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Special Analysis for the Disposal of the Oak Ridge National Laboratory Activated Metal Waste Stream at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada

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Acronyms and Abbreviations

Bq	becquerel
Bq m^{-3}	becquerel per cubic meter
Bq m^{-2} s^{-1}	becquerel per square meter per second
D&D	Decontamination and decommissioning
ft	foot/feet
FY	(Federal) fiscal year
LHS	Latin hypercube sample
m	meter(s)
mSv	milliseivert(s)
NNSS	Nevada National Security Site
ORNL	Oak Ridge National Laboratory
PA	Performance Assessment
RWMS	Radioactive Waste Management Site
SA	Special Analysis
SLB	Shallow land burial
TED	Total effective dose
UDQ	Unreviewed disposal question
UGTA	Underground Test Area
WAC	Waste Acceptance Criteria
y	years

1.0 Introduction

This special analysis (SA) evaluates whether the Oak Ridge National Laboratory (ORNL) Activated Metal waste stream (ORNLACTMETAL1, Revision 4) is suitable for disposal by shallow land burial (SLB) at the Area 5 Radioactive Waste Management Site (RWMS) on the Nevada National Security Site (NNSS). The ORNL Activated Metal waste stream consists of metal irradiated in ORNL research reactors (ORNL 2016a). The ORNL Activated Metal waste stream requires an SA to resolve two unreviewed disposal questions (UDQs). The first UDQ addresses whether it is acceptable to dispose 12 radionuclides with activity concentrations that exceed the NNSS Waste Acceptance Criteria (WAC) Action Level (U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office [NNSA/NFO] 2015a). The second UDQ evaluates the acceptability of disposing of 23 long-lived radionuclides without WAC action levels. Long-lived radionuclides without action levels are radionuclides not evaluated in the performance assessment (PA).

2.0 Methods

The SA evaluates the impact of the ORNL Activated Metal waste stream inventory on the long-term performance of the Area 5 RWMS.

2.1 Waste Description

The ORNL Activated Metal waste stream is activated metal produced in ORNL research reactors, accelerators, and research laboratories including the High Flux Isotope Reactor, the Spallation Neutron Source, the Low-Activation Materials Development Laboratory, and the Irradiated Fuels Examination Laboratory. The waste consists of disassembled target capsules, thermocouple wires, clamps, liners, control plates, nuts, bolts, pipes, reflectors, cages, beam flanges, ceramic and metal rabbits, proton beam windows and other related job control waste. The waste stream does not include spent nuclear fuel or waste from reprocessing spent nuclear fuel.

The waste stream includes 12 radionuclides that exceed the NNSS WAC action levels (Table 1). Disposal of the ORNL Activated Metal waste stream may significantly increase the inventory of lead-210 (^{210}Pb), cobalt-60 (^{60}Co), thorium-229 (^{229}Th), europium-154 (^{154}Eu), ^{152}Eu, and cesium-137 (^{137}Cs). All of these radionuclides, except ^{229}Th, have relatively short half-lives and will decay to insignificant levels during institutional control.

Table 1. Comparison of ORNL Activated Metal Waste Stream Inventory and the Disposed Inventory of Radionuclides Exceeding their Action Levels at Closure (NSTec 2016)

Nuclide	FY 2015 SLB Disposed Geometric Mean Inventory (Bq)	Geometric Mean ORNLACTMETAL1_4 Inventory (Bq)	Relative Percent Change
^{210}Pb	8.6E+11	3.26E+14	3.8E4
^{60}Co	5.9E+14	2.57E+16	4.4E3
^{229}Th	6.0E+11	1.04E+13	1.7E3
^{154}Eu	6.4E+13	4.91E+14	7.7E2
^{152}Eu	4.7E+13	2.75E+14	5.9E2
^{137}Cs	3.5E+15	1.18E+15	34
^{226}Ra	1.2E+12	7.51E+10	6.3

Nuclide	FY 2015 SLB Disposed Geometric Mean Inventory (Bq)	Geometric Mean ORNLACTMETAL1_4 Inventory (Bq)	Relative Percent Change
^{230}Th	3.6E+11	1.1E+10	3.1
^{234}U	1.8E+14	2.81E+12	1.6
^{3}H	3.5E+16	1.03E+14	0.29
^{90}Sr	4.4E+16	8.98E+13	0.20
^{99}Tc	7.0E+14	9.34E+11	0.13

The ORNL Activated Metal waste stream also includes 23 radionuclides with half-lives greater than 5 years that do not have WAC action levels. These are nuclides that were not expected to be disposed at the time the PA was prepared and thus were not evaluated in the PA (Table 2).

