell-3 vessels that remain were characterized for radioactive material inventory using the estimate of 1.829E-03 Ci of U-235. This value was based on large-area smears of the cells, physical samples of material taken from the cans of burned uranium-bearing material, physical samples from the vessel interiors, and estimates of the amount of material remaining in the vessels. Analytical results from smears from Cell-3 were used to determine other isotopes present in Cell-3 and their scaling factors to the U-235 activity. The remaining isotopes were scaled to the Cell-3 vessel U-235 activity. Individual isotopic activities from the three vessels were summed with the Cell-3 activity-over-surface-area characterization to determine the estimate of total residual radioactive material remaining in Cell-3.

2.6 Ad Hoc Calculation Characterization

2.6.1 WG/WH Tanks (Deep Tanks)

The CPP-601 deep tanks, (i.e., WG-100 and -101 and WH-100 and -101) were characterized by using projected activity values to provide a best estimate of the radioactive material inventory projected to remain in the WG/WH deep tanks after their closure, assuming the tanks have been flushed and drained, and 100 L of residual flush solution remains in the tanks. Analytical data of typical process waste solutions were used to estimate the activity of the residual isotopes. Other isotopes of interest, for which no analytical results were available, were scaled to the Cs-137 activity to account for these minor isotopes of interest common with process waste solutions.

2.6.2 N-Cell Raschig Rings

The method used to provide a best estimate of the radioactive material inventory remaining in the N-Cell Raschig rings was to estimate the volume of Raschig rings based on recent visual observation and then calculate the amount of radioactivity for the estimated volume of Raschig rings based on the empirical data obtained in October 2006 from the composite sample of Raschig rings and the material deposits. The remaining radionuclides of interest associated with process solutions associated with spent fuel processing are scaled to Cs-137 activity using the applicable source term scaling factors.

2.6.3 Abandoned Product Lines

The method used to provide a best estimate of the radioactive material inventory remaining in the abandoned product lines was to use known process solution U-235 mass concentrations ranging from 7 to 100 g/L for first cycle and 350 g/L for second/third cycle product and 6% piping system volume. Then the U-235 mass was converted to activity in units of curies. The assumed 6% volume was used as an estimate because it is thought to be representative of the expected volume of solution remaining in the cut and capped abandoned lines. The 6% volume estimate was taken from a historical event in which an abandoned RaLa (radioactive lanthanum) line was improperly capped. When the RaLa line was

pressure-tested, approximately 6% of the maximum line volume was expelled from the line. The abandoned product lines are considered to be similar to the abandoned RaLa lines.

Results for detected radionuclides in the soluble solids, insoluble solids, and Raschig ring composite samples from N-Cell were used to calculate isotopic scaling factors to U-235. The solids in deposits and on the Raschig rings are from leaks from the product line header in N-Cell, and, therefore, provide the best indication of the radionuclide abundances likely present in the abandoned product lines. Activity values of detected radionuclides, including Cs-137, were normalized to the U-235 activity. The remaining radionuclides that were either non-detects or not analyzed for, were scaled to the normalized Cs-137 activity using the applicable source-term scaling factors.

The following five radionuclides of concern have been identified for the Engineering Evaluation/Cost Analysis dose and risk assessments: I-129, Np-237, Tc-99, U-235, and U-234. Because the actual volume of remaining solution in the abandoned product lines is not certain, the maximum hypothetical curie content for these radionuclides based upon the theoretical total capacity of these lines was calculated. The abandoned products lines were assumed to be 100% full. Using the maximum possible line volumes, the limiting uranium concentrations, and the appropriate scaling factors, the hypothetical total curies for each radionuclide is 6.16E-4 (I-129), 5.36E-1 (Np-237), 1.20E-1 (Tc-99), 9.48E-1 (U-234), and 1.70E-1 (U-235). Because these lines are uranium product lines, the fission products are not likely to increase.

2.6.4 Fuel Reprocessing Complex Subsurface Releases

Over the operating history of the Fuel Reprocessing Complex, eight historic subsurface releases of radioactive process solutions are known to have occurred. Descriptions and accounts of these releases were compiled and are summarized in the following section. Estimates of the activity of certain radionuclides, namely Cs-137, Sr-90, I-129, H-3, and Tc-99, were based on historic analytical results associated with the releases to the subsurface soils. For purposes of the CPP-601/640 Fuel Reprocessing Complex Engineering Evaluation/Cost Analysis, additional radionuclides of interest include Np-237, U-234, U-235, U-236, U-238, Pu-238, Pu-239, and Pu-240. The additional radionuclides of interest, along with other radionuclides, were not analyzed for previously, but are likely present in the subsurface soils based on the known releases being primarily dissolver product from the Fuel Reprocessing Complex. Estimates for these additional radionuclides were interpolated by scaling them to the Cs-137 activity values from analytical results of the applicable release location subsurface soils.

