DOE/NV/03624--0097

UNREVIEWED DISPOSAL QUESTION EVALUATION: Disposal of the Transuranic Waste Processing Center Mixed Low-Level Waste at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada

April 2018

Prepared by

Mission Support and Test Services, LLC
Las Vegas, Nevada

Prepared for

U.S. Department of Energy
National Nuclear Security Administration
Nevada Field Office
Under Contract Number DE-NA0003624

DISCLAIMER

UNREVIEWED DISPOSAL QUESTION EVALUATION: Disposal of the Transuranic Waste Processing Center Mixed Low-Level Waste at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada

Prepared by: Gregory J. Shott — Digitally signed by Gregory J. Shott Date: 2018.04.03 14:16:52 -07'00' — Date: 4/10/2018

Gregory Shott
Principal Scientist

Reviewed by: Dawn N. Reed — Digitally signed by Dawn N. Reed Date: 2018.04.04 07:20:08 -07'00' — Date: 4/10/2018

Dawn Reed
Senior Scientist

Approved by: Gregory J. Shott — Digitally signed by Gregory J. Shott Date: 2018.04.03 14:17:11 -07'00' — Date: 4/10/2018

Gregory Shott
Principal Scientist

This Page Intentionally Left Blank

Table of Contents

This Page Intentionally Left Blank

Acronyms and Abbreviations

BN	Bechtel Nevada
Bq	becquerel
Bq m^{-3}	becquerel per cubic meter
Bq m^{-2} s^{-1}	becquerel per square meter per second
Cf	californium
DOE	U.S. Department of Energy
FY	(Federal) fiscal year
GM	geometric mean
GSD	geometric standard deviation
LHS	Latin hypercube sample
m	meter(s)
MLLW	mixed low-level waste
mSv	millisievert(s)
NNSA/NFO	U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office
NNSS	Nevada National Security Site
PA	Performance Assessment
R&D	research and development
Rn	radon
RWMS	Radioactive Waste Management Site
SLB	shallow land burial
SOFs	sum of fractions
Tc	technetium
TED	total effective dose
TWPC	Transuranic Waste Processing Center
UDQE	unreviewed disposal question evaluation
WAC	Waste Acceptance Criteria
y	years

This Page Intentionally Left Blank

1.0 Executive Summary

This Unreviewed Disposal Question Evaluation (UDQE) assesses whether the Transuranic Waste Processing Center (TWPC) Mixed Low-Level Waste (MLLW) (FWORCHMLLW103, Revision 11 [TWPC 2018]) is suitable for shallow land burial (SLB) at the Area 5 Radioactive Waste Management Site (RWMS) on the Nevada National Security Site (NNSS). Disposal of the TWPC MLLW waste stream meets all performance objectives of U.S. Department of Energy (DOE) Manual DOE M 435.1-1, *Radioactive Waste Management Manual*, Chapter IV, Section P (DOE 1999). The TWPC MLLW waste stream is recommended for acceptance without conditions.

2.0 Introduction

This UDQE addresses disposal of the TWPC MLLW waste stream at the Area 5 RWMS on the NNSS. The waste stream requires a UDQE because technetium-99 (^{99}Tc) exceeds the NNSS Waste Acceptance Criteria (WAC) Action Level (U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office [NNSA/NFO] 2016). The waste stream also includes two long-lived radionuclides, Cf-249 (^{249}Cf) and ^{251}Cf, which do not have WAC action levels and exceed their screening levels.

3.0 Analysis of Performance

The UDQE addresses the long-term performance of the Area 5 RWMS with the TWPC MLLW waste stream disposed in a SLB disposal cell.

3.1 Waste Description

The TWPC MLLW waste stream consists of heterogeneous debris including metal, plastic, cloth, paper, and glass materials. The waste was generated from the operation and later demolition of research and development (R&D), isotope laboratory, reactor, and radiochemical processing R&D facilities on or associated with the Oak Ridge National Laboratory.

The TWPC MLLW 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, 150 m^3, as reported on the waste profile (TWPC 2018, Section D.5) (Table 1).

