Radionuclide Selection for DCGL Development

May 16, 2012

Pacific Gas and Electric Company®

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Martin C. Erickson

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Reviewed By: Dan Rudolf Date: 3-29-13

Approved By: U W Berley Date: 4-3-13

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1.0 Executive Summary

An integral part in the development of the site-specific Derived Concentration Guideline Levels (DCGLs) for Humboldt Bay Power Plant (HBPP) is the identification of potential radionuclides present, at the time of Final Status Survey (FSS), which will contribute to the dose based assessment of the radiological status of the site. Radionuclide selection is a systematic approach to the identification of the potential nuclides and a deselecting of those nuclides which would not be present or would be present in insignificant concentrations.

The initial step in this process is to develop a theoretical suite of radionuclides that would be present in a reactor at shutdown. Comparisons of the materials present in HBPP were compared to those in a typical Boiling Water Reactor (BWR) so as to identify possible anomalies in the activation analysis. Additional nuclides were added to the list based on previous analyses and documentation (NUREG-4289 and HBPP HSA). Radionuclides with half-lives of two years or less were omitted from the list since these nuclides would have decayed at least eighteen half-lives since shutdown.

The next step was to determine which individual nuclides on the list would contribute 0.1 percent or less to the total activity present, providing the total activity from all discounted nuclides did not exceed one percent of the total activity. The total activity of all discounted nuclides equaled approximately 0.007 percent. Several nuclides met the criteria of contributing less than 0.1 percent to the total activity but could not be discounted because they have other methods of production in addition to activation of reactor components and/or have been observed in 10 CFR Part 61 waste stream analyses or site characterization samples.

In order to evaluate compliance with the dose criteria for discounted radionuclides, doses for both residential and occupancy scenarios for those nuclides supported by the DandD code were generated. The calculated total dose from discounted NUREG/CR-3474 radionuclides represents only 0.007 percent of the total calculated dose for the residential scenario. The calculated total dose from discounted NUREG/CR-3474 radionuclides represents only 0.0002 percent for the occupancy scenario. The activity represented by the radionuclides not supported by the DandD code resulted in a calculated total dose contribution of 1.36E-02 percent for inhalation exposure-to-dose conversion factors (DCFs) and 4.93E-03 percent for ingestion DCFs.

As a result of the analysis, an HBPP suite of nuclides was developed from the theoretical set of nuclides and the deletion of the remaining nuclides was justified.

2.0 Introduction

HBPP, Unit 3 was a natural circulation boiling water reactor and associated turbine-generator operated by Pacific Gas and Electric Company (PG&E). Unit 3 was granted a construction permit by the Atomic Energy Commission (AEC) on October 17, 1960, and construction began in November 1960. The AEC issued Provisional Operating License No. DPR-7 for Unit 3 in August 1962. Unit 3 achieved initial criticality on February 16, 1963, and began commercial operation in August 1963. On July 2, 1976, Unit 3 was shut down for annual refueling and to conduct seismic modifications. Seismic and geologic studies were in progress. In December 1980 it became apparent that the cost of completing required backfits might have made it uneconomical to restart the unit. Work was suspended at that time awaiting further guidance regarding backfitting requirements. In 1983, updated economic analyses indicated that restarting Unit 3 would probably not be economical, and in June 1983 PG&E announced its intention to decommission the unit.

As a part of the source-term abstraction process at HBPP, a site-specific suite of radionuclides potentially present in the site environs, or present as contamination on structural surfaces, at the time of FSS, must be identified. The purpose of this Technical Based Document is to provide the identification of those radionuclides and methodology behind the selection process.

3.0 Technical Position

The theoretical suite of radionuclides that could potentially still be present at HBPP (based upon the guidance contained in NUREG/CR-3474) is provided in Table 5-1 along with their half-lives and mode of decay. All gamma spectrometry analyses that are performed onsite for characterization or FSS surveys should include the detectable gamma emitters listed in Table 6-1 in the gamma spectrometry libraries for analysis. FSS samples sent to an offsite laboratory for analysis shall be analyzed for the suite of radionuclides listed in Table 6-1.

