DOE/NV/03624--1113

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

July 2021

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

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

Available as a digital download at no charge via the website below:

U.S. Department of Commerce
National Technical Information Service
5301 Shawnee Road
Alexandria, VA 22312
Phone: (800) 553-6847
Fax: (703) 605-6880
E-mail: info@ntis.gov; mailto:customerservice@ntis.gov
Online Ordering: https://classic.ntis.gov/search/

Available electronically at http://www.osti.gov

Available in paper for a processing fee to the U.S. Department of Energy and its contractors, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
Phone: (865) 576-8401
Fax: (865) 576-5728
E-mail: reports@osti.gov

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

Prepared by: Dawn N. Reed Digitally signed by Dawn N. Reed Date: 2021.07.12 08:37:36 -07'00'

Dawn Reed
Senior Scientist

Reviewed by: Gregory J. Shott Digitally signed by Gregory J. Shott Date: 2021.07.12 07:06:49 -07'00'

Gregory Shott
Principal Scientist

Approved by: Gregory J. Shott Digitally signed by Gregory J. Shott Date: 2021.07.12 09:52:28 -07'00'

Gregory Shott
Principal Scientist

This Page Intentionally Left Blank

Table of Contents

Acronyms and Abbreviations v
1.0 Executive Summary 1
2.0 Introduction 1
3.0 Analysis of Performance 1
3.1 Waste Description 1
3.2 Performance Assessment Modeling 3
4.0 Results and Interpretation 4
4.1 Performance Assessment Results 4
4.1.1 Air Pathway Results 4
4.1.2 All-Pathways Results 5
4.1.3 Intruder Results 7
4.1.4 ^{222}Rn Flux Density Results 8
5.0 Conclusions 9
6.0 References 11

This Page Intentionally Left Blank

Acronyms and Abbreviations

Am	americium
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
Cm	curium
DOE	U.S. Department of Energy
FY	(Federal) fiscal year
GM	geometric mean
GSD	geometric standard deviation
LHS	Latin hypercube sample
LLRW	low-level radioactive waste
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
Ra	radium
Rn	radon
RWMS	Radioactive Waste Management Site
SLB	shallow land burial
SOFs	sum of fractions
Tc	technetium
TED	total effective dose
TWPC	TRU Waste Processing Center
UDQE	unreviewed disposal question evaluation
UL	upper limit
WAC	Waste Acceptance Criteria
WARP	Waste Acceptance Review Panel
y	years

This Page Intentionally Left Blank

1.0 Executive Summary

This Unreviewed Disposal Question Evaluation (UDQE) assesses whether the U.S. Department of Energy (DOE), National Nuclear Security Administration (NNSA) Transuranic (TRU) Waste Processing Center Mixed Low Level Waste (MLLW), FWORCHMLLW103, Revision 13 [TWPC 2021]), 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 TRU Waste Processing Center MLLW meets all performance objectives of DOE Manual DOE M 435.1-1, *Radioactive Waste Management Manual*, Chapter IV, Section P (DOE 1999). The TRU Waste Processing Center MLLW waste stream is recommended for acceptance without conditions.

2.0 Introduction

This UDQE addresses disposal of the TRU Waste Processing Center MLLW at the Area 5 RWMS on the NNSS. The waste stream requires a UDQE because the representative activity concentration of technetium-99 (^{99}Tc) exceeds the NNSS Waste Acceptance Criteria (WAC) Action Level and the waste stream sum of fractions (SOFs) is greater than 1.0. Four long-lived radionuclides without Action Levels are present: americium-242m (^{242m}Am), californium-249 (^{249}Cf), californium-251 (^{251}Cf) and curium-247 (^{247}Cm). The total activity of these long-lived nuclides does not exceed their screening limits (Mission Support and Test Services [MSTS] 2018).

3.0 Analysis of Performance

The UDQE addresses the long-term performance of the Area 5 RWMS with the TRU Waste Processing Center MLLW disposed in a SLB disposal cell.