Table 1. TWPC MLLW Activity Concentration and Total Activity at the Time of Disposal Assumed for Performance Assessment Modeling

Nuclide	GM* Concentration (Bq m^{-3})	95th Percentile Concentration (Bq m^{-3})	GM Activity (Bq)	95th Percentile Activity (Bq)	GSD**
^{227}Ac	5.6E+06	1.7E+08	8.3E+08	2.6E+10	7.95
^{241}Am	4.2E+09	4.1E+10	6.3E+11	6.2E+12	3.99
^{242m}Am	2.0E+05	5.6E+05	3.0E+07	8.4E+07	1.87
^{243}Am	1.6E+08	1.3E+09	2.4E+10	2.0E+11	3.60
^{249}Cf	2.7E+07	6.9E+08	4.1E+09	1.0E+11	7.10
^{250}Cf	7.2E+08	2.0E+09	1.1E+11	3.0E+11	1.87
^{251}Cf	2.0E+07	5.7E+07	3.0E+09	8.6E+09	1.87

Nuclide	GM* Concentration (Bq m^{-3})	95th Percentile Concentration (Bq m^{-3})	GM Activity (Bq)	95th Percentile Activity (Bq)	GSD**
^{243}Cm	2.0E+07	1.3E+09	1.7E+10	3.3E+10	12.6
^{244}Cm	3.5E+10	7.0E+10	3.0E+09	2.0E+11	1.52
^{245}Cm	3.4E+08	6.8E+08	5.3E+12	1.1E+13	1.52
^{246}Cm	1.7E+08	6.8E+08	5.1E+10	1.0E+11	2.31
^{247}Cm	4.0E+06	7.3E+07	2.6E+10	1.0E+11	5.82
^{248}Cm	1.1E+06	6.2E+06	6.0E+08	1.1E+10	2.84
^{60}Co	8.1E+06	5.9E+08	1.7E+08	9.3E+08	13.4
^{137}Cs	7.9E+08	5.2E+09	1.2E+09	8.8E+10	3.13
^{152}Eu	7.7E+07	3.6E+08	1.2E+11	7.8E+11	2.52
^{154}Eu	1.1E+08	4.6E+08	1.2E+10	5.3E+10	2.39
^{237}Np	4.6E+08	1.3E+09	1.6E+10	6.9E+10	1.84
^{231}Pa	1.5E+07	2.9E+07	6.8E+10	1.9E+11	1.52
^{238}Pu	8.1E+08	1.6E+09	2.2E+09	4.4E+09	1.52
^{239}Pu	1.5E+09	3.0E+09	1.2E+11	2.4E+11	1.52
^{240}Pu	5.2E+08	1.0E+09	2.3E+11	4.5E+11	1.52
^{241}Pu	2.1E+10	4.1E+10	7.8E+10	1.6E+11	1.52
^{242}Pu	7.5E+07	1.4E+08	3.1E+12	6.2E+12	1.46
^{226}Ra	1.9E+07	5.3E+07	1.1E+10	2.1E+10	1.87
^{90}Sr	5.4E+09	5.4E+10	2.8E+09	8.0E+09	4.04
^{99}Tc	5.7E+10	1.6E+11	8.1E+11	8.1E+12	1.87
^{228}Th	4.4E+06	8.8E+06	8.6E+12	2.4E+13	1.52
^{229}Th	7.2E+07	5.0E+08	6.6E+08	1.3E+09	3.24
^{232}Th	6.3E+05	1.3E+06	1.1E+10	7.5E+10	1.52
^{232}U	6.0E+07	2.5E+09	9.5E+07	1.9E+08	9.58
^{233}U	1.5E+09	2.0E+11	9.0E+09	3.8E+11	19.4
^{234}U	9.6E+07	1.7E+09	2.3E+11	3.0E+13	5.72
^{235}U	5.6E+06	1.1E+07	1.4E+10	2.6E+11	1.52
^{236}U	4.6E+10	9.2E+10	8.3E+08	1.7E+09	1.52
^{238}U	1.8E+09	3.5E+09	6.9E+12	1.4E+13	1.52

*GM – geometric mean
**GSD – geometric standard deviation

The high activity concentration (upper limit, UL) 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

The TWPC MLLW, revision 11, required a UDQE because ^{99}Tc exceeds the WAC action level. Disposal of the total waste stream inventory would cause a negligible increase in the ^{99}Tc inventory and the SLB sum of fractions (SOFs) (Table 2).