4.0 Limitations

The suite of radionuclides listed in Table 5-1 is a theoretical list based on NUREG/CR-3474 and should not be used as a site-specific suite for developing DCGLs. The suite of

radionuclides listed in Table 6-1 is an HBPP site-specific suite of radionuclides for developing site-specific DCGLs.

5.0 Technical Bases

Potential radionuclides were evaluated from NUREG/CR-3474 "Long-Lived Activation Products in Reactor Materials", NUREG/CR-4289 "Residual Radionuclide Contamination Within and Around Commercial Nuclear Power Plants", and the Humboldt Bay Historical Site Assessment.

5.1 Theoretical Suite of Radionuclides

Development of the suite of radionuclides listed in Table 6-1 began with NUREG/CR-3474. This NUREG assessed the problems posed to reactor decommissioning by long-lived activation products in reactor construction materials. Samples of stainless steel, vessel steel, concrete and concrete ingredients were analyzed for up to 52 elements in order to develop a database of activated major, minor and trace elements. The list of radionuclides was developed by combining those radionuclides listed in Table 5.13, "Activity Inventory of PWR Internals at Shutdown (Total Ci)," and Table 5.15, "Inventories of PWR and BWR Vessel Walls at Shutdown (Total Ci)". Only radionuclides with half-lives of two or more years were included on the list. Radionuclides with half-lives less than two years would not be expected to be observed since two years or less represents eighteen or more half-lives since final shutdown of the HBPP reactor.

Table 5- 1

NUREG/CR-3474 Identified Activation Product Radionuclides

Radionuclide	Half Life (Years)	Decay Mode	Radionuclide	Half Life (Years)	Decay Mode
Ag-108m	4.18E+02	IT	Kr-81	2.29E+05	γ
Ag-110m	6.84E-01	β^-, γ	Kr-85	1.07E+01	β^-, γ
Ar-39	2.69E+02	β^-	Mn-53	3.70E+06	γ
Ba-133	1.05E+01	γ	Mn-54	8.56E-01	β^+, γ
C-14	5.73E+03	β^-	Mo-93	3.50E+03	γ
Ca-41	1.03E+05	β^+, γ	Nb-92m	2.78E-02	β^+, γ
Ce-141	8.90E-02	β^-, γ	Nb-94	2.03E+04	β^-, γ
Cl-36	3.01E+05	β^-	Ni-59	7.50E+04	β^+, γ
Co-58	1.94E-01	β^+, γ	Ni-63	1.00E+02	β^-
Co-60	5.27E+00	β^-, γ	Pb-205	1.51E+07	γ

NUREG/CR-3474 Identified Activation Product Radionuclides

Radionuclide	Half Life (Years)	Decay Mode	Radionuclide	Half Life (Years)	Decay Mode
Cr-51	7.58E-02	γ	Pm-145	1.77E+01	γ
Cs-134	2.06E+00	β^-, γ	Pu-239	2.41E+04	α, γ
Cs135	2.30E+06	β^-	Sb-124	1.65E-01	β^-, γ
Cs-137	3.02E+01	β^-	Sc-46	2.29E-01	β^-, γ
Eu-152	1.36E+01	β^-, γ	Se-79	1.13E+06	β^-
Eu-154	8.59E+00	β^-, γ	Sm-146	1.00E+08	α
Eu-155	4.76E+00	β^-, γ	Sm-151	9.30E+01	β^-, γ
Fe-55	2.70E+00	γ	Sn-121m	5.00E+00	β^-
Fe-59	1.22E-01	β^-	Sr-90	2.86E+01	β^-
H-3	1.23E+01	β^-	Tb-158	1.80E+02	β^-
Hf-178m	3.00E+01	IT	Tc-99	2.13E+05	β^-, γ
Ho-166m	1.20E+03	β^-, γ	U-233	1.59E+05	α, γ
I-129	1.57E+07	β^-, γ	Zn-65	6.69E-01	β^+, γ
			Zr-93	1.53E+06	β^-