3. CERLCA SITES BENEATH CPP-601 AND CPP-602

EDF-8293, Rev. 2, Table 6, presents the initial radiological source term used in the 2008 risk assessment. The 2008 risk assessment, EDF-8412, supported the *Engineering Evaluation/Cost Analysis for Decommissioning of the CPP-601/640 Fuel Reprocessing Facilities (*DOE-ID 2008b*)* and *Action Memorandum for Decommissioning CP-601/640 Fuel Reprocessing Facilities* (DOE-ID 2008a). The Engineering Evaluation/Cost Analysis and the Action Memorandum selected the final end state for these facilities. The radiological source term that would remain upon completion of the non-time critical removal actions for CPP-601, CPP-640, and the CERCLA sites beneath CPP-601 and CPP-602, which include CERCLA sites CPP-80, CPP-117, CPP-118, CPP-119, CPP-120, CPP-121, CPP-122, and CPP-123, was summarized in Table 6 of EDF-8923, Rev.2. Former site CPP-86 was encompassed by CPP-117. The residual source term for CPP-601 and CPP-640 was modified during the non-time critical removal action. Only the source term for the CERCLA sites remained unchanged. Table 1 presents unmodified information for the CERCLA sites, except radionuclides present at less than 1 µCi total and comprising less than 0.01% of the total were considered negligible and were unnecessary for purposes of this EDF and have been omitted to simplify calculations and presentation.

Table 1. Residual radioactive inventory of CERCLA sites beneath CPP-601 and CPP-602.[a]

Isotope	CERCLA Sites Beneath CPP-601/602 (Ci)	Isotope	CERCLA Sites Beneath CPP-601/602 (Ci)	Isotope	CERCLA Sites Beneath CPP-601/602 (Ci)
Ac-227	1.74E-06	H-3	2.50E+00	Sb-125	2.81E+00
Am-241	1.82E-01	I-129	1.80E-04	Se-79	1.68E-03
Am-242m	2.78E-05	Ni-59	2.60E-04	Sm-151	1.02E+00
Am-243	1.89E-04	Ni-63	3.37E-02	Sn-121m	2.27E-03
C-14	4.49E-04	Np-237	1.06E-01	Sn-126	1.13E-03
Cm-242	4.10E-03	Pa-231	6.01E-06	Sr-90	1.78E+02
Cm-243	3.56E-06	Pd-107	1.12E-04	Tc-99	2.06E-02
Cm-244	3.51E-03	Pm-146	3.15E-04	U-232	5.56E-05
Co-60	1.54E-01	Pm-147	2.39E+00	U-233	2.71E-06
Cs-134	1.40E-01	Pu-236	3.16E-06	U-234	1.81E-01
Cs-135	4.47E-03	Pu-238	6.12E+00	U-235	3.19E-02
Cs-137	1.78E+02	Pu-239	1.73E-01	U-236	2.46E-03
Eu-152	5.64E-01	Pu-240	1.75E-02	U-238	8.94E-04
Eu-154	2.61E+00	Pu-241	5.04E+00	Zr-93	7.96E-03
Eu-155	4.74E-01	Pu-242	3.80E-05		
Total					**1.82E+02**

a. Adapted from EDF-8293, Table 6.

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act

4. TBL-226

Technical Baseline (TBL)-226, "CPP-601 640 Fuel Reprocessing Complex Updated (Final) Radioactive Material Inventory," revised the residual source term for CPP-601 and CPP-640. This TBL updated the residual radioactive source term for CPP-601 and CPP-640 presented in EDF-8293, Rev. 2. After reviewing this updated information, minor corrections were necessary in three areas to improve the accuracy of the residual inventory, and they are summarized in Subsections 4.1 through 4.3.

4.1 Analytical Results for Non-detects

The preliminary analytical results from the laboratory for Ce-144 and Ra-226 initially were not flagged as non-detects for both the CPP-601 and CPP-640 waste tank systems. However, during the limitations and validations review, these results subsequently were marked as non-detects, and their use in the data package was discouraged. Because Ce-144 was not previously identified in the initial source-term inventory (EDF-8293, Rev. 2), that radionuclide is considered a non-detect and not reported in the source-term inventory. Ra-226 previously was reported in the initial source-term inventory (EDF-8293, Rev. 2); therefore, the same source-term inventory for Ra-226 will be presented in this final residual source-term inventory.