Table 2. Expected Increase in the Disposed Inventory of Radionuclides Exceeding their Action Levels and the Area 5 RWMS SOFs at Closure (10/1/2028)

Nuclide	FY 2017 SLB Disposed Geometric Mean Inventory	Geometric Mean FWORCHMLLW103_11 Inventory	Relative Percent Change
^{99}Tc	9.1E+14 Bq	8.6E+12 Bq	0.9
SLB SOFs	0.89	0.90	0.6

3.2 Performance Assessment Modeling

The performance assessment (PA) modeling adds the inventory of the TWPC MLLW waste stream to the Area 5 RWMS v4.201 model and determines if there is a reasonable expectation of meeting the performance objectives of DOE Manual DOE M 435.1-1, *Radioactive Waste Management Manual*, Chapter IV, Section P (DOE 1999). The PA model evaluates the TWPC MLLW waste stream radionuclide activity added to the inventory of post-1988 SLB waste disposed through FY 2017. The UDQE inventory also includes the Pit 6, Pit 13, and post-1988 Greater Confinement Disposal borehole inventories. The model is run with a 2.5-meter (m) 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 provides stable estimates of the mean and 95th percentile results 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. The UDQE only reports the mean results.

For comparison purposes, baseline results are obtained by running the model with the inventory disposed through FY 2017 and without the TWPC MLLW waste stream.

4.0 Results and Interpretation

4.1 Performance Assessment Results

4.1.1 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-m Area 5 RWMS 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 3). Addition of the TWPC MLLW increases the maximum resident air pathway TED at 1,000 years.

Table 3. Maximum Air Pathway Annual TED for a Resident at the Area 5 RWMS 100-m Site Boundary and the Waste Inventory Disposed through FY 2017

Scenario	Time of Maximum†	Mean (mSv)	95th Percentile (mSv)
Resident without FWORCHMLLW103_11 Waste Stream	1,000 y	1.8E-4	6.1E-4
Resident with FWORCHMLLW103_11 Waste Stream	1,000 y	1.9E-4	6.2E-4

† - years after closure

Addition of the TWPC MLLW increases the air pathway mean annual TED slightly throughout the 1,000 year compliance period (Figure 1). The maximum relative increase, 6.2%, occurs at 1,000 years.