Table 2. ORNL Activated Metals Waste Stream Activity of Long-Lived Radionuclides without Action Levels.

Nuclide	Half-Life (y)†	Geometric Mean Activity at Disposal 1/5/2016 (Bq)‡
^{10}Be	1.51E+06	1.61E+12
^{32}Si	153	1.72E+10
^{42}Ar	32.9	5.45E+10
^{44}Ti	60	1.62E+12
^{53}Mn	3.70E+06	6.53E+08
^{60}Fe	2.62E+06	2.55E+06
^{81}Kr	2.29E+05	1.30E+08
^{91}Nb	680	9.29E+11
^{92}Nb	3.47E+07	1.20E+06
^{93}Mo	4000	6.64E+12
^{97}Tc	4.21E+06	1.24E+06
^{98}Tc	4.20E+06	2.85E+05
^{108m}Ag	418	1.41E+08
^{145}Pm	17.7	5.07E+12
^{146}Pm	5.53	2.38E+11
^{148}Gd	74.6	1.65E+12
^{157}Tb	71	1.80E+12
^{158}Tb	180	5.01E+08
^{163}Ho	4566	1.02E+11
^{172}Hf	1.87	1.51E+14
^{193}Pt	50	5.40E+13
^{194}Hg	444	5.72E+08
^{194}Os	6	4.06E+11

† - NNDC (2016)
‡ - Product of waste profile representative activity concentration and waste stream volume

2.2 Performance Assessment Modeling

The PA modeling is performed by adding the inventory of the ORNL Activated Metal waste stream to the fiscal year (FY) 2015 baseline PA model (A5 RWMS version [v] 4.121) and determining if there is a reasonable expectation of meeting the U.S. Department of Energy (DOE) Manual DOE M 435.1-1, "Radioactive Waste Management Manual," Chapter IV, Section P performance objectives (DOE 1999).

The ORNL Activated Metal waste stream radionuclide activities are assumed to be lognormally distributed. The geometric mean of the distribution is assumed to be the product of the representative activity concentration and the total remaining volume, 54 m^3, as reported on the waste profile, except for ^{226}Ra (ORNL 2016a) (Table 3). The waste stream ^{226}Ra activity was estimated by the generator in response to comments generated during the Radioactive Waste Acceptance Program review of the waste profile (ORNL 2016b).

Table 3. ORNL Activated Metal Waste Stream Activity Concentration and Total Activity at the Time of Disposal Assumed for Performance Assessment Modeling

Nuclide	Geometric Mean Activity Concentration (Bq m^{-3})	95th Percentile Activity Concentration (Bq m^{-3})	Geometric Mean Activity (Bq)	95th Percentile Activity (Bq)	Geometric Standard Deviation
^{108m}Ag	2.62E+06	2.62E+06	1.41E+08	1.41E+08	1.01‡
^{26}Al	1.11E+06	2.13E+06	5.99E+07	1.15E+08	1.48
^{243}Am	1.81E+08	3.54E+08	9.77E+09	1.91E+10	1.50
^{39}Ar	1.53E+10	3.05E+10	8.26E+11	1.65E+12	1.52
^{42}Ar	1.01E+09	1.93E+09	5.45E+10	1.04E+11	1.48
^{133}Ba	3.02E+10	5.98E+10	1.63E+12	3.23E+12	1.51
^{10}Be	2.99E+10	5.98E+10	1.61E+12	3.23E+12	1.52
^{14}C	8.58E+10	1.72E+11	4.63E+12	9.29E+12	1.52
^{41}Ca	3.67E+07	7.34E+07	1.98E+09	3.96E+09	1.52
^{113m}Cd	1.79E+09	3.53E+09	9.67E+10	1.91E+11	1.51
^{36}Cl	1.56E+07	2.98E+07	8.42E+08	1.61E+09	1.48
^{243}Cm	9.19E+08	1.84E+09	4.96E+10	9.94E+10	1.52
^{244}Cm	9.19E+08	1.84E+09	4.96E+10	9.94E+10	1.52
^{245}Cm	5.57E+07	1.09E+08	3.01E+09	5.89E+09	1.50
^{246}Cm	5.57E+07	1.09E+08	3.01E+09	5.89E+09	1.50
^{60}Co	2.54E+15	5.08E+15	1.37E+17	2.74E+17	1.52
^{137}Cs	2.94E+13	5.87E+13	1.59E+15	3.17E+15	1.52
^{150}Eu	1.61E+09	3.19E+09	8.69E+10	1.72E+11	1.51
^{152}Eu	9.79E+12	1.96E+13	5.29E+14	1.06E+15	1.52
^{154}Eu	2.54E+13	5.07E+13	1.37E+15	2.74E+15	1.52
^{60}Fe	4.72E+04	9.01E+04	2.55E+06	4.87E+06	1.48
^{148}Gd	3.05E+10	6.03E+10	1.65E+12	3.26E+12	1.51
^{3}H	3.89E+12	7.76E+12	2.10E+14	4.19E+14	1.52
^{172}Hf	2.79E+12	5.53E+12	1.49E+14	2.99E+14	1.51
^{194}Hg	1.06E+07	1.06E+07	5.72E+08	5.72E+08	1.01‡
^{163}Ho	1.88E+09	3.71E+09	1.02E+11	2.00E+11	1.51
^{40}K	3.89E+03	7.43E+03	2.10E+05	4.01E+05	1.48
^{81}Kr	2.40E+06	4.58E+06	1.30E+08	2.47E+08	1.48