4.2 CPP-640 Waste Tanks

TBL-226 evaluated the remaining inventory for the CPP-640 waste tanks by taking the analyses from the highest radioactive tank (HW-101) and applying those results to all of the waste in the three tanks. While bounding, applying the highest results is considered overly conservative. The HW-100 and HW-101 tanks were operated similarly, but the third tank (HW-102) with the largest heel was significantly less radioactive. Table 2 shows the results for the radiological analyses for the HW-101 tank. Table 3 shows the estimated mass of the heel remaining in each tank. The analytical results from Tank HW-101 will be applied to both the HW-101 and the HW-100 tank residuals. While a complete radioactive analysis is not available for HW-102, the Cs-137 value from the gamma scan results used for the shipping screen for the sample from HW-102 can be used to develop a scaling factor that provides a more realistic evaluation of the residual radioactive source term. Table 4 shows the development of that scaling factor based upon Cs-137 that can be used to scale the radionuclides identified in the HW-101 tank to levels comparable for the HW-102 tank that is not nearly as radioactive. Table 5 presents the results of the recalculations for the residual radionuclide source term in the CPP-640 waste tanks. The "total" column in Table 5 will be used to revise Table 2 of TBL-226.

Table 2. Radiological results from CPP-640 HW-101 tank.

Reported Constituent	Analysis Date	Analysis Method	Concentration	Unit
Am-241	7/10/2008	Alpha spectrometry	4.74E+01	pCi/g
	7/10/2008	Alpha spectrometry	4.96E+01	pCi/g
		Average	4.85E+01	pCi/g
Co-60	7/15/2008	Gamma spectrometry	8.27E+06	pCi/g
		Average	8.27E+06	pCi/g
Cs-137	7/15/2008	Gamma spectrometry	5.27E+09	pCi/g
	7/16/2008	Gamma spectrometry	3.21E+09	pCi/g
		Average	4.24E+09	pCi/g
Np-237	7/23/2008	Alpha spectrometry	6.68E+00	pCi/g
	7/23/2008	Alpha spectrometry	7.54E+00	pCi/g
		Average	7.11E+00	pCi/g
Pu-238	7/7/2008	Alpha spectrometry	4.59E+02	pCi/g
	7/7/2008	Alpha spectrometry	5.77E+02	pCi/g
		Average	5.18E+02	pCi/g
Pu-239/240	7/7/2008	Alpha spectrometry	6.85E+03	pCi/g
	7/7/2008	Alpha spectrometry	8.78E+03	pCi/g
		Average	7.82E+03	pCi/g
Pu-241	7/10/2008	Liquid scintillation	9.37E+02	pCi/g
	7/10/2008	Liquid scintillation	1.72E+03	pCi/g
		Average	1.33E+03	pCi/g
Sr-90	7/10/2008	Gas proportional counter	6.88E+06	pCi/g
	7/10/2008	Gas proportional counter	9.09E+06	pCi/g
		Average	9.32E+06	pCi/g
U-233/234	7/14/2008	Alpha spectrometry	2.32E+04	pCi/g
	7/14/2008	Alpha spectrometry	2.52E+04	pCi/g
		Average	2.42E+04	pCi/g
U-235	7/14/2008	Alpha spectrometry	9.15E+02	pCi/g
	7/14/2008	Alpha spectrometry	9.65E+02	pCi/g
		Average	9.40E+02	pCi/g
U-238	7/14/2008	Alpha spectrometry	8.11E+03	pCi/g
	7/14/2008	Alpha spectrometry	9.83E+03	pCi/g
		Average	8.97E+03	pCi/g

Table 3. Mass of heel in CPP-640 waste tanks.

Tank	Heel Mass (g)	Mass (%)
HW-100	55,339	25%
HW-101	5,080	
HW-102	185,069	75%
Total	**245,488**	**100%**

Table 4. HW-102 scaling factor.

Isotope	HW-102 Gamma Scan Shipping Screen	HW-101 Gamma Scan (from Cs-137 Table 5)
Cs-137	4.43E+04 pCi/g[a]	4.24E+09 pCi/g
	HW-102 Scaling Factor = 1.04E-05	

a. Closure Report for ESP-013-07 (Kirchner 2008).

Table 5. Revised radionuclide content of CPP-640 waste tanks.

