Contract No:

This document was prepared in conjunction with work accomplished under Contract No. DE-AC09-08SR22470 with the U.S. Department of Energy (DOE) Office of Environmental Management (EM).

Savannah River National Laboratory™

OPERATED BY SAVANNAH RIVER NUCLEAR SOLUTIONS

We put science to work.™

A U.S. DEPARTMENT OF ENERGY NATIONAL LABORATORY • SAVANNAH RIVER SITE • AIKEN, SC

E-Area Low-Level Waste Facility Cover Overhang Analysis

T. Hang
G. P. Flach

May 2016

SRNL-STI-2016-00251, Revision 0

SRNL.DOE.GOV

DISCLAIMER

Printed in the United States of America

Prepared for
U.S. Department of Energy

Keywords: *E-Area, Cover Overhang*

Retention: *Permanent*

E-Area Low-Level Waste Facility Cover Overhang Analysis

T. Hang
G. P. Flach

May 2016

Savannah River National Laboratory ™

OPERATED BY SAVANNAH RIVER NUCLEAR SOLUTIONS

Prepared for the U.S. Department of Energy under contract number DE-AC09-08SR22470.

REVIEWS AND APPROVALS

AUTHORS:

T. Hang, Environmental Modeling	Date
G. P. Flach, Environmental Modeling	Date

TECHNICAL REVIEW:

B. T. Butcher, Jr., Environmental Modeling *(Reviewed per E7 2.60)*	Date

APPROVAL:

D. A. Crowley, Manager Environmental Modeling	Date
K. M. Kostelnik, Director Environmental Restoration Technologies	Date

REVISIONS

Revision	Description
0	Original issue

This page intentionally left blank

EXECUTIVE SUMMARY

PORFLOW related analyses were performed with a focus on Slit and Engineered Trenches to evaluate the minimum required cover overhang size that would prevent any adverse impact on the ELLWF overall performance. Cover overhang is defined as the lateral distance that a low-infiltration cover extends beyond the edge of the trench unit in any direction. Analyses were carried out for H-3 (short half-life), I-129 (very long half-life), and Sr-90 (moderate half-life with intermediate K_d) at different overhang sizes (5ft, 10ft, 20ft, 50ft, and infinite), cover timing (0yr, 10yr, 20yr, and 30yr), and scenarios (Intact and a limited Dynamic Compaction Case). H-3, I-129 and Sr-90 are representative of nuclides that typically drive the sum-of-fractions for a trench disposal unit. PORFLOW simulations show the following results:

- For H-3 and I-129:
  - Except when the cover is immediately installed, no difference in performance was observed for the various cover overhang sizes because most of the H-3 and I-129 inventory escapes before an impermeable cover is installed.
  - For Engineered Trenches and East and West Slit Trenches, disposal limits for H-3 and I-129 are based on 2008 PA simulations in which the interim closure cover system is first placed 30 years after waste disposal [1]. The extent of the cover overhang does not influence these disposal limits because the peak flux occurs before the interim closure cover is installed.
  - For the Center Slit Trenches minimal disposal limits were calculated assuming operational storm water runoff covers are installed at either 5, 10, or 15 years after the start of operations [2]. Slit Trenches 1-5 were operational between 5 to 15 years before receiving an operational cover, while neither of the remaining Center Slit Trenches, Slit Trenches 6 and 7, have been operational less than 10 years. Therefore, the extent of the cover overhang could have a minor impact on H-3 and I-129 disposal limits for this group. This impact is likely to be beneficial for the most restrictive groundwater pathway time intervals.

- For Sr-90:
  - Major difference in performance for the various cover overhangs.
  - Less impact of cover timing on performance.
  - When the cover is installed at 30 years:
    - for cover overhangs larger than about 40 feet, Sr-90 flux at the water table does not exceed flux peak for an infinite cover without dynamic compaction and trench subsidence at 130 years.
    - With dynamic compaction and 10% trench subsidence at 130 years, the cover overhang size has no impact on peak flux at water table because of the large increase in infiltration rate in the subsided sections of the trench unit.
    - Slit and Engineered Trench disposal limits for Sr-90 are based on the PA 10% non-crushable container case. Therefore the extent of the cover overhang does not influence disposal limits.

Based on these results the following measures are recommended:

- In general, the minimum cover overhang size to provide low infiltration is 40 feet.
- On the upgradient side of the ELLWF, the cover overhang can be less than 40 feet because a drainage system and adjoining cover system already exist to divert infiltration away from the waste zone.

- On the downgradient side and ends of the ELLWF, the combined cover overhang and closure cap side slope composed of low-permeability membrane must have a minimum horizontal length of 40 feet from the waste unit boundary.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ELLWF	E-Area Low-Level Waste Facility
K_d	Sorption Coefficient
PA	Performance Assessment
2D	Two-Dimensional

1.0 Introduction

The E-Area Low-Level Waste Facility (ELLWF) is composed of 200 acres for waste disposal and a surrounding buffer zone that extends out to the 100-m point of compliance for all disposal units. Disposal units within the ELLWF footprint include Slit Trenches, Engineered Trenches, Components-in-Grout Trenches, the Low Activity Waste Vault, the Intermediate Level Vault, and the Naval Reactor Component Disposal Areas [1]. ELLWF operations will be conducted in three phases: 30-year operational period, 100-year institutional control period, and final closure period (i.e., after 130 years). A low-infiltration runoff cover will be installed and maintained during the 100-year institutional control period. In preparation for the next Performance Assessment (PA) revision a new closure cap plot plan is being prepared by Design Engineering to reorient the cap crestline to run lengthwise down the overall ELLWF (i.e., essentially perpendicular to the existing PA model), and incorporate a high density polyethylene geomembrane over the existing geosynthetic clay layer to provide a composite hydraulic barrier that conforms to best closure cap design practices. The cover overhang was proposed to extend to 50 feet beyond the edge of all sides of the trenches as illustrated in Figure 1.