Nuclide	Geometric Mean Activity Concentration (Bq m^{-3})	95th Percentile Activity Concentration (Bq m^{-3})	Geometric Mean Activity (Bq)	95th Percentile Activity (Bq)	Geometric Standard Deviation
^{85}Kr	8.24E+07	1.63E+08	4.45E+09	8.80E+09	1.51
^{53}Mn	1.21E+07	2.32E+07	6.53E+08	1.25E+09	1.48
^{93}Mo	1.23E+11	2.46E+11	6.64E+12	1.33E+13	1.52
^{91}Nb	1.72E+10	3.41E+10	9.29E+11	1.84E+12	1.51
^{92}Nb	2.22E+04	4.24E+04	1.20E+06	2.29E+06	1.48
^{93m}Nb	1.18E+11	2.33E+11	6.37E+12	1.26E+13	1.51
^{94}Nb	2.21E+08	4.38E+08	1.19E+10	2.37E+10	1.51
^{59}Ni	9.71E+12	1.94E+13	5.24E+14	1.05E+15	1.52
^{63}Ni	8.18E+12	1.64E+13	4.42E+14	8.86E+14	1.52
^{194}Os	7.51E+09	1.48E+10	4.06E+11	7.99E+11	1.51
^{210}Pb	8.98E+12	1.75E+13	4.85E+14	9.45E+14	1.50
^{145}Pm	9.39E+10	1.86E+11	5.07E+12	1.00E+13	1.51
^{146}Pm	4.41E+09	8.71E+09	2.38E+11	4.70E+11	1.51
^{193}Pt	1.00E+12	2.00E+12	5.40E+13	1.08E+14	1.52
^{239}Pu	2.54E+08	2.54E+08	1.37E+10	1.37E+10	1.01‡
^{240}Pu	8.19E+07	8.19E+07	4.42E+09	4.42E+09	1.01‡
^{226}Ra†	6.25E+12	6.25E+12	7.55E+10	4.41E+11	2.91
^{228}Ra	3.12E+12	6.24E+12	1.68E+14	3.37E+14	1.52
^{32}Si	3.18E+08	6.07E+08	1.72E+10	3.28E+10	1.48
^{121m}Sn	5.47E+06	5.47E+06	2.95E+08	2.95E+08	1.01‡
^{90}Sr	2.26E+12	4.51E+12	1.22E+14	2.44E+14	1.52
^{157}Tb	3.33E+10	6.58E+10	1.80E+12	3.55E+12	1.51
^{158}Tb	9.28E+06	9.28E+06	5.01E+08	5.01E+08	1.01‡
^{97}Tc	2.30E+04	4.38E+04	1.24E+06	2.37E+06	1.48
^{98}Tc	5.27E+03	1.01E+04	2.85E+05	5.45E+05	1.48
^{99}Tc	1.73E+10	3.46E+10	9.34E+11	1.87E+12	1.52
^{228}Th	5.56E+10	5.56E+10	3.00E+12	3.00E+12	1.01‡
^{229}Th	1.92E+11	1.92E+11	1.04E+13	1.04E+13	1.01‡
^{230}Th	2.04E+08	2.04E+08	1.10E+10	1.10E+10	1.01‡
^{232}Th	2.43E+07	2.43E+07	1.31E+09	1.31E+09	1.01‡
^{44}Ti	3.00E+10	5.92E+10	1.62E+12	3.20E+12	1.51
^{233}U	3.15E+07	5.85E+07	1.70E+09	3.16E+09	1.46
^{234}U	5.20E+10	1.04E+11	2.81E+12	5.62E+12	1.52
^{235}U	4.58E+09	4.58E+09	2.47E+11	2.47E+11	1.01‡
^{236}U	4.70E+08	4.70E+08	2.54E+10	2.54E+10	1.01‡
^{238}U	2.37E+11	2.37E+11	1.28E+13	1.28E+13	1.01‡
^{93}Zr	1.19E+05	2.27E+05	6.43E+06	1.23E+07	1.48