Nuclide	HW-101 (pCi/g)	HW-100 & 101 (Ci)	HW-102 (Ci)	Total (Ci)
Am-241	4.85E+01	2.93E-06	9.37E-11	2.93E-06
Co-60	8.27E+06	5.00E-01	1.60E-05	5.00E-01
Cs-137	4.24E+09	2.56E+02	8.19E-03	2.56E+02
Np-237	7.11E+00	4.30E-07	1.37E-11	4.30E-07
Pu-238	5.18E+02	3.13E-05	1.00E-09	3.13E-05
Pu-239/240	7.82E+03	4.72E-04	1.51E-08	4.72E-04
Pu-241	1.33E+03	8.04E-05	2.57E-09	8.04E-05
Sr-90	9.32E+06	5.63E-01	1.80E-05	5.63E-01
U-234	2.42E+04	1.46E-03	4.67E-08	1.46E-03
U-235	9.40E+02	5.68E-05	1.82E-09	5.68E-05
U-238	8.97E+03	5.42E-04	1.73E-08	5.42E-04
Total		**2.57E+02**	**8.22E-03**	**2.57E+02**

4.3 Uranium-233/234 Analysis

The results from the alpha spectroscopy analysis for uranium cannot differentiate between U-233 and U-234. TBL-226 assumed that the two isotopes would be split evenly. This is inconsistent with past practices and is not supported by the various fuel types processed in CPP-640. This EDF assumes that the sample result would be representative of U-234 only.

4.4 Plutonium-239/240 Analysis

Similar to the U-233/234 discussion in Section 4.3, alpha spectroscopy cannot differentiate between Pu-239 and Pu-240. TBL-226 conservatively assumed that this mass represented Pu-239 only. This EDF retains that assumption.

4.5 Revised CPP-601 and CPP-640 Residual Radioactive Source-Term Inventory

Table 6 presents the results of revising Table 2 of TBL-226 to incorporate the changes from Subsections 4.1 through 4.3 for CPP-601 and CPP-640.

Table 6. Revised Table 2 of TBL-226 showing updated CPP-601 and CPP-640 residual radioactive source-term inventories.

Isotope	Sum of CPP-601 Existing Information (Ci)	WG/WH PEW (Deep) Tanks (Ci)	N-Cell U-235 Raschig Rings (Ci)	Abandoned Lines (Ci)	CPP-640 Cells 1–5 (Ci)	CPP-640 VES-HW-100/101/102 Tanks (Ci)	CPP-601/640 Complex Totals (Ci)
Ac-227	1.77E-06	—	—	—	—	—	1.77E-06
Am-241	**9.80E-03**	**2.02E-05**	**1.76E-02**	1.95E-02	1.97E-04	**2.93E-06**	**4.71E-02**
Am-242m	2.83E-05	1.73E-09	3.25E-07	8.57E-08	—	—	2.87E-05
Am-243	1.93E-04	1.I&E-08	2.22E-06	5.85E-07	—	—	1.96E-04
C-14	4.58E-04	1.72E-09	5.26E-06	1.39E-06	—	4.51E-06	4.69E-04
Ce-144	—	—	—	—	—	—	—
Cm-242	4.19E-03	3.38E-08	4.89E-05	1.29E-05	—	—	4.25E-03
Cm-243	3.64E-06	2.22E-10	4.18E-08	1.10E-08	—	—	3.68E-06
Cm-244	3.22E-03	4.61E-07	3.26E-04	8.59E-05	—	—	3.63E-03
Co-60	1.51E-01	**1.50E-02**	7.41E-03	1.96E-03	4.54E-02	**5.00E-01**	**7.20E-01**
Cs-134	1.42E-01	8.71E-06	1.64E-03	4.32E-04	—	—	1.44E-01
Cs-135	4.56E-03	2.79E-07	5.25E-05	1.38E-05	—	—	4.63E-03
Cs-137	1.82E+02	**3.95E+01**	2.09E+00	5.51E-01	9.08E+00	**2.56E+02**	**4.89E+02**
Eu-152	1.40E-02	8.56E-07	4.51E-01	1.19E-01	—	—	5.84E-01
Eu-154	2.36E+00	1.44E-04	2.71E-01	7.14E-02	—	1.09E-04	2.70E+00

Table 6. (continued).