α – Alpha decay
β^- – Beta decay
β^+ – Positron decay
γ – Gamma decay
IT – Isomeric transition

5.2 Discounting Insignificant Radionuclides

5.2.1 Activation Product Considerations

Since Table 5-1 includes trace-elements that would not likely be found at HBPP due to their low abundance, an evaluation of radionuclides that may be discounted as being of potential importance was performed. The total inventory for each radionuclide was determined from activity inventories provided in Table 5.13 and Table 5.15 of NUREG/CR-3474. From this information, the percentage of total inventory for each radionuclide (decayed to 07/01/16) was calculated. The results of this evaluation are provided in Table 5-2.

Table 5- 2

Evaluation of NUREG/CR-3474 Total Activity Fractions

Radionuclide	Activity - Ci				Percent Total	Less than 0.1%?
	Shroud	Vessel Cladding	Vessel Walls	Total Activity		
Ag-108m	2.18E-01	1.79E-01	7.39E-06	6.41E-05	2.67E-04	Yes
Ar-39	2.68E-01	2.43E-01	2.73E-05	1.00E-03	3.64E-04	Yes
Ba-133	1.00E+01	9.24E-01	3.23E-05	2.03E-04	1.38E-03	Yes
C-14	1.03E+02	1.03E+02	2.79E-03	1.19E-02	1.53E-01	No
Ca-41	2.00E-02	2.00E-02	5.20E-07	2.00E-06	2.98E-05	Yes
Cl-36	2.24E+00	2.24E+00	5.70E-05	1.43E-04	3.34E-03	Yes
Co-60	4.50E+05	3.91E+03	1.20E-01	8.30E-01	5.83E+00	No
Cs-134	3.37E+01	1.80E-04	5.23E-09	1.87E-08	2.68E-07	Yes
Cs-135	3.80E-04	3.80E-04	3.67E-10	2.46E-09	5.67E-07	Yes
Cs-137	2.11E+00	9.22E-01	8.74E-06	6.03E-05	1.37E-03	Yes*
Eu-152	2.09E-02	4.91E-08	6.12E-04	2.70E-03	4.94E-06	Yes*
Eu-154	1.28E+01	7.46E-01	2.68E-05	2.62E-04	1.11E-03	Yes*
Eu-155	5.06E+00	3.27E-02	1.10E-07	1.21E-06	4.87E-05	Yes
Fe-55	9.29E+05	8.81E+01	2.24E-03	1.08E-02	1.31E-01	No
H-3	1.83E+02	2.40E+01	1.83E-03	7.98E-03	3.57E-02	Yes*
Hf-178m	5.21E-01	2.26E-01	1.87E-05	3.08E-04	3.37E-04	Yes
Ho-166m	3.93E-01	3.85E-01	1.08E-05	1.56E-04	5.74E-04	Yes
I-129	5.90E-07	5.90E-07	4.40E-12	1.88E-12	8.80E-10	Yes*
Kr-81	2.24E-04	2.24E-04	5.40E-12	3.04E-11	3.34E-07	Yes
Kr-85	8.15E-01	7.87E-02	4.83E-07	2.12E-06	1.17E-04	Yes
Mn-53	6.51E-03	6.50E-03	8.00E-07	1.00E-05	9.71E-06	Yes
Mn-54	1.17E+04	2.39E-09	2.33E-13	2.60E-12	3.58E-12	Yes
Mo-93	1.08E+00	8.51E-04	3.47E-08	6.27E-07	1.27E-06	Yes
Nb-92m	6.36E-07	6.33E-07	2.20E-10	2.90E-09	9.49E-10	Yes
Nb-94	8.86E-01	8.85E-01	2.80E-05	7.19E-05	1.32E-03	Yes*
Ni-59	6.04E+02	6.04E+02	1.80E-02	8.00E-02	9.01E-01	No
Ni-63	8.00E+04	6.23E+04	1.79E+00	7.44E+00	9.29E+01	No
Pb-205	4.00E-06	4.00E-06	2.58E-10	3.04E-09	5.97E-09	Yes
Pm-145	4.40E-03	1.07E-03	3.16E-08	2.29E-08	1.60E-06	Yes
Pu-239	3.81E-02	3.80E-02	3.00E-06	6.79E-05	5.67E-05	Yes*
Se-79	1.40E-03	1.40E-03	9.80E-08	1.00E-06	2.09E-06	Yes
Sm-146	4.08E-10	4.07E-10	4.50E-14	6.20E-13	6.08E-13	Yes
Sm-151	5.32E-02	4.05E-02	1.38E-05	1.11E-04	6.06E-05	Yes
Sn-121m	1.07E-02	7.19E-05	6.72E-09	9.41E-08	1.07E-07	Yes
Sr-90	2.11E+00	8.80E-01	5.84E-06	2.54E-05	1.31E-03	Yes*
Tb-158	5.31E-03	4.49E-03	5.34E-07	6.77E-06	6.70E-06	Yes
Tc-99	2.10E-01	2.10E-01	9.00E-06	1.59E-04	3.13E-04	Yes*
U-233	2.25E-03	2.25E-03	1.30E-07	2.00E-06	3.36E-06	Yes
Zn-65	1.55E+03	9.00E-14	2.38E-18	1.68E-18	1.34E-16	Yes

