ENERGYSOLUTIONS

November 8, 2013 CD13-0302

Mr. Helge Gabert
Project Manager, DU Contract
Utah Division of Solid and Hazardous Waste
P.O. Box 144880
Salt Lake City, UT, 84114-4880

Subject: License No: UT2300249; RML #UT 2300249 –Condition 35 Compliance Report, Revision 1; Responses to Task 1 Preliminary Completeness Review

Dear Mr. Gabert:

On 1 June 2011, (in compliance with Condition 35.B of its Radioactive Material License UT2300249), Energy*Solutions* submitted to the Utah Division of Radiation Control the Report, "*Utah Low-Level Radioactive Waste Disposal License (RML UT2300249) – Condition 35 Compliance Report.*" In response, Energy*Solutions* received on 25 October 2013 from the Utah Department of Environmental Quality SC&A's "*Task 1: Preliminary Completeness Review.*"

Following examination of SC&A's Preliminary Completeness Review, Energy*Solutions* concurs with the statement made therein, "*It is possible that some comments included here may be judged to be technical comments [as opposed to findings of incompleteness]* ..."[1] Energy*Solutions* is hereby submitting 3 copies of revision 1 of its "*Utah Low-Level Radioactive Waste Disposal License (RML UT2300249) – Condition 35 Compliance Report,*" which provides in Appendix B the requested information SC&A found to be incomplete. Energy*Solutions* looks forward to providing specific responses to those comments that address the technical or regulatory adequacy of the Report, instead of its completeness, as part of our formal response to future Round 1 Interrogatories.

[1] SC&A. "Task 1: Preliminary Completeness Review – Clive Depleted Uranium Performance Assessment." Prepared by SC&A for the Utah Division of Radiation Control (Contract No. 146061), 25 October 2013, pg 1.

It is the understanding of Energy*Solutions* that we should expect to receive any Round 1 Interrogatories by 28 February 2014. Please contact me or Sean McCandless at 801-649-2000 if there are any comments or questions regarding this submittal.

Sincerely,

Vern C. Rogers
Environmental Manager

cc Rusty Lundberg, DRC
Don Verbica, DSHW

Enclosures

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

UTAH RADIOACTIVE MATERIAL

LICENSE - CONDITION 35 (RML UT2300249)

COMPLIANCE REPORT

(Revision 1)

November 8, 2013

For
Utah Division of Radiation Control
195 North 1950 West
Salt Lake City, UT 84114-4850

Energy*Solutions*, LLC
423 West 300 South, Suite 200
Salt Lake City, UT 84101

EXECUTIVE SUMMARY

In 2010, the Utah Board of Radiation Control initiated rulemaking to require a site-specific analysis for disposal of large quantities of depleted uranium. Since that time, Energy*Solutions* has received (and intends to dispose) 3,577 metric tons of depleted uranium waste that has been declared surplus from the Savannah River Site. However, Utah Administrative Code (UAC) Section R313-25-8(5) prohibits disposal of significant quantities of concentrated depleted uranium after June 1, 2010, until the Utah Division of Radiation Control Director approves a performance assessment that demonstrates that Energy*Solutions* will, following the disposal of large quantities of depleted uranium, continue to meet the performance standards specified in UAC R313-25-8.

As required by UAC R313-25-8(5), Energy*Solutions* has completed and hereby submits to the Division for Director approval an in-depth site-specific performance assessment for disposal of depleted uranium. Once approved, it is Energy*Solutions*' intention to begin disposal of significant quantities of depleted uranium in a Federal Cell using the currently-approved Class A West Embankment cover design. The Federal Cell was initially submitted for DRC approval as the "Class A South" cell, with a revised application and completeness review response package dated June 9, 2009. Energy*Solutions*' records show that DRC indicated interrogatories on this design were under preparation but not received at the time the application was withdrawn on May 2, 2011.

Because of the legacy processes, depleted uranium from the Savannah River Site contains small quantities of waste fission products and transuranic elements, in addition to depleted uranium. The estimated mass of depleted uranium from the Savannah River Site proposed for disposal in Energy*Solutions*' Federal Cell is 3,577 metric tons (5,408 drums). This depleted uranium Performance Assessment also evaluates acceptance and disposal of up to 700,000 metric tons of similar depleted uranium waste from the gaseous diffusion plants at Portsmouth, Ohio and Paducah, Kentucky.

License Condition 35.B of Energy*Solutions*' Radioactive Material License (UT 2300249) states,

> "*Performance assessment: A performance assessment, in general conformance with the approach used by the Nuclear Regulatory Commission (NRC) in SECY-08-0147, shall be submitted for Director review and approval no later than June 1, 2011. The performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period will be a minimum of 10,000 years. Additional simulations will be performed for a minimum 1,000,000-year time frame for qualitative analysis.*"

Energy*Solutions* demonstrates compliance with license condition 35 through the development and execution of the detailed, site-specific, probabilistic performance assessment using the GoldSim model. This model and the resulting findings demonstrate that Energy*Solutions*' proposed methods for disposal of large volumes of depleted uranium will ensure that ongoing operations, safe institutional control, and stable site closure can be conducted, and that the Federal Cell will comply with the Division's radiological criteria contained in the Radioactive Material License.

ENERGYSOLUTIONS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

Term	Definition
11e.(2)	Section 11e.(2) of the Atomic Energy Act of 1954, as amended
Ac	actinium
Act	Utah Radiation Control Act
ALARA	As Low As Reasonably Achievable
Am	americium
AMEC	AMEC Earth and Environmental, formerly AGRA Earth and
ASCE	American Society of Civil Engineers
ASTM	ASTM International, formerly American Society for Testing and
BLM	Bureau of Land Management
Bq	Becquerel
BWF	Bulk Waste Facility
CCE	certified cost engineer
CEDE	committed effective dose equivalent
CFR	U.S. Code of Federal Regulations
Ci	curie
cm/sec	centimeters per second
cm/yr	centimeters per year
CQA/QC	Construction Quality Assurance/Quality Control
CSF	cancer slope factor
CSLM	Controlled Low Strength Material
CSM	conceptual site model
CTC	Cover Test Cell
CWF	Containerized Waste Facility
DCF	dose conversion factor
DDE	deep dose equivalent
Division	Utah Division of Radiation Control
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DRC	Utah Division of Radiation Control
DU	depleted uranium
EDIS	electronic document imaging system
EIS	environmental impact statement

ACRONYMS AND ABBREVIATIONS (continued)

Term	Definition
EPA	U.S. Environmental Protection Agency
ETTP	East Tennessee Technology Park
EWIS	Electronic Waste Information System
FEIS	Final Environmental Impact Statement
FEP	features, events, and processes
FR	Federal Register
ft	foot/feet
Ft	feet; foot
ft/ft	feet per foot
ft-lbf/ft^3	foot-pound force per cubic foot (unit of energy density)
g	gram
GDP	gaseous diffusion plant
GTCC	greater than Class C waste
GWPL	groundwater protection limit(s)
GWQDP	groundwater quality discharge permit
ha	hectare
hr	hour; hours
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiation Protection
in	inch; inches
in/yr	inches per year
ka	thousand years ago
K_d	soil/water partition coefficient
kg	kilogram
km	kilometer
ky	thousand years
L	liter
LARW	low-activity radioactive waste
LLRW	low-level radioactive waste
LRA	License Renewal Application
m	meter
Ma	million years ago
MCL	maximum contaminant level(s)
Mg	megagram (one metric ton)
mg	milligram

ACRONYMS AND ABBREVIATIONS (continued)

Term	Definition
MLLW	mixed [hazardous and] low-level radioactive waste
mm	millimeters
MPa	megapascal
mrem	millirem
mrem/yr	millirem/yr
My	million years
NORM	Naturally-Occurring Radioactive Materials
NQA	Nuclear Quality Assurance
NRC	U.S. Nuclear Regulatory Commission
NTS	Nevada Test Site
NUREG	an NRC publication
PA	performance assessment
Pa	protactinium
PAWG	Performance Assessment Working Group (DOE)
pCi	picocurie
pCi/g	picocuries per gram
pCi/m^2-s	picocuries per square meter-second
Po	polonium
ppm	part per million
Pu	plutonium
QA	quality assurance
QAM	Quality Assurance Manual
QAP	Quality Assurance Program
R	Roentgen
Ra	radium
RfD	reference dose
RML	Radioactive Material License (UT2300249), as amended May 10, 2011.
Rn	radon
S&H	safety and health
SLB&M	Salt Lake Baseline and Meridian
SNM	Special Nuclear Material
SRS	Savannah River Site
Tc	technetium
TDS	total dissolved solids

ACRONYMS AND ABBREVIATIONS (continued)

Term	Definition
TEDE	total effective dose equivalent
TF	Treatment Facility
Th	thorium
TSD	Treatment, Storage and Disposal
U	uranium
UAC	Utah Administrative Code
UDOGM	Utah Division of Oil, Gas and Mining
UDSHW	Utah Division of Solid and Hazardous Waste
UDWQ	Utah Division of Water Quality
UMTRA	Uranium Mill Tailing Remedial Action
UNF	used nuclear fuel
URCA	Utah Radiation Control Act
URCB	Utah Radiation Control Board
UAC	Utah Radiation Control Rules
USACE	US Army Corps of Engineers
USGS	United States Geologic Survey
UWQB	Utah Water Quality Board
yr	year

1. INTRODUCTION

Energy*Solutions*, headquartered in Salt Lake City, Utah is a worldwide leader in the safe recycling, processing and disposal of nuclear material, providing innovations and technologies to the U.S. Department of Energy (DOE), commercial utilities, and medical and research facilities. At its Clive Facility, located 75 highway miles west of Salt Lake City, Energy*Solutions* operates a commercial treatment, storage and disposal facility for Class A low-level radioactive waste and Class A low-level mixed waste.

Historically, authorization for disposal of depleted uranium was approved by the Division at a concentration of 110,000 pCi/g beginning with License amendment 2 approved December 3, 1990. This activity was increased to the specific activity of depleted uranium; i.e., pure form; with approval of the Performance Assessment submitted in support of the 22 October 1998 License renewal (limiting the depleted uranium within a container to no greater than 370,000 pCi/g, upon receipt). Under this License authorization, approximately 18,400 Ci of depleted uranium were safely disposed in the at Clive between 1990 and 2010.

In 2010, the Utah Radiation Control Board initiated rulemaking to require a site-specific analysis before authorizing the disposal of large quantities of depleted uranium (DU). This rulemaking also applies to 3,577 metric tons (5,408 drums) of uranium trioxide (DUO_3) waste received from the Savannah River Site (SRS) in December, 2009. In compliance with the depleted uranium Performance Assessment prerequisite, Energy*Solutions* is temporarily holding these drums in storage (awaiting Director approval of this depleted uranium Performance Assessment). In the future, Energy*Solutions* is also considering disposal of depleted uranium from the gaseous diffusion plants at Portsmouth, Ohio and Paducah, Kentucky.

As is illustrated in Figure 1-1, Energy*Solutions* has evaluated a new Federal Cell, using the Division-approved and licensed Class A West Embankment cover design, as the ultimate destination for the large volumes of depleted uranium. The Federal Cell was initially submitted for DRC approval as the “Class A South” cell, with a revised application and completeness review response package dated June 9, 2009. Energy*Solutions*’ records show that DRC indicated interrogatories on this design were under preparation but not received at the time the application was withdrawn on May 2, 2011. Reviewers should note that the former Class A South cell included an isolation barrier between Class A and 11e.(2) wastes as well as a proposed system for monitoring groundwater beneath this barrier; in order to differentiate the source of any potential groundwater contamination as being from Class A or 11e.(2) wastes. Depending on the terms of DOE agreement to take stewardship of a Federal Cell, these features may not be required.

In accordance with Utah Administrative Code (UAC) R313-25-8(5)(a), Energy*Solutions* is required to complete and submit to the Division for Director approval an in-depth site-specific performance assessment for the disposal of significant volumes of depleted uranium. However, even once a technical analysis is approved, Energy*Solutions* recognizes the following policy issues that must be resolved before disposing of concentrated depleted uranium in the Federal Cell.

Figure 1-1, Energy*Solutions*' Proposed Federal Cell Location

1. NRC confirmation of the decision captured in NRC Order CLI-05-20 that depleted uranium is properly classified in accordance with 10 CFR 61 as Class A LLRW.

2. Completion of a Memorandum of Agreement with DOE assuming long-term stewardship of the Federal Cell.

3. Although the Performance Assessment evaluates disposal both above- and below-grade, depleted uranium will be disposed below grade to enhance assurance of continued isolation under geologic-time events such as the return of a large lake inundating Clive. Figure 1-2 below demonstrates that the entire depleted uranium inventory evaluated can be disposed in such a manner.

4. Even though groundwater beneath the Federal Cell is not potable, the 4 mrem/year groundwater dose standard found in R317-6-2 must be applied to scenarios out to 10,000 years.

5. Policymakers must resolve how the Federal Cell capacity relates to the Agreement signed between former Utah Governor Jon Huntsman and former Energy*Solutions* CEO Steve Creamer on March 15, 2007.

These policy-level issues are acknowledged to be relevant to any ultimate approval to dispose of depleted uranium; yet outside of the technical matters relating to environmental fate and transport evaluated under the Performance Assessment.

1.1 Licensing Overview

DOE remedial activities began for the Salt Lake City Vitro mill site in February 1985 and activities were completed in May 1989. Contaminated materials that remained at the site were excavated and relocated by the State of Utah to a newly acquired site, located 75 highway miles west of Salt Lake City at a location known as Clive, Utah. Adjacent to this operation, Energy*Solutions* (then known as Envirocare of Utah) began disposal operations at its Clive facility in 1988 under a State license (RML UT 2300249) to dispose of Naturally-Occurring Radioactive Materials (NORM). In 1990, Energy*Solutions* submitted a license application to modify its license to allow disposal of low-activity radioactive waste (LARW). In 1991, the Division granted this amendment request by issuing a license for LARW disposal. From time to time, the LARW disposal license has been amended to address Energy*Solutions'* changing needs and those of the public interest. Eventually, the license permitted disposal of Class A low-level radioactive waste (LLRW). In 2008, the Division renewed Energy*Solutions'* license (Energy*Solutions*, 2008).

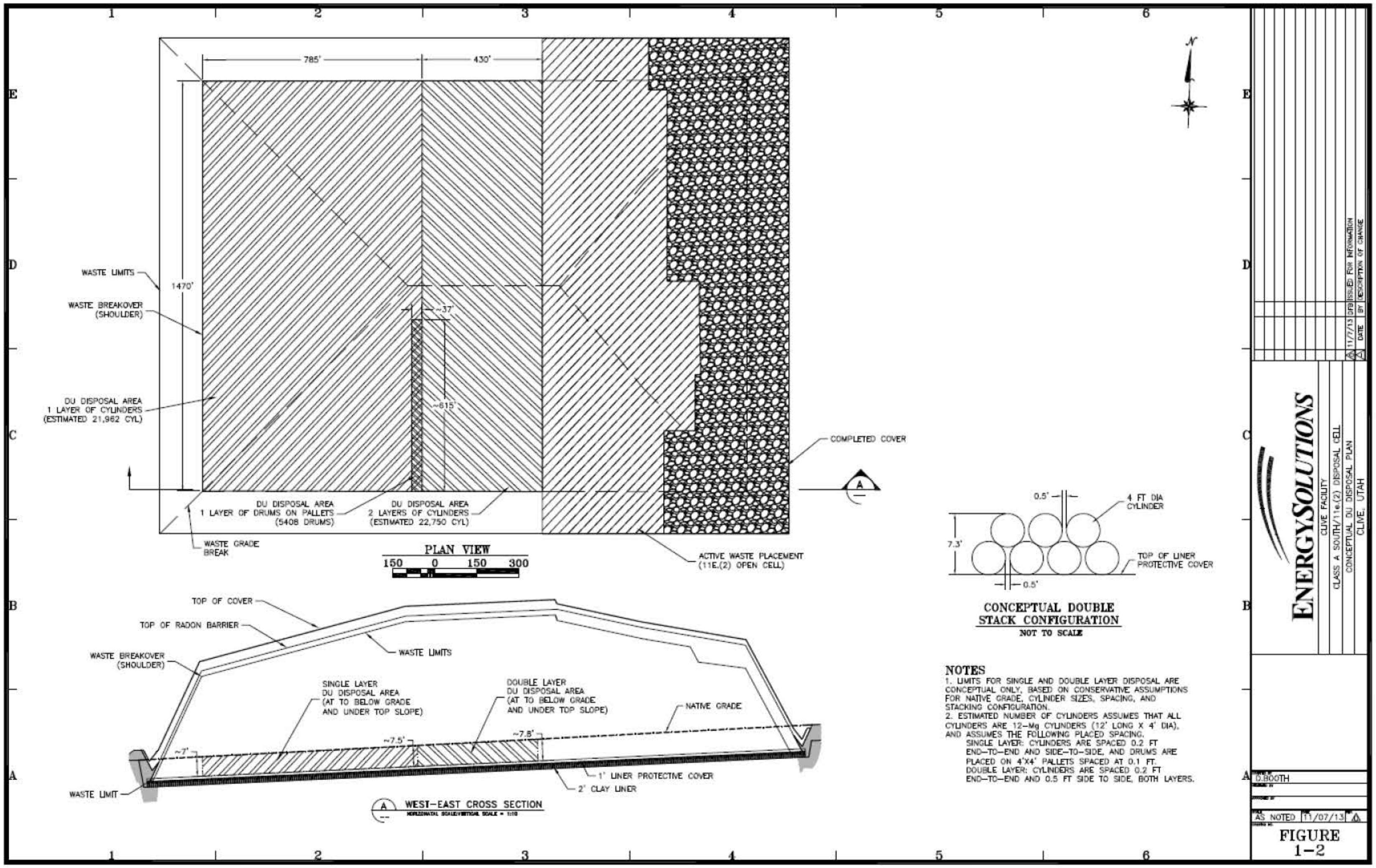

Figure 1-2, Federal Cell Below-Grade Depleted Uranium Capacity

In 2012, the Division amended Energy*Solutions'* Radioactive Material License # UT 2300249 and Ground Water Quality Discharge Permit No. UGW450005 to combine the Class A and Class A North disposal embankments into one embankment (termed *Class A West*), (McCandless, 2012). Since then, Energy*Solutions* has filed an additional application with the Division to again renew its Class A Radioactive Material License (Energy*Solutions*, 2012b).

Energy*Solutions* conducts other treatment and disposal operations in areas adjacent to its Class A West Embankment. These activities include mixed hazardous waste treatment and disposal under a Treatment, Storage and Disposal (TSD) State-issued Part B RCRA Solid Waste Permit (re-issued by the Executive Secretary of the Utah Solid and Hazardous Waste Control Board on April 4, 2003). The nature of mixed waste managed at the facility includes contaminated soils, process waste, debris and sludges. The mixed waste portion of the facility consists of a disposal cell, a treatment building, a storage building and an operations building.

Energy*Solutions* also disposes of uranium and thorium by-product material {11e.(2)} under a license originally issued by the U.S. Nuclear Regulatory Commission (NRC) as Byproduct Material License SMC-1559. Energy*Solutions*' 11e.(2) license is now administered by the Division (RML UT2300478).

In conjunction with licensed activities, Energy*Solutions'* operations are also subject to the provisions of Ground Water Quality Discharge Permit (GWQDP) UGW450005, issued by the Utah Division of Water Quality (UDWQ). In 2008, Energy*Solutions* was awarded a renewal for this permit. This permit specifies that groundwater quality protection levels for radioactive constituents must be met for no fewer than 500 years following facility closure. Energy*Solutions* has filed an application with the Division to renew its Ground Water Quality Discharge Permit (Energy*Solutions*, 2013). Similarly, Energy*Solutions* also operates under Air Quality Approval Order DAQE-AN0107170019-11, issued by the Utah Division of Air Quality (UDAW).

1.2 Other Associated Performance Assessments

To support the Division's approval of the Class A West amendment of Radioactive Material License UT2300249 (Class A West Amendment Application), Energy*Solutions* submitted a performance assessment that utilized the same PATHRAE, UNSAT-H, and HELP methodology employed for previous embankment licensing efforts, updating it to reflect the new Class A West geometry and cover design. Potential groundwater impacts from the Class A West Embankment with a traditional rock-armored cover system were demonstrated therein to be minimal (Whetstone, 2011).

On 14 February 2011, Energy*Solutions* requested concurrence from the Division that previous licensing activities allowed for the receipt and disposal of processed ion-exchange resin waste on a large-scale in the Class A West Embankment (Shrum, 2011a; Shrum, 2011b). The Division reviewed Energy*Solutions*' analysis supporting this request and determined that Energy*Solutions* could dispose in its Class A West Embankment up to 40,000 cubic feet per year of processed ion-exchange resin waste. However, in order to manage processed ion-exchange resin waste at volumes greater than 40,000 cubic feet per year, Energy*Solutions* would be required to conduct a new performance assessment analyses that include "*prediction of nuclide concentration and peak dose (at the time peak dose would occur) using updated dose conversion factors, and a suggested model time frame of 10,000 years, as well as any need to revisit/update the waste source term, receptor and exposure pathways*" (Lundberg, 2011).

In compliance with these requirements and in demonstration of the performance of an alternative evapotranspirative cover design, Energy*Solutions* submitted to the Division on 8 October 2012 an updated, site-specific Performance Assessment (Shrum, 2012). While not yet formally approved by the Division, this updated, site-specific Performance Assessment demonstrates the alternate evapotranspirative cover and Class A West Embankment's ability to protect the general public during operations, protect the general public after closure, protect the inadvertent intruder, and to be stable over time. In fact, the model demonstrates that the alternative evapotranspirative cover design significantly reduces infiltration of precipitation into waste to a range of 0.00019 cm/yr to 0.00025 cm/yr (Shrum, 2012), as compared to 0.09 cm/yr and 0.168 cm/yr infiltration projected through the originally-approved traditional rock armored cover's top and side slope (Whetstone, 2011). In fact, the alternative cover design performance demonstrates "*. . . that no radionuclides [at concentrations up to Class A limits] have the potential to reach the groundwater point of compliance within 10,000 years.*" (page 60 of Appendix A of Shrum, 2012). Given its improved ability to protect the groundwater resources and exposed general public, Energy*Solutions* will evaluate the alternative evapotranspirative cover design for the proposed Federal Cell in future revisions to the depleted uranium Performance Assessment.