Isotope	Sum of CPP-601 Existing Information (Ci)	WG/WH PEW (Deep) Tanks (Ci)	N-Cell U-235 Raschig Rings (Ci)	Abandoned Lines (Ci)	CPP-640 Cells 1–5 (Ci)	CPP-640 VES-HW-100/101/102 Tanks (Ci)	CPP-601/640 Complex Totals (Ci)
Eu-155	2.94E-01	1.80E-05	1.56E-01	4.10E-02	—	1.21E-04	4.91E-01
H-3	4.09E-01	6.71E-05	4.39E-03	1.16E-03	—	—	4.15E-01
l-129	4.24E-04	1.62E-07	1.31E-06	3.46E-07	—	5.00E-06	4.31E-04
Ni-59	2.65E-04	1.62E-08	3.06E-06	8.05E-07	—	—	2.69E-04
Ni-63	3.43E-02	3.29E-05	3.94E-04	1.04E-04	—	—	3.48E-02
Np-237	**2.01E-03**	3.33E-07	**2.68E-04**	2.04E-02	1.73E-03	**4.30E-07**	**2.44E-02**
Pa-231	6.13E-06	3.74E-10	7.04E-08	1.85E-08	—	—	6.22E-06
Pd-107	1.14E-04	6.97E-09	1.31E-06	3.46E-07	—	—	1.16E-04
Pm-146	3.22E-04	1.96E-08	3.70E-06	9.75E-07	—	—	3.27E-04
Pm-147	2.43E+00	1.49E-04	2.81E-02	7.39E-03	—	—	2.47E+00
Pu-236	3.22E-06	1.97E-10	3.71E-08	9.77E-09	—	—	3.27E-06
Pu-238	**1.46E+00**	1.22E-04	**3.88E-01**	2.99E-01	2.09E-02	**3.13E-05**	**2.17E+00**
Pu-239	**2.64E-02**	3.93E-05	**1.40E-02**	2.14E-02	7.88E-02	**4.72E-04**	1.41E-01
Pu-240	1.78E-02	1.09E-06	2.05E-04	5.40E-05	—	—	1.81E-02
Pu-241	5.19E+00	1.30E-05	2.26E-02	5.95E-03	8.19E-03	**8.04E-05**	5.23E+00
Pu-242	3.88E-05	2.37E-09	4.46E-07	1.17E-07	—	—	3.94E-05
Ra-226	—	—	—	—	—	1.73E-03	1.73E-03
Sb-125	2.88E+00	**1.31E-01**	1.69E-02	4.46E-03	6.73E-02	1.72E-04	3.10E+00
Se-79	1.71E-03	1.05E-07	1.97E-05	5.19E-06	—	—	1.73E-03
Sm-151	1.04E+00	6.36E-05	1.20E-02	3.16E-03	—	—	1.06E+00
Sn-121m	2.31E-03	1.41E-07	2.65E-05	6.99E-06	—	—	2.34E-03
Sn-126	1.16E-03	7.07E-08	1.33E-05	3.50E-06	—	—	1.18E-03
Sr-90	1.03E+02	**4.64E+00**	1.89E+00	4.96E-01	7.51E+00	**5.63E-01**	1.18E+02
Tc-99	5.10E-02	1.76E-07	5.18E-04	1.36E-04	3.25E-06	4.56E-02	9.73E-02
U-232	5.68E-05	3.46E-09	6.53E-07	1.72E-07	—	—	5.76E-05
U-233	**5.12E-07**	1.69E-10	—	8.36E-09	—	—	5.21E-07
U-234	1.98E-02	1.82E-07	1.29E-01	3.40E-02	4.77E-02	1.46E-03	2.32E-01
U-235	**1.45E-04**	1.25E-08	**4.44E-03**	**3.77E-03**	2.04E-03	**5.68E-05**	1.05E-02
U-236	2.51E-03	1.53E-07	2.89E-05	7.61E-06	—	—	2.55E-03

Table 6. (continued).

Isotope	Sum of CPP-601 Existing Information (Ci)	WG/WH PEW (Deep) Tanks (Ci)	N-Cell U-235 Raschig Rings (Ci)	Abandoned Lines (Ci)	CPP-640 Cells 1–5 (Ci)	CPP-640 VES-HW-100/101/102 Tanks (Ci)	CPP-601/640 Complex Totals (Ci)
U-238	**2.57E-04**	7.40E-09	**5.72E-05**	1.65E-06	1.66E-04	**5.42E-04**	1.02E-03
Zn-65	—	—	—	—	—	1.54E-04	1.54E-04
Zr-93	8.12E-03	4.97E-07	9.35E-05	2.46E-05	—	—	8.24E-03
Total	3.02E+02	4.44E+01	5.51E+00	1.70E+00	1.69E+01	2.57E+02	6.27E+02

PEW Process equipment waste

— Isotope not present

Yellow highlights identify cells corrected in this engineering design file.

Bold identifies values from TBL-226 that were modified from EDF-8293, Rev. 2.