† - Activity from ORNL (2016b)
‡ - Assumed nominal geometric standard deviation

The upper limit activity concentration is assumed to be the 95th percentile of the lognormal distribution. The geometric standard deviation of the lognormal distribution is calculated as:

$$GSD = e^{\frac{\ln(UL) - \ln(GM)}{1.65}}$$

where

GSD	=	geometric standard deviation (dimensionless)
UL	=	95th percentile activity, Bq
GM	=	geometric mean, Bq

In some cases, the estimated representative concentration and upper limit concentration are the same. These radionuclides are assigned a nominal geometric standard deviation of 1.01.

The SA is performed by adding the ORNL Activated Metal waste stream radionuclide activity to the inventory of post-1988 SLB waste disposed through FY 2015. In addition to the SLB inventory, the SA includes the Pit 6, Pit 13, and post-1988 Greater Confinement Disposal borehole inventories. The model is run with a 2.5-meter (m) (8.2-foot [ft]) closure cover for SLB disposal units.

The mean and median model results are calculated using 5,000 Latin hypercube samples (LHS). A sample size of 5,000 has been previously shown to provide stable estimates of the mean and 95th percentile results for earlier versions of the PA model (Bechtel Nevada [BN] 2006). A reasonable expectation of compliance with the performance objectives is assumed if the mean and median are less than the performance objectives for 1,000 years after closure. In every case, the mean was greater than the median. Only the mean results are reported in the SA.

For comparison purposes, baseline results are obtained by running the model with the inventory disposed through FY 2015 and without the ORNL Activated Metal waste stream.

2.3 Radionuclide Screening

The ORNL Activated Metal waste stream includes long-lived radionuclides not considered in the PA. The acceptability of these radionuclides is evaluated by comparing the waste stream total activity to inventory screening limits. The inventory screening limits are derived as the total activity added to the site inventory that would cause any PA result to be 0.001 times the applicable performance objective. The inventory screening limits assume continuous direct exposure to undiluted waste for one year. Radionuclides less than the inventory screening limits are assumed to have negligible impact on PA results and do not need to be included in the PA model. The ORNL Activated Metal waste stream activities are decayed to final closure on October 1, 2028, for comparison with the inventory screening limits.

3.0 Results

3.1 Long-Lived Radionuclides without Action Levels

Comparison of the ORNL Activated Metal waste stream activity of long-lived radionuclides with their screening limits indicates that the activities of 21 of 23 nuclides are less than their screening limits and can be screened from the PA modeling (Table 4). The two remaining nuclides, titanium-44 (^{44}Ti) and gadolium-148 (^{148}Gd), are included in the current PA model. Therefore, the PA results presented below assess the acceptability of these two radionuclides.

Table 4. Comparison of the Waste Stream Activity of Long-Lived Radionuclides without Action Levels with Their Screening Limits for Inclusion in PA Modeling.

Nuclide	Geometric Mean Activity at Closure on 10/1/2028 (Bq)	Inventory Screening Limit (Bq)
^{10}Be	1.61E+12	1.5E+13
^{32}Si	1.62E+10	4.5E+12
^{42}Ar	4.17E+10	4.4E+11
^{44}Ti	1.40E+12	6.3E+10
^{53}Mn	6.53E+08	1.5E+15
^{60}Fe	2.55E+06	5.2E+10
^{81}Kr	1.30E+08	3.6E+25
^{91}Nb	9.17E+11	2.8E+14
^{92}Nb	1.20E+06	1.9E+13
^{93}Mo	6.63E+12	2.3E+14
^{97}Tc	1.24E+06	2.9E+14
^{98}Tc	2.85E+05	9.9E+10
^{108m}Ag	1.39E+08	8.9E+10
^{145}Pm	3.08E+12	3.4E+13
^{146}Pm	4.82E+10	6.0E+10
^{148}Gd	1.46E+12	2.0E+10
^{157}Tb	1.59E+12	1.6E+14
^{158}Tb	4.77E+08	1.8E+11
^{163}Ho	1.01E+11	1.9E+15
^{172}Hf	1.34E+12	1.6E+13
^{193}Pt	4.53E+13	7.7E+14
^{194}Hg	5.61E+08	1.3E+11
^{194}Os	9.31E+10	1.5E+12