1.3 Regulatory Context

In the context of disposal of radioactive waste, a performance assessment is a quantitative evaluation of potential releases of radioactivity from a disposal facility into the environment and assessment of the resultant radiological doses. Energy*Solutions* commonly conducts performance assessments to demonstrate that its various embankments meet the required performance objectives throughout the required Period of Performance.

UAC R313-25-8(5)(a) requires that a performance assessment be performed and approved by the Director prior to the disposal of significant quantities of depleted uranium. The required performance assessment must meet the provisions of section 5(a) of R313-25-8 that requires that the performance assessment:

> *"demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively."*

In development of the required depleted uranium Performance Assessment, Energy*Solutions* considered guidance NRC has issued to assist applicants and licensees in applying these standards as they reflect years of experience with a variety of waste streams and disposal situations. NUREG-1573 is a key NRC guidance document for conducting performance assessments (NRC, 2000). Additional recent guidance is contained in NUREG-1854 (NRC, 2007).

In particular, there are four areas to consider in applying the performance standards within the context of a performance assessment. First is the compliance period. Second is the dose methodology. Third is the dose standard for the intruder. Fourth is embankment stability.

1.3.1 UAC R313-15-401: Periods of Performance versus Times of Compliance

Prior to implementing UAC R313-25 (e.g., 10 CFR 61), it had been a common practice at waste disposal facilities across the country to randomly dump some waste. This practice jeopardized package integrity and did not permit access to voids between packages so that they could be properly backfilled. Consolidation of wastes into this disposal configuration provided less stable support which could contribute to failure of the disposal embankment cover leading to increased precipitation infiltration and surface water intrusion.

To help achieve stability, NRC noted that, to the extent practicable, waste should maintain gross physical properties and identity over 300 years, under the conditions of disposal. NRC believes that the use of design features to achieve stability is consistent with the concept of ALARA and the use of the best available technology. It is NRC's view that waste forms or containers should be designed to be stable (i.e., maintain gross physical properties and identity, over 300 years). NRC also notes that an embankment should be evaluated for at least a 500-year time frame to address the potential impacts of natural events and phenomena.

About the same time as Part 61 was promulgated, NRC also put in place requirements for design of uranium mill tailings piles such as the Vitro site which is located immediately east of the Class A West Embankment. In addressing stability requirements for mill tailings, NRC recognizes the need to set practicable standards. NRC specifies that the design for mill tailings waste disposal shall provide reasonable assurance of control of radiological hazards to be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years.

In both cases (low-level radioactive waste and mill tailings disposal) NRC recognizes the need to set practical standards that can be implemented, (ranging from 200 up to 1,000 years). NRC also recognizes the design limitations and notes that reasonably achievable designs should be employed to the extent practicable. As such, it is generally not practical to set design standards beyond 1,000 years.

Consequently, an approach consistent with past standard setting practice is employed in this depleted uranium Performance Assessment for purposes of applying the performance standard for stability of the disposal site after closure (UAC R313-25-22). Analysis of the appropriate Periods of Performance and Times of Compliance applicable to this depleted uranium Performance Assessment includes the following promulgated requirements for disposal of depleted uranium waste in the Federal Cell.

1. 500 YEARS: Energy*Solutions'* Federal Cell (using the Division-approved Class A West Embankment cover design) is subject to performance limits on the release of groundwater contamination, as required by UAC R317-6-2 (delineated in Energy*Solutions'* Ground Water

Quality Discharge Permit). However, UAC R317-6-3 classifies groundwater beneath the Federal Cell as Class IV, "*non-potable, saline ground water.*" UAC R317-6-4.7 states: "*Protection levels for Class IV ground water will be established to protect human health and the environment.*" Specific Ground Water Protection Levels and periods of performance for Class IV groundwater are not set by rule. For disposal cells at Clive, this is accomplished by setting Best Available Technology performance standards for non-radiological and radiological contaminants in groundwater at Part I.D.1 as being 200 and 500 years, respectively. Because of this, the Period of Performance for protection of groundwater resources from further degradation is 500 years, following Federal Cell closure.

2. <u>1,000 YEARS</u>: In addition to preservation of the current condition of its groundwater resource, Energy*Solutions* is also required "*When calculating the total effective dose equivalent to the average member of the critical group, the licensee shall determine the peak annual total effective dose equivalent dose expected within the first 1,000 years after decommissioning.*" [UAC R313-15-401(4)]. While specifically referencing a time duration following decommissioning, these requirements specifically, "*apply only to ancillary surface facilities that support radioactive waste disposal activities,*"[UAC R313-15-401(1)] and not the Federal Cell, itself. As such, the 1,000 year Total Effective Dose Equivalent (TEDE) limit is a Time of Compliance and not applicable to the specific Period of Performance following closure of the Federal Cell.

   Furthermore, no specific Period of Performance for the closed Federal Cell has been promulgated in UAC R313-25-20, as related to the protection of a hypothetical inadvertent intruder. However, NRC guidance has historically assessed intruder scenarios for a time period equivalent to that indicated in UAC R313-15-401(4), (e.g., 1,000 years after Federal Cell closure), (NRC, 1986). The Federal Cell performance for 1,000 years for the protection of an inadvertent intruder is also supported by the precedent time periods required by 10 CFR 20, Subpart E (for decommissioned sites), 10 CFR 40, Appendix A (for uranium mill tailings), and DOE Order 435.1.

   The 500-year Period of Performance for engineered barriers used to limit inadvertent intrusion is not the same as the promulgated Period of Performance for protection of the general population from releases of radioactivity. As such, NRC deemed the engineered barriers and concentration limits inherent with the Class A classification are sufficient to demonstrate protection of an inadvertent intruder.

3. <u>10,000 YEARS</u>: UAC R313-25-8(5)(a) includes reference to a 10,000-year Period of Performance for "*any facility that proposes to land dispose of significant quantities of concentrated depleted uranium,*" [UAC R313-25-8(5)(a)]. Similarly, NRC's environmental impact statement for 10 CFR 61 recognizes the need for a Period of Performance, "*commensurate with the persistence of the hazard of the source,*" (NRC 1981; NRC 1982; NRC 2000).

Energy*Solutions* recognizes that a Period of Performance of 10,000 years was similarly evaluated as part of the NEPA analysis in the Draft Environmental Impact Statement (DEIS) for 10 CFR 61 (NRC, 1981). NRC's Performance Assessment Working Group (formed to provide information and recommendations on performance assessment methodology required by 10 CFR 61.41) also recommends a 10,000-year Period of Performance, considering it "*sufficient to capture the risk from the short-lived radionuclides (the bulk of the activity disposed) and the peaks from the more mobile long-lived radionuclides, which tend to bound the potential doses at longer timeframes,*" (NRC, 2000).

Given the nature of depleted uranium, a qualitative analysis beyond 10,000 years (e.g., out to peak concentrations) is also warranted to inform the Performance Assessment. Use of the 10,000 year Period of Compliance is also consistent with federal regulations (e.g., 40 CFR 191) and NRC guidance. Extending the analysis qualitatively until a peak is also consistent with NUREG-1573 recommendations.

The NRC has taken a similar approach with the NRC Decommissioning Criteria for the West Valley Demonstration Project at the West Valley Site (NRC, 2002). It is noteworthy that the only Federal standard that goes beyond 10,000 years for compliance is the standard for Yucca Mountain (NRC, 2002). That provision provides a two-level dose standard with a higher dose limit of 100 mrem after 10,000 years.

Separate from requirements to preserve the groundwater resource for a 500-year Time of Compliance, the Utah Division of Drinking Water and U.S. EPA have promulgated radionuclide concentration limits (e.g., maximum contaminant levels of MCLs) in drinking water, based on the associated health effects from ingestion. EPA has developed MCLs for four groupings of radionuclides: (A) Ra-226 and Ra-228; (B) man-made beta and photon emitters; (C) gross alpha, excluding uranium isotopes and radon; and (D) U-234, U-235 and U-238, based on a maximum committed effective dose equivalent (CEDE) of 4 mrem/year. This dose standard is reflected in Division's requirement UAC R313-25-19, which states "*No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater.*"

In compliance with these regulatory requirements, Energy*Solutions* has addressed applicable requirements and guidance in revision of the Periods of Performance and Times of Compliance assessed in this depleted uranium Performance Assessment, as follows:

1. <u>500 YEARS</u>: In compliance with groundwater resource protection standards of UAC R317-6, as embodied in Part I.D.1 of Ground Water Quality Discharge Permit No. UGW450005, the depleted uranium Performance Assessment projects expected groundwater well concentrations for a Period of Performance of 500 years, following Federal Cell closure.

2. <u>10,000 YEARS</u>: Energy*Solutions* has maintained the original 10,000-year Period of Performance for demonstration of protection of the general public and the hypothetical inadvertent intruder. While beyond the regulatory requirements of UAC R317-6, the

depleted uranium Performance Assessment projects peak isotopic groundwater well concentrations and doses for a Period of Performance of 10,000 years, following Federal Cell closure.

As part of an unrelated investigation, NRC staff specifically asked the Division to "*provide further information on its position that the onsite residential and agricultural intruder pathways for the [EnergySolutions] site are unrealistic.*" In response, Division staff

> "*stated that onsite residential and/or farming scenarios at the [EnergySolutions] facility are unrealistic for several reasons. First, the site conditions of low precipitation (i.e., approximately 5-6 inches/year) and high evapotranspiration rates (i.e., approximately 40 - 50 inches/year). Also, there is a lack of suitable irrigation water . . . and the soil is extremely saline. Secondly, Tooele County has designated this part of the county as Heavy Industry and Hazardous Waste Zones which bars any such residential and/or farming uses*" (NRC, 2005).

The Division's judgment of the unrealistic nature of farming, discover, drilling, or residential intruder scenarios is consistent with the requirements of UAC R313-25-7(8).

While the Division is on record agreeing that the groundwater classification, level of its totally dissolved solids, and other naturally-occurring constituents create completely unpotable groundwater, (thereby eliminating all reasonable possibility of any member of the public from receiving such a groundwater dose), Energy*Solutions* has revised the depleted uranium Performance Assessment to demonstrate that no members of the general public who could hypothetically survive consumption of the natural groundwater beneath the Federal Cell with either the Division-Approved rock-armor design for the Class A West Embankment or alternate evapotranspirative cover design currently under review, will receive a CEDE in excess of 4 mrem/year within a 10,000-year Period of Performance.

3. DEEP TIME: UAC R313-25-8(5(a) requires that, "*additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively.*" Consequently, for purposes of informing the Performance Assessment, a qualitative assessment of the Embankment longevity and depleted uranium fate and transport out to geologic time frames is considered. Because of the magnitudes of uncertainties associated therein, NUREG-1573 "*recommends that assessments beyond 10,000 years not be used for determining regulatory compliance with the performance objectives.*" (pg 3-16 of NRC, 2000).

1.3.2 UAC R313-25: Performance Objectives

This depleted uranium Performance Assessment demonstrates compliance with the four primary UAC R313-25 performance objectives described below.

1.3.2.1 *UAC R313-25-19: Protection of the General Public*

The key endpoints of this depleted uranium Performance Assessment are estimated future, post-closure potential doses to members of the public. The performance objectives required in UAC R313-25-19 are the following:

> *"Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ of any member of the public. No greater than 4 mrem committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable, (ALARA)."*

However, NRC based these performance objectives on the dated International Commission on Radiological Protection (ICRP) 2 dose methodology (ICRP, 1959). By comparison, current health physics practices follow the dose methodology used in UAC R313-15, which are based on ICRP 30 methodology (ICRP, 1979). For consistency, NRC recommends, "*that the performance assessment be consistent with the methodology approved by the NRC in Part 20 for comparison with the performance objective [of 10 CFR 61.41]*" (NRC, 2000). Since UAC R313-15 establishes a TEDE limit, rather than the whole body dose, NRC notes in NUREG-1573,

> *"As a matter of policy, the Commission considers 0.25 mSv/year (25 mrem/year) TEDE as the appropriate dose limit to compare with the range of potential doses represented by the older limits that had whole-body dose limits of 0.25 mSv/year (25 mrem/year) (NRC, 1999, 64 FR 8644; see Footnote 1). Applicants do not need to consider organ doses individually because the low value of the TEDE should ensure that no organ dose will exceed 0.50 mSv/year (50 mrem/year)."* (NRC, 1999, 64 FR 8644; see Footnote 1).

This approach was also taken for Yucca Mountain in 10 CFR Part 63, NUREG-1854 and NUREG-1573, and in the NRC Decommissioning Criteria for West Valley. Therefore, while this depleted uranium Performance Assessment does not specifically consider organ doses individually, comparison to a more conservative value of the TEDE ensures that no organ doses exceed the promulgated limitations of UAC R313-25-19.

In this depleted uranium Performance Assessment, Energy*Solutions* also demonstrates compliance with the performance objective requiring that no members of the living general public (following consumption of the natural groundwater beneath the Federal Cell) receive a CEDE in excess of 4 mrem/year from any potential depleted uranium contamination (including daughters and other contaminants associated with depleted uranium) leached from the Federal Cell, within a 10,000-year Period of Performance.

1.3.2.2 *UAC R313-25-20: Protection of the Inadvertent Intruder*

UAC R313-25-20 requires assurance of protecting individuals from the consequences of inadvertent intrusion into depleted uranium waste disposed in the Federal Cell. An inadvertent intruder is someone who is exposed to waste unintentionally and without realizing it is there (after loss of institutional control). This is distinct from an intentional intruder, who might be interested in deliberately disturbing the site, or extracting materials from it, or who might be driven by curiosity or scientific interest.

> *"Design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed."* [UAC R313-25-20]

Another important term to define in evaluation of this Performance Objective is an intruder barrier:

> *"A sufficient depth of cover over the waste that inhibits contact with waste and helps to ensure that radiation exposure to an inadvertent intruder will meet the performance objectives set forth in this part, or engineered structures that provide equivalent protection to the inadvertent intruder."* [UAC R313-25-2]

This Federal Cell disposal methodology (using the Division-approved Class A West cover design) already exceeds the intruder barrier requirements of UAC R313-25 in the following ways.

- An engineered embankment is an important component in intruder protection. Reliance on engineered features is based on the assumption that an intruder encountering the barrier would recognize it as something out of the ordinary and cease attempts at construction or agriculture (thereby reducing their exposure to radiation). The combination of the cover system and depth of disposal protects an intruder from penetrating the Federal Cell and contacting the depleted uranium waste.

- As was demonstrated with the Division's approval of the Class A West design, the design and operation of the Federal Cell provides a more stable disposal than is required by UAC R313-25. The placement of depleted uranium waste below grade within the Federal Cell, the compacted sand, the placement and compaction of waste above the layers of depleted uranium waste, and either the cover currently-approved rock armor or alternate evapotranspirative covers combine to form a stable disposal configuration. The Division-approved Class A West Embankment design has already been shown to provide stability to ensure the long-term compaction combine to resist slumping and differential settlement, which limits infiltration and reduces the potential for dispersion of the waste over time. In addition to improving the performance of the disposal site, this provides inherent protection for the inadvertent intruder, since it provides a "*recognizable and nondispersible waste*" as contemplated in UAC R313-15-1009.

- Energy*Solutions* has modeled placement of depleted uranium below grade within the Federal Cell. The result is that even the top layer of depleted uranium waste is more than 5 meters below the Division-approved Class A West Embankment cover, which is sufficient to satisfy disposal requirements for waste classified at Class C limits. The 5-meter thick barrier also inhibits access by an inadvertent intruder. This barrier is composed of earth, other Class A LLRW, and other similar materials.

Although UAC R313-25-20 requires that an inadvertent intruder be protected, NRC staff acknowledged that applicants and licensees are not expected to perform specific intruder dose analyses, because the waste classification itself and segregation requirements were developed to inherently provide inadvertent intruder protection, (NRC, 2000). Even so, this depleted uranium Performance Assessment demonstrates protection of inadvertent intruders.

While an unlimited number of inadvertent intruder scenarios can be developed, Division requirements limit such development to include, "*Identification of the known natural resources at the disposal site whose exploitation could result in inadvertent intrusion into the wastes after removal of active institutional control.*" UAC R313-25-7(8). Of similarly sentiment, NRC's Performance Assessment Working notes that,

> "*the overall intent [of exposure scenario development guidance] is to discourage excessive speculation about future events and the PAWG does not intend for analysts to model long-term transient or dynamic site conditions, or to assign probabilities to natural occurrences. . . The parameter ranges and model assumptions selected for the LLW performance assessment should be sufficient to capture the variability in natural conditions, processes, and events. . . Therefore, PAWG recommends that new site conditions that may arise directly from significant changes to existing natural conditions, processes, and events do not need to be quantified in LLW performance assessment modeling . . . With respect to human behavior, it may be assumed that current local land-use practices and other human behaviors continue unchanged throughout the duration of the analysis. For instance, it is reasonable to assume that current local well-drilling techniques and/or water use practices will be followed at all times in the future.*" (NRC, 2000).

NRC further supports the importance of selecting appropriate inadvertent intruder scenarios that reflect current practices and site environments in its guidance to Regulators reviewing performance assessments to,

> "*[1] verify that conceptual models for the biosphere include consistent and defensible assumptions based on regional practices and characteristics (i.e., conditions known to exist or expected to exist at the site or surrounding region); [2] verify that intermediate results (e.g., fluxes, travel times) are physically reasonable;. . . [3] evaluate the types of scenarios . . . considered in the intruder analysis and confirm that the scenarios considered are appropriate for the site; [4]verify that assumptions and parameters used in defining the exposed intruder, including location and behavior of the intruder, timing of the intrusion, and exposure pathways, are consistent with the current regional practices; and [5] if a garden is assumed in the scenario [implying it is not always required], verify that the garden size is appropriate and consistent with regional practices*" NRC (2007).

Examples of traditional exposure scenarios typically used to evaluate potential inadvertent intruder doses (in compliance with UAC R313-25-20) are described in NRC's draft Environmental Impact Statement supporting 10 CFR 61 (NRC 1981a) and the Update of Part 61 Impacts Analysis Methodology (NRC 1986). The methodology described therein includes evaluation of exposure pathways within a group of four inadvertent intruder scenarios including intruder discovery, intruder drilling, intruder construction, and intruder agriculture. These inadvertent intrusion scenarios represent a potential series of events that are initiated by the successful completion of a water supply well. However, NRC further notes that,

> "*it would be unreasonable to expect the inadvertent intruder to initiate housing construction at a comparatively isolated location before assuring that water for home and garden use will be available. Thus, this scenario (intruder-driller) is assumed to precede the following three scenarios*" (NRC, 1986).

The intruder-drilling scenario is assumed to be an initiating event for the intruder-construction and intruder-agriculture scenarios (NRC 1986, Section 4.1.1.1). This scenario assumes that, in an effort of mining subsurface resources, waste is brought to the ground surface in a mixture with cover material, unsaturated zone material, and drilling mud and is then contained in a mud pit used by the driller. The driller (a separate individual from that in any subsequent exposure scenario) is assumed to be exposed by direct gamma radiation from the waste mixture in the mud pit (NRC, 1986). However, lacking the precursory subsurface mineral resources (NRC 1986, Section 4.2.1), the intruder-driller scenario is inapplicable to the Federal Cell.

The intruder-discovery scenario described in Section 4.2.3 of NRC (1981) involves external exposure to discoverable wastes that are clearly distinguishable from natural materials. The dose assessment methodology described in NRC (1981) was updated in NUREG/CR-4370 (NRC, 1986). Exposure to the intruder-discoverer is assumed to be limited to the topmost waste layer, since the intruder "*would likely stop excavating before digging too deep into the rest of the waste*" (NRC 1986, Section 4.2.3). The intruder-discovery scenario for stable waste streams in the first 500 years after closure is assumed to preempt the intruder-agriculture scenario (and, presumably, the intruder-construction scenario) because construction and inhabitation of a home will not occur once the waste has been discovered and recognized (NRC 1986, Section 4.2.3).

The intruder-construction scenario involves direct intrusion into disposed wastes for activities associated with the construction of a house {(e.g., installing utilities, excavating basements, and similar activities [as described in Section 4.2.2 of NRC (1986)]}. However, because there is no historic evidence of prior residential construction at the Federal Cell, the extreme salinity of Federal Cell's native soils, the unpotable groundwater, the severe lack of irrigation sources, and the inadequacy of precipitation to support agriculture, the inadvertent intruder-construction scenario is not considered reasonable for the Federal Cell nor included in this depleted uranium Performance Assessment.

The intruder-agriculture scenario assumes an individual is living in the home built under the intruder-construction scenario, and is also exposed from gardening activities involving the waste/soil mixture excavated during construction (NRC 1986, Section 4.2.4). As with the inadvertent intruder-construction scenario, the lack of historic evidence of prior residential agriculture at the Federal Cell, the extreme salinity of Federal Cell's native soils, the unpotable groundwater, the severe lack of irrigation sources, and the inadequacy of precipitation to support agriculture, the inadvertent intruder-agriculture scenario is not considered "*reasonable*" for the Federal Cell nor included in this depleted uranium Performance Assessment.

As is presented above in Section 1.3.1, the Division is on record agreeing that the groundwater classification, level of its totally dissolved solids, and other naturally-occurring contaminants create completely unpotable groundwater, (thereby eliminating all reasonable possibility of any member of the public from receiving such a groundwater dose). The Division's judgment of the unrealistic nature of farming, discover, drilling, or residential intruder scenarios is consistent with the requirements of UAC R313-25-7(8).

An archeological survey of the area surrounding the Federal Cell was performed in 1981, as part of the siting criteria used for the Vitro disposal cell (AERC, 1981). This survey found no evidence of long-term residential or agricultural resource sites. A similar cultural and archaeological resource survey was conducted in 2001 (Sagebrush, 2001). In addition to the new survey, Sagebrush's (2001) report also summarized five additional cultural resource inventories performed within a mile of the subject area, between the original 1981 and 2001 studies. In all surveys, Sagebrush reported no paleontological, prehistoric, or historic resources were discovered in the survey area. In fact, no evidence has been discovered that suggests the Federal Cell has ever been inhabited or developed for agriculture by permanent residents in the past (probably due to unfavorable conditions for human habitation).