5. TBL-247

The residual radioactive source-term inventory for the CPP-627 facility was presented in Table 5 of TBL-247, "CPP-627 Remaining Piping Residual Solids Source Term." Table 7 presents the residual radioactive source term for CPP-627.

Table 7. Residual radioactive source-term inventory for CPP-627.

Isotope	Total Ci
Am-241	1.63E-05
Cm-242	8.89E-10
Cm-244	3.19E-06
Co-60	4.52E-07
Cs-134	2.22E-06
Cs-137	7.41E-03
Eu-154	3.56E-05
Eu-155	5.11E-06
Np-237	8.89E-06
Pu-238	4.52E-04
Pu-239	1.48E-05
Sr-90	4.15E-03
U-234	2.74E-06
U-235	9.63E-08
U-238	1.41E-08
Total	**1.21E-02**

6. TBL-324

The residual radioactive source-term inventory for CPP-602 was presented in Table 1 of TBL-324, "CPP-602 Basement Remaining Radionuclide Activity," and is presented in Table 8.

Table 8. Residual radioactive source-term inventory for CPP-602.

Isotope	Total Ci
Am-241	2.36E-06
Bi-212	2.17E-07
C-14	3.48E-09
Cs-137	1.38E-03
H-3	3.11E-06
I-129	3.21E-09
Np-237	1.80E-07
Pa-233	1.15E-07
Pa-234m	3.87E-08
Pb-212	2.17E-07
Pu-238	2.21E-05
Pu-239/240	5.10E-07
Pu-241	2.21E-05
Ra-224	2.17E-07
Rn-220	2.17E-07
Sr-90	1.09E-04
Tc-99	6.90E-06
Th-228	2.30E-08
Th-231	3.22E-07
Th-234	3.87E-08
U-232	2.19E-07
U-234	1.43E-05
U-235	3.58E-07
U-236	2.58E-06
U-238	7.55E-08
Total	**1.57E-03**

7. CUMULATIVE SOURCE TERM

Table 9 summarizes the information presented in the previous sections and provides a total residual radioactive source-term inventory for the remaining radionuclides after the non-time critical removal actions have been completed for the CPP-601, CPP-602, CPP-627, and CPP-640 facilities, including the CERCLA sites beneath the CPP-601 and CPP-602 facilities.

Table 9. Total source-term inventory for the residual radioactive material remaining after non-time critical removal actions at CPP-601, CPP-602, CPP-627, and CPP-640 facilities, including CERCLA sites beneath the CPP-601 and CPP-602 facilities,.

Isotope	CERCLA Sites (Ci)	CPP-601/640 (Ci)	CPP-627 (Ci)	CPP-602 (Ci)	Total (Ci)
Ac-227	1.74E-06	1.77E-06	0.00E+00	0.00E+00	3.51E-06
Am-241	1.82E-01	4.71E-02	1.63E-05	2.36E-06	2.29E-01
Am-242m	2.78E-05	2.87E-05	0.00E+00	0.00E+00	5.65E-05
Am-243	1.89E-04	1.96E-04	0.00E+00	0.00E+00	3.85E-04
Bi-212	0.00E+00	0.00E+00	0.00E+00	2.17E-07	2.17E-07
C-14	4.49E-04	4.69E-04	0.00E+00	3.48E-09	9.18E-04
Cm-242	4.10E-03	4.25E-03	8.89E-10	0.00E+00	8.36E-03
Cm-243	3.56E-06	3.68E-06	0.00E+00	0.00E+00	7.25E-06
Cm-244	3.51E-03	3.63E-03	3.19E-06	0.00E+00	7.15E-03
Co-60	1.54E-01	7.20E-01	4.52E-07	0.00E+00	8.75E-01
Cs-134	1.40E-01	1.44E-01	2.22E-06	0.00E+00	2.84E-01
Cs-135	4.47E-03	4.63E-03	0.00E+00	0.00E+00	9.09E-03
Cs-137	1.78E+02	4.89E+02	7.41E-03	1.38E-03	6.67E+02
Eu-152	5.64E-01	5.84E-01	0.00E+00	0.00E+00	1.15E+00
Eu-154	2.61E+00	2.70E+00	3.56E-05	0.00E+00	5.31E+00
Eu-155	4.74E-01	4.91E-01	5.11E-06	0.00E+00	9.66E-01
H-3	2.50E+00	4.15E-01	0.00E+00	3.11E-06	2.91E+00
I-129	1.80E-04	4.31E-04	0.00E+00	3.21E-09	6.11E-04
Ni-59	2.60E-04	2.69E-04	0.00E+00	0.00E+00	5.29E-04
Ni-63	3.37E-02	3.48E-02	0.00E+00	0.00E+00	6.85E-02
Np-237	1.06E-01	2.44E-02	8.89E-06	1.80E-07	1.31E-01
Pa-231	6.01E-06	6.22E-06	0.00E+00	0.00E+00	1.22E-05
Pa-233	0.00E+00	0.00E+00	0.00E+00	1.15E-07	1.15E-07
Pa-234m	0.00E+00	0.00E+00	0.00E+00	3.87E-08	3.87E-08
Pb-212	0.00E+00	0.00E+00	0.00E+00	2.17E-07	2.17E-07
Pd-107	1.12E-04	1.16E-04	0.00E+00	0.00E+00	2.27E-04
Pm-146	3.15E-04	3.27E-04	0.00E+00	0.00E+00	6.42E-04