3.1 Waste Description

The TRU Waste Processing Center MLLW waste stream consists of heterogenous 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) facilities, an isotope laboratory, a reactor, and radiochemical processing facilities on or associated with the Oak Ridge National Laboratory (TWPC 2021).

The TRU Waste Processing Center MLLW 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 2021, Section D.5).

Table 1. TRU Waste Processing Center 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

Nuclide	GM† Concentration (Bq m^{-3})	95th Percentile Concentration (Bq m^{-3})	GM Activity (Bq)	95th Percentile Activity (Bq)	GSD‡
^{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
^{252}Cf	1.1E+08	2.2E+08	1.7E+10	3.3E+10	1.52
^{243}Cm	2.0E+07	1.3E+09	3.0E+09	2.0E+11	12.6
^{244}Cm	3.5E+10	7.0E+10	5.3E+12	1.1E+13	1.52
^{245}Cm	3.4E+08	6.8E+08	5.1E+10	1.0E+11	1.52
^{246}Cm	1.7E+08	6.8E+08	2.6E+10	1.0E+11	2.31
^{247}Cm	4.0E+06	7.3E+07	6.0E+08	1.1E+10	5.82
^{248}Cm	1.1E+06	6.2E+06	1.7E+08	9.3E+08	2.84
^{60}Co	8.1E+06	5.9E+08	1.2E+09	8.8E+10	13.4
^{137}Cs	7.9E+08	7.0E+09	1.2E+11	1.1E+12	3.76
^{152}Eu	7.7E+07	3.6E+08	1.2E+10	5.3E+10	2.52
^{154}Eu	1.1E+08	4.6E+08	1.6E+10	6.9E+10	2.39
^{237}Np	4.6E+08	1.3E+09	6.8E+10	1.9E+11	1.84
^{231}Pa	1.5E+07	2.9E+07	2.2E+09	4.4E+09	1.52
^{238}Pu	8.1E+08	1.6E+09	1.2E+11	2.4E+11	1.52
^{239}Pu	1.5E+09	3.0E+09	2.3E+11	4.5E+11	1.52
^{240}Pu	5.2E+08	1.0E+09	7.8E+10	1.6E+11	1.52
^{241}Pu	2.1E+10	4.1E+10	3.1E+12	6.2E+12	1.52
^{242}Pu	7.5E+07	1.4E+08	1.1E+10	2.1E+10	1.46
^{226}Ra	1.9E+07	5.3E+07	2.8E+09	8.0E+09	1.87
^{90}Sr	5.4E+09	5.4E+10	8.1E+11	8.1E+12	4.04
^{99}Tc	5.7E+10	1.6E+11	8.6E+12	2.4E+13	1.87
^{228}Th	4.4E+06	8.8E+06	6.6E+08	1.3E+09	1.52
^{229}Th	7.2E+07	5.0E+08	1.1E+10	7.5E+10	3.24
^{232}Th	6.3E+05	1.3E+06	9.5E+07	1.9E+08	1.52
^{232}U	6.0E+07	2.5E+09	9.0E+09	3.8E+11	9.58
^{233}U	1.5E+09	2.0E+11	2.3E+11	3.0E+13	19.4
^{234}U	9.6E+07	1.7E+09	1.4E+10	2.6E+11	5.72
^{235}U	5.6E+06	1.1E+07	8.3E+08	1.7E+09	1.52
^{236}U	4.6E+10	9.2E+10	6.9E+12	1.4E+13	1.52
^{238}U	1.8E+09	3.5E+09	2.6E+11	5.3E+11	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 TRU Waste Processing Center MLLW, revision 13, required a UDQE because the representative activity concentration of ^{99}Tc exceeds the NNSS WAC and the waste stream sum of fractions (SOFs) is greater than 1.0. The concentration of radium-226 (^{226}Ra) is also near its Action Level. The TRU Waste Processing Center MLLW only slightly increases the 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 2020* SLB Disposed GM Inventory	FWORCHMLLW103_13 GM Inventory	Relative Percent Change
^{99}Tc	9.7E+14 Bq	8.6E+12 Bq	0.9
^{226}Ra	1.6E+12 Bq	2.8E+09 Bq	0.2
SLB SOFs	0.80	0.81	0.4