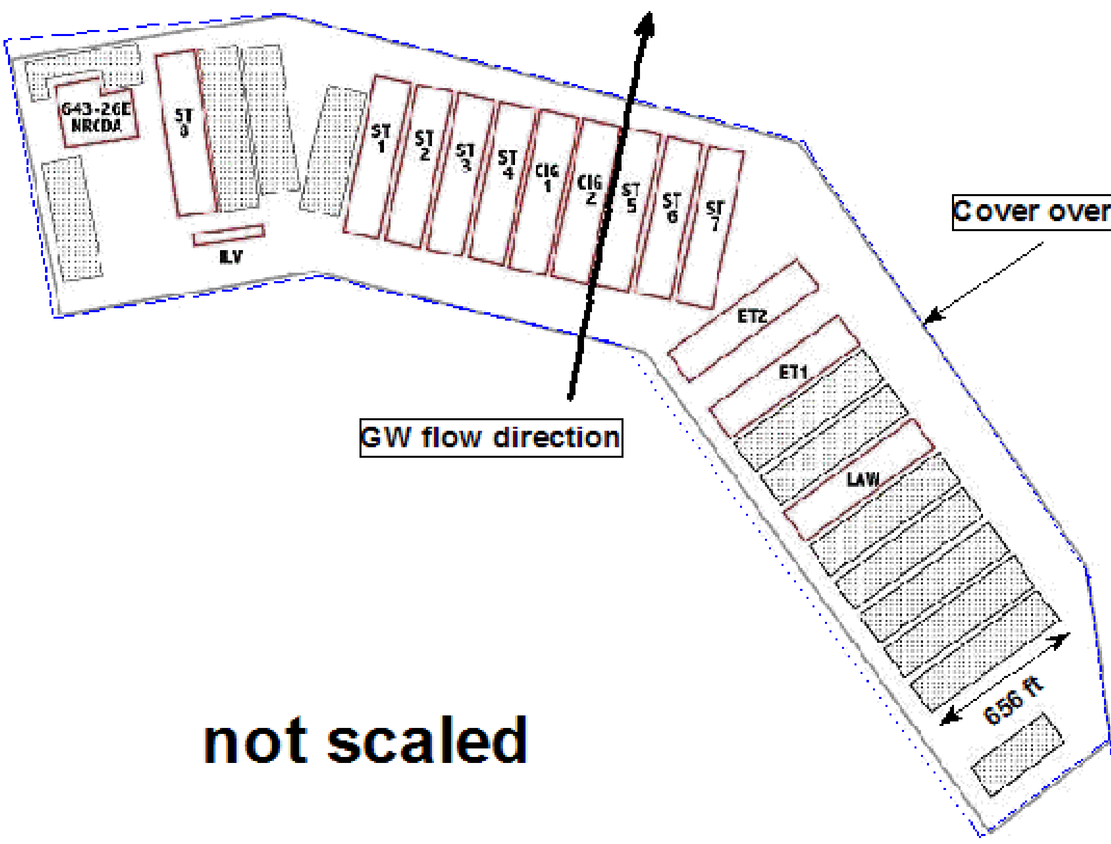

Figure 1. ELLWF Cover Overhang

This study performs PORFLOW related analyses with a focus on Slit and Engineered Trenches to evaluate the minimum required cover overhang size that would prevent any adverse impact on the ELLWF overall performance as simulated in Performance Assessment modeling.

2.0 Modeling Approach

This study is based on similar methodology employed in the ELLWF performance assessment work.

- PORFLOW Version 6.30.2 was used for analysis runs.
- Intact Scenarios: No property or geometry changes were assumed for 1,000 years with infiltration rates being 40cm/yr and 0.91cm/yr for uncovered and covered areas, respectively.
- Scenarios with dynamic compaction and 10% subsidence: At the end of the 100-year institutional period, dynamic compaction was conducted and 10% of trenches were assumed to subside as carried out in the performance assessment (PA) analyses.
- Nuclides: H-3, I-129, and Sr-90.
- Cover overhang distances: 5ft, 10ft, 20ft, 50ft, and infinite extent (i.e., cover extends beyond point of any practical impact on waste zone flow and transport).
- Time to begin lower infiltration due to placement of the cover: 0yr, 10yr, 20yr, and 30yr.
- Vadose Zone model domain: Two-dimensional (2D) cross-section down the *long* axis of the trench disposal unit (656 feet) (Trench model represented as a 2D slice along the *short* axis of the trench disposal unit in the 2008 PA).

The ELLWF PA Slit and Engineered Trench analyses implicitly assume infinite cover extent on the up and downgradient ends of the disposal unit. Because the 2D model in the present analysis is set up perpendicular to the PA model (i.e., it represents the cross-section along the *long* axis of the trench) this analysis implicitly assumes infinite cover extent along the sides (i.e., side-gradient edges) of the trench unit. However, recommendations in this report on minimum cover overhang size should be considered to apply to all edges.

The ELLWF PA Slit and Engineered Trench analyses implicitly consider "non-crushable" waste container disposals ranging between 0% and 10% of the total trench area. Non-crushable containers are those higher void containers that do not collapse to a denser waste form when subjected to dynamic compaction prior to cover system placement. In the PA analysis, these non-crushable containers are assumed to collapse immediately after cover system placement, creating localized cap subsidence and higher infiltration. Depending on the radionuclide, either the 0% or the 10% non-crushable case defines waste disposal radioactivity limits. In the present analysis the Intact Scenarios maintain the initial material properties, infiltration rates and model geometry throughout the entire 1,000-yr simulation period (i.e., assumes no dynamic compaction, increased infiltration or long-term waste layer subsidence). The present "Dynamic Compaction and 10% Subsidence" case resembles the PA 10% non-crushable case.

3.0 Simulation Results

3.1 <u>Intact Scenarios</u>

In the Intact Scenarios, a 656-foot long trench was modeled as a two-dimensional cross-section with four material zones as displayed in Figure 2. The cover overhang, implemented as a spatially varying condition applied to the top surface (not shown), can extend to both sides of the trench. The model domain provides sufficient space from the trench edge to the boundary (i.e., 100ft on each side) for size variation of the cover overhang. Because the trench was intact for the entire simulation, only a single waste zone was needed.