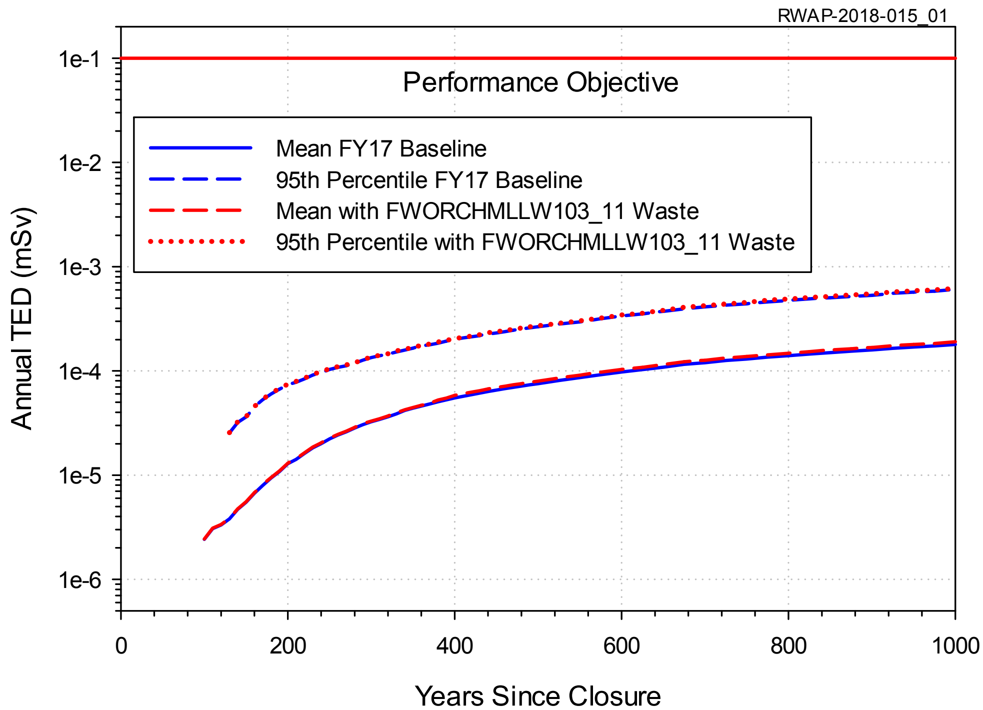

Figure 1. Air Pathway Annual TED Time History for a Resident at the 100-m Boundary with and without the FWORCHMLLW103_11 Waste Stream

4.1.1.1 Alternative Air Pathway Scenarios

Uncertainty contributed by the selected exposure scenario was evaluated by calculating the air pathway annual TED for alternative scenarios. The scenarios evaluated are the transient occupancy scenario, the resident with agriculture 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 are described in the PA (BN 2006).

The maximum of the mean and the 95th percentile TEDs are all less than the performance objective for all of the alternative scenarios (Table 4). 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 TWPC MLLW increases the maximum result for all scenarios.

Table 4. Maximum Air Pathway Annual TEDs for Alternative Scenarios with the FY 2017 Inventory

Scenario	Inventory	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Transient Occupancy	FY 2017 Baseline Inventory	1,000 y	7.2E-5	2.5E-4
	FY 2017 with FWORCHMLLW103_11	1,000 y	7.7E-5	2.5E-4
Resident with Agriculture	FY 2017 Baseline Inventory	1,000 y	3.9E-4	1.3E-3
	FY 2017 with FWORCHMLLW103_11	1,000 y	4.1E-4	1.4E-3
Open Rangeland/Cane Spring	FY 2017 Baseline Inventory	1,000 y	5.9E-9	1.4E-8
	FY 2017 with FWORCHMLLW103_11	1,000 y	6.3E-9	1.5E-8
Open Rangeland/NNSS Boundary	FY 2017 Baseline Inventory	1,000 y	1.0E-7	2.4E-7
	FY 2017 with FWORCHMLLW103_11	1,000 y	1.1E-7	2.5E-7

4.1.2 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 5). Addition of the TWPC MLLW waste has no significant effect on the maximum resident all-pathways annual TED.

Table 5. Maximum All-Pathways Annual TED for a Resident at the Area 5 RWMS 100-m Site Boundary and the Waste Inventory Disposed through FY 2017

Scenario	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Resident without FWORCHMLLW103_11 Waste Stream	1,000 y	1.1E-3	2.8E-3
Resident with FWORCHMLLW103_11 Waste Stream	1,000 y	1.1E-3	2.9E-3

Addition of the TWPC MLLW slightly increases the all-pathways TED throughout the compliance period (Figure 2). The maximum increase in the all-pathways annual TED is 2.9% at 1,000 years.