Evaluation of NUREG/CR-3474 Total Activity Fractions

Radionuclide	Activity - Ci				Percent Total	Less than 0.1%?
	Shroud	Vessel Cladding	Vessel Walls	Total Activity		
Zr-93	1.41E-04	1.41E-04	6.90E-09	8.10E-08	2.10E-07	Yes
Total	6.70E+04	1.94E+00	8.38E+00	6.70E+04	**1.00E+02**	
Total percent of activity discounted					6.57E-03	

* Radionuclides meet the criteria of contributing less than 0.1 percent of the total activity but cannot be discounted because they have other methods of production in addition to activation of reactor components and/or have been observed in 10 CFR Part 61 waste stream analyses or site characterization samples.

Based on the above evaluation, it was determined that individual radionuclides which contributed less than 0.1 percent of the total activity could be discounted providing that dose contributed by the sum of the those radionuclides does not exceed one percent of the total calculated dose. The total percentage of activity attributed to radionuclides that meet these criteria amounts to 0.007 percent.

With the exception of Co-60, radionuclides with half-lives less than 5.4 years identified in NUREG/CR-4289 were discounted and not included in the list provided in Table 5–3. Based on the time period from final shutdown of HBPP to the anticipated completion of the license termination in 2016, it is highly unlikely that any activity from radionuclides with half-lives less than 5.4 years (7 half-lives) would remain significant. Although Co-60 has a half-life of 5.27 years, the HBPP HSA reported a September 1, 2006 inventory of 672.3 Ci of Co-60. Assuming a July 1, 2016 license termination (estimated date at the TBD development), the Co-60 inventory at that time would still be approximately 172 Ci. Therefore, it is appropriate to retain Co-60 in the list of potential radionuclides.

Radionuclides identified in NUREG/CR-4289 along with their half-lives in years and their decay modes, are provided in Table 5–3.