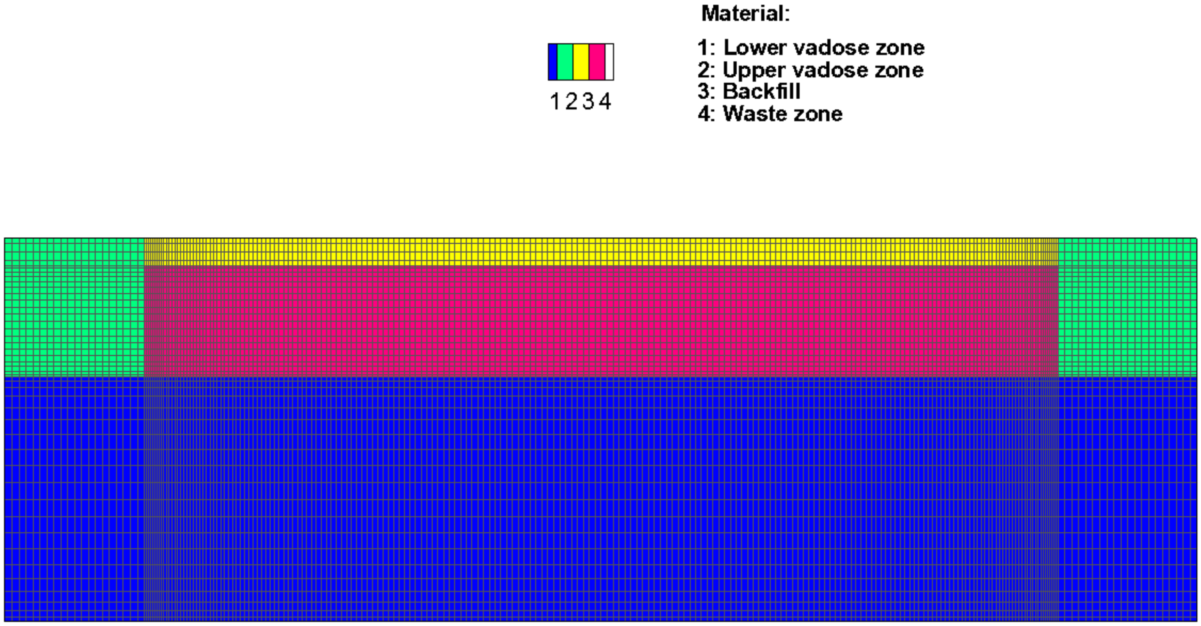

Figure 2. ELLWF Trench Geometry (Intact)

To assess a range of radionuclide behaviors, H-3 (short half-life) and I-129 (very long half-life) were chosen for analysis due to their high mobility. In addition, Sr-90 was identified as a radionuclide of interest because of its unique combination of moderate half-life and intermediate sorption coefficient (K_d, mL/g) relative to other parent radionuclides modeled in the PA as shown in Table 1.

Table 1. Nuclides in PA with moderate half-life

	Half-Life	Kd			
Nuclides	(year)	Lower VZ	Upper VZ	Backfill	Waste
Cm-244	1.81E+01	1100	8500	8500	8500
Pu-238	8.78E+01	270	5900	5900	5900
Pu-241	1.43E+01	270	5900	5900	5900
Sr-90	2.89E+01	5	17	17	17

PORFLOW runs were performed for H-3, I-129, and Sr-90 at varying conditions of cover overhang size and time of cover placement. In this scenario, low-infiltration conditions begin with placement of an interim cover at the end of operations and continues through installation of the final cover system (replacing the interim cap) to the end of the 1,000-year simulation period. Flux (given in mol/yr unit) at the water table was captured in each run over the entire simulation time of 1,000 years. Fluxes are displayed in Figures 3 to 6 for H-3, Figures 7 to 10 for I-129, and Figures 11 to 14 for Sr-90. The results show that for H-3 and I-129 there is no difference in performance for the various cover overhangs except when the cover is immediately installed. Engineered Trench and East and West Trench disposal limits for H-3 and I-129 are based on cover placement after 30 years and the peak flux occurs within 30 years. Therefore the size of the cover has no impact on disposal limits.

For the Center Slit Trenches minimal disposal limits were calculated assuming operational storm water runoff covers are installed at either 5, 10, or 15 years after the start of operations [2]. Slit Trenches 1-5 were operational between 5 to 15 years before receiving an operational cover, while neither of the remaining Center Slit Trenches, ST6 and ST7, have been operational less than 10 years. Therefore, the extent of the cover overhang could have a minor impact on H-3 and I-129 disposal limits for this group. This impact is likely to be beneficial for the most restrictive groundwater pathway time intervals.

For Sr-90 the cover timing has less impact on performance than the various cover overhangs. The highest flux occurs when the cover is installed at 30 years (PA 0% non-crushable case). For this case, with cover overhangs larger than 40ft, Sr-90 flux does not exceed the flux peak for an infinite cover. However, disposal limits for Sr-90 are controlled by the 10% non-crushable PA case, so a conclusion on the impact of cover extent on Sr-90 limits is deferred to the next section.

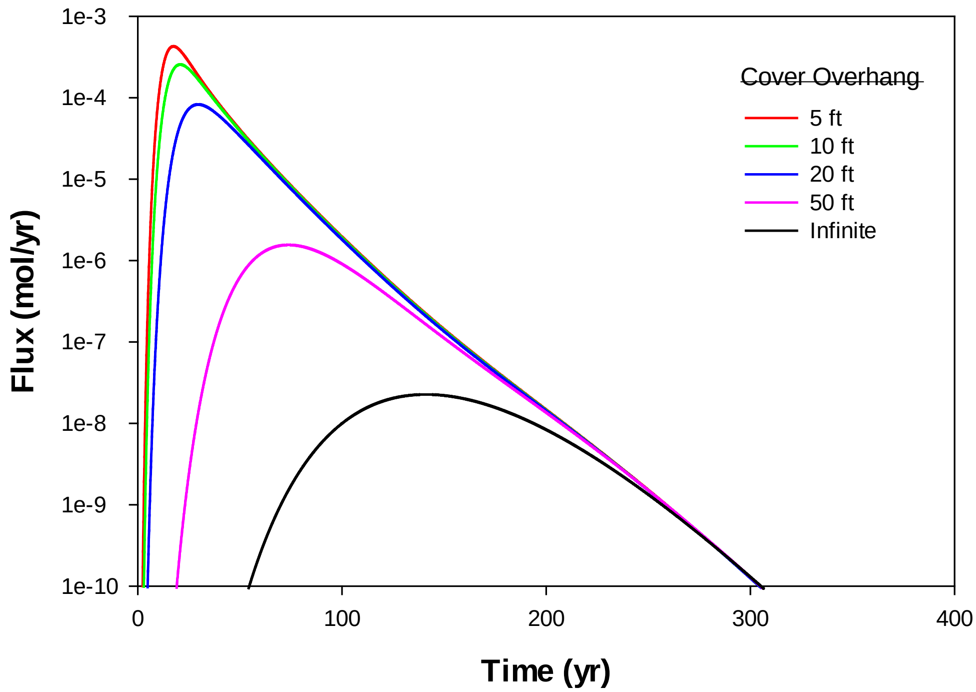

Figure 3. H-3 Flux at Water Table (Cover at 0yr)