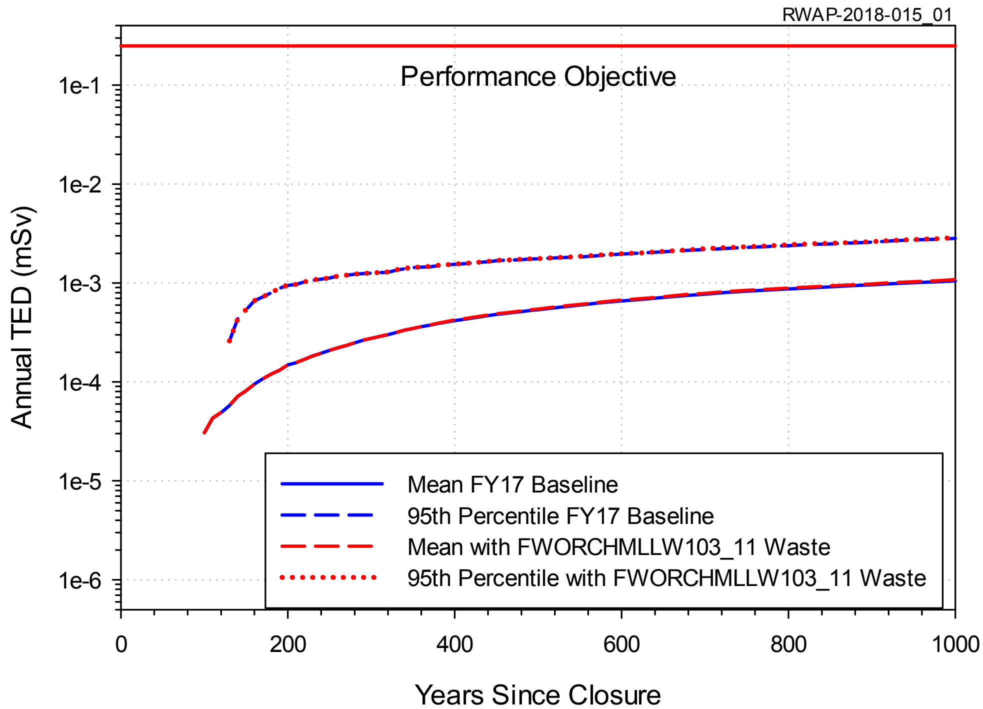

Figure 2. All-Pathways Annual TED Time History for a Resident at the 100-m Boundary with and without FWORCHMLLW103_11 Waste Stream

4.1.2.1 Alternative All-Pathways Scenarios

Uncertainty contributed by the selected exposure scenarios was evaluated by calculating the all-pathways annual TED for alternative scenarios. The scenarios evaluated are the transient occupancy scenario, the resident with agriculture 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 are described in the PA (BN 2006).

The mean and 95th percentile all-pathways annual TEDs are all less than the performance objective for all 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 TWPC MLLW has no significant effect on the maximum annual TED for the open rangeland scenarios. The maximum results for the transient occupancy and resident with agriculture scenarios increase.

Table 6. Maximum All-Pathways Annual TEDs for Alternative Scenarios

Scenario	Inventory	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Transient Occupancy	FY 2017 Baseline Inventory	1,000 y	6.6E-3	1.6E-2
	FY 2017 with FWORCHMLLW103_11	1,000 y	6.7E-3	1.6E-2
Resident with Agriculture	FY 2017 Baseline Inventory	1,000 y	2.6E-2	8.4E-2
	FY 2017 with FWORCHMLLW103_11	1,000 y	2.7E-2	8.5E-2
Open Rangeland/Cane Spring	FY 2017 Baseline Inventory	1,000 y	4.5E-3	1.5E-2
	FY 2017 with FWORCHMLLW103_11	1,000 y	4.5E-3	1.6E-2
Open Rangeland/NNSS Boundary	FY 2017 Baseline Inventory	1,000 y	4.7E-3	1.6E-2
	FY 2017 with FWORCHMLLW103_11	1,000 y	4.7E-3	1.7E-2

4.1.3 Intruder Results

Intruder results are evaluated for acute intruder scenarios only. NNSA/NFO institutional control policy is to maintain and enforce use restrictions (NNSA/NFO 2015). 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 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 7). Addition of the TWPC MLLW increases the maximum acute intruder scenario mean results occurring at 1,000 years.

Table 7. Maximum TED for Acute Intrusion Scenarios at the Area 5 RWMS and the Waste Inventory Disposed through FY 2017

Scenario	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Drilling Intruder without FWORCHMLLW103_11	1,000 y	1.4E-3	2.5E-3
Drilling Intruder with FWORCHMLLW103_11	1,000 y	1.5E-3	2.5E-3
Construction Intruder without FWORCHMLLW103_11	1,000 y	1.0	1.8
Construction Intruder with FWORCHMLLW103_11	1,000 y	1.1	1.9

Addition of the TWPC MLLW increases the mean acute construction TED throughout the compliance period (Figure 3). The maximum relative increase of 3.2% occurs at 1,000 years.