*FY – fiscal year

3.2 Performance Assessment Modeling

The performance assessment (PA) modeling adds the inventory of the TRU Waste Processing Center MLLW waste stream to the Area 5 RWMS v4.208ba model and determines if there is a reasonable expectation of meeting the performance objectives of DOE M 435.1-1, *Radioactive Waste Management Manual*, Chapter IV, Section P (DOE 1999). The PA model evaluates the TRU Waste Processing Center MLLW waste stream radionuclide activity added to the inventory of post-1988 SLB waste disposed through FY 2020. 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 2020 and without the TRU Waste Processing Center 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 a representative person 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 TRU Waste Processing Center MLLW increases the maximum resident air pathway TED.

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 2020

Scenario	Time of Maximum†	Mean (mSv)	95th Percentile (mSv)
Resident without FWORCHMLLW103_13 Waste Stream	1,000 y	1.4E-4	4.4E-4
Resident with FWORCHMLLW103_13 Waste Stream	1,000 y	1.5E-4	4.5E-4

† - years after closure

Addition of the TRU Waste Processing Center MLLW waste stream increases the air pathway mean annual TED throughout the compliance period. The maximum relative increase, 8.0%, occurs at 1,000 years (Figure 1).

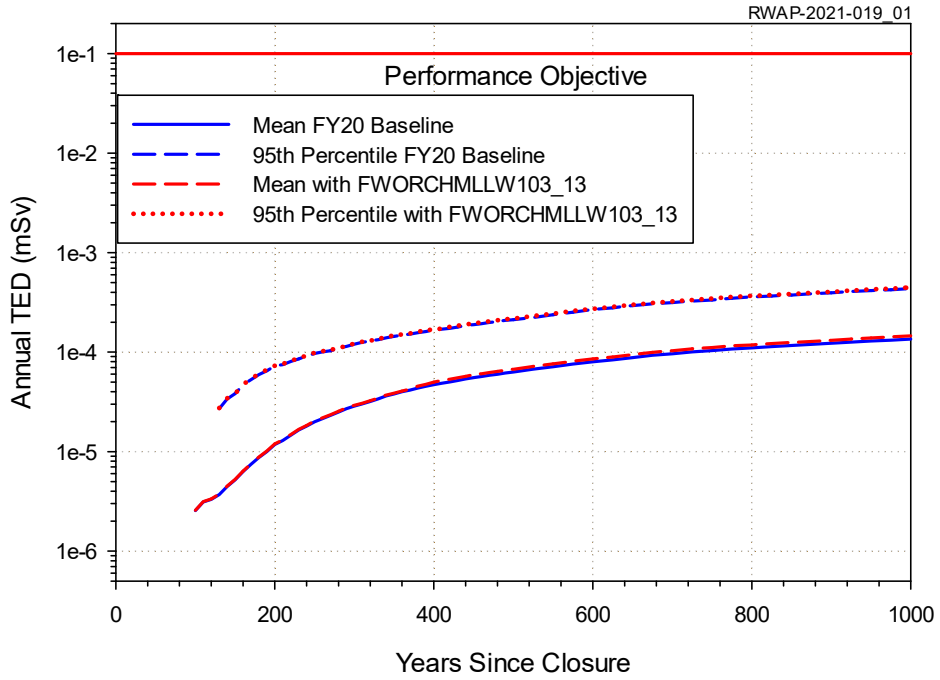

Figure 1. Air Pathway Annual TED Time History for a Resident at the 100-m Boundary with and without the FWORCHMLLW103_13 Waste Stream

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 TRU Waste Processing Center MLLW waste stream increases the maximum result in all scenarios.