Table 5- 3

Radionuclides Identified in NUREG/CR-4289

Radionuclide	Half Life (Years)	Decay Mode
Am-241	4.32E+02	α, γ
C-14	5.73E+03	β-
Cm-244	1.81E+01	α, γ
Co-60	5.27E+00	β-, γ
Cs-137	3.02E+01	β-
Eu-152	1.36E+01	β-, γ
Eu-154	8.80E+00	β-, γ
H-3	1.23E+01	β-
I-129	1.57E+07	β-, γ

Radionuclides Identified in NUREG/CR-4289

Radionuclide	Half Life (Years)	Decay Mode
Nb-94	2.03E+04	β-, γ
Ni-59	7.50E+04	γ
Ni-63	1.00E+02	β-
Np-237	2.14E+6	α, γ
Pu-238	8.78E+01	α, γ
Pu-239	2.41E+04	α, γ
Pu-240	6.60E+03	α, γ
Sr-90	2. 86E+01	β-
Tc-99	2.13E+05	β-, γ

α – Alpha decay
β- – Beta decay
γ – Gamma decay

5.2.2 Potential Discounted Dose Considerations

Based on the above evaluation, it was determined that individual radionuclides which contributed less than 0.1 percent of the total activity in Table 5-2 could be discounted from the list of Table 5-1 identified radionuclides providing that potential dose contributed by the sum of the radionuclides discounted does not exceed one percent of the total calculated dose. The radionuclides that meet the criteria of contributing less than 0.1 percent-of the total activity include:

Eu-155	Hf-178m	Ho-166m	Kr-81	Kr-85	Mn-53	Mn-54
Mo-93	Nb-92m	Pb-205	Pm-145	Se-79	Sm-146	Sm-151
Sn-121m	Tb-158	Zn-65	Zr-93	U-233	Ar-39	Ba-133
Ca-41	Cl-36	Cs-134	Cs-135	Ag-108m		

Although originally included in the list of theoretical radionuclides, the naturally occurring radionuclides K-40, U-234, U-235, U-236 and U-238 have not been detected in characterization/waste stream samples at concentrations distinguishable from naturally occurring concentrations. Therefore, these radionuclides have been discounted from any further consideration. In order to evaluate compliance with the dose criteria for discounted radionuclides, the NRC developed computer code DandD, Version 2.1.0 was used to calculate doses for both residential and occupancy scenarios for those nuclides supported by the DandD code. The DandD code was used with the NRC determined default parameters to represent a conservative screening tool. Input concentrations for each radionuclide used in the residential scenario were their percent of total activity input as concentration in pCi/g. Input concentrations-for each radionuclide used in the occupancy scenario were 1,000 times their percent of total

activity input as surface contamination in dpm/100 cm^2. Calculated doses for the following nuclides were developed using the DandD code:

Cl-36	Ca-41	Mn-54	Zn-65	Se-79	Zr-93	Mo-93
Cs-134	Cs-135	Sm-151	Eu-155	Ho-166m	U-233	Sn-121m

The calculated total dose from discounted NUREG radionuclides represents only 0.007 percent of the total calculated dose for the residential scenario. The calculated total dose from discounted NUREG radionuclides represents only 0.0002 percent for the occupancy scenario. Therefore, it is appropriate to discount these radionuclides. Summary reports for the DandD calculations are included in Attachment A. Summary Results are depicted in Tables 5-4 and 5-5.

Table 5- 4

Building Occupancy			
Nuclide	Not discounted All pathways dose (mrem)	Nuclide	Discounted All pathways dose (mrem)
H-3	7.86E-06	Cl-36	1.89E-04
C-14	1.13E-03	Ca-41	1.39E-07
Fe-55	8.20E-04	Mn-54	2.84E-12
Co-60	2.10E+01	Zn-65	7.02E-17
Ni-63	1.45	Se-79	7.01E-08
Sr-90	4.21E-03	Zr-93	1.61E-07
Nb-94	4.14E-03	Mo-93	9.73E-08
Tc-99	6.76E-06	Cs-134	5.29E-07
Cs-137	1.82E-04	Cs-135	1.08E-08
Eu-152	1.00E-05	Sm-151	4.33E-06
Eu-154	2.51E-03	Eu-155	8.33E-06
Pu-239	5.81E-02	Ho-166m	2.43E-03
		U-233	1.08E-03
Total	2.25E+01	Sn-121m	3.83E-09
		Total	3.71E-03
		% Total	0.0002