Energy*Solutions* acknowledges that the nearest human resident is located approximately 7.5 miles from the Federal Cell. This single residence supports a caretaker for the Utah Department of Transportation rest stop on Interstate-80. Impacts to this residence are considered in this depleted uranium Performance Assessment. However, it is not reasonable to assume additional residential development in the region due to the natural characteristics of the disposal site, as well as Tooele County zoning restrictions.

In compliance with UAC R313-25-20 and Division directive, Energy*Solutions* has included credible inadvertent industrial intrusion scenarios in its depleted uranium Performance Assessment. However, since (1) the Federal Cell's groundwater is unpotable and will not support a residence or agriculture, (2) the expense of treating Federal Cell's groundwater with conventional technologies is preventing current industrial occupants from using treatment; (3) Federal Cell's geology holds no mineral resources of value, and (4) Federal Cell's current practices and county-zoning limit use of the area to only industrial purposes, this depleted uranium Performance Assessment only includes scenarios of inadvertent intrusion that may result from recreational and industrial pursuits (e.g., similar to those apparent with Energy*Solutions'* current developed neighbors).

The performance standard for protection of individuals from inadvertent intrusion (UACR313-25-20) further requires "*...protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste.*" However, these regulations are silent on the specific dose standard to apply. Since UAC R313-25 has been issued, the standard used by NRC (and included in the pending revisions to 10 CFR 61 and associated Branch Technical Position analysis) and others for low-level radioactive waste disposal licensing has been an intruder standard of 500 mrem/yr. The 500 mrem/yr standard is also used in DOE's waste determinations implementing the 10 CFR 61 performance objectives (NUREG-1854). It is noted that 500 mrem/yr was also the standard proposed in 10 CFR 61 in 1981 (46 FR 38081, July 24, 1981). The Statement of Considerations for the final rule did not object to the number. It was removed apparently at the request of EPA, because of its concern of how one would monitor it or demonstrate compliance with it, but not because EPA disagreed with it (47 FR57446, 57449, December 27, 1982). A dose standard of 500 mrem/yr is also used as part of the license termination rule dose standard for intruders (10 CFR 20.1403). Consequently, this depleted uranium Performance Assessment applies a 500 mrem/yr threshold for the intruder dose for purposes of applying the performance standard for protection of individuals from inadvertent industrial intrusion.

1.3.2.3 *UAC R313-25-21: Protection of Individuals During Operations*

UAC R313-25-21 states that "*Operations at the land disposal facility shall be conducted in compliance with the standards for radiation protection set out in R313-15 of these rules, except for release of radioactivity in effluents from the land disposal facility, which shall be governed by R313-25-19.*" Historical records submitted annually to the Division demonstrate that impacts from Energy*Solutions'* existing Class A West Embankment operations are minimized by administrative controls within the applicable regulatory limits. Furthermore, personnel and environmental monitoring data (submitted quarterly to the Division) confirm that the applicable limits for the Class A West Embankment are met on a continuing basis. Since there is no change being proposed for construction of the Federal Cell for ultimate disposal of depleted uranium in the types of waste or necessary administrative controls that will be managed, protection of individuals during operations will continue as already demonstrated (DRC, 2012).

UAC R313-25-21 also states that "*every reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable, ALARA.*" Energy*Solutions'* Radiation Protection Program ensures that all reasonable actions are taken to reduce radiation exposures and effluent concentrations from operations associated with the Division-approved Class A West Embankment to levels that are considered, "*As Low As Reasonably Achievable*" (ALARA). A report of Energy*Solutions'* independent ALARA Program audit is provided annually to the Division in conjunction with conditions of its Radioactive Material License UT 2300478. Since there are no changes being proposed in the waste types and classifications that are proposed to be disposed of in the Federal Cell, the current ALARA Program will not require revision as part of this depleted uranium Performance Assessment.

1.3.2.4 *UAC R313-25-22: Stability of the Disposal Site After Closure*

To help achieve stability, NRC notes that to the extent practicable disposed waste should maintain gross physical properties and identity over 300 years, under the conditions of disposal (NRC, 1986). NRC believes that the use of design features to achieve stability is consistent with the concept of ALARA and the use of the best available technology. It is NRC's view that to the extent practicable, waste forms or containers should be designed to be stable (i.e., maintain gross physical properties and identity, over 300 years). NRC also notes that a site should be evaluated for at least a 500-year time frame to address the potential impacts of natural events or phenomena.

Consequently, through approval of its Class A West Amendment Application, Energy*Solutions* has demonstrated that its Class A West Embankment and cover design will provide long-term stability and that the use of the best available technology in setting design standards in the range from 200 up to 1,000 years is appropriate to provide site stability to the extent practicable (Sections 3.1.3, 3.2.3, 5.1, and 6.3 of McCandless, 2012). As such, this depleted uranium Performance Assessment model of a Federal Cell using the Division-approved Class A West Embankment cover design does not trigger the need to conduct additional stability analysis.

1.3.2.5 *Groundwater Protection Limits*

In addition to these radiological criteria, the State of Utah imposes limits on groundwater contamination, as stated in the Ground Water Quality Discharge Permit UGW450005 (Permit) (Energy*Solutions*, 2010). Part I.C.1 of the Permit specifies that GWPLs shall be used for the Embankment. The Permit specifies general mass and radioactivity concentrations for several constituents of interest to depleted uranium waste disposal. These GWPLs are derived from Ground Water Quality Standards listed in UAC R317-6-2 Ground Water Quality Standards. Exceptions to values in that table are provided for specific constituents in specific wells, tabulated in Table 1B of the Permit.

It is important to note groundwater beneath the Federal Cell is classified as Class IV, saline ground water, according to UAC R317-6-3 Ground Water Classes, and is highly unlikely to serve as a future water source. The underlying groundwater in the vicinity of the Federal Cell is of naturally poor quality because of its high salinity and, as a consequence, is not suitable for most human uses, and is not potable for humans. Analysis conducted by the World Health Organization in 2003 suggested associations between TDS concentrations in drinking water and the incidence of cancer, coronary heart disease, arteriosclerotic heart disease, cardiovascular disease, and total mortality rates in studies conducted in Australia and the former Soviet Union (WHO, 2003). In the study in Australia, it was determined that mortality from all categories of ischaemic heart disease and acute myocardial infarction was increased in a community with high levels of soluble solids, calcium, magnesium, sulfate, sodium, chloride, fluoride, alkalinity, total hardness, and pH when compared with one in which levels were lower. Similarly, the results of an epidemiological study in the former Soviet Union indicated that the average number of cases of inflammation of the gallbladder and gallstones over a 5-year period increased with the mean level of dry residue (a measure of TDS) in the groundwater.

Since the background water quality of the groundwater renders it unsafe and unusable for consumption, groundwater protection standards are applied at the Federal Cell as a non-degradation or Best Available Technology (BAT) standard. No dose is possible through the groundwater pathway, since its consumption is impossible without extensive treatment. However, the BAT standards for groundwater do not provide any additional protection in terms of human health.

1.4 Historical Management of Depleted Uranium

Large-scale uranium enrichment in the United States began as part of atomic bomb development by the Manhattan Project during World War II. Uranium enrichment activities were subsequently continued under the U.S. Atomic Energy Commission and its successor agencies, including DOE. The K-25 plant in

Oak Ridge, Tennessee[1] was the first of three gaseous diffusion plants constructed to produce enriched uranium. The K-25 plant ceased operations in 1985, but uranium enrichment continues at facilities located in Paducah, Kentucky and Portsmouth, Ohio. These two plants are now operated by the United States Enrichment Corporation, created by law in 1993 to privatize uranium enrichment.

In the gaseous diffusion process, a stream of heated uranium hexafluoride (UF_6) gas is separated into a stream of UF_6 gas containing enriched U_{235} (EUF_6) and a stream of UF_6 gas depleted in U_{235} (DUF_6). The enriched uranium materials are used for manufacturing commercial reactor fuel, (typically contains 2 to 5% U_{235}), and military applications (requiring up to 95% U_{235}). The DUF_6 waste materials of interest to this Compliance Report typically contain U_{235} concentrations as low as 0.2 to 0.4%. Since the 1950s, DUF_6 waste materials have been stored at all three storage sites in large steel cylinders, similar to that illustrated in Figure 1-3.

Depleted uranium was also produced at DOE's Savannah River Site. The Savannah River Site produced depleted uranium as a byproduct of the nuclear material production programs, where irradiated nuclear fuels were reprocessed to separate out the fissionable Pu_{239}. Uranium billets were produced at the DOE Fernald, Ohio site, fabricated into targets at Savannah River Site, and then irradiated in the Savannah River Site production reactors to produce Pu_{239}. The irradiated targets were processed and fission products separated from the plutonium and uranium, which were then separated from each other. After additional purification, the depleted uranium-bearing waste stream was then processed into uranium trioxide (DUO_3). While still classified as depleted uranium, this DUO_3 also contains small quantities of waste fission products and transuranic elements. The Savannah River Site produced approximately 36,000 (55-gal) steel drums of DUO_3 during the production campaigns. This DUO_3, a solid powder at room temperature and pressure, is considered to be relatively homogeneous, based on known process controls and operations. The 5,408 drums of DUO_3 proposed for disposal in the Federal Cell are from this process; the remaining drums have been disposed elsewhere by DOE.

Because storage began in the early 1950s, many of the drums and cylinders now show evidence of external corrosion and increased breach risk. When a DUF_6 container is breached, the contents react with moisture in air to form caustic hydrofluoric acid (HF) and solid uranyl fluoride (UO_2F_2). By 1998, breaches were identified in eight cylinders (two at Paducah, two at Portsmouth, and four at K-25), generally around spots previously damaged by handling activities. Similarly, a significant number of drums at the Savannah River Site have been placed into overpacks as a mitigating action for corrosion control and to prevent spills.

[1] The site of the K-25 plant is now called the East Tennessee Technology Park (ETTP), but is referred to by its original name, the K-25 site, in this Compliance Report.

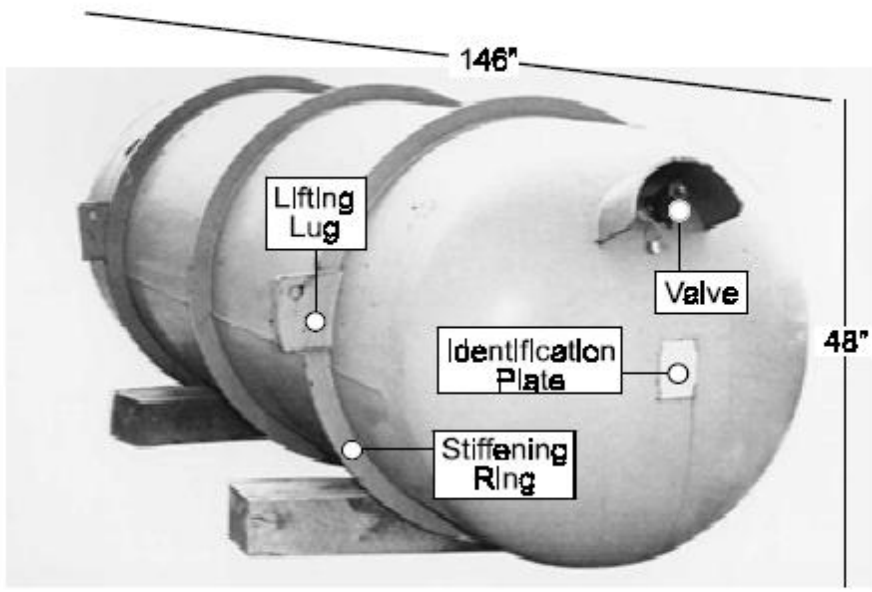

Figure 1-3, Typical Depleted Uranium Storage Cylinder (DOE, 1999)

In an effort to reduce risks associated with container breach, Public Law 107-206, the 2002 Supplemental Appropriations Act for Further Recovery from and Response to Terrorist Attacks on the United States (commonly referred to as the "*Terrorist Attack Response Act*") requires DOE to design, construct, and operate facilities at Paducah and Portsmouth, for conversion of DUF_6 to the safer form, depleted triuranium octaoxide (U_3O_8). As part of this revised management strategy, all K-25 DUF_6 cylinders were shipped in 2004 to Portsmouth to be eventually converted to U_3O_8. The Terrorist Attack Response Act further required that the U_3O_8 be stored at Paducah and Portsmouth until there is a determination that all or a portion of the depleted uranium is no longer needed. At that point, the U_3O_8 is to be disposed of as low-level radioactive waste. DOE estimates the inventory of U_3O_8 that will eventually require disposal to be approximately 700,000 metric tons over a 20 to 25 year period (DOE, 2007).

Conversion to U_3O_8 is a preferential management strategy, because DUF_6 is a volatile, white, crystalline solid. Conversely, U_3O_8 is kinetically and thermodynamically stable and is the most common form of uranium found in nature. U_3O_8 can be produced in rotary kiln or fluidized-bed reactors by application of superheated steam and hydrogen (from dissociated ammonia) to DUF_6 (producing solid UO_2F_2 powder and gaseous HF). The powder UO_2F_2 is then defluorinated through heat and steam addition to create U_3O_8.

1.5 Report Scope

UAC R313-25-8(5)(a) requires Energy*Solutions* to demonstrate to the Division that proposed methods for disposal of depleted uranium will not compromise the Federal Cell's implementation of the Division-approved Class A West Embankment design's demonstrated ability to meet the performance objectives of UAC R313-25. Toward that end, Energy*Solutions* has conducted this depleted uranium probabilistic Performance Assessment using GoldSim modeling software (GoldSim, 2011).

The GoldSim model, developed and managed by the GoldSim Technology Group, is a Monte Carlo simulation software solution for dynamically modeling complex systems in business, engineering and science. GoldSim supports decision and risk analysis by simulating future performance while quantitatively representing the uncertainty and risks inherent in all complex systems. GoldSim is a general purpose simulator that utilizes a hybrid of several simulation approaches, combining an extension of system dynamics with some aspects of discrete event simulation, and embedding the dynamic simulation engine within a Monte Carlo simulation framework. As part of a joint effort by NRC and DOE, the GoldSim model and the supporting sub-models have undergone extensive reviews concerning its use to demonstrate compliance with the individual protection standards (Pensado, et. al, 2002).

This Report documents the depleted uranium Performance Assessment, conducted in compliance with UAC R313-25-8(5)(a). Analysis includes evaluation of potential groundwater migration of contaminants to a Point of Compliance well for a period of 500 years following embankment closure, projected peak groundwater well concentrations and general public doses for a period up to 10,000 years following Federal Cell closure, doses to hypothetical individuals who have inadvertently intruded into the waste within 10,000 years following Federal Cell closure, and additional simulations out to deep geologic time frames to qualitatively inform the Performance Assessment.

2. DEPLETED URANIUM PERFORMANCE ASSESSMENT COMPONENTS

Revision 0 of this Compliance Report included the Neptune Modeling Report as its Appendix A. Preparation of revision 1 of this Compliance Report has not resulted in a need for Energy*Solutions* to revise Neptune's original model (as previously submitted). Therefore, all references to Appendix A in revision 1 of the Compliance Report reference Appendix A, as submitted with revision 0.

Components of this depleted uranium Performance Assessment include a current long-term climate record representative of the Federal Cell; improved representation of near-surface processes that affect net infiltration, such as evaporation and runoff; representation of movement of water through the Division-approved Class A West Embankment cover design; and evaluation of radiation dose for hypothetical inadvertent intruder scenarios following the closure of the Federal Cell.

2.1 Site Characteristics

The proposed location for Energy*Solutions'* Federal Cell is west of the Cedar Mountains in Clive, Utah. Clive is located along Interstate-80, approximately 3 miles south of the highway, in Tooele County. The Federal Cell will be approximately 50 air-miles east of Wendover, Utah and approximately 75 highway miles west of Salt Lake City, Utah. The Federal Cell will sit at an elevation of approximately 4,275 feet above mean sea level (amsl) and be accessed by both highway and rail transportation. The Federal Cell will be southwest of DOE's above-ground disposal embankment used for disposal of uranium mill tailings that were removed from the former Vitro Chemical company site in South Salt Lake City between 1984 and 1988.

Currently, the Division-approved Class A West Embankment receives waste shipped via truck and rail. Depleted uranium waste will be disposed below native grade in the permanent near surface engineered disposal Federal Cell that uses the Division-approved Class A West Embankment cover design as clay-lined with an engineered cover consisting of either multiple layers of natural soil and rock (already approved by the Division) or an alternate evapotranspirative cover (currently under review by the Division). The Division-approved Federal Cell design (i.e., the Class A West Embankment design) has been shown to perform for a minimum of 500 years based on requirements of UAC R313-25-8, which provides long-term disposal with minimal need for active maintenance after site closure (DRC, 2012).

2.1.1 Climate

Energy*Solutions* has operated a weather station at Clive since July 1992. The station monitors wind speed and direction, 2-m and 10-m temperatures, precipitation, pan evaporation and solar radiation. A 20-year Summary Report from January 1, 1993 through December 31, 2012, provided to the Division on February 19, 2013, has been incorporated into this depleted uranium Performance Assessment (MSI, 2013). Since the Federal Cell will be located entirely within Section 32, this information adequately characterizes the site. Furthermore, the Federal Cell will have no significant effects upon the meteorological conditions or air quality of the region.

2.1.2 Weather Patterns

The Federal Cell region is in the Intermountain Plateau climatic zone that extends between the Cascade-Sierra Nevada Ranges and the Rocky Mountains and is classified as a middle-latitude dry climate or steppe. Hot dry summers, cool springs and falls, moderately cold winters, and a general year-round lack of precipitation characterize the climate. Mountain ranges tend to restrict the movement of weather systems into the area, but the area is occasionally affected by well-developed storms in the prevailing regional westerlies. The mountains act as a barrier to frequent invasions of cold continental air. Precipitation is generally light during the summer and early fall and reaches a maximum in spring when storms from the Pacific Ocean are strong enough to move over the mountains. During the late fall and winter months, high pressure systems tend to settle in the area for as long as several weeks at a time.

2.1.3 Temperature

Regional climate is regulated by the surrounding mountain ranges, which restrict movement of weather systems in the vicinity. The most influential feature affecting regional climate is the presence of the Great Salt Lake, which can moderate downwind temperatures since it never freezes (NRC, 1993). Frequent invasions of cold air are restricted by the mountain ranges in the area. Data from 1992 through 2012 indicate that monthly temperatures range from about -2°C (29°F) in December to 26°C (78°F) in July (MSI, 2013).

2.1.4 Winds

In the 20-year period of time (July 1993 through December 2012) the most frequent (and predominant) winds were from the south-southwest direction, with the second most frequent direction being the east-northeast, followed by the south. Wind Rose data incorporated into this depleted uranium Performance Assessment has been obtained from the on-site weather station (MSI, 2013).

2.1.5 Precipitation

The Federal Cell will receive an average of 8.62 inches of precipitation per year. Measurements taken at the Clive weather station show that the lowest monthly precipitation recorded was 0 inches in May 2001. The highest recorded monthly precipitation was 4.28 inches, in May 2011 (MSI, 2013).

2.1.6 Evaporation

Pan evaporation measurements are taken from April through October when ambient temperatures remain above freezing. Maximum hourly evaporation values usually occur in July. The 18-year average annual evaporation at the Clive weather station is 52.73 inches (excluding 2 years of reported instrument malfunction) (MSI, 2013).

2.1.7 Geology

The Energy*Solutions* Federal Cell will be located on the eastern fringe of the Great Salt Lake Desert. The Clive site is located in, and is bounded by, the Great Salt Lake Desert to the west at approximate elevations of 4,250 to 4,300 feet amsl. Also to the west, low-lying hills rise 50 to 100 feet from the desert floor. To the east and southeast, the site is bounded by the north-south trending Lone Mountains, which rise to a height of 5,362 feet amsl. At the base of the Lone Mountains alluvial fans slope gently toward the west at a gradient of approximately 40 feet per mile. The site has topographic relief of approximately

11 feet, sloping in a southwest direction at a gradient of approximately 0.0019. The most recent characterization of the site geology and hydrogeology is reported in the Revised Hydrogeologic Report (Energy*Solutions*, 2012a).

As with the Division-approved Class A West Embankment, the Federal Cell will rest on Quaternary lakebed deposits of Lake Bonneville. Site subsurface logs indicate that lacustrine deposits extend to at least 250 feet underneath the site. The underlying Tertiary and Quaternary age valley fill is composed of semi-consolidated clays, sands, and gravel where it comes in contact with bedrock. Although the exact depth to and relationships of various bedrock units are unknown, the presence of nearby outcrops and the regional block-faulted basins suggest that the valley-fill deposits are several hundred feet thick within the area of the site. Estimated down-dip projections from bedrock outcrop on the southwest corner of Section 31 and bedrock found at depth in Clean Harbors wells suggest that the contact may dip to the east about three degrees.

To the north of the site are the Grayback Hills, composed of Permian-Triassic carbonates. Igneous extrusives form a resistant cover on the Grayback Hills, and are mapped as late-Eocene trachyandesite lava flows and andesite/dacite volcaniclasitcs.

Geomorphic processes at the site are limited to micro processes that occur in the soil. For example the Great Salt Lake Desert is located in a semiarid to arid region where precipitation is less than evaporation. When the soil water evaporates, dissolved mineral matter is precipitated and forms calcium carbonate, gypsum and alkali (sodium and potassium carbonates) in the soil. Macro geomorphic processes are almost nonexistent where the general rate of weathering is very slow. This is due to the low amounts of precipitation, the lack of fluvial activities and the lack of relief at the site.

2.1.8 Hydrogeology

Alluvial and lacustrine sediments that fill the valley floor are estimated to extend to depths ranging from 300 to over 500 feet. North-south trending mountains and outcrops define the hydrogeologic boundaries for the aquifer system. Lone Mountain located two miles east of the site, rises approximately 950 feet above the valley floor. The Grayback Hills located to the north and outcropping features to the west rise 500 feet and 230 feet respectively above the valley floor (Energy*Solutions*, 2012a).

Four hydrostratigraphic units have been delineated in the unsaturated zone and shallow aquifer system at the Federal Cell, consisting of upper silty clay/clayey silt (Unit 4), upper silty sand (Unit 3), middle silty clay (Unit 2), and lower sand/silty sand (Unit 1). The site aquifer system consists of a shallow unconfined aquifer that extends through the upper 40 feet of lacustrine deposits. A confined aquifer begins around 40 to 45 feet below the ground surface and continues through the valley fill. Due to the low precipitation and relatively high evapotranspiration, little or no precipitation reaches the upper unconfined aquifer as direct vertical infiltration. Groundwater recharge is primarily due to infiltration at bedrock and alluvial fan deposits which then travels laterally and vertically through the unconfined and confined aquifers. Groundwater flow in this area is generally directed north to northeasterly. Although the term “aquifer” is used to describe water-bearing zones at the Clive facility, hydraulic conductivities and transmissivities are relatively low.