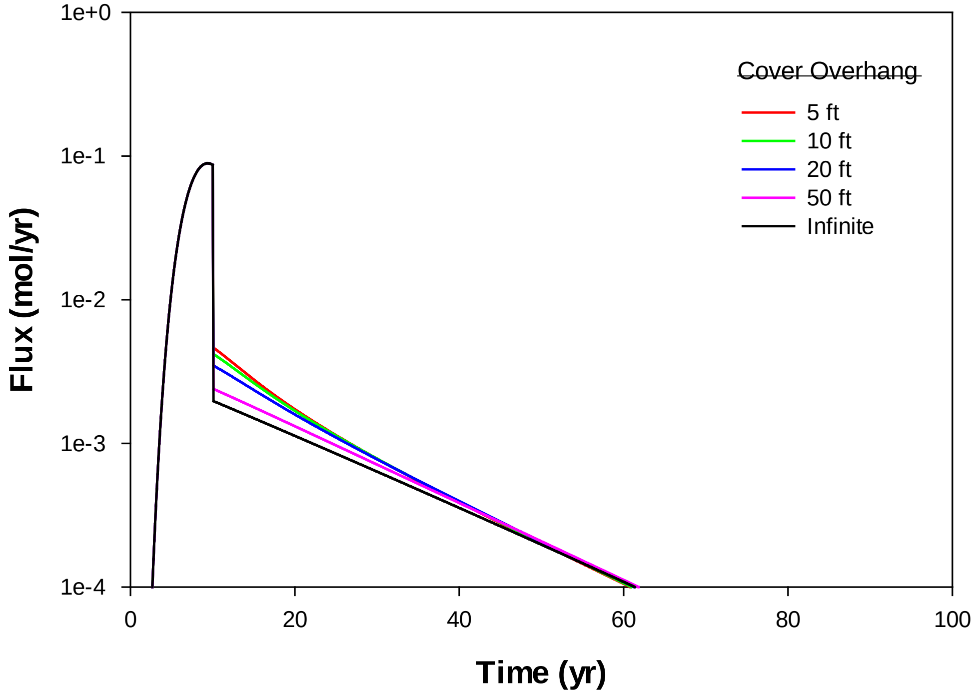

Figure 4. H-3 Flux at Water Table (Cover at 10yr)

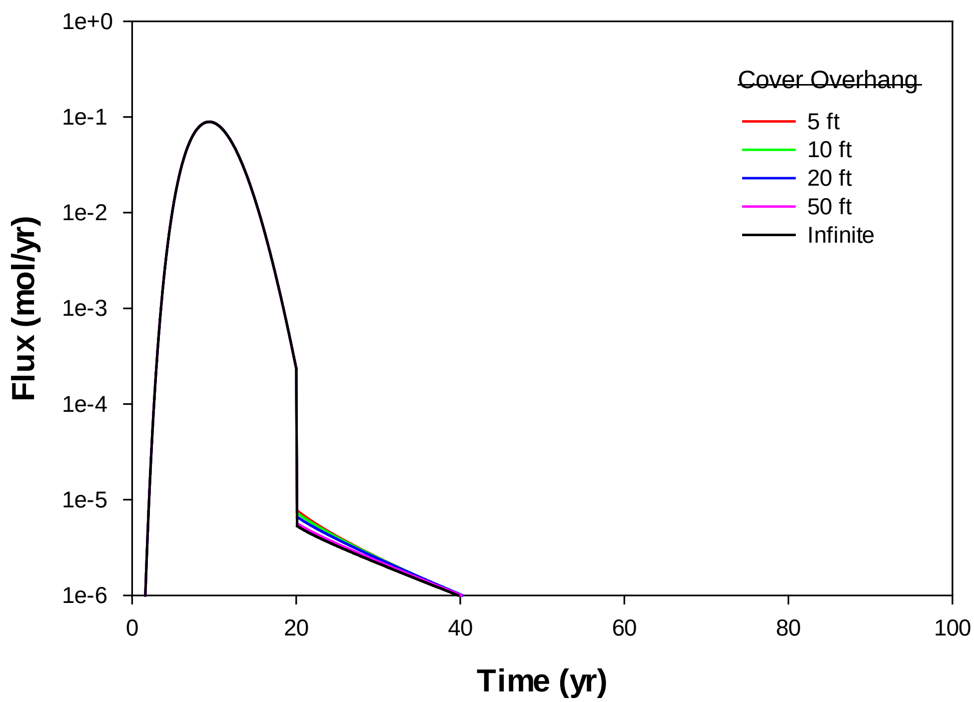

Figure 5. H-3 Flux at Water Table (Cover at 20yr)

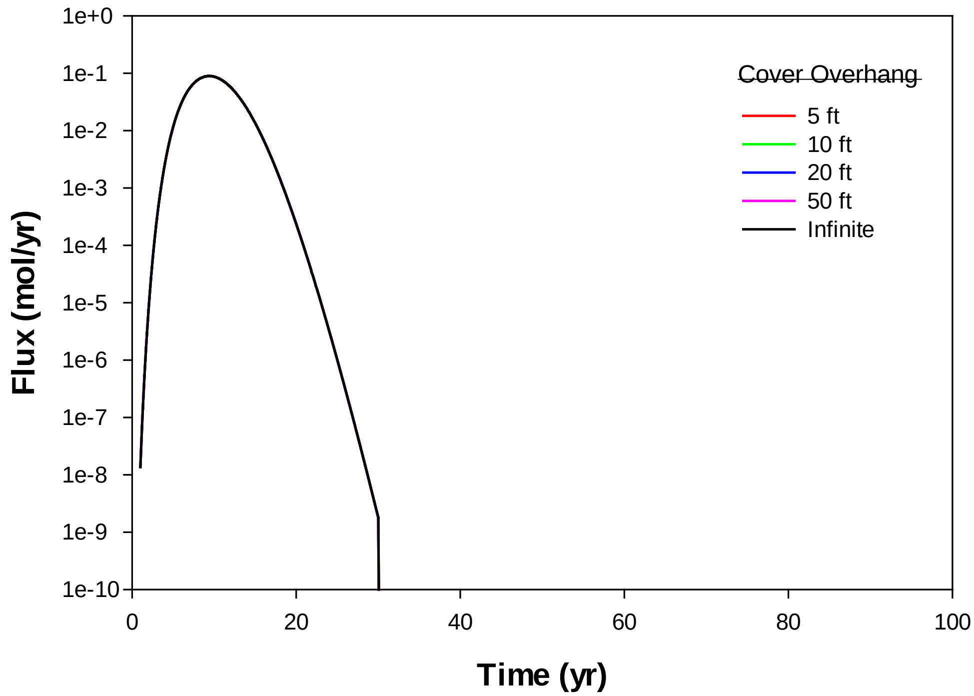

Figure 6. H-3 Flux at Water Table (Cover at 30yr)