Table 4. Maximum Air Pathway Annual TEDs for Alternative Scenarios with the FY 2020 Inventory

Scenario	Inventory	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Transient Occupancy	FY 2020 Baseline Inventory	1,000 y	5.5E-5	1.8E-4
	FY 2020 with FWORCHMLLW103_13	1,000 y	5.9E-5	1.9E-4
Resident with Agriculture	FY 2020 Baseline Inventory	1,000 y	2.9E-4	9.6E-3
	FY 2020 with FWORCHMLLW103_13	1,000 y	3.1E-4	9.9E-4
Open Rangeland/Cane Spring	FY 2020 Baseline Inventory	1,000 y	4.1E-9	1.1E-8
	FY 2020 with FWORCHMLLW103_13	1,000 y	4.4E-9	1.1E-8
Open Rangeland/NNSS Boundary	FY 2020 Baseline Inventory	1,000 y	7.0E-8	1.9E-7
	FY 2020 with FWORCHMLLW103_13	1,000 y	7.5E-8	1.9E-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 TRU Waste Processing Center MLLW waste stream increases 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 2020

Scenario	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Resident without FWORCHMLLW103_13 Waste Stream	1,000 y	9.8E-4	2.5E-3
Resident with FWORCHMLLW103_13 Waste Stream	1,000 y	1.0E-3	2.6E-3

Addition of the TRU Waste Processing Center MLLW waste stream increases the all-pathways TED throughout the compliance period. The maximum relative increase in the all-pathways annual TED is 3.1% at 1,000 years (Figure 2).

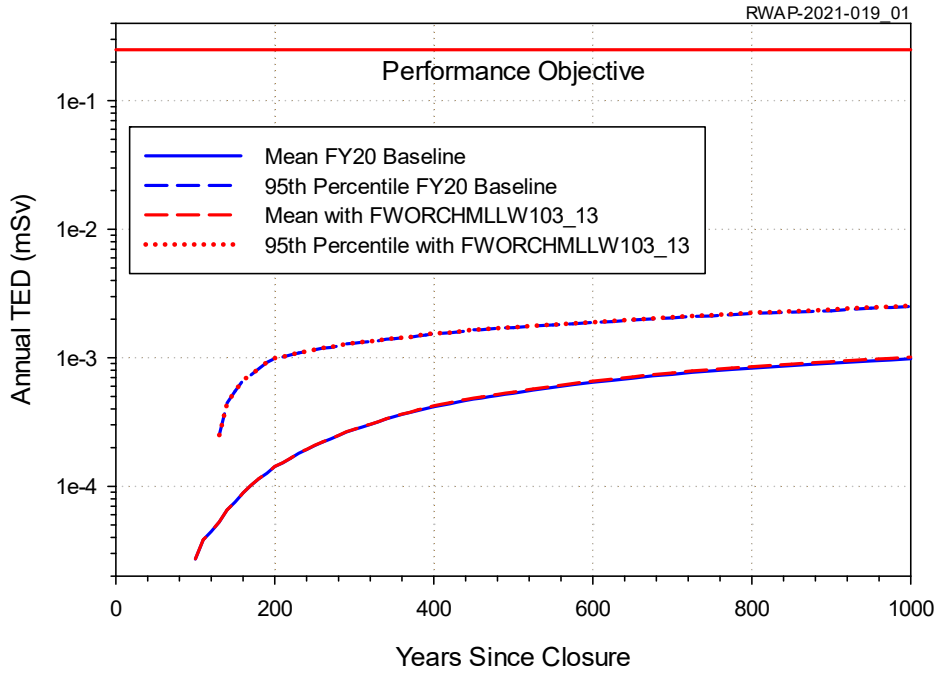

Figure 2. All-Pathways Annual TED Time History for a Resident at the 100-m Boundary with and without FWORCHMLLW103_13 Waste Stream

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 TRU Waste Processing Center MLLW has no significant effect on the maximum annual TED for all alternate scenarios.