Fresh water from the recharge zones along the mountain slopes develops progressively poorer chemical quality in response to dissolution of evaporate-minerals during its travel through the regional-scale flow systems. The groundwater quality in the unconfined aquifer at the Federal Cell is saline with concentrations of several chemical species (sulfate, chloride, total dissolved solids, iron, and manganese) significantly exceeding the EPA secondary drinking water standards.

2.1.9 Surface Water

The area to contain the Federal Cell lies within the Great Basin drainage, a closed basin having no outlet. The site drains generally toward the west-southwest toward the eastern fringe of the Great Salt Lake Desert.

The nearest usable body of water to the Federal Cell is to the east, 28.1 miles away. At this location, a perennial stream flows from Big Spring (1,000 feet south of I-80) to the Timpie Springs Waterfowl Management Area, about 2,000 feet north of I-80. Activities at the Energy*Solutions'* Federal Cell will have no effect on surface-water quantities or quality at the Federal Cell. There are no perennial surface-water systems associated with the Federal Cell. Water necessary for construction is provided by existing wells in the vicinity requiring transport to the site, or impounded water.

No surface water bodies are present on the Federal Cell. The nearest stream channel ends about two miles east of the site and is typical of all drainages along the transportation corridors within 20 miles of the site. Stream flows from higher elevations evaporate and infiltrate into the ground before reaching lower, flatter land. The stream channel reduces until there is no evidence of a stream. The watershed up-gradient of the site covers approximately 46 square miles.

2.1.10 Groundwater

Local groundwater recharge from meteoric sources is generally limited, since pan-evaporation greatly exceeds precipitation (NRC, 1993). Recharge is more likely to occur in areas adjoining the surrounding mountain ranges, moving as subsurface flow to the center of the basin. Given the strong evaporation potential at the site, it is expected that some water in the unsaturated zone (vadose zone) move upward. An upward gradient is not only due to evaporation of water at the ground surface, it is also driven by the transpiration of plants, which pulls water from the ground and releases it to the dry atmosphere. The coupled effect of these two processes, known as evapotranspiration, serves to keep near-surface soils dry enough that precipitation often does not penetrate to lower soils.

Groundwater at the Federal Cell is found within a low-permeability saline aquifer starting near the bottom of the Unit 3 stratigraphic unit, and saturating the Unit 2 stratigraphic unit. The depth to groundwater is between approximately 20 and 30 feet bgs at an approximate elevation of 4,250 ft amsl (Brodeur, 2006). The regional (saturated) groundwater system flows primarily to the east-northeast toward the Great Salt Lake (Energy*Solutions,* 2013) and the local shallow groundwater follows a slight horizontal gradient to the north-northeast. Occasional transient shallow aquifer mounding occurs due to infiltration of surface water.

The underlying groundwater in the vicinity of the Federal Cell is of naturally poor quality because of its high salinity and, as a consequence, is not suitable for most human uses (NRC, 1993). Groundwater beneath the Federal Cell ranges in total dissolved solids (TDS) from 30,000 mg/L to 100,000 mg/L, with a site-wide average TDS content of 40,500 mg/L. The predominant cations and anions are sodium and chloride, respectively. For comparison purposes, sea water typically has a TDS content of 35,000 mg/L, thus the salinity content at the site is higher than average sea water.

2.1.11 Ecology

Ecological exploratory field studies were recently conducted in 2012 to quantify biogeography, bioturbation, and biological communities near the Federal Cell to assess local ecological analogs (SWCA, 2012). These studies observed that average plant species cover consists of 14.3% black greasewood, 5.9% Sandberg bluegrass, and approximately 3% cover each of shadscale saltbrush and gray molly occurring in low densities with 1.6% and 1.3% cover, respectively. Ground cover is dominated by 79.2% biological soil crust cover.

Field studies also included small mammal trappings, with 83 deer mice and one kangaroo rat trapped. Small mammals were observed in the north portion of Section 29 (i.e., immediately north of the licensed-Section 32 on which will be located the Federal Cell). Burrows of deer mice, kangaroo rats, ground squirrels, and badgers were also observed during the field studies.

Nineteen ant mounds were recorded and measured, with an average of 24 ant mounds observed per hectare. The average individual ant mound area and volume were estimated to be approximately 2,683 cm^2 and 28,348 cm^3, respectively. The belowground area of the excavated ant mounds was found to be relatively shallow, with most of the ant nests within 0.6 meters of the surface.

Analyses of plant species cover, small mammal densities, animal burrow volumes, ant mound volumes, and soil chemistry and nutrition parameters identified several relationships between the variables under consideration. Positive correlations were witnessed between total vegetation cover, mammal densities, and burrow volumes. In contrast, no correlation was observed between total vegetation cover and ant mound area or volume. There were strong positive correlations between ant mound area, mound volume, and cover of weedy species. There was also a strong, negative correlation between ant mounds and soil silt, and somewhat strong negative correlations between animal densities, burrow volumes, and soil clay content. Field studies concluded that the high soil pH did not appear to be limiting for any of the native or weedy plant species observed. However, plant cover, particularly of shadscale saltbrush, showed strong, negative correlations with high soil salinity.

SWCA also examined the root density and maximum rooting depth of dominant plant species near the Federal Cell. Observed root densities were higher near the surface of the soil, where roots were mostly fibrous with few woody structures. A few large, woody roots were encountered in deeper soils. Rooting depths were shallower than expected, with the maximum rooting depth of dominant woody plant species ranging from 16 to 28 inches. Woody plant species maximum rooting depths were proportional to aboveground plant mass with an above-ground height root depth ratio of 1:1 and an above-ground width root depth ratio of approximately 1.4:1. The halogeton-disturbed plot had higher ratios of plant height and width to maximum rooting depth (1.4:1 and 1.7:1, respectively). The low proportion of roots to above-ground biomass is expected for annual plants, which invest the bulk of their energy in reproduction and little energy in root systems.

2.2 Federal Cell Design

The new Federal Cell is proposed to be directly connected to the west side of the existing 11e.(2) Embankment, but separated south of the Class A West Embankment. Such a location provides a relative disposal footprint of 1,786,050 ft^2. The embankment design provides a total airspace volume of 13,216,770 ft^3 for placement of depleted uranium below grade within the same CLSM disposal configuration requirements currently in use at the Class A West Embankment. As such, when accounting for the added fill volume provided by the CLSM, a total Federal Cell depleted uranium disposal capacity is estimated as 6,100,000 ft^3 (which is sufficient capacity for disposal of the targeted depleted uranium from SRS, Portsmouth plant and Paducah facility).

Note that the former Class A South design included an isolation barrier and groundwater monitoring system beneath this barrier, intended to provide separation between Class A LLRW and 11e.(2) waste materials. This separation was considered necessary due to the differing long term stewardship regimes applicable to each waste type (Class A waste staying with the state of Utah and 11e.(2) going to the Department of Energy). It is anticipated that these distinctions will not be required for a Federal Cell, and accordingly the isolation barrier and groundwater monitoring system will not be necessary.

Analyses in support of the Class A West Embankment cover design are applicable to the Federal Cell on the following bases:

1. The Class A West Embankment has a larger surface area and thicker overall waste column than the Federal Cell. This indicates that bounding conditions have been evaluated for infiltration, runoff, and static and seismic stability.

2. Waste characteristics and placement procedures will be identical, as captured in the LLRW and 11e.(2) Construction Quality Assurance/Quality Control (CQA/QC) Manual.

3. Embankment liner and construction procedures will be identical, as captured in the LLRW and 11e.(2) Construction Quality Assurance/Quality Control (CQA/QC) Manual.

2.3 Federal Cell Cover Designs

Principle design features of the licensed Class A West Embankment have been demonstrated to provide long-term isolation of waste, minimize the need for continued active maintenance after site closure, and improve the site's natural characteristics in order to protect public health and safety (Sections 3.1 – 3.3 of McCandless, 2012). The environment, site personnel, and the public are protected from unsafe levels of radiation both during and after active disposal operations (Sections 4.2 and 4.4 of McCandless, 2012). Long-term stabilization of the Class A West Embankment is accomplished through erosion control and flood protection (Sections 3.1.5, 3.2.5, 3.4.4, and 5.1.1 of McCandless, 2012). Additionally, the Class A West Embankment custodial maintenance and surveillance are performed to assure continued long-term compliance with applicable regulatory standards (Section 6.3 of McCandless, 2012). As such, the Division-approved Class A West Embankment cover design will perform equivalently on the Federal Cell. As with the Division-approved Class A West Embankment, the controlled areas of the Federal Cell will be fenced both during construction and after operation to prevent public access (Sections 3.1.11, 4.3.6, 7.0, 7.1.3, 7.3, and 8.7 of McCandless, 2012).

The current Division-approved Class A West Embankment cover design to be used on the Federal Cell is a critical component in the isolation of waste from the leaching potential of infiltration. DOE's Vitro Embankment and Energy*Solutions*' LARW Embankment use a traditional rock armor cover design similar to that currently approved for construction on the Class A West Embankment. In the rock armor cover design, the top slope (with a modeled infiltration rate of 0.09 cm/yr) consists of the following, from top to bottom:

- **Rip Rap cobbles**. Approximately 24 inches of Type-B rip rap will be placed on the top slopes, above the upper (Type-A) filter zone. The Type-B rip rap used on the top slopes ranges in size from 0.75 to 4.5 inches with a nominal diameter of approximately 1.25 to 2 inches. Engineering specifications indicate that not more than 50% of the Type B rip rap would pass a 1 1/4-inch sieve.

- **Filter Zone (Upper)**. Six inches of Type-A filter material will be placed above the sacrificial soil in the top slope cover. The Type-A filter material ranges in size from 0.08 to 6.0 inches, with 100% passing a 6-inch sieve, 70% passing a 3-inch sieve, and not more than 10% passing a no. 10 sieve (0.079 inch). The Type-A size gradation corresponds to a poorly sorted mixture of coarse sand to coarse gravel and cobble, according to the Universal Soil Classification System.

- **Sacrificial Soil (Frost Protection Layer)**. A 12-inch layer consisting of a mixture of silty sand and gravel will be placed above the lower filter zone to protect the lower layers of the cover from freeze/thaw effects. The sacrificial soil material ranges in size from <0.003 to 0.75 inches, with 100% passing a 3/4-inch sieve, 50.2% passing a no. 8 sieve (0.093 inch), and 7.6% passing a no. 200 sieve (0.003 inch).

- **Filter Zone (Lower)**. Six inches of Type-B filter material will be placed above the radon barrier in the top slope cover. This filter material ranges in size from 0.2 to 1.5 inches, with 100% passing a 1 1/2- inch sieve, 24.5% passing a 3/4-inch sieve, and 0.4% passing a no. 4 sieve (0.187 inch). The Type-B size gradation corresponds to a coarse sand and fine gravel mix, according to the Universal Soil Classification System.

- **Radon Barrier**. The top slope cover design contains an upper radon barrier consisting of 12 inches of compacted clay with a maximum hydraulic conductivity of $5x10^{-8}$ cm/sec and a lower radon barrier consisting of 12 inches of compacted clay with a hydraulic conductivity of $1x10^{-6}$ cm/sec or less.

The design for the Division-approved Class A West Embankment's traditional rock armored side slope cover is different, but similar to the top slope, (except for the thickness of the waste layer and the material used in the rip rap layer). The layers used in the Class A West Embankment side slope cover (with a modeled infiltration rate of 0.168 cm/yr) consist of the following, from bottom to top:

- **Rip Rap cobbles**. Approximately 24-inches of Type-A rip rap will be placed on the side slopes above the Type-A filter zone. The Type-A rip rap ranges in size from 2 to 16 inches (equivalent to coarse gravel to boulders) with a nominal diameter of 12 inches. Engineering specifications indicate that 100% of the Type-A rip rap would pass a 16-inch screen and not more than 50% would pass a 4 1/2- inch screen.

- **Filter Zone (Upper)**. (Same design as top slope.)

- **Frost Protection Layer (Sacrificial Soil)**. (Same design as top slope.)

- **Filter Zone (Lower)**. The thickness of the Type B filter in the side slope will be 18 inches. The Type B filter material in the side slope will have the same size specifications as the top slope.

- **Radon Barrier**. (Same design as top slope.)

Evapotranspirative covers are increasingly being employed as alternative cover designs for municipal solid waste and hazardous waste sites in arid and semiarid climates. Unlike conventional rock armor cover systems, which use materials with low permeability to limit movement of water into waste, evapotranspirative cover systems minimize water percolation by storing and releasing water through evaporation from the soil surface and through transpiration from vegetation. The primary objective of evapotranspirative cover systems is to use the water balance components of soil and vegetation to hold precipitation and release it through soil surface evaporation or transpiration without allowing water percolation into waste layers.

Since the amendment of the Resource Conservation and Recovery Act Subtitle D (40 CFR 258.60) in March 2004, evapotranspirative cover systems and demonstration sites have been installed at hazardous and radioactive waste disposal facilities in the arid west, including Hill Air Force Base (Utah), Monticello Mill Tailings (Utah), Los Alamos National Laboratory (New Mexico), Sandia National Laboratories (New Mexico), Sierra Blanca (Texas), Rocky Mountain Arsenal (Colorado), and the Hanford Site (Washington) (Rock et.al, 2012). In addition to these facilities, evapotranspirative cover systems have been proposed for the U.S. Ecology Nevada Site (Nevada), the Molycorp Tailings Facility (New Mexico), and Clean Harbors (Utah).

While not yet formally approved, Energy*Solutions* has petitioned the Division for approval to construct an alternative evapotranspirative cover design on their Class A West Embankment (Shrum, 2012). To support that petition, Energy*Solutions* conducted an updated, site-specific Performance Assessment that demonstrates the alternate evapotranspirative cover design's ability to protect the general public during operations, protect the general public after closure, protect the inadvertent intruder, and to be stable over time. The model shows that the alternative evapotranspirative cover design significantly reduces infiltration into waste to the range of 0.00019 cm/yr to 0.00025 cm/yr (Shrum, 2012). This reduced infiltration further demonstrated that "*. . . that no radionuclides have the potential to reach the groundwater point of compliance within 10,000 years.*" (page 60 of Appendix A of Shrum, 2012).

The arrangement of evapotranspirative cover design for use as an alternate cover on the Federal Cell (once approved by the Division for construction on the Class A West Embankment) is (beginning at the top of the cover):

- **Surface layer**. This layer is composed of native vegetated Unit 4 material with 15% gravel mixture. This layer is 6 inches thick. The functions of this layer are to control runoff, minimize erosion, and maximize water loss from evapotranspiration. This layer of silty clay used in both evapotranspirative designs provides storage for water accumulating from precipitation events, enhances losses due to evaporation, and provides a rooting zone for plants that will further decrease the water available for downward movement.

- **Evaporative Zone layer**. This layer is composed of Unit 4 material. The thickness of this layer is varied in the Performance Assessment from 6 inches to 18 inches, to evaluate the influence of additional thickness on the water flow into the waste layer. The purpose of this layer to provide additional storage for precipitation and additional depth for plant rooting zone to maximize evapotranspiration.

- **Frost Protection Layer**. This material ranges in size from 16 inches to clay size particles. This layer is 18 inches thick. The purpose of this layer is to protect layers below from freeze/thaw cycles, wetting/drying cycles, and inhibit plant, animal, or human intrusion.

- **Upper Radon Barrier**. This layer consists of 12 inches of compacted clay with a low hydraulic conductivity. This layer has the lowest conductivity of any layer in the cover system. This is a barrier layer that reduces the downward movement of water to the waste and the upward movement of gas out of the disposal cell.

- **Lower Radon Barrier**. This layer consists of 12 inches of compacted clay with a low hydraulic conductivity. This is a barrier layer placed directly above the waste that reduces the downward movement of water.

A second alternate evapotranspirative cover design under consideration by the Division includes the addition of a filter zone between the frost protection layer and the upper radon barrier. This addition consists of six inches of Type-B filter material, placed below the frost protection material layer in evapotranspirative cover design. The filter material ranges in size from 0.2 to 1.5 inches. The Type-B size gradation corresponds to a coarse sand and fine gravel mix. This high conductivity layer is placed on the upper radon barrier which has the lowest conductivity of any layer in the cover system. The function of this coarse-to-fine interface is to collect water that has drained vertically from the layers above and direct it laterally to a surface drainage system. As such, if approved for construction on the Class A West Embankment, the alternate evapotranspirative cover design will perform equivalently on the Federal Cell.

2.4 Source Term

Because the Class A West Amendment Application already successfully demonstrated the Class A West Embankment design's ability to safely contain disposed waste inventories up to the Class A limits of UAC R313-15-1009 (which also applies to any Class A waste used as fill in the Federal Cell), the waste inventory considered in this depleted uranium Performance Assessment has been limited to the disposal of depleted uranium wastes in the Federal Cell of two general waste types: 1) depleted uranium trioxide (DUO_3) waste from the Savannah River Site (SRS) and 2) anticipated depleted uranium waste as U_3O_8 from gaseous diffusion plants (GDPs) at Portsmouth, Ohio and Paducah, Kentucky. The species list consists of the following radionuclides:

- Depleted Uranium
  - **uranium isotopes:** U-232, -233, -234, -235, -236, -238
  - **progeny of uranium:** Pb-210, Rn-222, Ra-226, -228, Ac-227, Th-228, -229, -230, -232, Pa-231

- **Other Wastes Ass**ociated with the Depleted Uranium Canisters:
  - **Miscellaneous fission product:** Sr-90, Tc-99, I-129, Cs-137
  - **transuranic radionuclides:** Np-237, Pu-239, -239, -240, -241, -242, Am-241

Additionally, the quantity and characteristics of depleted uranium waste from other sources that has already been disposed of at Clive has previously been modeled and is therefore not included (in support of condition 6 of License UT2300249, issued 3 December 1990 at a limit of 110,000 pCi/g; and increased to 370,000 pCi/g, the specific activity of depleted uranium, on 22 October 1998).

The list of radionuclides associated with the depleted uranium wastes are classified by R313-15-1009 as no more than Class A. Those nuclides classified as Class A according to Tables I or II of UAC R313-15-1009 [or classified according to UAC R313-15-1009(2)(f)] are listed in Section 4.1.2.2 and Appendix 4 of Appendix A from revision 0. Concentration limits for radionuclides not listed on Table I or Table II of R313-15-1009 are set at their respective specific activities.

2.4.1 Partitioning Coefficients (K_d)

The partitioning coefficient is the equilibrium ratio of the adsorbed contaminant concentration in soil or waste (mg/kg) to the concentration in the pore water or leachate (mg/L). Higher K_d values indicate that the specific radionuclide is more likely to partition to the soil and less likely to be released into groundwater. The K_d values used in the depleted uranium Performance Assessment have evolved over time, as radionuclide inventories changed and more information was obtained from the literature and from site-specific K_d testing. The modeling performed in this depleted uranium Performance Assessment incorporates the current approved K_d values for the site. The modeling preferentially uses

- Approved site-specific K_d values;
- The lowest measured soil K_d values published in the literature; and
- Published K_d values calculated from the soil:plant ratio.

Approved site-specific K_d values were available for Cs, Np-237, Tc-99, and U. The most conservative (lowest) K_d values found in the literature were used for nuclides that did not have site-specific K_d values. The soil:plant ratio was only used where actual measured soil K_d values are not available, and the published K_d value from the soil:plant ratio was decreased by two orders of magnitude to be conservative.

2.4.2 Fractional Release Rate

The depleted uranium Performance Assessment treats the Federal Cell contaminated zone as a single homogeneous source of changing thickness and radionuclide concentrations as the result of leaching, erosion, and in-growth and decay. Erosion or human activities result in redistribution of the contaminated soil that, in turn, creates new contaminated zones.

As natural precipitation infiltrates through either the Division-approved rock armor or under-review alternate evapotranspirative cover and into the depleted uranium zone, radionuclides are leached from the waste and transported through the unsaturated (vadose) zone and saturated zone (aquifer) to a down-gradient Point of Compliance. Fractional releases of contamination from the Federal Cell into the groundwater pathway are characterized by a water/soil concentration ratio for each radionuclide, which is defined as the ratio of the radionuclide concentration in the water to the radionuclide concentration in the contaminated zone.

2.4.3 Waste Containers

While they provide enhanced intruder barriers, no other waste isolation due to containerization is considered in the depleted uranium Performance Assessment. The depleted uranium Performance Assessment model considers the time required for the water to percolate through the Federal Cell cover. Although the initial waste moisture contents cannot be known with certainty, due to the inherent variability in the waste and in climatic conditions while the embankment is open, previous open-cell modeling suggests that drying of the waste occurs. Therefore, the moisture content in the waste at the time of cell closure will be below the levels reached at eventual pseudo-steady-state.

2.5 Disposal In-Depth Scenario

Energy*Solutions* proposes to dispose of depleted uranium below grade in a licensed Federal Cell. The general design aspect of the Federal Cell mirrors the Division-approved Class A West Embankment and is that of a hipped cover, with relatively steep sloping sides nearer the edges. The upper part of the Federal Cell has a more moderate slope than the sides. Only the top slope region is modeled in Section 4.1.2.1 and Appendix 3 of Appendix A from revision 0, since no depleted uranium will be placed beneath the Federal Cell's side slopes.

The Division-approved Class A West Amendment Application addresses the pertinent characteristics of the principal design features for waste placement and backfill in the Federal Cell. Depleted uranium waste included in this analysis may take a variety of physical forms, including soil or soil-like material, compressible debris, incompressible debris, oversized debris, and containerized Class A LLRW. Liquid waste may not be disposed in the Federal Cell. Waste placement activities will be conducted in accordance with the CQA/QC Manual.

With downward contaminant transport pathways influencing groundwater concentrations, and upward contaminant transport pathways influencing dose and uranium hazard, a balance is achieved in the placement of different kinds of waste. The depleted uranium Performance Assessment examines three disposal in-depth scenarios (with one being the below-ground option being considered for configuration of the depleted uranium waste within the Federal Cell). As with the Division-approved Class A West Embankment design, the peak height within the Federal Cell that is available for waste disposal is 75.3 ft from the engineered cover to the Federal Cell's liner. Revision 0 of this Compliance Report assumed disposal in a Class A South embankment. The supporting GoldSim model has not been reconstructed to reflect a Federal Cell, because prior analysis is bounding.