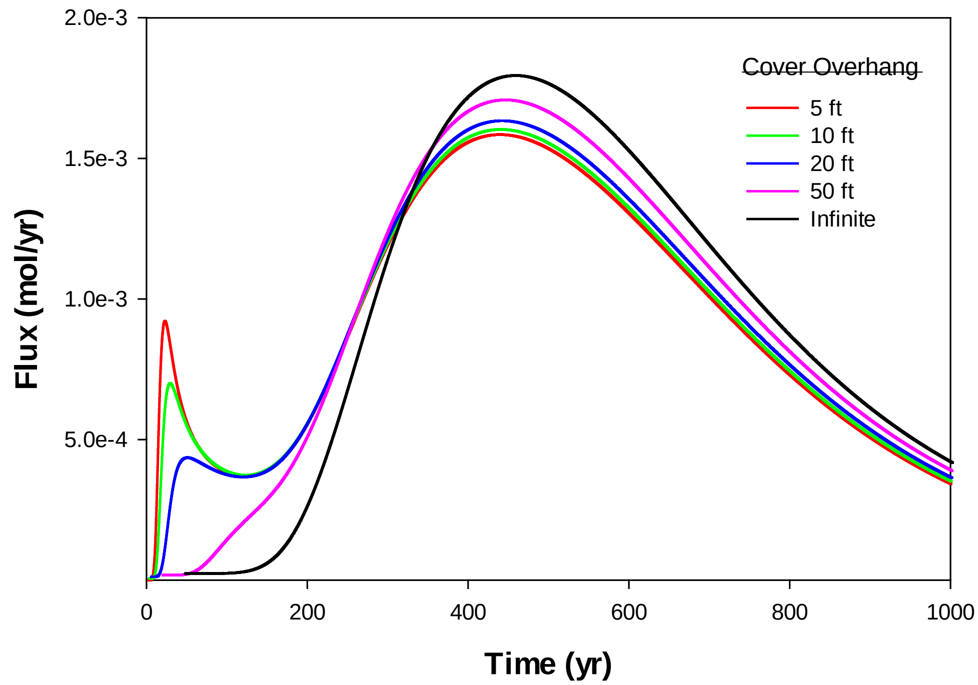

Figure 7. I-129 Flux at Water Table (Cover at 0yr)

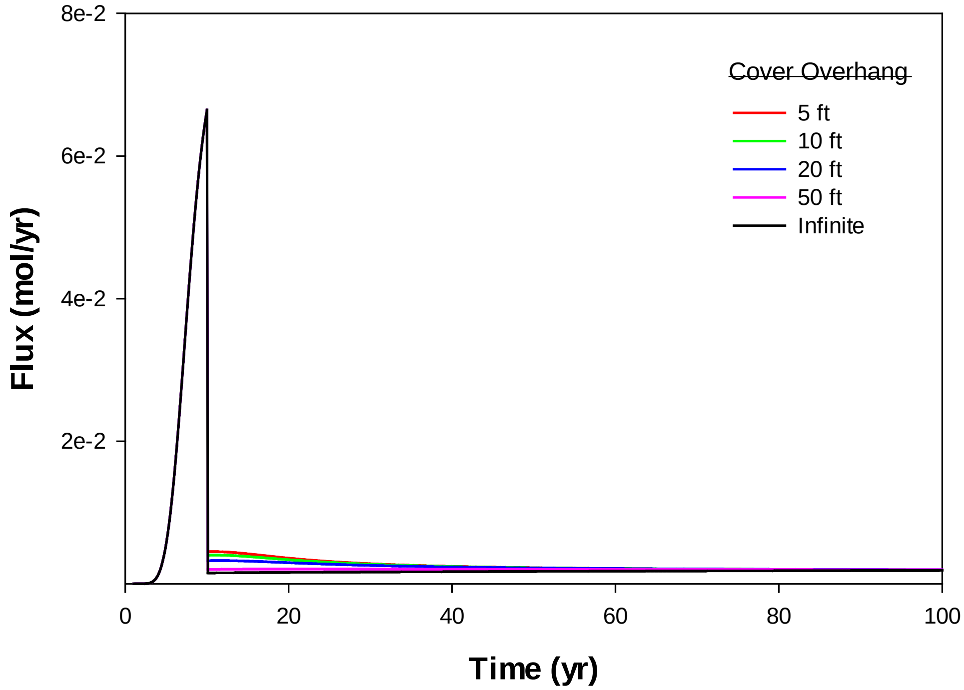

Figure 8. I-129 Flux at Water Table (Cover at 10yr)

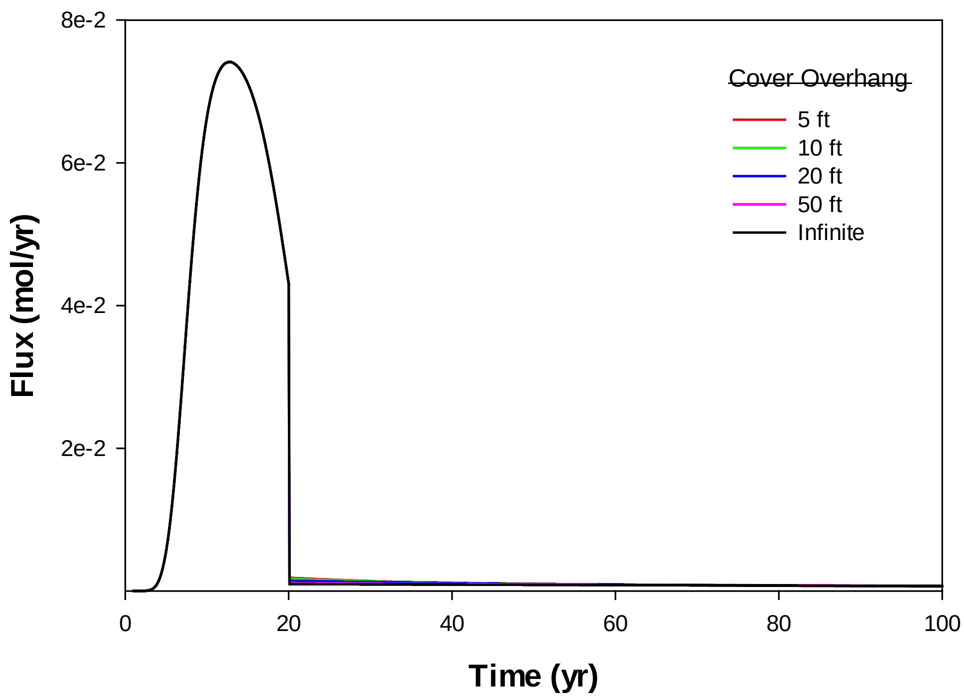

Figure 9. I-129 Flux at Water Table (Cover at 20yr)