3.2 Performance Assessment Results

3.2.1 Air Pathway Results

The air pathway annual total effective dose (TED) is evaluated for the resident exposure scenario using 5,000 LHS realizations. The resident exposure scenario estimates the dose to an adult residing in a home at the 100 meters (m) (330 feet [ft]) site boundary. A complete description of the exposure scenario can be found in the earlier PA documentation (BN 2006). The annual TED is calculated for a period of 1,000 years after closure. The maximum mean and 95th percentile annual TED occur at 1,000 years and are both less than the 0.1 millisievert (mSv) limit (Table 5). Addition of the ORNL Activated Metal waste stream moderately increases the maximum resident air pathway TED. The increase is due predominantly to ^{229}Th.

Table 5. Maximum Air Pathway Annual TED for a Resident at the Area 5 RWMS 100-m (330-ft) Site Boundary and the Waste Inventory Disposed through FY 2015

Scenario	Time of Maximum†	Mean (mSv)	95th Percentile (mSv)
Resident with FY 2015 Baseline Inventory	1,000 y	1.5E-4	5.1E-4
Resident with ORNLACTMETAL1_4 Waste Stream	1,000 y	1.7E-4	5.9E-4

† - years after closure

Addition of the ORNL Activated Metal waste stream increases the air pathways mean and 95th percentile annual TED throughout the compliance period (Figure 1). The largest relative increase in the mean, approximately 17%, occurs at 450 years after closure.

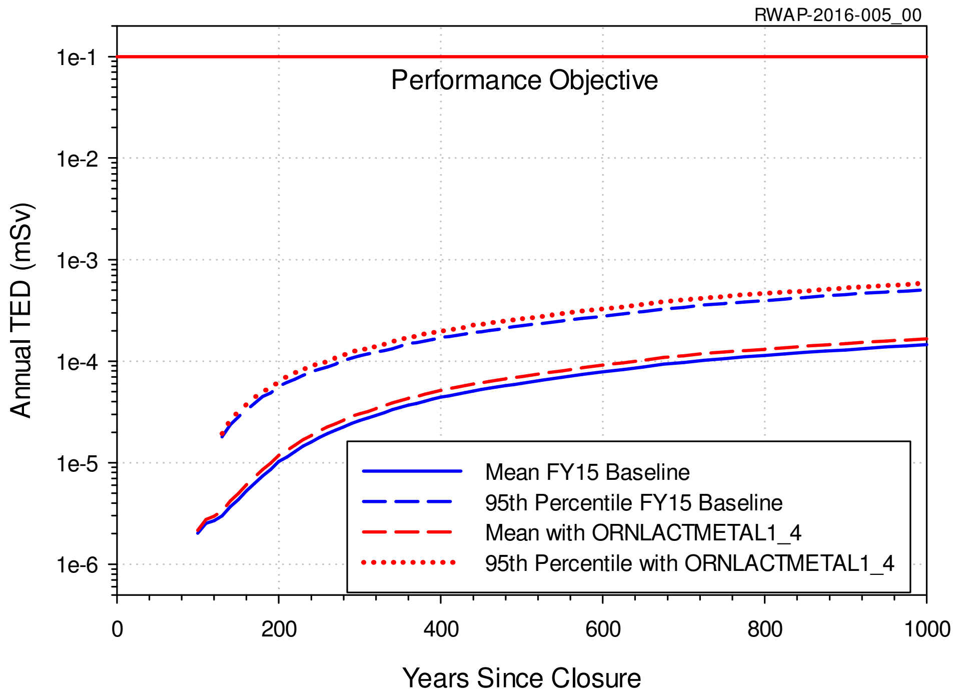

Figure 1. Air Pathway Annual TED Time History for a Resident at the 100-m (330-ft) Boundary with and without the ORNLACTMETAL1_4 Waste Stream

3.2.1.1 Alternative Air Pathway Scenarios

Uncertainty contributed by the selected exposure scenario was evaluated by calculating air pathway annual TED for alternative scenarios. The scenarios evaluated are the transient occupancy scenario, the resident farmer scenario, and open rangeland scenarios for a ranch at two plausible locations: one at the NNSS boundary closest to the Area 5 RWMS and another at Cane Spring. The scenarios and their assumptions have been described previously (BN 2006).