- Cover Thickness (inches) : Federal Cell = 72, CAS = 66, and;

- Top Slope Infiltration Rate (cm/year): Federal Cell = 0.09, CAS = 0.277

No depleted uranium waste is modeled beneath the Federal Cell's side slopes in the depleted uranium Performance Assessment. The configuration options examined are (depths are downward from the base of the top slope engineered cover).

1. **3m Model**
   Clean Fill from cover to 9.9 ft
   GDP contaminated waste from 9.9 ft to 11.6 ft
   SRS waste from 11.6 ft to 13.23 ft
   GDP uncontaminated waste from 13.23 ft to 44.65 ft

2. **5m Model**
   Clean Fill from cover to 16.54 ft
   GDP contaminated waste from 16.54 ft to 18.19 ft
   SRS waste from 18.19 ft to 19.84 ft
   GDP uncontaminated waste from 19.84 ft to 44.65 ft

3. **10m Model (completely below grade)**
   Clean Fill from cover to 33.07 ft
   GDP contaminated waste from 33.07 ft to 34.72 ft
   SRS waste from 34.72 ft to 36.38 ft
   GDP uncontaminated waste from 36.38 ft to 44.65 ft

As with the Division-approved Class A West Embankment, the design of the Federal Cell enables isolation from Energy*Solutions'* other embankments after it has been filled and covered. Thus, once the Federal Cell is closed, it will not be disturbed by continuing operations at the site. As with the Division-approved Class A West Embankment, the final Federal Cell cover integrates long-term water and erosion control methods into the overall design, thus eliminating the need for active maintenance of a closed Federal Cell. Compliance with this requirement has therefore been sufficiently demonstrated. Additionally, the sensitivity of the projected results to variations in Federal Cell characteristics and disposal scenarios (according to the Division-approved Class A West Embankment design) is addressed in Appendix 15 of Appendix A from revision 0.

2.6 Receptors and Exposure Scenarios

Receptors in the depleted uranium Performance Assessment are categorized in UAC R313-25-8 according to the labels "*members of the public*" and "*inadvertent intruders*." A member of the public is essentially a receptor who is exposed outside the boundaries of the Federal Cell, where the inadvertent intruder is someone who intrudes onto the Federal Cell and may directly contact the waste. The "*critical group*" receptors evaluated are modeled to receive exposure both upon the Federal Cell and in adjacent areas according to the activities foreseen (ranching, recreational, and industrial uses). These scenarios are evaluated under post- institutional control conditions.

The GoldSim Model has been run with and without consideration for the formation of gullies. Scenarios run without gullies are reported as exposure scenarios to members of the general public. Conversely, exposure scenarios wherein it is assumed that gullies are formed (i.e., signifying potential intrusion into the Federal Cell) are reported as exposure scenarios to inadvertent intruders.

2.6.1 Ranching Scenario

The land surrounding the Federal Cell is currently utilized for cattle and sheep grazing. Ranchers typically use off-highway vehicles (OHVs), including four-wheel drive trucks) for transport. Activities are expected to include herding, maintenance of fencing and other infrastructure, and assistance in calving and weaning. Ranchers may be exposed to contamination via the pathways outlined in Table 1 and Appendix 11 of Appendix A from revision 0.

2.6.2 Recreation Scenario

Recreational uses on the land surrounding the Federal Cell may involve OHV use, hunting, target shooting of inanimate objects, rock-hounding, wild-horse viewing, and limited camping. It is assumed in the depleted uranium Performance Assessment that recreational OHV riders ("*Sport*" OHVers; i.e. , OHV users who use their vehicles for recreation alone) and hunters using OHVs ("*Hunters*"), both of whom may also camp at the site, represent the most highly-exposed recreational receptors. Recreationalists may be exposed to contamination via the pathways outlined in Table 1 and Appendix 11 of Appendix A from revision 0.

2.6.3 Industrial Scenario

Most of the land within a 10-mile radius of the Federal Cell is public domain administered by BLM. This dry and arid desert area limits other viable uses of the land. Three hazardous waste facilities are located near the Federal Cell:

- Clean Harbors' Grassy Mountain facility, a commercial, hazardous waste, treatment, storage and disposal facility located greater than ten miles north-northwest of Energy*Solutions'* proposed Federal Cell. This facility was issued its original permit to operate on June 30, 1988;

- Clean Harbors' Aragonite facility a 140 million Btu slagging rotary kiln with a vertical afterburner chamber located approximately 8 miles east-northeast of Energy*Solutions'* proposed Federal Cell. This facility applied for its original permit to operate on July 22, 1987; and,

- Clean Harbors Clive facility, a defunct incinerator site currently permitted for transfer and storage of hazardous waste located approximately 1.25 miles west of Energy*Solutions'* proposed Federal Cell. This facility applied for its original permit to operate on February 14, 1988.

No new industrial facilities have been established in this area of Tooele County's West Desert since June 30, 1988. Individuals who work at these facilities do not live on site, nor do they represent permanent residential population centers.

Tooele County currently has 28 zoning districts including MG-H for Hazardous Industries and MG-EX for mining, sand and gravel excavation. In 1987, the West Desert Hazardous Industry Area or Corridor (WDHIA), with a MG-H zoning designation, was created to prohibit the construction of private dwellings and to provide an area in a remote locations where hazardous and low-level radioactive waste could be stored, treated and disposed in a safe manner (referred to as hazardous industries). The corridor consisted of 78,720 acres at a time when there was a boom in the hazardous and radioactive waste industry. Residential construction was prohibited within a ten mile radius of a hazardous industry (Tooele County, 2012). On 22 November 22 2005, the Tooele County Planning Commission decreased the size of the WDHIA to 9,440 acres and changed the corridor to four non-contiguous areas, surrounded by State Trust, MG-EX zoned and BLM lands. The prohibited distance to residential development was decreased from ten to five miles to accommodate a request by UDOT to have a resident live at the rest stop on I-80 (Tooele County, 2012).

As such, a credible exposure scenario included in the depleted uranium Performance Assessment is that of an industrial worker. The Industrial Worker is assumed to be exposed to contamination via the same pathways outlined for the rancher in Table 1 and Appendix 11 of Appendix A from revision 0 (with the difference being that the amount of time an Industrial Worker is exposed is 2,000 hours per year according to the same exposure frequency distribution as illustrated in Figure 12 of Appendix 11 of Appendix A from revision 0).

2.6.4 Other General Public Exposure Scenarios

The ranching, recreation, and industrial scenarios are characterized by potential exposure related to activities both on the Federal Cell and in the adjoining area. Specific off-site points of potential exposure also exist for other receptors based upon present-day conditions and infrastructure. Unlike ranching, recreational, and industrial receptors who might be exposed by a variety of pathways on or adjacent to the site, these off-site receptors would likely only be exposed to wind-dispersed contamination, for which inhalation exposures are likely to predominate. Five specific off-site locations and receptors are evaluated in the depleted uranium Performance Assessment, including:

- Travelers on Interstate-80, which passes 4 km to the north of the site;
- Travelers on the main east-west rail line, which passes 2 km to the north of the site;
- Workers at the Utah Test and Training Range (UTTR, a military facility) to the south of the Federal Cell, who may occasionally drive on an access road immediately to the west of the Federal Cell fence line;
- The resident caretaker at the east-bound Interstate-80 rest facility (the Grassy Mountain Rest Area at Aragonite) approximately 12 km to the northeast of the site, and,
- OHV riders at the Knolls OHV area (BLM land that is specifically managed for OHV recreation) 12 km to the west of the site.

3. ANALYSIS OF FEDERAL CELL PERFORMANCE

As documented in the modeling report included in Section 5 and Appendix 16 of Appendix A from revision 0, the GoldSim platform was selected for this depleted uranium Performance Assessment, because of its ability to probabilistically simulate complex processes known to have a significant role in water flow in landfill covers in arid regions, including water flow in variably-saturated porous media, material hydraulic property functions, atmospheric surface boundary conditions including precipitation and evapotranspiration, root water uptake, and free-drainage boundary conditions.

3.1 Protection of the Post-Closure General Public

By rule, the depleted uranium Performance Assessment's specific technical information, "*shall include the following analyses needed to demonstrate that the performance objectives of UAC R313-25 will be met: Analyses demonstrating that the general population will be protected from releases of radioactivity shall consider the pathways of air, soil, ground water, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate a reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in UAC R313-25-19"* [UAC R313-25-8(1)].

The information contained in Section 6.2 and 6.3 of Appendix A from revision 0 and other relevant documents Energy*Solutions* has submitted indicate that the requirements of R313-25-8(1) have been met. Each of the major media pathways of this requirement is addressed in the following paragraphs. Original evaluations contained in the Class A West Amendment Application demonstrate compliance of the Division-approved design for exposures from normal operating conditions and accident scenarios. As such, construction of a Federal Cell using the Division-approved Class A West Embankment design does not create any further unanalyzed conditions for exposures from normal operation conditions and accident scenarios.

3.1.1 <u>Air Pathway</u>

Analysis conducted in support of the Class A West Amendment Application demonstrated that the transport of dust to the site boundary during operations (affected mainly by the natural site characteristics, including wind speed, wind direction, and atmospheric stability conditions) is well below regulatory limits. Similarly, the depleted uranium Performance Assessment projects potential releases of depleted uranium from the Federal Cell through the air pathway will be far below regulatory limits.

As stated in the Class A West Amendment Application, Energy*Solutions*' engineering and operational controls prevent the resuspension and dispersion of waste particulates during operations. DOE is required to ship their depleted uranium in containers. Depleted uranium will not be dumped in bulk, but rather disposed in its shipping container, in CLSM. Water spray is used in the cells as need to prevent resuspension of radioactivity. As such, depleted uranium management for the Federal Cell will also be compliant.

Haul roads are also wetted and maintained to prevent the resuspension and dispersion of particulate depleted uranium. Polymers are spread on inactive, open areas to bind the surface and prevent resuspension. Energy*Solutions* also performs routine air monitoring to identify if an airborne situation is developing that may require corrective actions.

After final placement of the depleted uranium waste and closure of the Federal Cell, the Division-approved Class A West Embankment design prevents any further migration of radioactivity through the air pathway because all waste will be beneath a thick earthen cover. Analysis presented in Section 6.2 of Appendix A from revision 0 demonstrates that the maximum dose to a member of the public following Federal Cell closure and institutional control is far below applicable regulatory limits.

During operations, radon releases are projected to be negligible because of low Ra_{226} parent waste concentrations and the Division-approved cover designs include clay radon barriers that limit the surface radon flux to less than 20 pCi/m^2-s, resulting in potential radon exposures well within limits. The Division-approved Class A West Embankment design is based on the disposal of uranium mill tailings, which are initially higher in Ra_{226} than the depleted uranium (which require time periods exceeding the 10,000-year regulatory limit to in-grow due to uranium chain decay). As such, demonstration of its performance for the Class A West Embankment is directly applicable to the Federal Cell.

For accident conditions, depleted uranium dust or particulate matter could be released to the atmosphere and inhaled by individuals. The Class A West Amendment Application and the Federal Cell analysis documented in Section 6.2 of Appendix A from revision 0 evaluate tornado and severe winds, train derailment, truck turnover or collision, and truck fire. All analyses show that the maximum dose to a member of the public is less than 25 mrem/yr, even if the individual is continually present at the Federal Cell boundary.

3.1.2 Soil Pathway

As summarized in Section 6.2.1 of Appendix A from revision 0, the soil pathway involves the exposure of the public to contaminated depleted uranium from the Federal Cell. If an exposure occurred, doses could result from external radiation or ingestion of soil on dirty hands. The primary site characteristic that prevents the likelihood of such exposures during operations and institutional control is the site's remote location (the low population density in the site vicinity, and the lack of natural resources to provide for population expansion). Therefore, this pathway was not considered.

The Division-approved design of the Class A West Embankment also contributes to minimizing exposures to contaminated soil by members of the public. After closure of the Federal Cell, all depleted uranium and other waste will be covered. The Division-approved cover system contains a surface layer of riprap to protect against erosion and human intrusion. Beneath the riprap, the cover system contains a drainage layer and a clay radon barrier. The alternate evapotranspirative cover design under review consists of layers of soil and mulch similar to native area conditions.

During operation, the Federal Cell will be monitored in a manner consistent with that approved in the Class A West Amendment Application and Environmental Monitoring Program, to ensure that no releases or doses have occurred via the soil pathway.

3.1.3 Groundwater Pathway

As is described in Section 6.1.1 of Appendix A from revision 0, the groundwater pathway is assessed using GoldSim. The primary site characteristics that prevent public exposures via the groundwater pathway are the very poor groundwater quality at the site, the low population density, and the relatively slow groundwater flow velocities. The groundwater is not potable because of its very high concentration of dissolved salts. This characteristic alone prevents any appreciable consumption of the water by humans or livestock. The horizontal groundwater flow velocity is approximately 0.5 meters per year, resulting in groundwater travel times of approximately 60 years from the toe of the side slope region of the Federal Cell to the compliance well.

When used on the Federal Cell, several of the Division-approved Class A West Embankment design features provide protection of the public from exposure to waste via the groundwater pathway. The Division-approved Class A West Embankment cover system allows very little water to flow into the disposed waste. This will limit the contamination of the groundwater by minimizing the contact of water with the depleted uranium waste. Another Class A West Embankment division-approved design feature for use on the Federal Cell is the bottom clay liner below the disposed depleted uranium waste. The clay absorbs many of the radionuclides and slows their potential release from the cell and subsequent transport to the water table aquifer.

The infiltration model for the Federal Cell and Division-approved Class A West Embankment covers use GoldSim to demonstrate that the infiltration and radionuclide transport models show that any depleted uranium waste disposed will satisfy all of the groundwater protection criteria, provided that the concentrations of Tc_{99} are limited to the concentrations used in the transport modeling. Since the Tc_{99} disposal concentrations are already limited to 1,720 pCi/g under the Class A West side slope, Energy*Solutions* proposes the same Federal Cell disposal limitations of 1,720 pCi/g under the side slope and 23,800 pCi/g under the top slope. Since the design will be equivalent as the Division-approved Class A West Embankment, all other radionuclide concentrations in the Federal Cell will be limited only by what is necessary for the waste to qualify as Class A. This groundwater modeling provides a conservative estimate for the groundwater exposure scenario.

Radionuclide transport was modeled with the GoldSim model assuming a 4 mrem/year groundwater protection level. The model calculated the release and transport of depleted uranium radionuclides from the Federal Cell, through the unsaturated zone, and horizontally through the shallow unconfined aquifer to a compliance-monitoring well located 90 feet from the edge of the Federal Cell. The groundwater modeling included many conservative assumptions that helped to ensure that the radionuclide concentrations at the compliance monitoring well were not underestimated. For example, the distance from the bottom of the waste to the aquifer was decreased from its actual value by 1.3 feet to conservatively account for the effects of the capillary fringe at the water table and to account for variations in the water table level. No delay factors for waste container life were used to delay the onset of radionuclide releases from depleted uranium waste. The transport modeling shows that, for most depleted uranium radionuclides at the Class A limits, groundwater protection levels are met for 500 years after disposal of the waste.

3.1.4 Surface Water Pathway

Due mainly to the natural site characteristics, there are no radioactive releases expected through the surface water pathway from non-intruder scenarios. The annual precipitation is low and the evaporation is high. No permanent surface water bodies exist in the site vicinity. In addition, the site is far from populated areas. Since they mirror the Division-approved Class A West Embankment, the Federal Cell design features also minimize the potential for releases by the surface water pathway. Federal Cell design includes drainage ditches around the waste disposal areas. After precipitation events, these ditches divert runoff from the closed disposal cell cover to areas away from the disposal cells.

3.1.5 Vegetation Pathway

Vegetation models developed for the depleted uranium disposal evaluate the redistribution of soils, and contaminants within the soil, by native flora and fauna. The biotic models are consistent with observed flora and fauna on and near the Federal Cell, with flora and fauna characteristic of Great Basin alkali flat and Great Basin desert shrub communities.

The Compliance Report evaluates the effects of vegetation on the cover system. Vegetation had two primary effects on the cover system: increasing the hydraulic conductivity of the cover material and root clogging of the lateral drainage layers. During operation of the Federal Cell, releases and doses through the plant pathway are limited by the design, operation, and maintenance of the Federal Cell. Plants on the site will be removed and prevented from contacting waste materials. After final placement of the cover, releases and doses from the plant pathway are limited by the site's natural characteristics, which include low rainfall, thin plant cover, and the presence of plants that are highly efficient at removing water from the soil and transpiring the moisture back to the atmosphere.

The plant uptake pathway is not a viable exposure pathway at the Federal Cell, because of natural site characteristics and design features of the Federal Cell. Exposure by the plant uptake pathway could occur by (1) the production of food crops in contaminated soil at the site, and (2) root intrusion into the waste by native plants that are subsequently consumed by humans or animals. The natural site's characteristics help prevent exposures via the plant uptake pathway because there is insufficient water at the site for the production of food crops. In addition, saline soils present at the site limit the number and type of plant species that can tolerate such conditions. Additionally, there are few deep-rooted native plants in the site vicinity. Even those deep-rooted native plants present in the site vicinity do not have root depths sufficient to penetrate the Division-approved cover systems, overlying wastes, and into the depth at which depleted uranium is modeled for disposal (i.e., greater than 5 meters below the base of the cover).

Design features of the Division-approved Class A West Embankment also help limit exposures for the Federal Cell via the plant uptake pathway. A thick earthen cover will be placed over the Federal Cell to make the waste less accessible to plant roots after closure. After closure, some limited plant species may set roots in the overlying Sacrificial Soil which possesses a higher moisture storage capacity. The overall scarcity of deep-rooted plant species in the site vicinity and the configuration of the Division-approved earthen cover design will offer an inhospitable environment for extension of these types of roots into the waste.

3.1.6 Burrowing Animals Pathway

In the arid environment of the Federal Cell, ants fill a broad ecological niche as predators, scavengers, trophobionts and granivores. However, it is their role as burrowers that is modeled. Ants burrow for a variety of reasons but mostly for the procurement of shelter, the rearing of young, and the storage of foodstuffs. How and where ant nests are constructed plays a role in quantifying the amount and rate of subsurface soil transport to the ground surface near the Federal Cell. Factors relating to the physical construction of the nests, including the size, shape, and depth of the nest, are key to quantifying excavation volumes. Factors limiting the abundance and distribution of ant nests such as the abundance and distribution of plant species, and intra-species or inter- species competitors, also can affect excavated soil volumes. Parameters related to ant burrowing activities include nest area, nest depth, rate of new nest additions, excavation volume, excavation rates, colony density, and colony lifespan. The GoldSim model evaluates the impact of ant burrowing on the transport of contaminants using the following three steps:

1. Identification of which ant species overwhelmingly contribute to the rearrangement of soils near the surface of the Federal Cell.

2. Calculation of soil and contaminant excavated volume using maximum depth, nest area, nest volume, colony density, colony life span, and turnover rate for predominant ant species.

3. Calculation of burrow density as a function of depth to determine the distribution of contaminants within the vertical soil profile for each predominant ant species.

Other than ants, burrowing animals are not considered a viable exposure pathway, given the combination of site characteristics and design features. Burrowing animals at the site include jackrabbits, mice, foxes, and ants. After final placement of the Division-approved cover, the thick soil and rock cover that isolates the waste from burrowing animals, will control releases and doses. Because of this, the likelihood of any animals burrowing through the entire cover, overlying waste, and exhuming depleted uranium materials is sufficiently low that it was not included in the safety assessment calculations. As such, the burrowing animal pathway is not expected to result in any exposures to humans.

3.1.7 Post Closure Doses to Members of the General Public

Table 3-1 presents the maximum dose to members of the general public due to the disposal of depleted uranium in the Federal Cell. The reported 95% upper confidence interval of the mean peak doses is commonly used to represent reasonable maximum exposure in CERLCA risk assessments. Compliance with the performance objectives for the member of the general public of 25 mrem in a year is clearly established. Compliance is demonstrated.

Table 3-1

Peak Total Effective Dose Equivalent to the General Public
(mrem/yr within 10,000 years)

Receptor	Mean	Median	95% Percentile
Industrial Worker	0.0088	0.0069	0.022
Rancher	0.0060	0.0047	0.015
hunter	0.00025	0.00021	0.00062
OHV enthusiast	0.00039	0.00031	0.00094
I-80 receptor	1.5e-7	1.2e-7	3.9e-7
Knolls receptor	1.6e-6	1.2e-6	4.3e-6
Rail road receptor	2.4e-7	1.9e-7	6.1e-7
Rest area receptor	3.1e-5	2.5e-6	7.8e-6
UTTR access road	7.8e-5	6.2e-5	0.0002

This depleted uranium Performance Assessment includes projections of radionuclide transport in groundwater, assuming a 4 mrem/year general public protection groundwater ingestion dose criterion. The GoldSim platform calculated the release and transport of depleted uranium radionuclides from the Federal Cell, through the unsaturated zone, and horizontally through the shallow unconfined aquifer to a compliance-monitoring well located 90 feet from the edge of the Federal Cell. Because of the low infiltration rates associated with the alternate evapotranspirative Class A West Embankment cover design, it is projected that no water that infiltrates through the alternate evapotranspirative cover at the beginning of the modeling period will reach the point of compliance within 10,000 years. Therefore, no depleted uranium radionuclide concentrations were predicted to arrive at or be ingested by members of the general public from the Point-of-Compliance well within the 10,000 year assessment period.

Even so, Table 3-2 estimates 100-percent mortality of all members of the general public that consume native groundwater from beneath the Federal Cell. The major contributions to total mortality are the extremely high TDS, sulfate, and chloride concentrations naturally present in this Class IV aquifer. As such, any increase in the already-high native radiologic groundwater concentrations will have insignificant impacts to the overall non-radiologically-dominated mortality due to ingestion of the native groundwater. Therefore, even when considering the relatively higher infiltration rates of the Division-approved Class A West Embankment's rock armor cover design, doses to the general public (where no members of the public remain living following consumption of native groundwater) will still be below 4 mrem/year. Therefore, inclusion of depleted uranium with either the Division-approved Class A West rock armor cover or the alternate evapotranspirative cover still under review, do not compromise the Federal Cell's performance and protection of the general public from radiological dose resulting from ingestion of groundwater.