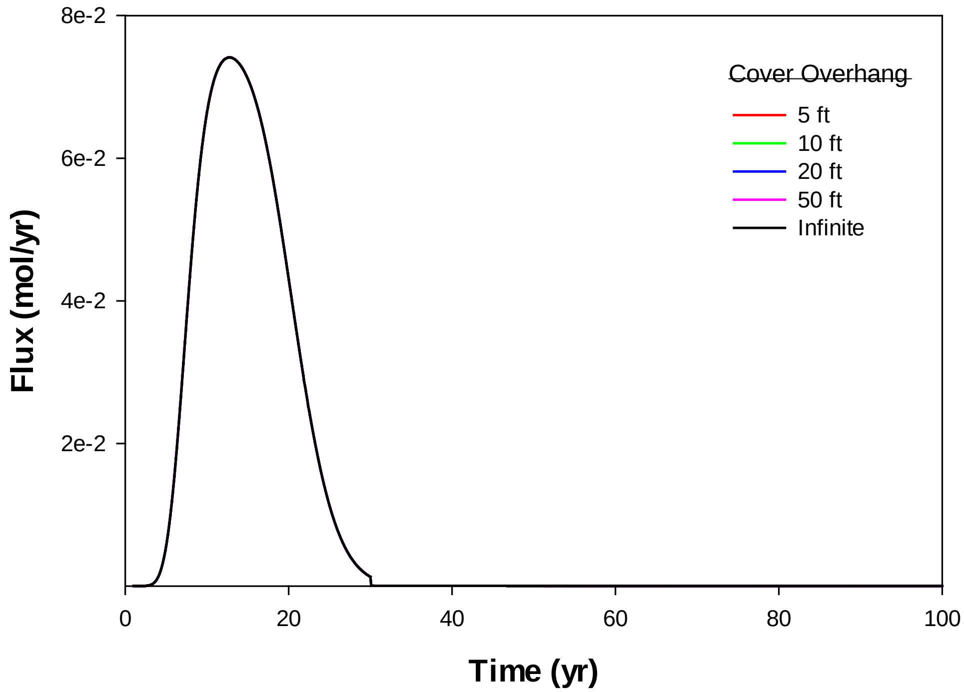

Figure 10. I-129 Flux at Water Table (Cover at 30yr)

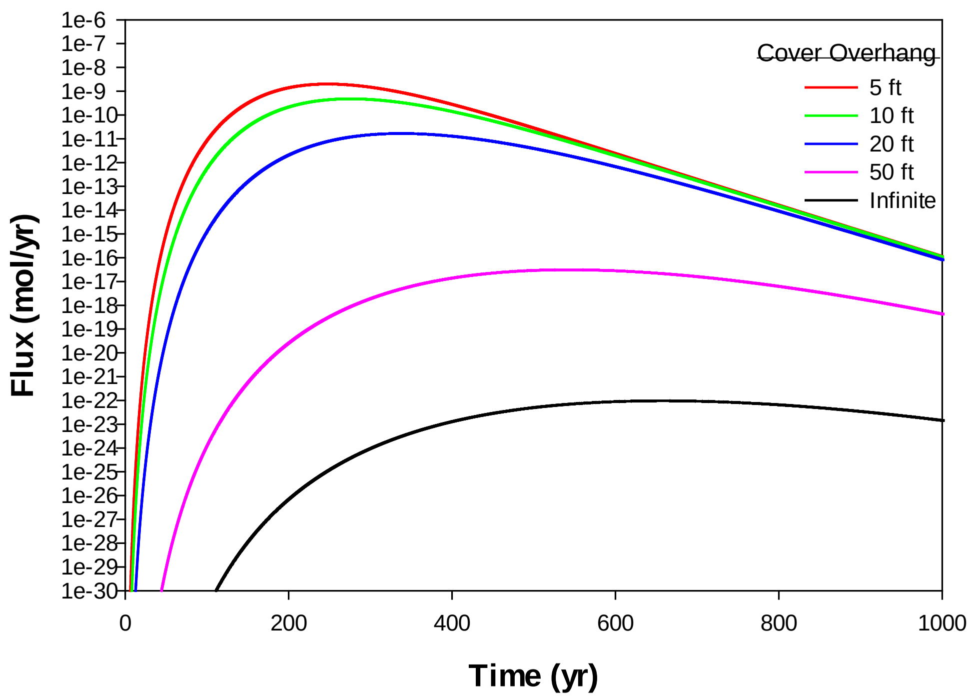

Figure 11. Sr-90 Flux at Water Table (Cover at 0yr)

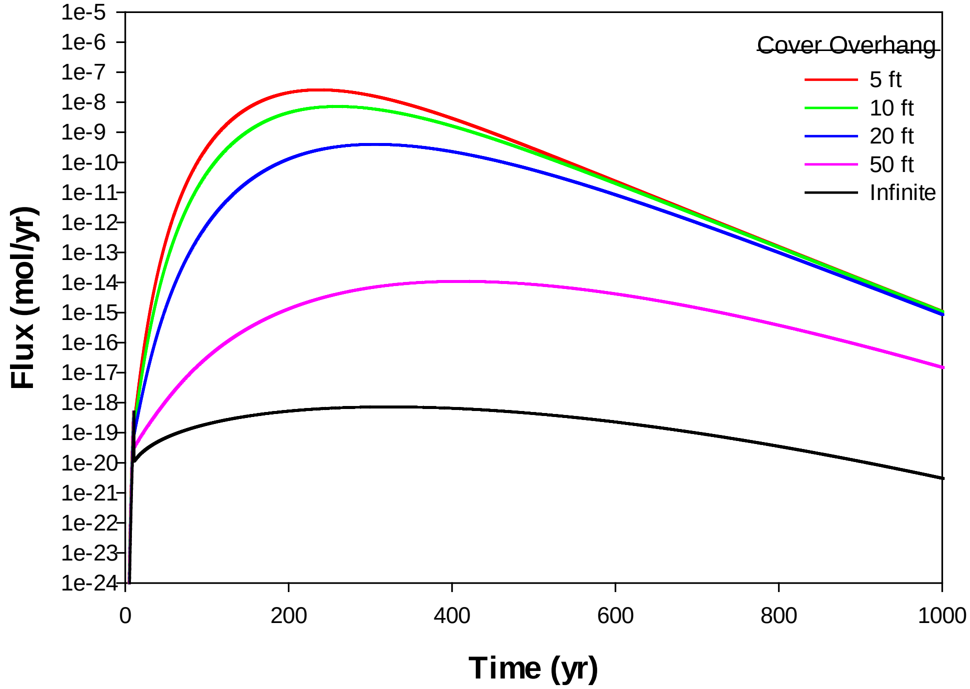

Figure 12. Sr-90 Flux at Water Table (Cover at 10yr)