Table 5- 5

Residential			
Nuclide	Not discounted All pathways dose (mrem)	Nuclide	Discounted All pathways dose (mrem)
H-3	1.29E-02	Cl-36	2.82E-01
C-14	1.08E-01	Ca-41	1.36E-05
Fe-55	3.14E-04	Mn-54	6.22E-12
Co-60	3.88E+01	Zn-65	3.64E-16
Ni-63	7.02E-01	Se-79	2.65E-07
Sr-90	2.06E-02	Zr-93	2.09E-09
Nb-94	5.71E-03	Mo-93	1.65E-07
Tc-99	5.14E-04	Cs-134	1.21E-06
Cs-137	1.17E-03	Cs-135	6.91E-08
Eu-152	1.42E-05	Sm-151	8.55E-08
Eu-154	3.46E-03	Eu-155	4.29E-06
Pu-239	6.66E-04	Ho-166m	2.58E-03
		U-233	4.17E-06
Total	3.97E+01	Sn-121m	1.46E-09
		Total	2.85E-01
		% Total	0.007%

DandD does not support the following radionuclides and could not calculate their dose contribution:

Ar-39 Mn-53 Kr-81 Kr-85 Ba-133 Ag-108m

Pm-145 Sm-146 Tb-158 Hf-178m Pb-205

The activity represented by the radionuclides not supported by the DandD code is calculated to be only 2.80E-03 percent of the total activity presented in NUREG/CR-3474. Of these radionuclides, Ar-39, Kr-81 and Kr-85 are noble gases and it is highly unlikely that they would still be present in soil and on structural surfaces. Therefore, it is appropriate to discount Ar-39, Kr-81 and Kr-85. Potential dose contribution from the remaining radionuclides not supported by the DandD code was evaluated by comparison of the inhalation and ingestion dose conversion factors (DCFs) contained in Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion.* Weighted DCFs were calculated for each discounted radionuclide and summed for both inhalation and ingestion DCFs. These totals were then compared to the sum of the weighted DCFs for the two most abundant radionuclides, Co-60 and Ni-63. This resulted in a total of 1.36E-02 percent for inhalation DCFs and 4.93E-03 percent for

ingestion DCFs. The calculations to demonstrate these results are provided in Table 5-6.

Table 5- 6

		Inhalation			Ingestion		
Radionuclide	**Percent total**	**DCF**	**Weighted DCF**	**% total Wt. DCF**	**DCF**	**Weighted DCF**	**% total Wt. DCF**
Mn-53	9.71E-06	1.35E-10	1.22E-15	1.94E-07	2.92E-11	2.65E-16	3.22E-07
Ba-133	1.38E-03	2.11E-09	3.57E-12	5.68E-04	9.19E-10	1.55E-12	1.89E-03
Pm-145	1.60E-06	6.85E-09	1.21E-14	1.92E-06	1.28E-10	2.24E-16	2.73E-07
Sm-146	6.08E-13	2.23E-05	1.26E-17	2.00E-09	5.51E-08	3.12E-20	3.80E-11
Tb-158	5.70E-06	6.91E-08	4.40E-13	7.00E-05	1.19E-09	7.58E-15	9.23E-06
Hf-178m	3.37E-04	1.79E-07	6.19E-11	9.84E-03	5.68E-09	1.97E-12	2.39E-03
Pb-205	5.97E-09	1.06E-09	5.90E-18	9.38E-10	4.41E-10	2.46E-18	2.99E-09
Ag-108m	2.55E-04	7.66E-08	1.95E-11	3.10E-03	2.06E-09	5.25E-13	6.40E-04
			Total	1.36E-02		Total	4.93E-03
Co-60	9.37E+00	5.91E-08	5.54E-07		7.28E-09	6.82E-08	
Ni-63	8.92E+01	8.39E-10	7.48E-08		1.56E-10	1.39E-08	
		Total	6.29E-07		Total	8.21E-08	