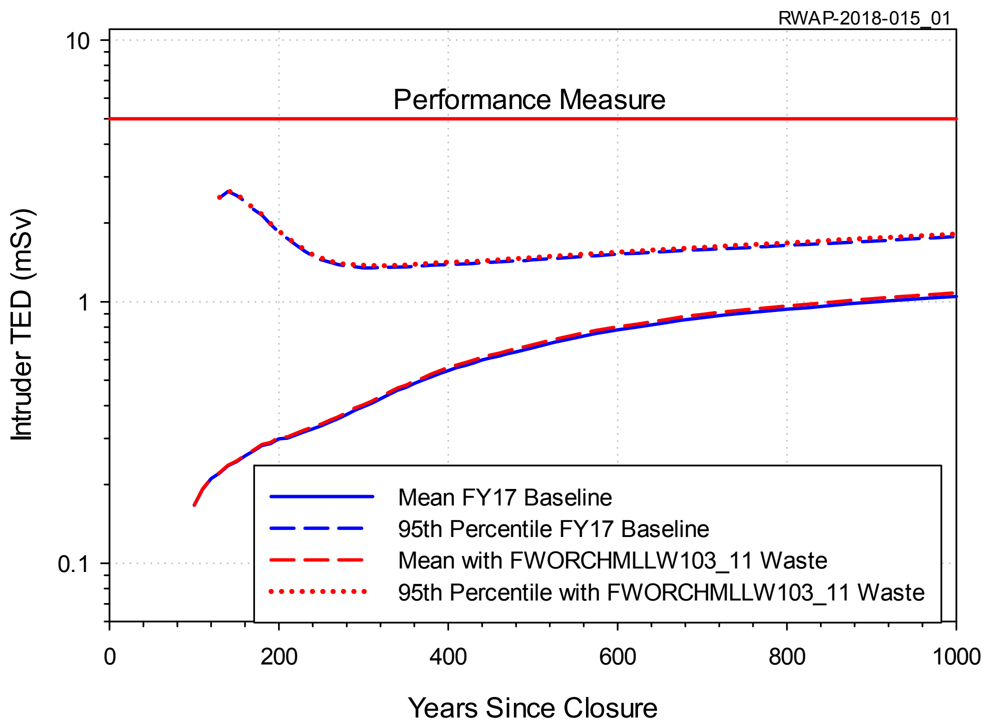

Figure 3. Acute Construction Intrusion Scenario TED Time History with and without the FWORCHMLLW103_11 Waste Stream

4.1.4 ^{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 densities 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 8).

Addition of the TWPC MLLW waste has no significant effect on the maximum ^{222}Rn flux density at 1,000 years. This waste stream does not require an increased depth of burial to attenuate ^{222}Rn flux.

Table 8. Maximum ^{222}Rn Flux Density at the Area 5 RWMS and the Waste Inventory Disposed through FY 2017

Inventory	Time of Maximum	Mean (Bq m^{-2} s^{-1})	95th Percentile (Bq m^{-2} s^{-1})
FY 2017 without FWORCHMLLW103_11	1,000 y	0.23	0.52
FY 2017 with FWORCHMLLW103_11	1,000 y	0.23	0.52

Addition of the TWPC MLLW waste stream increases the mean ^{222}Rn flux density throughout the compliance period. The maximum increase in flux, 0.2%, occurs at closure and decreases thereafter (Figure 4).