The maximum mean and the 95th percentile TEDs are all less than the performance objective for all of the alternative scenarios (Table 6). Although the exposure scenario is a source of uncertainty, there is a high likelihood of compliance for a range of reasonable scenarios. Addition of the ORNL Activated Metal waste stream increases the maximum air pathway TED for all scenarios. The increases are due predominantly to ^{229}Th.

Table 6. Maximum Air Pathway Annual TEDs for Alternative Scenarios with the FY 2015 Inventory

Scenario	Inventory	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Transient Occupancy	FY 2015 Baseline Inventory	1,000 y	7.4E-5	2.6E-4
	FY 2015 with ORNLACTMETAL1_4	1,000 y	8.5E-5	3.0E-4
Resident with Agriculture	FY 2015 Baseline Inventory	1,000 y	4.0E-4	1.4E-3
	FY 2015 with ORNLACTMETAL1_4	1,000 y	4.6E-4	1.7E-3
Open Rangeland/Cane Spring	FY 2015 Baseline Inventory	1,000 y	5.3E-9	1.5E-8
	FY 2015 with ORNLACTMETAL1_4	1,000 y	6.1E-9	1.7E-8
Open Rangeland/NNSS Boundary	FY 2015 Baseline Inventory	1,000 y	9.0E-8	2.5E-7
	FY 2015 with ORNLACTMETAL1_4	1,000 y	1.0E-7	2.9E-7

3.2.2 All-Pathways Results

The all-pathways annual TED is also calculated for the resident exposure scenario. The maximum mean and 95th percentile resident all-pathways annual TEDs are less than the 0.25 mSv limit (Table 7). Addition of the ORNL Activated Metal waste stream increases the maximum resident all-pathway annual TED. The increase is due predominantly to ^{229}Th.

Table 7. Maximum All-Pathways Annual TED for a Resident at the Area 5 RWMS 100-m (330-ft) Site Boundary and the Waste Inventory Disposed through FY 2015

Scenario	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Resident with FY 2015 Baseline Inventory	1,000 y	7.4E-4	2.3E-3
Resident with ORNLACTMETAL1_4 Waste Stream	1,000 y	8.3E-4	2.6E-3

Addition of the ORNL Activated Metal waste stream increases the all-pathways annual TED throughout the compliance period (Figure 2). The largest relative increase in the mean, 25%, occurs at 110 years after closure.

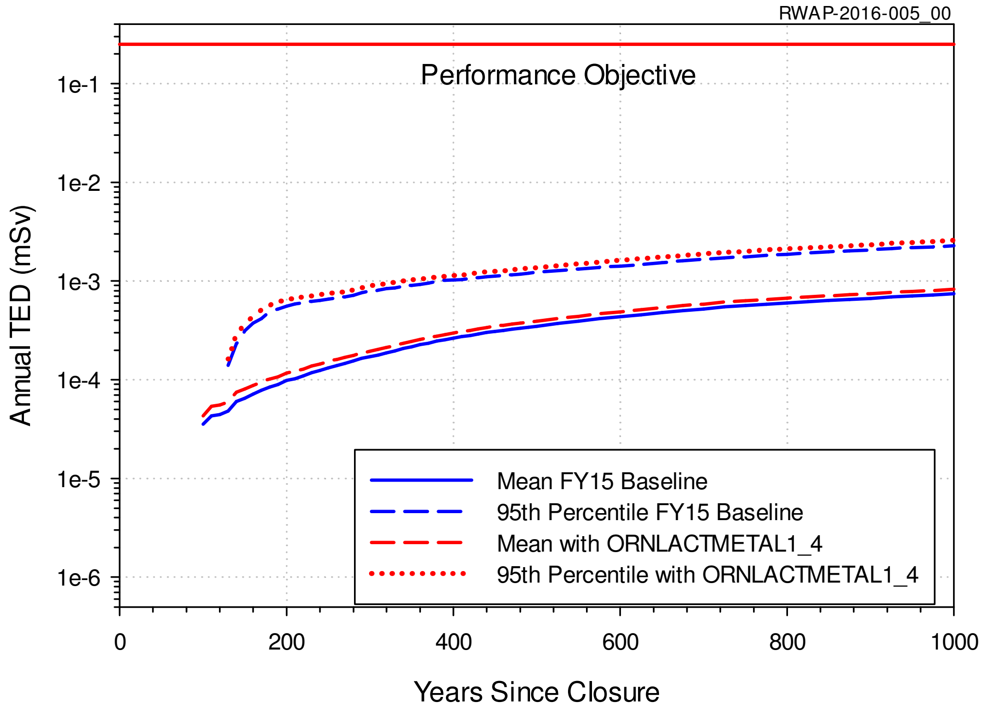

Figure 2. All-Pathways Annual TED Time History for a Resident at the 100-m (330-ft) Boundary with and without the ORNLACTMETAL1_4 Waste Stream