Additionally the potential external dose contribution from the remaining radionuclides not supported by the DandD code was evaluated by comparing the summed weighted Exposure to Contaminated Ground Surface DCFs contained in Federal Guidance Report No. 12, *External Exposure to Radionuclides in Air, Water, and Soil for the comparison of the external dose component* to the most abundant gamma producing radionuclide Co-60. No external dose component contributed greater than 9.69E-05 percent as shown in Table 5-7.

Table 5- 7

	% Total Weighted DCF								
Nuclide	Gonad	Breast	Lung	R Marrow	B Surface	Thyroid	Remainder	Effective	Skin
Mn-53	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ba-133	2.49E-05	2.54E-05	2.37E-05	2.30E-05	3.42E-05	2.38E-05	2.35E-05	2.46E-05	2.52E-05
Pm-145	4.79E-10	5.29E-10	3.03E-10	2.21E-10	9.88E-10	3.49E-10	3.05E-10	4.04E-10	5.65E-10
Sm-146	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tb-158	2.06E-07	2.07E-07	2.03E-07	2.02E-07	2.24E-07	2.03E-07	2.03E-07	2.05E-07	2.08E-07

				% Total	Weighted	DCF			
Nuclide	Gonad	Breast	Lung	R Marrow	B Surface	Thyroid	Remainder	Effective	Skin
Hf-178m	3.30E-05	3.35E-05	3.19E-05	3.11E-05	4.28E-05	3.18E-05	3.16E-05	3.27E-05	3.32E-05
Pb-205	4.55E-16	9.39E-16	1.81E-18	3.69E-17	1.57E-16	4.13E-17	1.10E-16	3.10E-16	1.62E-14
Ag-108m	1.75E-05	1.76E-05	1.70E-05	1.68E-05	1.97E-05	1.70E-05	1.70E-05	1.73E-05	1.76E-05
Total	7.57E-05	7.67E-05	7.28E-05	7.10E-05	9.69E-05	7.28E-05	7.23E-05	7.48E-05	7.62E-05

Therefore, it is appropriate to discount all of the radionuclides not supported by the DandD code.

5.3 HBPP Historical Site Assessment

Historical 10 CFR Part 61 analyses have also identified Pu-241 and the combination radionuclides of Cm-243/244 and Cm-245/246 to be present in the waste streams analyzed. Therefore, these radionuclides should be added to the list of radionuclides potentially present.

6.0 Conclusion

Table 6–1 represents a list of radionuclides potentially present at HBPP based on applying the described screening criteria to the combined list of potential radionuclides from regulatory guidance contained in NUREG/CR-3474 and NUREG/CR-4289 and historical 10 CFR Part 61 analyses.

Table 6- 1

HBPP Site-Specific Suite of Radionuclides

Radionuclide	Half Life (Years)
*Cm-243/244	1.81E+01
*Cm-245/246	4.75E+03
Am-241	4.32E+02
C-14	5.73E+03
Co-60	5.27E+00
Cs-137	3.02E+01
Eu-152	1.36E+01
Eu-154	8.80E+00
H-3	1.23E+01
I-129	1.57E+07
Nb-94	2.03E+04
Ni-59	7.50E+04
Ni-63	1.00E+02
Np-237	2.14E+06
Pu-238	8.78E+01
Pu-239	2.41E+04
Pu-240	6.60E+03
Pu-241	1.44E+01
Sr-90	2. 86E+01
Tc-99	2.13E+05

*Listed half-life is the shortest half-life for the radionuclides in the pair

7.0 References

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