3.2 Protection of the Post-Closure Inadvertent Intruder

Exposure doses to inadvertent intruders are also assessed by Energy*Solutions'* GoldSim model. Based upon current and reasonably anticipated future land uses, three future use inadvertent intruder exposure scenarios were identified in which gullies are assumed to be formed: ranching, recreation, and industrial.

After institutional controls are no longer maintained, it is expected that exposures to contamination in the ranching, recreation, and industrial scenarios (wherein gullies are projected to be formed in the closed cover) could occur on the Federal Cell. The primary exposure routes for the ranching, recreation, and industrial scenarios include ingestion, inhalation, and external irradiation. Chapter 6.2.1 of Appendix A from revision 0 discusses the design performance objectives of the Federal Cell to protect inadvertent intruders from exposure. As is demonstrated, the radiation dose to an inadvertent intruder is not expected to exceed radiation limits. Several design features provide the required protection. Overall features include:

- Lack of nearby residential population
- Federal Cell cover system

Table 3-2

Mortality Rates From The Consumption Of Native Groundwater

	Average Native Groundwater Concentration[a]	Radiological Mortality Slope Factor (per µCi)[b]	Risk[d]
Radiologics (pCi/L)			
H-3	2.89E+02	3.49E-08	3.08E-07
C-14	8.46E+00	1.07E-06	2.76E-07
K-40	4.18E+02	1.59E-05	2.03E-04
I-129	1.94E+00	1.51E-05	8.90E-07
Np-237	4.02E-01	4.07E-05	4.99E-07
Ra226	5.05E-01	2.65E-04	4.09E-06
Ra-228	9.75E-01	7.40E-04	2.20E-05
Sr-90	1.09E+00	4.96E-05	1.65E-06
Tc-99	5.52E+00	1.58E-06	2.67E-07
Th-230	2.15E-01	6.18E-05	4.06E-07
Th-232	1.14E-01	6.92E-05	2.41E-07
U-234	2.10E+00	4.59E-05	2.94E-06
U-235	1.75E-01	4.48E-05	2.39E-07
U-238	1.11E+00	4.18E-05	1.42E-06
		Drinking Water Unit Risk (per µg/L)[c]	
Anions (mg/L)			
Bromide	1.56E+01	2.00E-05	3.12E-01
Chloride	3.14E+04	5.00E-04	1.57E+04
Nitrate	1.63E+00	8.00E-03	1.31E+01
Nitrite	1.38E+00	5.00E-04	6.91E-01
Sulfate	6.52E+03	1.44E-01[e]	9.39E+05
Metals (mg/L)			
Antimony	5.00E-03	2.00E-06	1.00E-05
Arsenic (ICP)	8.80E-02	2.50E-07	2.20E-05
Arsenic (GFAA)	4.30E-02	2.50E-07	1.08E-05
Barium	1.90E-02	1.00E-03	1.90E-02
Beryllium	3.00E-03	1.00E-05	3.00E-05
Cadmium	4.40E-03	2.50E-06	1.10E-05
Chromium	1.80E-02	1.50E-05	2.70E-04
Cyanide	6.00E-03	3.00E-06	1.80E-05
Mercury	3.00E-04	1.50E-06	4.50E-07
Molybdenum	6.64E-01	2.50E-05	1.66E-02
Selenium (GFAA)	3.80E-02	2.50E-05	9.50E-04
Silver	8.00E-03	2.50E-05	2.00E-04
TDS	6.08E+04	1.64E-02[e]	1.00E+06

	Clive's Average Natural Groundwater Concentration[a]	Drinking Water Unit Risk (per µg/L)[c]	Risk[d]
Zinc	6.60E-02	1.50E-03	9.90E-02
Volatiles (mg/L)			
Acetone	1.51E+01	4.50E-03	6.81E+01
2-Butanone (MEK)	1.43E+01	2.10E-05	3.01E-01
Carbon disulfide	3.74E+00	5.00E-04	1.87E+00
Chloroform	2.44E+00	5.00E-05	1.22E-01
1,2-Dichloroethane	2.44E+00	2.60E-06	6.33E-03
Methylene chloride	2.39E+00	2.10E-05	5.02E-02
1,1,2-Trichloroethane	1.36E+01	1.60E-06	2.18E-02
Vinyl Chloride	1.28E+01	2.10E-05	2.70E-01
Semi-Volatiles (mg/L)			
Benz(a)anthracene	3.94E+01	2.10E-04	8.27E+00
Benzo(a)pyrene	3.94E+01	2.10E-04	8.27E+00
Benzo(b)fluoranthene	4.11E+01	2.10E-04	8.64E+00
Benzo(k)fluoranthene	3.94E+01	2.10E-04	8.28E+00
Chrysene	3.94E+01	2.10E-04	8.27E+00
Dibenz(a,h)anthracene	3.94E+01	2.10E-04	8.27E+00
Diethyl phthalate	6.61E+00	4.00E-01	2.64E+03
2-Methylnaphthalene	5.46E+00	1.00E-04	5.46E-01
Naphthalene	4.79E+00	1.00E-04	4.79E-01
Pesticides (mg/L)			
Chlordane	5.47E+00	1.00E-05	5.47E-02
		TOTAL CARCINOGENIC MORTALITY RISK	**1.96E+06**

[a] Long-term average concentrations from up-gradient well GW-19A, (Energy*Solutions*, 2012c). Reported concentration for non-naturals is an average of the detection limit.

[b] (Eckerman,1999).

[c] (EPA, 2013).

[d] Deaths per 1,000,000 individuals.

[e] (Patterson, 2005)

- Waste Form
- Limitation of depleted uranium waste under Federal Cell top slope

Operations specific features include

- Fences
- Buffer zone
- Security plan

Post-Closure specific features include:

- Granite markers

While onsite occupation is unlikely, the impact on Federal Cell performance by inadvertent intruders is modeled in the depleted uranium Performance Assessment via the possible formation of gullies that are caused by human intervention (e.g., OHV activity, cattle trails), which may result in direct human contact with the waste for future receptors. For those cases when gullies are formed, which is assumed to be affected by human intervention, comparison of doses is made to Inadvertent Intruder performance objectives.

Table 3-3 summarizes the maximum dose to the inadvertent intruder at the Federal Cell due to the disposal of depleted uranium. The reported 95% upper confidence interval of the mean peak doses is commonly used to represent reasonable maximum exposure in CERLCA risk assessments. Compliance with the performance objectives for the inadvertent intruder of 500 mrem in a year is clearly established for all three disposal configurations.

3.3 Protection of Individuals During Operations

Energy*Solutions*' Radiation Protection Program, required by UAC R313-15-101(1) and evaluated and approved as part of its Class A West Amendment Application, outlines Energy*Solutions'* radiation protection program (Sections 7.0, 7.1, 7.3, and 7.4 of McCandless, 2012). Additionally, Energy*Solutions*' Safety and Health Manual describes site safety, incident reporting, emergency response, equipment operation, personal protective equipment, respiratory protection, medical surveillance, exposure monitoring, hazard communication, confined space entry, and other safety related programs (Sections 8.4, 8.6, 8.7 of McCandless, 2012). Included therein are descriptions of Energy*Solutions*' ALARA program, including dose goals that are significantly below the regulatory dose criteria for workers. Since its creation, Energy*Solutions*' radiological control program has successfully maintained worker exposures as a fraction of the regulatory limit, as demonstrated by worker dosimetry records and calculation of CEDEs (Sections 4.3, 4.4, 7.0, 7.1, 7.3, and 7.4 of McCandless, 2012). Energy*Solutions* actively reviews work practices, performs operational radiological surveys and has an active ALARA review committee. The

Table 3-3

Peak Total Effective Dose Equivalents to the Inadvertent Intruder (mrem/yr within 10,000 years)

Receptor	Mean	Median	95% Percentile
Industrial Worker	0.0087	0.0068	0.022
Rancher	0.0059	0.0046	0.015
Hunter	0.00026	0.00020	0.00062
OHV enthusiast	0.00039	0.00031	0.00096

data clearly demonstrates Energy*Solutions*' proactive approach has resulted in successfully maintaining worker doses ALARA. Given that the Federal Cell's design will mirror that of the Division-approved Class A West Embankment and not require operational or procedural revision, protection of individuals during Federal Cell operations is demonstrated.

Operation-related exposures from the soil pathway involve the exposure of the public to contaminated material from the Federal Cell. If an exposure occurs, doses for this pathway result from external radiation or ingestion of soil on dirty hands. The primary site characteristic that prevents the likelihood of such exposures during operations and institutional control is the site's remote location (the low population density in the site vicinity, and the lack of natural resources to provide for population expansion). During operation, the Federal Cell will be monitored in the same manner as the Division-approved Class A West Embankment (as described in Energy*Solutions*' Environmental Monitoring Program), to ensure that no releases or doses have occurred via the soil pathway (Section 4.4 of McCandless, 2012). Because of these administrative controls, inclusion of additional volumes of depleted uranium does not compromise the Federal Cell's performance and protection of the general public from exposure via the soil pathway during operations.

Energy*Solutions*' engineering and operational controls also prevent the resuspension and dispersion of particulates during operations. Depleted uranium will be shipped and disposed in containers, then surrounded by CLSM. Water spray is used in the cells as needed to prevent resuspension of radioactivity. Haul roads are also wetted and maintained to prevent the resuspension and dispersion of particulate waste. Polymers are spread on inactive, open areas to bind the surface and prevent resuspension. In support of its Division-approved Class A West Embankment operations, Energy*Solutions* also performs continuous air monitoring to identify excessive airborne releases that require corrective actions, suspending all waste handling operations when winds exceed 30 mpg (Section 4.4 of McCandless, 2012). Because of these administrative controls, inclusion of additional volumes of depleted uranium does not compromise the Federal Cell's performance and protection of the general public from atmospheric transport of contaminants during operations.

The nearest stream channel is greater than five miles east of the Federal Cell. Surface water from precipitation is directed away from the waste disposal embankment by drainage ditches and berms. As with the Division-approved Class A West Embankment, during Federal Cell operations, possibly contaminated contact storm-water is recovered and conveyed to evaporation ponds where it is monitored and controlled. No contact storm-water is released offsite, thereby maintaining releases from surface water ALARA (Section 3.1.5, 3.2.5, 3.4.4, and 4.0 of McCandless, 2012). During operation, the Federal Cell will be monitored as described in Energy*Solutions*' Environmental Monitoring Program, to ensure that no releases or doses have occurred via the surface water pathway (Section 4.4 of McCandless, 2012). Because of these administrative controls, inclusion of additional volumes of depleted uranium does not compromise the Federal Cell's performance and protection of the general public from the surface water pathway during operations.

During operation of the Federal Cell, releases and doses through the plant pathway are limited by the design, operation, and maintenance of the Federal Cell. Plants on the site are removed and prevented from contacting waste materials. Similarly, releases and doses from the burrowing animal pathway are prevented by the design, operation, and maintenance of the Federal Cell. Measures to prevent burrowing animals from contacting waste materials during cover construction will be the same as those currently in use at the Class A West Embankment. Because of these administrative controls, inclusion of additional volumes of depleted uranium does not compromise the Federal Cell's performance and protection of the general public from plant or animal driven migration of contaminants during operations.

3.4 Post-Closure Stability of the Federal Cell

Satisfaction of UAC R313-25-21 demonstrates that the performance standard for stability of the Division-approved Class A West Embankment must be sited, designed, and closed to achieve long-term stability to eliminate to the extent practicable the need for ongoing active maintenance of the site following closure. The intent of this requirement is to provide reasonable assurance that long-term stability of the disposed waste and the disposal site will be achieved. As such, the Federal Cell (mirroring the Division-approved Class A West Embankment design) also satisfies UAC R313-25-21.

Prior to implementing Part 61, it had been a common practice at waste disposal facilities to randomly dump some waste. This practice jeopardized package integrity and did not permit access to voids between packages so that they could be properly backfilled. Consolidation of wastes would provide a less stable support which could contribute to failure of the disposal unit cover leading to increased precipitation infiltration and surface water intrusion.

To help achieve stability, NRC noted that to the extent practicable the waste should maintain gross physical properties and identity over 300 years, under the conditions of disposal. NRC believed that the use of design features to achieve stability was consistent with the concept of ALARA and the use of the best available technology. It was NRC's view that to the extent practicable, waste forms or containers should be designed to be stable (i.e., maintain gross physical properties and identity, over 300 years). NRC also noted that a site should be evaluated for at least a 500-year time frame to address the potential impacts of natural events or phenomena should also be applied.

About the same time as Part 61 was promulgated, NRC also put in place requirements for design of uranium mill tailings piles such as the Vitro site which is adjacent to the Clive site. In addressing stability requirements for mill tailings, NRC recognized the need to set practicable standards. NRC specified that the design shall provide reasonable assurance of control of radiological hazards to be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years.

In both cases (low-level radioactive waste and mill tailings disposal) NRC recognized the need to set practical standards that can be implemented. The design standards range from 200 up to 1,000 years. NRC recognized the design limitations and noted that reasonably achievable designs should be employed to the extent practicable. It is not practical to set design standards for stability beyond 1,000 years.

Post-closure stability was evaluated in licensing the Class A West Embankment. In its approval, the Division determined that the Class A West Embankment design meets the regulatory-required performance objective stability criteria, "*The licensee has evaluated the long-term stability of the proposed CAW embankment, including analyses of the effects of natural processes that include erosion, mass wasting, slope failure, foundation settlement and settlement of wastes and backfill, infiltration through the cover and adjacent soils, and surface drainage at the disposal site. The analyses were developed to provide reasonable assurance that there will not be a need for ongoing active maintenance of the CAW Embankment cell and associated drainage features following final closure of the CAW Embankment. Collectively, the analyses completed for the proposed CAW Embankment demonstrate, to the Divisions satisfaction . . . that long-term stability of the CAW Embankment will be achieved with reasonable assurance.*" (pg 79 of URA, 2012).

Disposal of containers of depleted uranium in CLSM in the Federal Cell (mirroring the Division-approved Class A West Embankment design) is consistent with the waste disposal methods considered in that licensing action; i.e., a solid waste is disposed in a CLSM matrix that fills voids and prevents subsidence. Therefore, post-closure stability of the embankment is met.

3.5 Stability of the Federal Cell In Geologic Time

"*The specific technical information shall also include the following analyses needed to demonstrate that the performance objectives of UAC R313-25 will be met: Analyses of the geologic-time stability of the disposal site shall be based upon qualitative analyses of active natural processes including submersion, erosion, mass wasting, infiltration through covers over disposal areas and adjacent soils, and surface drainage of the disposal site. The analyses shall provide reasonable assurance that there will not be a need for critical design features to address geologic-time depleted uranium waste dispersal.*" [UAC R313-25- 8(4)(d) and UAC R313-25-8(5)]

While included in this depleted uranium Performance Assessment as part of improving qualitative understanding of Federal Cell performance, Energy*Solutions* agrees with NRC cautions and recognizes that regulatory compliance should include limited, "*consideration given to the issue of evaluating site conditions that may arise from changes in climate or the influences of human behavior should be limited so as to avoid unnecessary speculation*"(NRC, 2000). Furthermore, "*[t]hese events are envisaged as broadly disrupting the disposal site region to the extent that the human population would leave affected areas as the ice sheet or shoreline advances. Accordingly, an appropriate assumption under these conditions would be that no individual is living close enough to the facility to receive a meaningful dose.*" (NRC, 2000).

As such, geologic-time trends are examined in this Compliance Report, by exploring simulations until the time of peak radioactivity. For this Compliance Report, peak radioactivity associated with radon production from depleted uranium, occurs at about 2.1 million years (My). The time frame of this component requires consideration of climatic changes that have occurred historically on approximately 100 thousand years (ky) cycles for more than 1 My. These cycles include periods of extensive glaciation and inter-glacial periods.

The planet is currently in an inter-glacial period. In effect, the 10 ky model is projected under inter-glacial conditions, and the deep time model includes an evaluation of the effect on depleted uranium disposal of future 100-ky glacial cycles for the next 2.1 My. Analysis conducted in support of this Compliance Report qualitatively assesses the potential impact of glacial epoch pluvial lake events on the overall depleted uranium waste embankment from 10 ky through 2.1 My post-closure. A pluvial lake is a consequence of periods of extensive glaciation, and results from low evaporation, increased cloud cover, increased albedo, and increased precipitation in landlocked areas.

The Federal Cell's principal design features have been designed to perform their required functions over the period of hundreds of years, qualitative trends in depleted uranium transport away from the Federal Cell during geologic-time frames have also been evaluated (see Section 6.5 of Appendix A from revision 0). In conjunction with this design feature, it is important to note that scenarios included in this Compliance Report demonstrate that waste placed below ground surface escape the effects of pluvial lake erosion. As such, it is concluded that the Federal Cell will not require further design changes or ongoing active maintenance following Federal Cell closure.

3.6 Post-Closure Protection of the Groundwater Resource

The Class A West Embankment analysis (applicable to the Federal Cell) for the rock armored cover design projects that 0.09 cm/yr and 0.168 cm/yr of water will infiltrate through the traditional rock armored cover's top and side slope, respectively (Whetstone, 2011), with the differences in infiltration rates due to the top and side slope design differences. It further demonstrates that at these levels, the Federal Cell's use of the Division-approved Class A West Embankment with a rock armored cover will satisfy all of the groundwater protection criteria for radionuclide concentrations limited by what is necessary for the waste to qualify as Class A (with the exceptions of Bk-247, Ca-41, Cl-36, I-129, Re-187, and Tc-99, as limited in condition 55.A of License UT2300249). Because of the relatively lower infiltration rates associated with the alternate evapotranspirative Class A West Embankment cover design, it is projected that no water that infiltrates through the alternate evapotranspirative cover at the beginning of the modeling period will reach the point of compliance within 10,000 years. Therefore, no limitations beyond those associated with a Class A classification for depleted uranium radionuclide concentrations are necessary to protect members of the general public from ingestion of groundwater at the Point-of-Compliance well within the 10,000 year assessment period.

The groundwater protection criteria are based on an annual dose of 4 mrem to an individual drinking groundwater. The projected dose from the groundwater pathway is zero because of the poor groundwater quality. The high salinity of the groundwater, without rigorous treatment, prevents its use for drinking, livestock watering, or crop irrigation. Groundwater protection requirements place limits on the individual radionuclide concentrations in the groundwater at the compliance-monitoring well. The radionuclide concentration limits must not be exceeded for at least 500 years following closure of the Federal Cell.

Table 3-4 summarizes the distribution of the peak groundwater concentrations at the compliance point within the 500-year regulatory limit. As is illustrated, the mean (of the peak of the means) and the 95th percentile for Tc_{99} and I_{129} exceed the GWPL in the 10m Model beneath the Division-approved Class A West rock armor cover. In such a situation, compliance with GWPLs can be maintained by disposal concentration limitations similar to those applied to the Class A West Embankment disposal. Conversely, construction of the alternate evapotranspirative cover under review by the Division requires no such disposal limitations.

Table 3-4

Peak Groundwater Concentrations
(pCi/L within 500 years)

Cover Model	GWPL	Mean	Median	95% Percentile
Rock Amor Cover (Division-Approved):				
Sr_{90}	42	0	0	0
Tc_{99}	3,790	14,000	110	81,000
I_{129}	21	13	5.8e-07	81
Th_{230}	83	1.5e-21	3.8e-37	1.2e-26
Th_{232}	92	1.3e-27	0	9.3e-33
Np_{237}	7	7.6e-18	0	4.7e-26
U_{233}	26	2.9e-17	2.3e-32	4.7e-22
U_{234}	26	1.6e-16	3.0e-32	2.1e-21
U_{235}	27	1.6e-17	2.6e-33	1.8e-22
U_{236}	27	2.4e-17	4.3e-33	3.2e-22
U_{238}	26	1.4e-15	2.4e-31	1.7e-20
Alternate Evapotranspirative Cover (under review):[2]				
Sr_{90}	42	0	0	0
Tc_{99}	3,790	0	0	0
I_{129}	21	0	0	0
Th_{230}	83	0	0	0
Th_{232}	92	0	0	0
Np_{237}	7	0	0	0
U_{233}	26	0	0	0
U_{234}	26	0	0	0
U_{235}	27	0	0	0
U_{236}	27	0	0	0
U_{238}	26	0	0	0

[2] As projected in McCandless, (2012).

4. CONCLUSIONS

As part of its approval of the Class A West Amendment Application, the Division acknowledged that Energy*Solutions'* overall cell design, operation, construction, and monitoring program is in compliance with all applicable regulatory requirements, noting

> "*On November 26, 2012, the Director of the Division of Radiation Control (DRC) approved the proposed amendments to the EnergySolutions (Licensee and Permittee) Low-Level Radioactive Waste Disposal License (RML UT 2300249) and Ground Water Quality Discharge Permit (No. UGW450005). The license amendments and permit modifications were part of a request submitted by EnergySolutions in May 2011 to combine the two existing low-level radioactive waste disposal embankments into a single disposal embankment.*" (DRC, 2012).

As such, activities conducted at Energy*Solutions'* Class A West Embankment are designed to protect the health and safety of workers, the general public, and the environment. Energy*Solutions'* operations are conducted under the ongoing regulatory scrutiny of the Division, Utah Division of Solid and Hazardous Waste, Utah Division of Air Quality, and Utah Division of Water Quality. These inspectors provide continuing assurance that the interests of radiological and environmental safety are properly addressed.

For the majority of applicable regulatory requirements, disposal of depleted uranium in a Federal Cell mirroring the Division-approved Class A West Embankment does not impact the Division's prior certification of Energy*Solutions'* compliance. However, as a result of a desire to dispose of depleted uranium and in compliance with UAC Rule 313-25-8(5), Energy*Solutions* has conducted a detailed, probabilistic performance assessment to demonstrate to the Division that:

1) its proposed methods for disposal of depleted uranium in the Federal Cell will ensure that future operations, institutional control, and site closure will continue to be conducted safely,

2) the Federal Cell will continue to comply with its performance objectives, and

3) the Federal Cell will continue to be in compliance with applicable Division requirements.