3.2.2.1 Alternative All-Pathways Scenarios

Uncertainty contributed by the selected exposure scenarios was evaluated by calculating the all-pathway annual TED for alternative scenarios. The scenarios evaluated are the transient occupancy scenario, the resident farmer scenario, and open rangeland scenarios for a ranch with two plausible exposure locations: one at the NNSS boundary closest to the Area 5 RWMS and another at Cane Spring. The scenarios and their assumptions have been described previously (BN 2006).

The mean and 95th percentile annual TEDs are all less than the performance objective for all alternative scenarios (Table 8). Although the exposure scenario is a source of uncertainty, there is a high likelihood of compliance for a range of reasonable scenarios. Addition of the ORNL Activated Metal waste stream increases the maximum all-pathway TED for all scenarios except the open rangeland scenarios.

Table 8. Maximum All-Pathway Annual TEDs for Alternative Scenarios

Scenario	Inventory	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Transient Occupancy	FY 2015 Baseline Inventory	1,000 y	5.8E-3	1.4E-2
	FY 2015 with ORNLACTMETAL1_4	1,000 y	6.2E-3	1.5E-2
Resident with Agriculture	FY 2015 Baseline Inventory	1,000 y	2.3E-2	7.7E-2
	FY 2015 with ORNLACTMETAL1_4	1,000 y	2.4E-2	7.8E-2
Open Rangeland/Cane Spring	FY 2015 Baseline Inventory	1,000 y	2.7E-3	9.8E-3
	FY 2015 with ORNLACTMETAL1_4	1,000 y	2.7E-3	9.8E-3
Open Rangeland/NNSS Boundary	FY 2015 Baseline Inventory	1,000 y	2.9E-3	1.1E-2
	FY 2015 with ORNLACTMETAL1_4	1,000 y	2.9E-3	1.1E-2

3.2.3 Intruder Results

Intruder results are evaluated for acute intruder scenarios only. NNSA/NFO institutional control policy is to maintain and enforce use restrictions (U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office 2015b). The proposed land-use restrictions are assumed to eliminate the possibility of chronic intrusion for 1,000 years.

The acute drilling scenario estimates the TED to a drill crew drilling a water well through a disposal unit. Exposure to contaminated drill cuttings occurs while augering a surface casing for the well. The acute construction scenario estimates the dose to construction workers building a residence on a disposal unit. Construction workers are exposed to waste exhumed from the construction excavation.

The maximum mean and 95th percentile acute intruder TEDs occur at 1,000 years and are less than the 5 mSv performance measure for both the drilling and construction acute intrusion scenarios (Table 9). Addition of the ORNL Activated Metal waste stream slightly increases the maximum acute intruder scenario results.

Table 9. Maximum TED for Acute Intrusion Scenarios at the Area 5 RWMS and the Waste Inventory Disposed through FY 2015

Scenario	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Drilling Intruder without ORNLACTMETAL1_4	1,000 y	1.5E-3	2.5E-3
Drilling Intruder with ORNLACTMETAL1_4	1,000 y	1.6E-3	2.8E-3
Construction Intruder without ORNLACTMETAL1_4	1,000 y	1.1	2.0
Construction Intruder with ORNLACTMETAL1_4	1,000 y	1.3	2.2

3.2.4 ^{222}Rn Flux Density Results

The radon-222 (^{222}Rn) flux density is averaged over the area of all post-1988 disposal units. The maximum mean and 95th percentile ^{222}Rn flux density occur at 1,000 years and are less than the 0.74 becquerel per square meter per second (Bq m^{-2} s^{-1}) performance objective (Table 10). Addition of the ORNL Activated Metal waste stream slightly increases the maximum ^{222}Rn flux density.