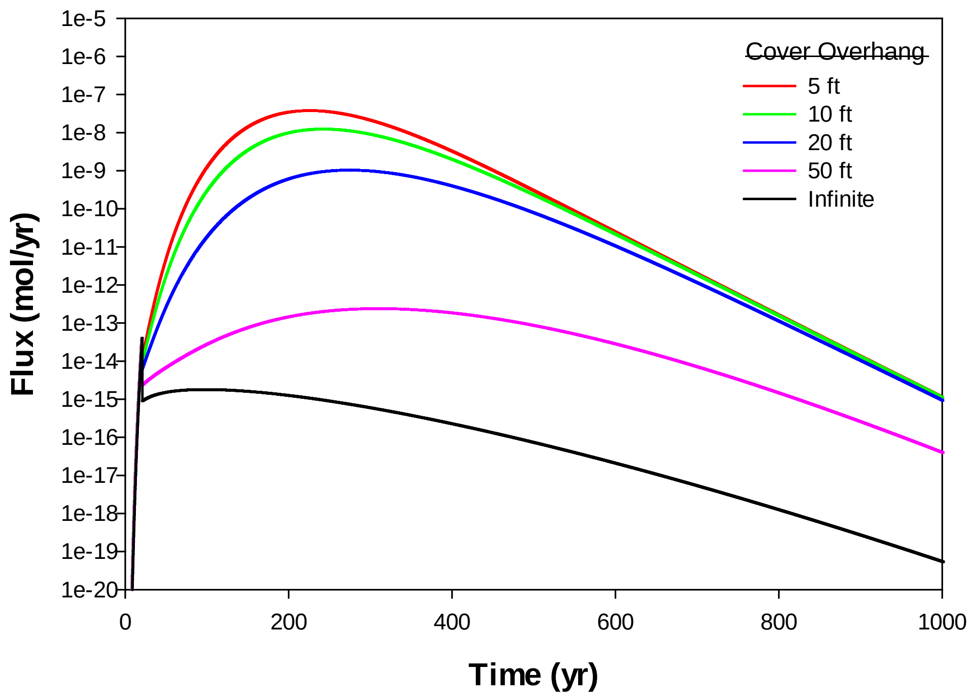

Figure 13. Sr-90 Flux at Water Table (Cover at 20yr)

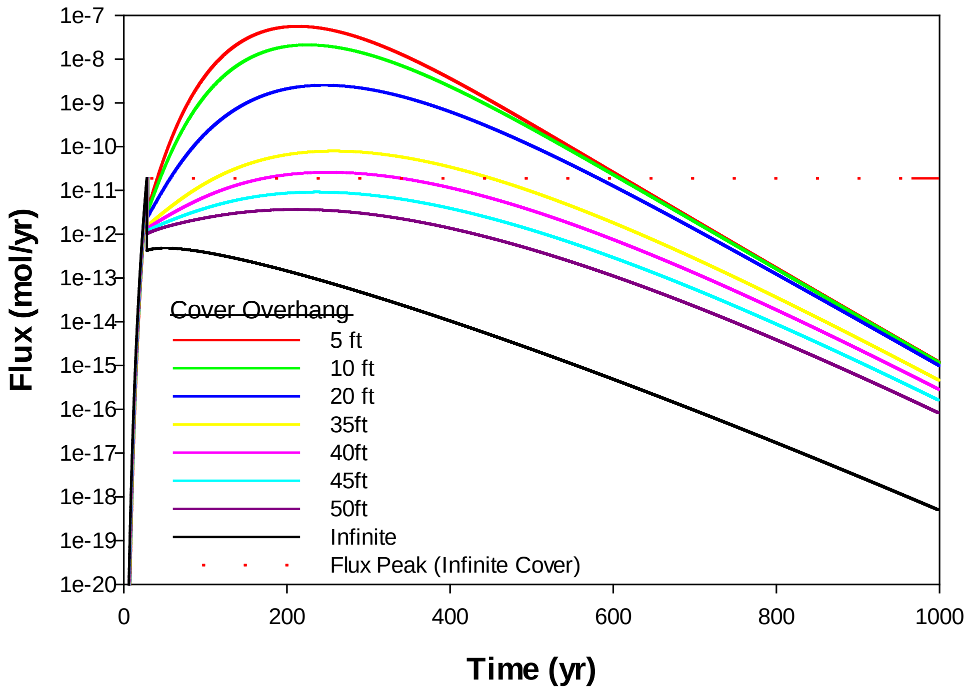

Figure 14. Sr-90 Flux at Water Table (Cover at 30yr)

3.2 Dynamic Compaction and 10% Subsidence

In these scenarios, PORFLOW runs were performed in a similar fashion as in the Performance Assessment analyses assuming 10% non-crushable waste. At the end of the 100-year institutional period, dynamic compaction was conducted and 10% of trenches assumingly subsided. Due to dynamic compaction the waste zone was compressed to a thin 2.5-foot layer at the trench bottom. The trench geometry shown in Figure 2 was therefore revised to accommodate this closure condition. The new geometry is displayed in Figure 15. At the beginning of each PORFLOW run, waste was uniformly distributed in the entire waste zone (i.e., both upper and lower waste zones). After dynamic compaction, waste in the upper waste zone was re-allocated to the lower waste zone.

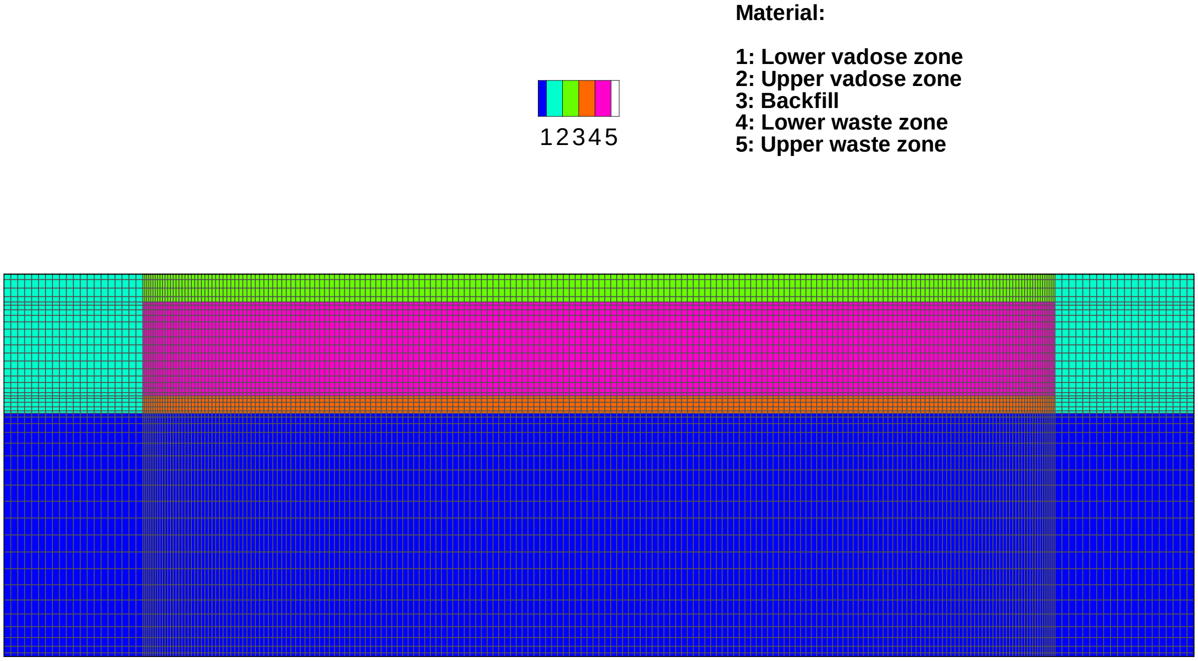

Figure 15. ELLWF Trench Geometry (Dynamic Compaction)