Table 9. (continued).

Isotope	CERCLA Sites (Ci)	CPP-601/640 (Ci)	CPP-627 (Ci)	CPP-602 (Ci)	Total (Ci)
Pm-147	2.39E+00	2.47E+00	0.00E+00	0.00E+00	4.85E+00
Pu-236	3.16E-06	3.27E-06	0.00E+00	0.00E+00	6.42E-06
Pu-238	6.12E+00	2.17E+00	4.52E-04	2.21E-05	8.29E+00
Pu-239	1.73E-01	1.41E-01	1.48E-05	5.10E-07	3.14E-01
Pu-240	1.75E-02	1.81E-02	0.00E+00	5.10E-07	3.55E-02
Pu-241	5.04E+00	5.23E+00	0.00E+00	2.21E-05	1.03E+01
Pu-242	3.80E-05	3.94E-05	0.00E+00	0.00E+00	7.73E-05
Ra-224	0.00E+00	0.00E+00	0.00E+00	2.17E-07	2.17E-07
Ra-226	0.00E+00	1.73E-03	0.00E+00	0.00E+00	1.73E-03
Rn-220	0.00E+00	0.00E+00	0.00E+00	2.17E-07	2.17E-07
Sb-125	2.81E+00	3.10E+00	0.00E+00	0.00E+00	5.91E+00
Se-79	1.68E-03	1.73E-03	0.00E+00	0.00E+00	3.41E-03
Sm-151	1.02E+00	1.06E+00	0.00E+00	0.00E+00	2.08E+00
Sn-121m	2.27E-03	2.34E-03	0.00E+00	0.00E+00	4.61E-03
Sn-126	1.13E-03	1.18E-03	0.00E+00	0.00E+00	2.31E-03
Sr-90	1.78E+02	1.18E+02	4.15E-03	1.09E-04	2.96E+02
Tc-99	2.06E-02	9.73E-02	0.00E+00	6.90E-06	1.18E-01
Th-228	0.00E+00	0.00E+00	0.00E+00	2.30E-08	2.30E-08
Th-231	0.00E+00	0.00E+00	0.00E+00	3.22E-07	3.22E-07
Th-234	0.00E+00	0.00E+00	0.00E+00	3.87E-08	3.87E-08
U-232	5.56E-05	5.76E-05	0.00E+00	2.19E-07	1.13E-04
U-233	2.71E-06	5.21E-07	0.00E+00	0.00E+00	3.23E-06
U-234	1.81E-01	2.32E-01	2.74E-06	1.43E-05	4.13E-01
U-235	3.19E-02	1.05E-02	9.63E-08	3.58E-07	4.24E-02
U-236	2.46E-03	2.55E-03	0.00E+00	2.58E-06	5.01E-03
U-238	8.94E-04	1.02E-03	1.41E-08	7.55E-08	1.92E-03
Zn-65	0.00E+00	1.54E-04	0.00E+00	0.00E+00	1.54E-04
Zr-93	7.96E-03	8.24E-03	0.00E+00	0.00E+00	1.62E-02
Total	**3.81E+02**	**6.27E+02**	**1.21E-02**	**1.57E-03**	**1.01E+03**

8. COMPARISON TO EDF-8293, REVISION 2

Table 10 compares the residual radioactive source term presented in EDF-8293, Rev. 2, that was used in the 2008 risk assessment to the final total residual radioactive source-term inventory presented in this EDF for the residual radioactive material remaining after completion of the non-time critical removal actions at CPP-601, CPP-602, CPP-627, and CPP-640 facilities, including the CERCLA sites beneath the CPP-601 and CPP-602 facilities,. The last column shows the percentage difference between the two source terms. The Co-60 and Cs-137 values represent approximately a two-fold increase. This increase is primarily attributable to the heels left within the waste tanks in CPP-601 and CPP-640. These contaminants do not contribute significantly to long-term risk due to their relatively short half-lives. The residual inventory of Am-241, Np-237, Pu-238, Pu-239, U-233, and U-235 significantly decreased because substantial efforts were made to reduce the amount of special nuclear material left behind in these facilities.