This depleted uranium Performance Assessment demonstrates Energy*Solutions*' continued regulatory compliance resulting from its proposed disposal of depleted uranium. As such, it is concluded that acceptance and disposal of depleted uranium produced at DOE's Savannah River Site can be completed compliant with regulatory requirements. Furthermore, this report also demonstrates that Energy*Solutions* may accept and dispose of similar depleted uranium waste from the gaseous diffusion plants at Portsmouth, Ohio and Paducah, Kentucky, and depleted uranium waste from the National Enrichment Facility currently under construction in New Mexico (up to the limits and configurations modeled in the Performance Assessment).

Energy*Solutions* further supports its claims of compliance with Division Rules through the development and execution of a detailed, probabilistic performance assessment using the GoldSim model. This model and the resulting findings demonstrate to the Division that Energy*Solutions*' proposed methods for disposal of depleted uranium will ensure that future operations, institutional control, and site closure can be conducted safely, and that the site will comply with the Division's radiological criteria contained in the UAC.

While included in this Compliance Report as part of improving qualitative understanding of the Federal Cell's performance, Energy*Solutions* agrees with NRC cautions and recognizes that regulatory compliance should include limited,

> "*consideration given to the issue of evaluating site conditions that may arise from changes in climate or the influences of human behavior should be limited so as to avoid unnecessary speculation*"(NRC, 2000).

Furthermore,

> "*[t]hese events are envisaged as broadly disrupting the disposal site region to the extent that the human population would leave affected areas as the ice sheet or shoreline advances. Accordingly, an appropriate assumption under these conditions would be that no individual is living close enough to the facility to receive a meaningful dose.*" (NRC, 2000).

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APPENDIX A

Responses to Preliminary Completeness Review (25 October 2013)

Responses to Preliminary Completeness Review (25 October 2013)

Responses to the Division's individual completeness findings (listed in italics) are provided herein. A full list of references cited below can be found in the Division's Preliminary Completeness Review (25 October 2013). Additionally, since no revisions have been required to Appendix A of revision 0 of the Compliance Report (originally submitted in June of 2011), it has not been reproduced as part of revision 1of the Compliance Report. As such, references to specific sections and appendices of Appendix A can be found in the initial submittal (revision 0) of Appendix A of the Compliance Report.

It is recognized that the stated purpose of the Preliminary Completeness Review (PCR) of revision 0 of Energy*Solutions'* depleted uranium Performance Assessment is to ascertain whether or not all necessary components have been included and addressed. It is not the stated purpose, however, to make judgment on the technical and regulatory adequacy of the submittal components, "*It should be emphasized that this [PCR] does not address the technical merits of the EnergySolutions documents, but only whether the submission is complete when tested against the cited Utah regulations and guidance documents. . . [However,] in some instances, the distinction between completeness and technical comments is not distinct. [As such,] it is possible that some of the comments included here may be judged to be technical comments . . .*" (PCR, pg. 2).

The Division has indicated that technical Interrogatories are being prepared that will likely lead to a revision of the depleted uranium Performance Assessment GoldSim model. In order to more efficiently target subsequent revisions to the depleted uranium Performance Assessment GoldSim model, Energy*Solutions* is deferring response to those findings of the Preliminary Completeness Review that focus on the regulatory adequacy, technical accuracy, and content justification instead of incompleteness (as summarized in Table A-1). It is hoped by doing so that the review process is expedited; as a revised model at this stage might require re-starting some aspects of the review. Therefore, this response does not include re-submittal of Appendix A to the Compliance Report nor any of its attachments; since those have not been revised at this time.

NUREG-1573 defines a Performance Assessment as "*a quantitative analysis used in connection with demonstrating compliance with the . . . post-closure performance objective(s) governing radiological protection of the general public.*" Energy*Solutions* submitted its depleted uranium Performance Assessment in compliance with Utah Administrative Code (UAC) R313-25-8(5)(a), in demonstration that it will be able to maintain radiological protection of the general public, as a result of the disposal of depleted uranium. However, the Preliminary Completeness Review cites the absence of regulatory components in the depleted uranium Performance Assessment that have already demonstrated to the Division's satisfaction as part of the Class A West Embankment design (McCandless, 2012).

Table A-1

Summary of Preliminary Completeness Review Findings of Technical Merit

PCR Section	Comment Identifier
2.1	Comment 1, Inadequate References
	Comment 5. Assumption that CAS Cell Design was Acceptable
2.2	Section 1.4, Basis for Performance Assessment.
	Sections 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, and 2.11.
	R313-25-2 defines "inadvertent intruder" with regard to activities that might occur after site closure.
	Section 2.18, R313-25-19, Protection of the General Population from Releases of Radioactivity (starting on p. 2-27) – Concerns 3, 4, 5, and 6.
3.1	Comment 1
	Comment 4. Deep Time – Time:
	Comment 5. Deep Time – Sediment Concentration
	Comment 8. PA Intent:
	Comment 11. Inconsistent Definitions:
	Comment 12. Incomplete Figures:
	Comment 13. Incomplete Discussion of Sensitivity Plots:
	Comment 15. Federal vs. Agreement-State Regulations:
3.2	ES, page 2.
	ES, page 6.
	Section 1.3, page 16, paragraph 1; Section 4.1.2.11, page 39; Section 6.4, page 77, paragraph 1.
	Section 1.3, page 16.
	Section 4.1.2.7, page 32.
	Section 4.1.2.8, page 32.
	Section 4.1.2.8.2, page 34.
	Section 4.1.2.10.1, page 37.
	Section 4.1.2.10.1, page 27
	Section 4.1.2.12, page 39.
	Section 4.1.2.12, page 40.
	Section 5.1.7, page 45.
	Section 5.2, page 45.
	Section 6.1.1, page 55.
	Section 6.1.1, page 57.
	Section 6.1.2, page 58.
	Section 6.2.2, page 63.
	Section 6.2.2, page 64.
	Section 6.2.2, page 65.
	Section 6.2.2, page 67.
	Section 6.3.1, page 68.
	Section 6.3.1, page 68-69.

Table A-1
(continued)

PCR Section	Comment Identifier
	Section 6.3.2, page 70.
	Section 6.3.2, page 71.
	Section 6.3.2, page 72.
	Section 6.4, Table 11, page 76.
	Section 6.5, page 78.
	Section 6.5, page 78.
	Section 6.5.1, page 79.
	Section 6.5.1, page 80.
	Section 7.1, page 83.
	Section 7.2, page 85.
4.1	Comment 1.
4.2	Section 4.1.1, page 5.
	Section 6.0, page 9.
5.2	Pages vi and vii.
	Section 1, page 1.
	Section 1, page 1.
	Section 3, page 5.
	Section 3.4.2.2, page 11.
	Section 4.2.2, page 18.
	Section 5, page 20, first paragraph.
	Section 5, page 20, last paragraph.
	Section 5, page 21, Containerization.
	Section 6, page 22.
	Section 6, page 22.
	Section 7.1.1.1, page 27.
	Figure 7.2.1.5, page 40.
	Section 7.2.2, page 42.
	Section 8.3, page 45.
	Section 8.2, page 45.
	Section 9.1.1, page 47.
	Section 9.2, page 51.
	Section 10.3.1, page 57.
6.1	Comment 1.
	Comment 2.
6.2	Section 2.2.2, page 6.
	Section 2.3.2, page 7.
	Section 3.1.2, page 10.
	Section 3.2.1, page 12.
	Section 3.2.2, page 14.

Table A-1
(continued)

PCR Section	Comment Identifier
	Section 3.2.3, page 16. Section 3.3, page 17. Section 3.3, page 18. Section 3.3, page 19. Section 3.3, page 20. Section 3.5.2.3, page 23.
7.2	Section 2, page 7. Section 3.1, page 11. Section 3.2, page 15. Section 5.1.5 and 5.1.6, page 27. Section 8.0, page 30. Section 8.3, page 37. Section 9.2.1, page 49.
8.1	Comment 1.
8.2	Section 1.0, Table 3, page 2. Section 5.0, page 17. Section 5.0, page 18. Section 5.0, page 18.
9.2	Section 3.3, page 4. Section 4.2, page 11.
10.1	Comment 1. Comment 2.
10.2	Section 4, page 5.
11.2	Section 3.1, page 11. Section 3.3.1, page 16; Section 3.3.3, page 18. Section 3.4.3, page 22. Section 3.4.5, page 25. Section 3.4.5, page 25. Section 4.5, page 30.
12.2	Section 1, page 1. Section 1, page 1; Section 2, page 2. Section 2, page 3.
13.1	Comment 1.

Table A-1
(continued)

PCR Section	Comment Identifier
15.1	Comment 1. Missing Approvals
	Comment 2. Lack of Page Numbers:
	Comment 3. GoldSim Model Calibration:
15.2	Section 5.0, Table 2.
	Appendix B. Section 2.6.

2.0 REVIEW OF ENERGY*SOLUTIONS* "UTAH LOW-LEVEL RADIOACTIVE WASTE DISPOSAL LICENSE – CONDITION 35 (RML UT2300249) COMPLIANCE REPORT," JUNE 1, 2011

2.1 GENERAL COMMENTS

Comment 1, Inadequate References: In general, the Compliance Report[3] refers to the 2008 EnergySolutions license renewal application as justification for limiting further consideration of numerous issues addressed in the plans and manuals provided as part of the license renewal application. When addressing a specific issue, without review of the relevant plan or manual in the Compliance Report, sufficient reasons have not been provided by EnergySolutions to conclude that revisions are not necessary. Individual review of each technical issue should be documented and provided as necessary. At a minimum, specific citations (chapter, section, page, etc) to past license renewal applications with descriptions and justification need to be added. Examples of this problem include, but are not limited to: Section 2-2, page 2-4, refers "Occupation Dose Limits for Adults," where the licensee states there is a plan or manual that addresses exposures but does not provide a name, chapter or page number or Section 2-7, page 2-6, "Posting Requirements" where the licensee refers to the Radiation Safety Manual but does not provide chapter or page number.

Energy*Solutions'* Response: Since its initial submittal, the Division has approved the design associated with Energy*Solutions'* Class A West Amendment Application to Radioactive Material License UT2300249. More specific references to and added justification from the approved Class A West Amendment Application have been provided in response to the Comment 1 Interrogatory.

Comment 2. Over-reliance on Past Licensing Activities: In addition to the primary function as the site-specific PA, the Compliance Report and its Appendix A also serve as a license amendment application request. As such, the Compliance Report is expected to have sufficient detail to provide a complete picture of the large-quantity DU disposal proposal. However, sufficient detail is lacking. Too much reliance is placed on past licensing activities without showing how past work embraces DU disposal. See comment for Paragraph 4 of page 4 for examples of the deficiencies.

Energy*Solutions'* Response: The revised Compliance Report includes additional detail supporting statements that rely on prior licensing actions.

Comment 3. Erroneous Rule References: Multiple errors have been made in citations to the Utah Radiation Control Regulations. Please re-examine all references and correct them as needed.

Energy*Solutions'* Response: Citations to the Utah Radiation Control Regulations have been reviewed for accuracy in the main report.

[3] Energy*Solutions*, "Utah Low-Level Radioactive Waste Disposal License – Condition 35 (RML UT2300249) Compliance Report," June 1, 2011

<u>Comment 4. Failure to Consider Multiple Rules in R313-15 and R313-25:</u> On multiple locations in the Compliance Report, EnergySolutions fails to identify key rule requirements applicable to a major license amendment such as the DU waste proposal. In other locations, key phrases from existing rules have been omitted without explanation or justification. These are identified in the discussion below, and must be corrected.

Energy*Solutions'* Response: Since the depleted uranium Performance Assessment has been submitted in compliance with UAC R313-25-8(5)(a) and not in and of itself as an actual application for License issuance or renewal, the request to address the rules cited in the Division's Interrogatory are inapplicable. This is particularly the case since the Division is actively reviewing the 2012 License Renewal Application. The report has been re-written to focus only on R313-25-8(5)(a).

<u>Comment 5. Assumption that CAS Cell Design was Acceptable:</u> At multiple locations in the June 1, 2011 DU submittal, the licensee assumes that the CAS Cell design was acceptable to DEQ. This assumption is unwarranted because DRC review of this proposal was never completed. The DEQ acknowledges two EnergySolutions submittals that included engineering design information, dated January 4, 2008 and June 9, 2009. Between these submissions, DRC provided EnergySolutions a November 26, 2008, Completeness Review. Based on our records, no other interrogatory was prepared by DRC or delivered to EnergySolutions. In fact, on May 2, 2011, EnergySolutions submitted a request to retract its January 4, 2008, CAS Cell license amendment request. As a result, after the EnergySolutions response to this Completeness Review, DEQ will re-open the project and begin a detailed review of both the January 4, 2008, and June 9, 2009, EnergySolutions submittals. In the event that EnergySolutions decides to alter or modify these design submittals, and to expedite review of the DU proposal, any design changes made by EnergySolutions will need to be provided upon submittal of your response to this DEQ Completeness Review.

Energy*Solutions'* Response: Since its initial submittal, the Division has approved the design associated with Energy*Solutions'* Class A West Amendment Application to Radioactive Material License UT2300249. More specific references to and added justification from the approved design and analysis of Class A West Amendment Application (as applicable to the Federal Cell) have been provided.

<u>Comment 6. Clive Facility Definition:</u> The PA uses the term "Clive facility" or sometimes just the term "the facility" throughout. Please define the term "Clive Facility" and describe what that entails, in particular, distinguishing it from its component parts.

Energy*Solutions'* Response: The term has been removed from the main report.

2.2 SPECIFIC COMMENTS

Section 1.3. This section lists the expected mass of DU waste, in the form of U3O8, from the DOE de-conversion facilities at Paducah, Kentucky, and Portsmouth, Ohio (projected for a 20–25-year operating period). Please provide an estimate of the total mass of DU waste that has been and will be received from the Savannah River Site (SRS), and identify its chemical and physical form. If any other source or generator of DU waste is considered for Clive disposal, please indicate its specific source (by generator), chemical/physical form(s), estimates of total mass, and volume.

Energy*Solutions'* Response: Sections 1, 1.4, and 2.3 of the report identifies the mass of depleted uranium received from SRS as "*3,577 metric tons*." Furthermore, Section 1.4 notes, "*DOE estimates the inventory of U_3O_8 that will eventually require disposal to be approximately 700,000 metric tons over a 20 to 25 year period.*" Other radiological characteristics are summarized in Report section 2.3. A more detailed description has already been provided in Appendix 4 of Appendix A from revision 0.

Section 1.4, Basis for Performance Assessment. This section makes reference to parts of R313-25-8(5). On page 1-8, the applicant proposes to use an intruder dose of 500 millirem per year (mrem/year). However, Utah Radiation Control Rule R313-15-401 states, in part, that the License Termination Rule applies only to ancillary surface facilities that support radioactive waste disposal activities. Therefore, it appears the 500 mrem/yr dose standard does not apply to the disposal embankment; and instead the 25/75/25 mrem/yr dose requirements of UAC R313-25-19 should apply instead. Additional detail on DEQ findings in this matter are found below. In addition, the NRC had not considered large quantities of DU as radioactive waste when it promulgated 10 CFR Part 61 in 1982.

DRC staff acknowledge that NRC staff have proposed to the Commission consideration of a 500 mrem/yr dose standard for the inadvertent intruder. However, this federal rulemaking effort will not be complete for a year or more. In the meantime, the DEQ licensing action is based on current DRC rule requirements. Therefore, if EnergySolutions is intent on using a 500 mrem/year for the intruder dose, please explain and justify why this would protect human health and the environment. Also, be advised that EnergySolutions will need to request a variance from the Utah Radiation Control Board.

Energy*Solutions'* Response: Additional justification for the use of a 500 mrem/yr inadvertent intruder dose has been provided in Section 1.3 in response to the Division's Interrogatory.

Table 2-1, Applicable Requirements Potentially Impacted by the Disposal of Depleted Uranium (pp. 2-2 and 3). Please make the following modifications to the table:

1. *R313-15-402 – please delete this reference, it is not applicable to the CAS Cell. For more information, see discussion below.*
2. *R317-6 – description on how this rule applies has been omitted. Please revise the table.*

Energy*Solutions'* Response: Since the Compliance Report has been re-written to focus on UAC R313-25-8(5)(a), this table has been deleted.

<u>Sections 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, and 2.11</u>. These sections each broadly mention various plans or manuals submitted to the Division of Radiation Control as part of previous licensing activities. However, they should make more specific reference to the relevant discussion in the appropriate plan or manual; e.g., by chapter and page. For example, Section 2.2 states that the 2008 license renewal application includes models demonstrating that atmospheric pathway doses to the general public during operations will remain below required regulatory levels. The text should cite the specific place(s) in the documents that discusses the models to confirm that they included the handling of large quantities of DU.

Energy*Solutions'* Response: Since its initial submittal, the Division has approved the design of Energy*Solutions'* Class A West Amendment Application to Radioactive Material License UT2300249. More specific references to and added justification from the approved design of Class A West Amendment Application have been provided in support of the Federal Cell in the main report.

<u>Section 2.8, R313-15-906; Procedures for Receiving and Opening Packages.</u> This section discusses receipt and opening of waste packages at Clive. In Section 1.3, EnergySolutions also describes how DOE has identified corroded 55-gallon drums of DU waste at the SRS that have been overpacked (p. 1-6); and discovery of corroded DUF6 Storage Cylinders (DUF6 Cylinders) at their Paducah, Kentucky, and Portsmouth, Ohio, facilities (p. 1-6). Please disclose: (1) the range of weight (tare, net, and gross) expected for each type of DU waste package, for each physical/ chemical form of DU waste, be it UO3 or U3O8; and (2) if the Paducah and Portsmouth DU waste will be shipped to Clive in existing DUF6 Cylinders. Please explain how currently approved EnergySolutions waste handling procedures (in various plans), designed for management of solid LLRW materials, will apply to DUF6 Cylinders, designed by DOE for storage of gaseous DUF6.

Energy*Solutions'* Response: Sections 1, 1.4, and 2.3 of the report identifies the mass of depleted uranium received from SRS as "*3,577 metric tons*." Furthermore, Section 1.4 notes, "*DOE estimates the inventory of U_3O_8 that will eventually require disposal to be approximately 700,000 metric tons over a 20 to 25 year period.*" Other radiological characteristics are summarized in Report section 2.3. Additionally, a more detailed description has already been provided in Appendix 4 of Appendix A from revision 0. Energy*Solutions* does not proposed to make changes to the current waste handling and disposal procedures already approved by the Division as part of the Class A West Amendment Application. Specifically, depleted uranium will be disposed in the Federal Cell in CLSM in accordance with existing CQA/QC Manual requirements for CLSM mix design, placement controls, and void filling.

<u>Section 2.9, R313-15-1002; Method for Obtaining Approval of Proposed Disposal Procedures (p. 2-7).</u> Regarding the 55-gallon (~7.35 ft3) drums from SRS (in UO3 form) and DUF6 Cylinders mentioned in Section 1.3, it appears the latter will be significantly larger (~151 ft3). Please verify whether or not the same DUF6 cylinders will be re-used for DU waste transport to Clive,

and if they will be directly disposed in the embankment. If any other types of DU waste containers are to be used for transport and disposal, please indicate their size, volume, type, and weight, etc. Please justify how existing waste disposal procedures at Clive, designed for disposal of containers of LLRW solid materials, will apply to disposal of the recycled DUF6 Cylinders filled with DU oxides.

Energy*Solutions'* Response: The size and type of container used for depleted uranium disposal is irrelevant based on the way the conceptual model is constructed. No credit is taken for the container or placement methodology beyond the assumption of a stable embankment at closure. This means that current broad controls over waste placement apply without revision – if disposed in containers, voids within and surrounding the container must be filled with CLSM (a low-strength flowable concrete grout). In other words, physical behavior of the recycled DUF_6 cylinders filled with depleted uranium oxides will be consistent with that of other LLRW solid materials. Figure 2-1 of the Compliance Report demonstrates that the Federal Cell's disposal capacity is sufficient for the targeted depleted uranium disposal.

<u>Section 2.10, R313-15-1009; Waste Classification (p. 2-7).</u> Table 2-2 provides concentrations of radioactive elements, including U-235, found in some of the DU waste streams. However, the Compliance Report has not addressed the applicability of License Condition 13 to the disposal of large quantities of DU containing U-235. Further review of License Condition 13 should be documented and submitted.

Additionally, Utah Radiation Control Rule R313-15-1009 provides a concentration limit for Ra 226 as a Class A waste. Because of the very long half-life of DU (principally U-238), the concentration of Ra-226 in the waste will continue to increase for thousands of years beyond the 10,000-year period assessed in the PA and will eventually exceed the Class A concentration limit. A discussion of the matter should be provided.

Energy*Solutions'* Response: License Condition 13 applies to Special Nuclear Material (SNM). The Nuclear Regulatory Commission defines SNM as:

> "*'Special nuclear material' (SNM) is defined by Title I of the Atomic Energy Act of 1954 as plutonium, uranium-233, or uranium enriched in the isotopes uranium-233 or uranium-235. The definition includes any other material that the Commission determines to be special nuclear material, but does not include source material. The NRC has not declared any other material as SNM.*"

There is no data to indicate that there is anything more than trace amounts of U-235 that would not exceed that allowed by the SNM exemption.

The concentration limits in R313-15-1009 apply to classification at the time of disposal. The stated purpose of the depleted uranium Performance Assessment is to evaluate the long-term implications of increasing concentration of U-238 daughter products. Therefore, the method for determining classification is not applicable at some arbitrary future time.

<u>R313-25-6; General Information Omitted.</u> Review of the CR shows this section of the rule has been omitted. Please modify it to ensure, at a minimum, the requirements of R313-25-6(3) and (4) are included and adequately addressed.

Energy*Solutions'* Response: Since the Compliance Report has been re-written to focus on UAC R313-25-8(5)(a), this table has been deleted.

<u>R313-25-2 defines "inadvertent intruder" with regard to activities that might occur after site closure.</u> However, the first paragraph on page 2-15 refers to the "protection of inadvertent intruders from radiation exposures during facility operations," which is inconsistent with this definition. The paragraph should be revised to address this apparent inconsistency.

Energy*Solutions'* Response: The inadvertent intruder discussion in Section 1.3 has been clarified.

<u>R313-25-9(1) and (2), Institutional Information - Omission.</u> No discussion is provided in the EnergySolutions CR about how and when EnergySolutions will comply with the requirements of this rule. In that the Clive facility is not located "… on land not owned by the federal or state government …", please demonstrate that binding legal provisions are in place "… for assumption of ownership in fee by the federal or a state agency." Alternatively, explain how EnergySolutions will provide other institutional controls to enable long-term site control and maintenance for a minimum period of 10,000 years or more after site closure.