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

Scenario	Inventory	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Transient Occupancy	FY 2020 Baseline Inventory	1,000 y	7.2E-3	1.7E-2
	FY 2020 with FWORCHMLLW103_13	1,000 y	7.2E-3	1.7E-2
Resident with Agriculture	FY 2020 Baseline Inventory	1,000 y	2.7E-2	8.5E-2
	FY 2020 with FWORCHMLLW103_13	1,000 y	2.7E-2	8.6E-2
Open Rangeland/Cane Spring	FY 2020 Baseline Inventory	1,000 y	4.7E-3	1.6E-2
	FY 2020 with FWORCHMLLW103_13	1,000 y	4.7E-3	1.6E-2
Open Rangeland/NNSS Boundary	FY 2020 Baseline Inventory	1,000 y	4.9E-3	1.7E-2
	FY 2020 with FWORCHMLLW103_13	1,000 y	4.9E-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 2019). 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 TED remain less than the 5 mSv performance measure for both the drilling and construction acute intrusion scenarios (Table 7). Addition of the TRU Waste Processing Center MLLW waste stream has no significant effect on the maximum intruder TED.

Table 7. Maximum TED for Acute Intrusion Scenarios at the Area 5 RWMS and the Waste Inventory Disposed through FY 2020

Scenario	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Drilling Intruder without FWORCHMLLW103_13	1,000 y	1.5E-3	2.5E-3
Drilling Intruder with FWORCHMLLW103_13	1,000 y	1.5E-3	2.5E-3
Construction Intruder without FWORCHMLLW103_13	1,000 y	0.76	1.2
Construction Intruder with FWORCHMLLW103_13	1,000 y	0.80	1.2

Addition of the TRU Waste Processing Center MLLW waste stream increases the mean acute construction TED throughout the compliance period. The maximum increase in the all-pathways annual TED is 4.4% at 1,000 years (Figure 3).

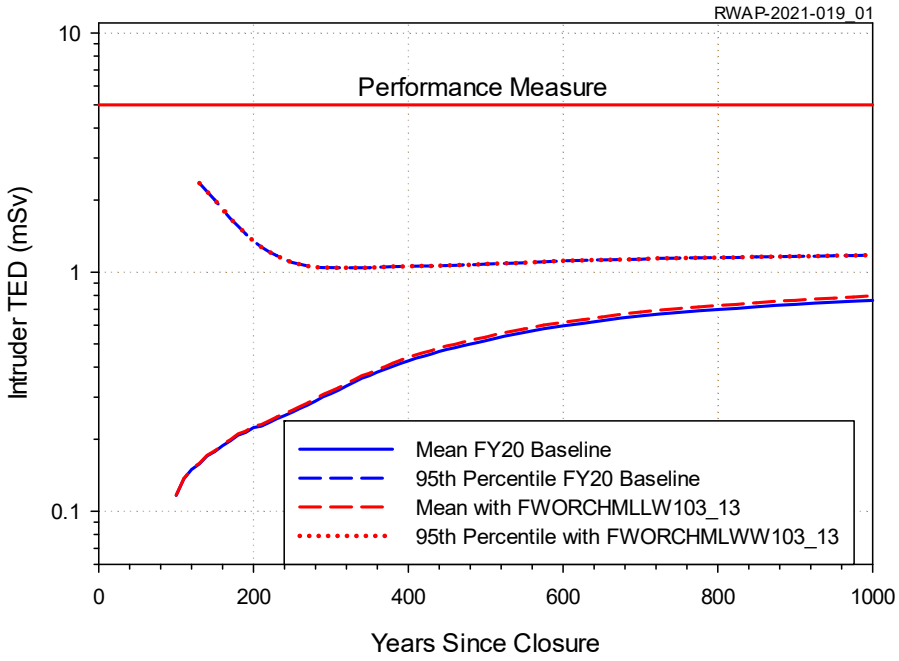

Figure 3. Acute Construction Intrusion Scenario TED Time History with and without the FWORCHMLLW103_13 Waste Stream

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 cells. 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 TRU Waste Processing Center MLLW 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 2020

Inventory	Time of Maximum	Mean (Bq m^{-2} s^{-1})	95th Percentile (Bq m^{-2} s^{-1})
FY 2020 without FWORCHMLLW103_13	1,000 y	0.26	0.55
FY 2020 with FWORCHMLLW103_13	1,000 y	0.26	0.55

Addition of the TRU Waste Processing Center MLLW waste stream increases the mean ^{222}Rn flux density throughout the compliance period (Figure 4). The maximum relative increase, 0.2%, occurs at 330 years.