Table 10. Percentage change from EDF-8293, Rev. 2, to updated inventory.

Isotope	EDF-8293, Rev. 2 (Ci)	EDF-10239 (Ci)	% Change
Ac-227	3.54E-06	3.51E-06	−1%
Am-241	3.71E-01	2.29E-01	−38%
Am-242m	5.65E-05	5.65E-05	0%
Am-243	3.84E-04	3.85E-04	0%
Bi-212	0.00E+00	2.17E-07	New
C-14	9.17E-04	9.18E-04	0%
Cm-242	8.35E-03	8.36E-03	0%
Cm-243	7.26E-06	7.25E-06	0%
Cm-244	7.15E-03	7.15E-03	0%
Co-60	3.85E-01	8.75E-01	127%
Cs-134	2.84E-01	2.84E-01	0%
Cs-135	9.09E-03	9.09E-03	0%
Cs-137	3.71E+02	6.67E+02	80%
Eu-152	1.15E+00	1.15E+00	0%
Eu-154	5.32E+00	5.31E+00	0%
Eu-155	9.66E-01	9.66E-01	0%
H-3	2.91E+00	2.91E+00	0%
I-129	6.11E-04	6.11E-04	0%
Ni-59	5.29E-04	5.29E-04	0%
Ni-63	6.85E-02	6.85E-02	0%
Np-237	2.16E-01	1.31E-01	−39%

Table 10. (continued).

Isotope	EDF-8293, Rev. 2 (Ci)	EDF-10239 (Ci)	% Change
Pa-231	1.22E-05	1.22E-05	0%
Pa-233	0.00E+00	1.15E-07	New
Pa-234m	0.00E+00	3.87E-08	New
Pb-212	0.00E+00	2.17E-07	New
Pd-107	2.28E-04	2.27E-04	0%
Pm-146	6.41E-04	6.42E-04	0%
Pm-147	4.86E+00	4.85E+00	0%
Pu-236	6.42E-06	6.42E-06	0%
Pu-238	1.24E+01	8.29E+00	−33%
Pu-239	4.27E-01	3.14E-01	−26%
Pu-240	3.56E-02	3.55E-02	0%
Pu-241	1.03E+01	1.03E+01	0%
Pu-242	7.73E-05	7.73E-05	0%
Ra-224	0.00E+00	2.17E-07	New
Ra-226	1.73E-03	1.73E-03	0%
Rn-220	0.00E+00	2.17E-07	New
Sb-125	5.78E+00	5.91E+00	2%
Se-79	3.41E-03	3.41E-03	0%
Sm-151	2.08E+00	2.08E+00	0%
Sn-121m	4.61E-03	4.61E-03	0%
Sn-126	2.31E-03	2.31E-03	0%
Sr-90	2.93E+02	2.96E+02	1%
Tc-99	1.18E-01	1.18E-01	0%
Th-228	0.00E+00	2.30E-08	New
Th-231	0.00E+00	3.22E-07	New
Th-234	0.00E+00	3.87E-08	New
U-232	1.13E-04	1.13E-04	0%
U-233	5.51E-06	3.23E-06	−41%
U-234	4.15E-01	4.13E-01	0%
U-235	6.64E-02	4.24E-02	−36%
U-236	5.01E-03	5.01E-03	0%

Table 10. (continued).

Isotope	EDF-8293, Rev. 2 (Ci)	EDF-10239 (Ci)	% Change
U-238	2.01E-03	1.92E-03	−4%
Zn-65	1.54E-04	1.54E-04	0%
Zr-93	1.62E-02	1.62E-02	0%
Total	**7.12E+02**	**1.01E+03**	**141%**

Yellow highlight indicates increased residual source term for specific isotope.
Green highlight indicates decreased residual source term for specific isotope.

9. SUMMARY

The residual radioactive source term presented in Table 9 of this EDF will be used to evaluate groundwater risk from the residual radioactive source term remaining after completion of the non-time critical removal actions for CPP-601, CPP-602, CPP-627, and CPP-640. Also, the CERCLA sites beneath CPP-601 and CPP-602 were evaluated. These CERCLA sites include CPP-80, CPP-117, CPP-118, CPP-119, CPP-120, CPP-121, CPP-122, and CPP-123,. Former site CPP-86 was encompassed by CPP-117.

10. REFERENCES

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