PORFLOW runs were carried out for Sr-90 at different cover overhang sizes assuming the cover was installed at 30 years. Again flux at the water table was captured in each run over the entire simulation period. Figure 16 displays Sr-90 flux at the water table for 1,000 years. The results show that, due to the large increase in infiltration rate caused by trench subsidence, the cover overhang size has no impact on peak flux at the water table.

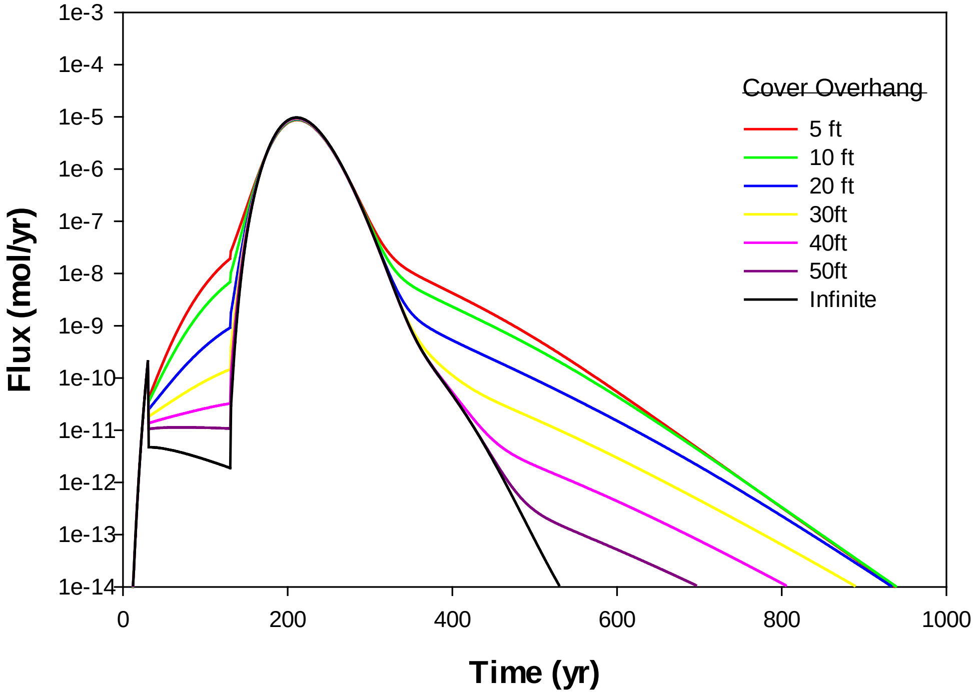

Figure 16. Sr-90 Flux at Water Table (Cover at 30yr, Dynamic Compaction and 10% Subsidence at 130 years)

4.0 Conclusions

The impact of cover overhangs on the overall ELLWF performance was evaluated for H-3 (short half-life), I-129 (very long half-life), and Sr-90 (moderate half-life with intermediate K_d) at different overhang sizes (5ft, 10ft, 20ft, 50ft, and infinite), cover timing (0yr, 10yr, 20yr, and 30yr) and scenarios (Intact and a limited Dynamic Compaction case). PORFLOW simulations show the following results:

- For H-3 and I-129:
  - Except when the cover is immediately installed, no difference in performance was observed for the various cover overhang sizes because most of the H-3 and I-129 inventory escapes before an impermeable cover is installed.
  - For Engineered Trenches and East and West Slit Trenches, disposal limits for H-3 and I-129 are based on 2008 PA simulations in which the interim closure cover system is first placed 30 years after waste disposal [1]. The extent of the cover overhang does not influence these disposal limits because the peak flux occurs before the interim closure cover is installed.
  - For the Center Slit Trenches minimal disposal limits were calculated assuming operational storm water runoff covers are installed at either 5, 10, or 15 years after the start of operations [2]. Slit Trenches 1-5 were operational between 5 to 15 years before receiving an operational cover, while neither of the remaining Center Slit Trenches, Slit Trenches 6 and 7, have been operational less than 10 years. Therefore, the extent of the cover overhang could have a minor impact on H-3 and I-129 disposal limits for this group. This impact is likely to be beneficial for the most restrictive groundwater pathway time intervals.

- For Sr-90:
  - Major difference in performance for the various cover overhangs.
  - Less impact of cover timing on performance.
  - When the cover is installed at 30 years:
    - for cover overhangs larger than about 40 feet, Sr-90 flux at the water table does not exceed flux peak for an infinite cover without dynamic compaction and trench subsidence at 130 years.
    - With dynamic compaction and 10% trench subsidence at 130 years, the cover overhang size has no impact on peak flux at the water table because of the large increase in infiltration rate in the subsided sections of the trench unit.
    - Slit and Engineered Trench disposal limits for Sr-90 are based on the PA 10% non-crushable container case. Therefore the extent of the cover overhang does not influence disposal limits.

Based on these results the following measures are recommended:

- In general the minimum cover overhang size to provide low infiltration is 40 feet.
- On the upgradient side of ELLWF, the cover overhang can be less than 40 feet because a drainage system and adjoining cover system already exist to divert infiltration away from the waste zone.
- On the downgradient side of ELLWF, the combined cover overhang and closure cap side slope composed of low-permeability membrane must have a minimum horizontal length of 40 feet from the waste unit boundary.

5.0 References

[1] *"E-Area Low-Level Waste Facility DOE 435.1 Performance Assessment,"* WSRC-STI-2007-00306, Rev. 0, July 2008.

[2] *"Special Analysis of Operational Stormwater Runoff Covers over Slit Trenches"*, SRNL-STI-2008-00397, Rev. 0, December 18, 2008.

This page intentionally left blank

Distribution:

B. T. Butcher, 773-42A
D. A. Crowley, 773-42A
G. P. Flach, 773-42A
T. Hang, 703-41A
L. L. Hamm, 753-A
K. M. Kostelnik, 773-42A
M. R. Millings, 773-42A
R. R. Seitz, 773-42A
F. G. Smith, III, 773-42A
Environmental Modeling Files,
  773-42A – Rm. 243
Records Administration (EDWS)