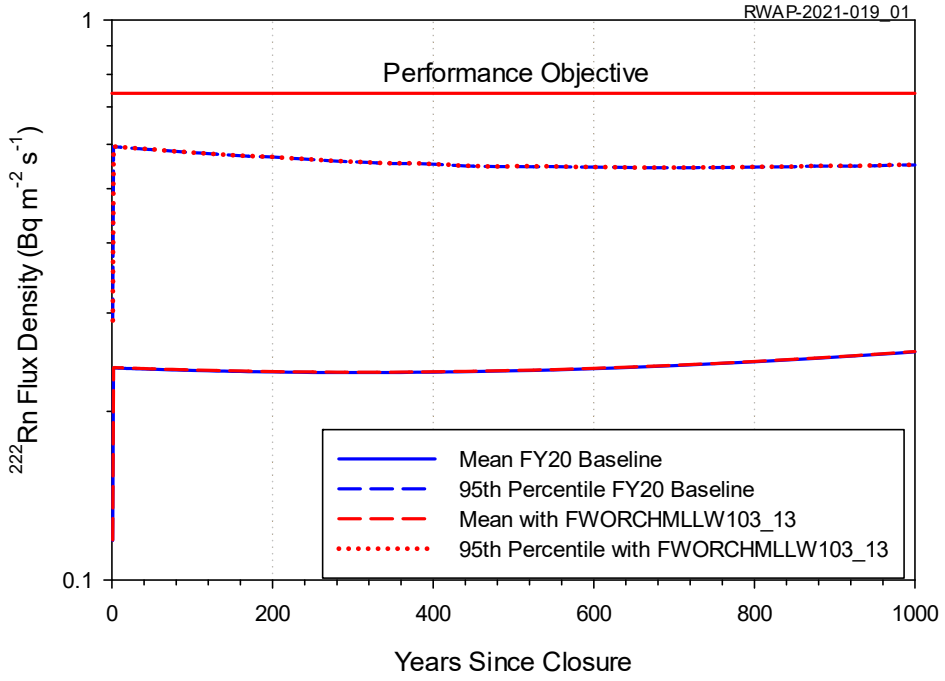

Figure 4. ^{222}Rn Flux Density Time History with and without the FWORCHMLLW103_13 Waste Stream

5.0 Conclusions

The effect of adding the TRU Waste Processing Center MLLW inventory to the inventory of waste disposed through the end of FY 2020 was evaluated with the Area 5 RWMS v 4.208ba PA model. Addition of the TRU Waste Processing Center MLLW inventory increase the PA results. The results indicate that all performance objectives can be met for 1,000 years with disposal of the TRU Waste Processing Center MLLW in an Area 5 RWMS SLB disposal cell. All maximum mean and 95th percentile results remain less than their respective performance objectives throughout the compliance period. No mean result exceeds the Low-Level Radioactive Waste Review Group notification criterion of exceeding 50% of a performance objective. The TRU Waste Processing Center MLLW is acceptable for disposal without conditions.

This Page Intentionally Left Blank

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.

DOE, see U.S. Department of Energy.

Mission Support and Test Services, LLC. 2018. *UNREVIEWED DISPOSAL QUESTION EVALUATION: Development and Testing of Revision 2.0 Performance Assessment Screening Limits*. DOE/NV/03624--0212. Las Vegas, NV. August 2018.

MSTS, see Mission Support and Test Services, LLC.

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

Transuranic Waste Processing Center. 2021. TRU Waste Processing Center Mixed Low-Level Waste Waste Profile Data Sheet. Lenoir City, TN: FWORCHMLLW103, Rev. 13, June 4, 2021. (16 pages)

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. 2016. *Nevada National Security Site Waste Acceptance Criteria*. Las Vegas, NV: DOE/NV--325-16-00. November 2016.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2019. *Institutional Control of the Nevada National Security Site*. NFO P 454.X, Rev. 1. Las Vegas, NV. October 29, 2019.