Table 10. Maximum ^{222}Rn Flux Density at the Area 5 RWMS and the Waste Inventory Disposed through FY 2015

Inventory	Time of Maximum	Mean (Bq m^{-2} s^{-1})	95th Percentile (Bq m^{-2} s^{-1})
FY 2015 Baseline Inventory	1,000 y	0.20	0.46
FY 2015 with ORNLACTMETAL1_4	1,000 y	0.21	0.48

Addition of the ORNL Activated Metal waste stream increases the ^{222}Rn flux density throughout the compliance period (Figure 3). The largest relative increase in the flux density, 14%, occurs at closure.

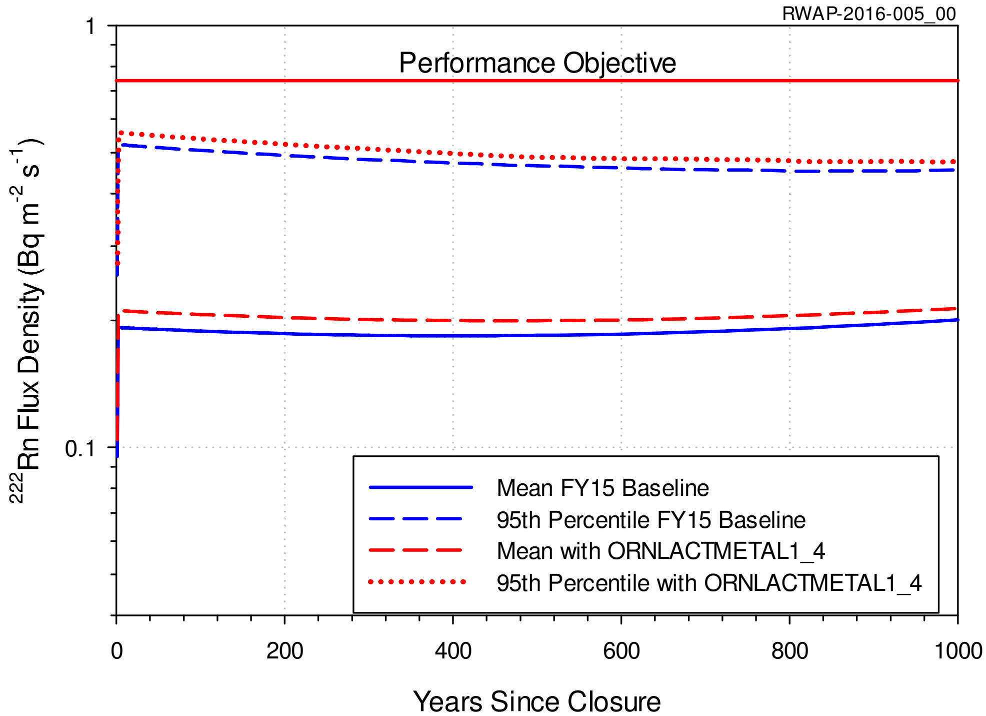

Figure 3. ^{222}Rn Flux Density Time History with and without the ORNLACTMETAL1_4 Waste Stream

4.0 Conclusions

The effect of adding the ORNL Activated Metal waste stream inventory to the inventory of waste disposed through the end of FY 2015 was evaluated with the A5 RWMS v 4.121 PA model. The results indicate that all performance objectives can be met with disposal of the ORNL Activated Metal in an Area 5 RWMS SLB trench. Addition of the ORNL Activated Metal inventory slightly increases most PA results. The increases in TED are due predominantly to disposal of ^{229}Th. All maximum mean and 95th percentile results remain less than their respective performance objectives throughout the compliance period. No result exceeds the Low-Level Radioactive Waste Review Group notification criterion of exceeding 50% of a performance objective.

Acceptance of the ORNL Activated Metal waste stream may cause significant relative increases in the inventories of ^{210}Pb, ^{60}Co, ^{229}Th, ^{154}Eu, ^{152}Eu, and ^{137}Cs. Of the 23 long-lived radionuclides without action levels, only two, ^{44}Ti and ^{148}Gd, exceeded screening limits requiring inclusion in the PA model. Both radionuclides are included in the current PA baseline model. The special analysis results indicate that the ^{44}Ti and ^{148}Gd inventories are acceptable.

The ORNL Activated Metal waste stream is suitable for disposal by SLB at the Area 5 RWMS. The SA assumes a ^{226}Ra inventory provided by the generator. The profile's acceptance should be limited to this inventory. The ORNL Activated Metal waste stream is recommended for approval with the condition that the ^{226}Ra inventory be limited to 4.5E11 Bq (15 Ci).

5.0 References

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