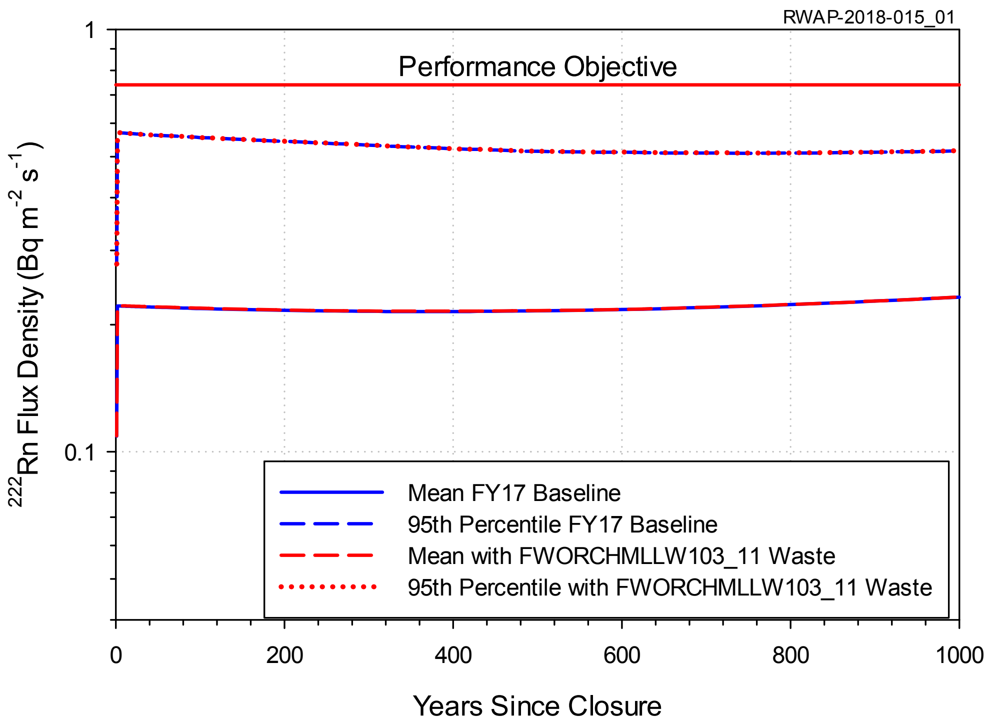

Figure 4. ^{222}Rn Flux Density Time History with and without the FWORCHMLLW103_11 Waste Stream

5.0 Conclusions

The effect of adding the TWPC MLLW waste stream inventory to the inventory of waste disposed through the end of FY 2017 was evaluated with the Area 5 RWMS v 4.201 PA model. The results indicate that all performance objectives can be met with disposal of the TWPC MLLW waste stream in an Area 5 RWMS SLB unit. Addition of the TWPC MLLW inventory has no significant effect on the maximum PA results. All maximum mean and 95th percentile results remain less than their respective performance objectives throughout the compliance period. The UDQE results include the dose from ^{249}Cf and ^{251}Cf, indicating that their inventories are acceptable. No result exceeds the Low-Level Radioactive Waste Review Group notification criterion of exceeding 50% of a performance objective. The TWPC MLLW waste stream is acceptable for disposal without conditions.

6.0 References

Bechtel Nevada. 2006. *Addendum 2 to the Performance Assessment for the Area 5 Radioactive Waste Management Site at the Nevada Test Site, Nye County, Nevada: Update of Performance Assessment Methods and Results*. Las Vegas, NV: Bechtel Nevada. DOE/NV/11718--176ADD2.

BN, see Bechtel Nevada.

NNSA/NFO, see U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office.

Transuranic Waste Processing Center. 2018. Mixed Low-Level Waste Profile Data Sheet. FWORCHMLLW103, Rev. 11. North Wind Solutions, LLC. Lenoir City, TN. February 6, 2018.

TWPC, see Transuranic Waste Processing Center.

U.S. Department of Energy. 1999. *Radioactive Waste Management Manual*. Washington, D.C.: U.S. Department of Energy. DOE M 435.1-1.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, 2015. *Institutional Control of the Nevada National Security Site*. Las Vegas, NV: NFO P 454.X, Rev. 0. 10/14/15.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2016. *Nevada National Security Site Waste Acceptance Criteria*. Las Vegas, NV: DOE/NV--325-16-00. November 2016.