Energy*Solutions'* Response: In accordance with License Condition 12, the Clive facility was granted an exemption to the land ownership requirements.

In accordance with R313-25-28(2), "*The period of institutional controls will be determined by the Director, but institutional controls may not be relied upon for more than 100 years*". Therefore, Energy*Solutions* is prohibited from providing "*…other institutional controls to enable long-term site control and maintenance for a minimum period of 10,000 years or more after site closure.*" Accordingly, the Performance Assessment evaluates environmental fate and transport of contaminants of concern correctly assuming no active maintenance or control measures.

It is noted that Utah Code Annotated 19-3-106.2 provides for a perpetual care fund to address the care and maintenance of a commercial radioactive waste disposal facility beginning 100 years after the date of final closure of the facility. This fund has a minimum target initial balance of $100 million, met through a combination of annual cash payments, earnings on the fund balance, and surety funding. Furthermore, Energy*Solutions* recognizes that agreement to secure stewardship over the Federal Cell must be obtained from DOE prior to DU disposal (as is outlined in Section 1 of the Compliance Report).

<u>Section 2.15, R313-25-10; Financial Qualifications to Carry Out Activities (p. 2-23)</u>. It appears this section addresses the requirements of R313-25-10. In light of the fact that 2.5 of the 3 different DU waste depths considered in the CR are above native ground elevation, please

explain and justify why the Director should not revise the surety to address the need for long-term disposal site maintenance should future pluvial lakes cause wave-cut erosion.

Energy*Solutions'* Response: In accordance with R313-25-28(2), "*The period of institutional controls will be determined by the Director, but institutional controls may not be relied upon for more than 100 years*". Therefore, Energy*Solutions* is prohibited from providing "*…other institutional controls to enable long-term site control and maintenance for a minimum period of 10,000 years or more after site closure.*" Accordingly, the Performance Assessment evaluates environmental fate and transport of contaminants of concern correctly assuming no active maintenance or control measures. Furthermore, Energy*Solutions* recognizes that agreement to secure stewardship over the Federal Cell must be obtained from DOE prior to depleted uranium disposal (as is outlined in Section 1 of the Compliance Report). Finally, although the Performance Assessment evaluates disposal both above- and below-grade, depleted uranium will be disposed below grade to enhance assurance of continued isolation under geologic-time events such as the return of a large lake inundating Clive. Figure 1-2 of the Compliance Report demonstrates that the entire depleted uranium inventory evaluated can be disposed in such a manner.

<u>R313-25-16; Transfer of License – Omission.</u> No description is found in the CR to explain and justify how the DU waste proposal will comply with this requirement. Specific attention must be given to R313-25-16(5).

Energy*Solutions'* Response: In accordance with License Condition 12, the Clive facility was granted an exemption to the land ownership requirements. Under the land ownership exemption, Energy*Solutions* is not required to transfer the license as contemplated in R313-25-16. "*Following closure and the period of post-closure observation and maintenance, the licensee **<u>may</u>** apply for an amendment to transfer the license to the disposal site owner* [emphasis added]."Accordingly, evaluation of compliance with R313-25-16 is not needed until such time as an application to transfer is proposed. Furthermore, Energy*Solutions* recognizes that agreement to secure stewardship over the Federal Cell must be obtained from DOE prior to DU disposal (as is outlined in Section 1 of the Compliance Report).

<u>Section 2.17; R313-25-18, Individual Exposure Assurance (p. 2-27)</u> – In the last paragraph of this section, please disclose where the Requirements 2508-1 through 4 can be found, or alternatively, provide those references as an attachment to the revised CR. Also, because the DU waste and progeny in-growth will pose higher risks to human health and the environment with time, please describe and justify how future adverse exposures to individuals can be controlled and prevented in light of the fact that there are no provisions currently in place for the Clive disposal site "… for assumption of ownership in fee by the federal or state agency" [see R313-25-9(2)]. Please describe in detail how the DU waste proposal will allow EnergySolutions to comply with the requirements of R313-25-19 (protection of general public) and R313-25-22 (inadvertent intruder protection). Alternatively, EnergySolutions may cross-reference those sections of the CR that resolve these requirements.

Energy*Solutions'* Response: Protection of the general public and the inadvertent intruder are discussed in sections 3.1 and 3.2, respectively, of the Compliance Report.

Section 2.18, R313-25-19, Protection of the General Population from Releases of Radioactivity (starting on p. 2-27) – Several concerns were found in this section during our review, as follows:

1. *EnergySolutions Requirements Section (pp. 2-27 and 28) – This section omits the 4 mrem/yr dose limit for the groundwater pathway mandated by R313-25-19. Please correct this omission and revise the section accordingly. In order to comply with the provisions of R313-25-8(5)(a), please demonstrate how dose to an individual via the groundwater pathway will remain below this limit for 10,000 years or more after site closure.*

   Energy*Solutions'* Response: Demonstration of compliance with a 4 mrem/yr groundwater standard has been added in Section 3.1.

2. *Basis for Dose Conversion – We appreciate the argument that dose limits in R313-25-19 are based on whole body dose, and that more modern means are available to determine dose to an individual, namely a total effective dose equivalent (TEDE) methodology. Please disclose what internationally recognized publication (and dose conversion factors) was used by Neptune to calculate the TEDE doses quoted in Table 2-3 and the Ground Water Protection Levels found in Table 2-4. We recognize that this information is in the DU PA but should be included here as well or appropriately cross-referenced.*

   Energy*Solutions'* Response: As noted in the Division's Interrogatory, the information requested has been included in Appendices 4, 11, and 12 of Appendix A from revision 0. Energy*Solutions* finds no performance objective in R313-25-8(5)(a) requiring an additional summary of this information in the main report.

3. *Unidentified Exposure Scenarios – Neither the EnergySolutions CR text nor the tables themselves identify the exposure scenario(s) represented by the predictions listed in Tables 2-3 and Table 2-4. Please identify all exposure scenarios used in these tables. Please confirm how much of the DU waste was exposed at the surface for each of the waste depths listed in these tables. Please identify the percentage of the embankment area where DU waste was exposed by erosion in each exposure scenario.*

   Energy*Solutions'* Response: While already included in Appendix 11 of Appendix A from revision 0, a summary of the exposure scenarios has been added in report Section 2.4 and 2.5.

4. *Peak Doses in Table 2-3 – Please identify the DU waste isotopes and exposure pathways behind each receptor scenario listed in this table. Please also explain how the doses may vary, should certain fundamental assumptions change in the Neptune predictions, including, but not limited to, DU waste nuclides, source term activity, cover system erosion rates, relative area of cover system eroded (or area of DU waste exposed) in the model, etc.*

Energy*Solutions'* Response: While already included in Appendices 11 and 15 of Appendix A from revision 0 (thereby signifying a complete component), a summary of the exposure scenarios and associated sensitivity analysis have been added in report Section 2.4 and 2.5.

5. *Groundwater Pathway, 500-Year Groundwater Prediction Timeframe, Table 2-4 – Please explain and justify how a 500-year simulation of concentrations in the groundwater pathway can demonstrate EnergySolutions compliance with the minimum 10,000 year quantitative predictions required by R313-25-8(5)(a) for each exposure pathway. Alternatively, provide results of groundwater fate and transport modeling for a minimum 10,000-year period after site closure.*

   Energy*Solutions'* Response: The stated purpose of the table (now labeled as Table 3-4) is to demonstrate the Federal Cell's ability to comply with requirements of Energy*Solutions'* Ground Water Quality Discharge Permit (as per UAC R317-6). Refer to the discussion in Section 3.1 and Table 3-2 for the depleted uranium Performance Assessment's demonstration of compliance with the 10,000 year groundwater standard.

6. *Groundwater Protection Levels, Table 2-4 – Please disclose if any differences exist in the dosimetry and/or dose conversion methods used to derive the Ground Water Protection Levels listed, versus those doses methods used for Table 2-3. If there are differences, please explain and justify why they should be acceptable, i.e., why they represent the most modern dosimetry methodology.*

   Energy*Solutions'* Response: The groundwater transport methodology employed in the depleted uranium Performance Assessment is described in Appendices 5, 6, 7, and 11 of Appendix A from revision 0 (thereby being a complete component of the required submittal). Ground Water Protection Levels were taken from the Ground Water Quality Discharge Permit, Table 1A; Table 1A includes notes as to the derivation of each standard listed.

7. *Groundwater Point of Compliance, Table 2-4 – Please identify the relative horizontal location and distance of the compliance monitoring well from the CAS Cell, as used in the groundwater transport model.*

   Energy*Solutions'* Response: Since its initial submittal, the Division has approved the design associated with Energy*Solutions'* Class A West Amendment Application to Radioactive Material License UT2300249. The same methodology of Sections 4.4, 5.4, 6.1, and Attachment 3 of that Amendment Application that detail the location and distances also applies to the Federal Cell and the Point of Compliance well.

<u>R313-25-23; Disposal Site Suitability Requirements for Land Disposal – Near-Surface Disposal - Omission.</u> No text is provided in the EnergySolutions CR to address how the DU proposal will meet the requirements of this section of state rule. Please amend the CR to address and resolve each of the 11 requirements found in this rule. In all cases, site suitability must be considered in light of the "deep time" aspects for DU disposal and progeny in-growth. Where engineered features are not sufficient to control and contain the proposed DU waste, please explain and

justify how site characteristics will come to bear to sequester and control DU contaminants, and protect public health and the environment.

One key omission that must be carefully addressed is driven by the above-grade disposal planned for the DU waste. Any demonstration of compliance with R313-25-23 must include pluvial lake formation and wave-cut erosion. In your resolution of this requirement, EnergySolutions may be able to draw on discussions submitted to demonstrate compliance with R313-25-7 (see Division comments above).

Energy*Solutions'* Response: Suitability of the Class A West Embankment design was approved by the Division in their acceptance of the Class A West Amendment Application. Suitability of this same design also applies to the Federal Cell. See also sections 2.4 and 2.5 of the Compliance Report. Although the Performance Assessment evaluates disposal both above- and below-grade, depleted uranium will be disposed below grade to enhance assurance of continued isolation under geologic-time events such as the return of a large lake inundating Clive. Figure 1-2 of the Compliance Report demonstrates that the entire depleted uranium inventory evaluated can be disposed in such a manner.

Section 2.22, R313-25-24: *Disposal Site Design for Near-Surface Land Disposal (p. 2-38). The state rule lists 6 requirements that must be met. Unfortunately, EnergySolutions has only addressed the first one (site design features). Please revise the CR to address facility compliance with the missing five requirements; i.e., R313-25-24(2) thru (6). In this process, please ensure that both the engineered disposal embankment and site characteristics together can provide protection of public health and the environment, pursuant to R313-25, for at least 10,000 years post-closure.*

Energy*Solutions'* Response: Suitability of the Class A West Embankment was approved by the Division in their acceptance of the design from the Class A West Amendment Application. See also sections 3.4 and 3.5 of the Compliance Report for its applicability to the Federal Cell.

R313-25-25 thru 30: Multiple Rule Omissions. *These requirements in the DRC rule have been omitted from the CR, and must be included with justification for how the DU proposal will comply with the respective rules. In total, there are 20 regulatory items needing consideration and resolution, as follows:*

Rule	*Title*
R313-25-25	*Near Surface Land Disposal Facility Operation and Disposal Site Closure*
R313-25-26	*Environmental Monitoring*
R313-25-27	*Alternative Requirements for Design and Operations*
R313-25-28	*Institutional Requirements*
R313-25-30	*Applicant Qualifications and Assurances*

Please revise the CR to resolve this omission, so that the DEQ review can move forward.

Energy*Solutions'* Response: Demonstration of the Class A West Embankment's compliance with these requirements has already been approved by the Division in their acceptance of the Class A West Amendment Application. This demonstration is therefore directly applicable to the proposed Federal Cell.

Section 2.25, R313-25-32; Financial Assurance for Institutional Control (pp. 2-38 and 2-39). The requirements text in the first two paragraphs of this section is from R313-25-31(1)(a) and (b), and not from R313-25-32. Please remove. Because significant quantities of DU disposal were not considered by the NRC in its original 10 CFR 61 rulemaking (circa early 1980s), please explain and justify why a 100-year Institutional Control period, as required by R313-25-28(2), is adequate for shallow land disposal of DU waste where progeny in-growth creates a greater future risk to human health and the environment.

Energy*Solutions'* Response: In accordance with R313-25-28(2), "*The period of institutional controls will be determined by the Director, but institutional controls may not be relied upon for more than 100 years*". Therefore, Energy*Solutions* is prohibited from relying upon institutional controls beyond 100 years after closure. Accordingly, the Performance Assessment evaluates environmental fate and transport of contaminants of concern correctly assuming no active maintenance or control measures.

3.0 REVIEW OF NEPTUNE AND COMPANY, INC., APPENDIX A, "FINAL REPORT FOR THE CLIVE DU PA MODEL VERSION 1.0," JUNE 1, 2011

3.1 GENERAL COMMENTS

Comment 1. Intergenerational Consequences: The ALARA analysis presented in Section 6.4 of the Final Report[4] implies that either an undiscounted value of $1,000 per person-rem or a discounted value of $2,000 per person-rem may be used, and it includes discount factors of 3% and 7%. Two issues with these values needs to be considered.

First, as stated in NUREG-1530 and included in revisions of NUREG/BR-0058, it is the policy of the NRC to use a value of $2,000 per person-rem for ALARA determinations.

Second, as stated in NUREG/BR-0058, Revision 4, when intergenerational consequences are involved, lower discount rates (including potentially no present worth, or 0%) should be used:

For certain regulatory actions, such as those involving decommissioning and waste disposal issues, the regulatory analysis may have to consider consequences that can occur over hundreds, or even thousands, of years. The OMB recognizes that special considerations arise when comparing benefits and costs across generations. Under these circumstances, OMB continues to see value in applying discount rates of 3 and 7 percent. However, ethical and technical

[4] Neptune and Company, Inc., "Final Report for the Clive DU PA Model version 1.0," June 1, 2011 (including Appendices 1 through 17) (hereafter Appendix A to the Compliance Report; also referred to as "Final Report")

arguments can also support the use of lower discount rates. Thus, if a rule will have important intergenerational consequences, one should consider supplementing the analysis with an explicit discussion of the intergenerational concerns such as how future generations will be affected by the regulatory decision. Additionally, supplemental information could include a presentation of the values and impacts at the time in which they are incurred with no present worth conversion. In this case, no calculation of the resulting net value or value-impact ratio should be made. Also, one should consider a sensitivity analysis using a lower, but positive discount rate.

Energy*Solutions'* Response: ALARA analysis is presented in Section 6.4 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Comment 2. Inadvertent Intruder: The definition of "inadvertent intruder" in 10 CFR 61.2 is:

> *"…a person who might occupy the disposal site after closure and engage in normal activities, such as agriculture, dwelling construction, or other pursuits in which the person might be unknowingly exposed to radiation from the waste."*

Utah Administrative Code (UAC) R313-25-2 defines "inadvertent intruder" as:

> *"…a person who may enter the disposal site after closure and engage in activities unrelated to post closure management, such as agriculture, dwelling construction, or other pursuits which could, by disturbing the site, expose individuals to radiation."*

Both definitions are similar, in that they suggest agriculture and dwelling construction as activities that an inadvertent intruder might take. However, they differ in that the NRC's definition requires the inadvertent intruder to "occupy the disposal site," while the UAC's definition only requires the inadvertent intruder to "enter the disposal site." Synonyms for "occupy" include "live in," "dwell in," "reside in," and "inhabit;" thus, a hunter or off-highway vehicle enthusiast who occasionally "enters" the site would not meet the NRC's definition of inadvertent intruder but would meet the UAC's definition. On the one hand, the UAC's definition means that many more individuals can be classified as inadvertent intruders; on the other hand, it does not require that the inadvertent intruder be someone who inhabits the site and who would likely receive the largest exposure.

UAC R313-25-20 provides a different perspective on inadvertent intruders than does UAC R313-25-2:

> *"Design, operation, and closure of the land disposal facility shall ensure protection of any individuals inadvertently intruding into the disposal site and occupying the site or contacting the waste after active institutional controls over the disposal site are removed."*

UAC R313-25-20 requires protection of individuals occupying the site (or contacting the waste) rather than those who are simply entering the site and, therefore, is more akin to the definition in 10 CFR 61.2.

As documented in NRC 2012, the NRC is proposing to amend 10 CFR 61.13 to specifically require licensees under 10 CFR Part 61 to conduct an inadvertent intruder analysis. The proposed language states, in part:

> *"An intruder assessment shall: (1) Assume that an inadvertent intruder occupies the disposal site at any time during the compliance period after the period of institutional controls ends, and engages in normal activities including agriculture, dwelling construction, resource exploration or exploitation (e.g., well drilling), or other reasonably foreseeable pursuits that unknowingly expose the intruder to radiation from the waste."*

Note that the proposed language specifies occupancy.

Given the apparently dissimilar definitions, the Final Report should explain why the selected approach, which does not consider site occupancy, was selected.

Energy*Solutions'* Response: See responses provided in Preliminary Completeness Review Section2.2, comments 1.4 and R313-25-2.

Comment 3. Compliance Period: UAC R313-25-8(5)(a) includes the statement:

> *"For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years."*

The Final Report performs all of its analyses (except the deep time) at 10,000 years, the minimum allowed under UAC R313-25-8(5)(a). Furthermore, the Final Report does not discuss the rationale behind the selection of 10,000 years as the period of performance.

The NRC (2011b) and the Utah Division of Radiation Control (UDRC 2012) have both expressed concerns regarding limiting the compliance period (or period of performance) to 10,000 years. The applicant should provide the basis for using the minimum compliance period and justify why a longer period of analysis should not be required in light of R313-25-8(1)(b).

Energy*Solutions'* Response: See Energy*Solutions'* responses provided in Section 2.2 to Section 2.18, point 5.

Comment 4. Deep Time – Time: In defining the length of the deep time assessment, the Executive Summary (ES) (page 5) states:

> *"Peak activity of the waste occurs when the principal parent 238U (with a half-life that is approximately the age of the earth—over 4 billion years), reaches secular equilibrium with its decay products. This occurs at roughly 2.1 My from the time of isotopic separation, …"*

In order to determine whether 2.1 million years (My) is the appropriate time for deep time assessment, the applicant should clarify the above statement. First, decay products usually reach secular equilibrium with their principal parent, rather than the other way around. Second, the *text should discuss how the value of 2.1 My was determined based on a half-life of 4.49 × 10^9 years for U-238 and the half-lives of its decay products (e.g., 244,500 years for U-234).*

Energy*Solutions'* Response: Deep time is description in the Executive Summary of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Comment 5. Deep Time – Sediment Concentration: Section 6.5.2 of the Final Report provides U-238 lake sediment concentrations derived from successive lake events. Section 7.2 (page 84) then states, "Despite these possible conservatisms in the deep-time model, the lake water and lake sediment concentrations are small." The report should give the basis for presenting only the U-238 sediment concentrations (rather than the full U-238 decay series), as well as the basis for concluding that these concentrations are "small."

For example, 40 CFR 192.12(a) states:

> *"The concentration of radium-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than—*
>
> *(1) 5 pCi/g, averaged over the first 15 cm of soil below the surface, and*
>
> *(2) 15 pCi/g, averaged over 15 cm thick layers of soil more than 15 cm below the surface."*

Although 40 CFR 192.12 was developed specifically for the cleanup of uranium mill tailings sites under Title 1 of the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), the U.S. Environmental Protection Agency (EPA) has used the criteria in 40 CFR Part 192 when setting remediation goals at Comprehensive Environmental Response, Compensation, and Liability Act sites with radioactive contamination. The applicant should indicate why the 40 CFR Part 192 soil criteria should not apply to the deep time assessment.

Energy*Solutions'* Response: Sediment concentration methodology for the deep time is described in Section 6.5.2 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Comment 6. Ra-226 Class A Concentration Limit: Table 1 of UAC R313-15-1009 includes a 10 nanocuries per gram (nCi/g) limit on the concentration of Ra-226 that can be included as Class A waste. The specific activity of U-238 in DU3O8 is about 285 nCi/g. As the U-238 decays, the activities of its daughter products build towards the U-238 activity. After 10,000 years, the Ra-226 activity would be about 0.2 nCi/g, but after about 61,000 years, it would exceed the Class A limit in Table 1 of R313-15-1009. After about 266,000 years, it would exceed the Class C limit of 100 nCi/g. The applicant should provide justification for disposing of material that will exceed the regulatory limits. A qualitative analysis of estimated temporal changes in Ra-226 activity concentration should be provided as part of the associated deep-time analysis.

Energy*Solutions'* Response: The concentration limits in R313-15-1009 apply to classification at the time of disposal. The stated purpose of the depleted uranium performance assessment is to evaluate the long-term implications of increasing concentration of U-238 daughter products. Therefore, the method for determining classification is not applicable at some arbitrary future time. The effects of the deep-time temporal changes in Ra-226 activity have been evaluated in the depleted uranium Performance Assessment,

> "*Peak activity of the waste occurs when the principal parent ^{238}U (with a half-life that is approximately the age of the earth- over 4 billion years), reaches secular equilibrium with its decay products [, including Ra-226]. This occurs at roughly 2.1 My from the time of isotopic separation, and the model evaluates the potential future of the site in this context.*" (page 5 of Appendix A from revision 0).

Comment 7. Other Wastes: Section 2.2 (page 25) of the Final Report states:

> *"…this Clive DU PA Model considers only to the long-term performance of DU disposed in this waste cell [the Class A South]."*

UAC R313-25-8(5)(a) requires:

> *"…a performance assessment…for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of…."*

The applicant should indicate the basis for not including in the PA "other wastes" and waste already disposed of. This is of particular concern because the applicant has proposed that the 11e.(2) wastes share the same Federal Cell as the DU (Appendix 3, "Embankment Modeling for the Clive DU PA Model," May 28, 2011, Figure 2). Additionally, during the October 10, 2011, meeting, Neptune (on behalf of EnergySolutions) indicated that low-level radioactive waste (LLW) would be disposed of in the CAS cell along with the DU.

The applicant should indicate the basis and justification for not including in the PA "other wastes", including 11e.(2) waste disposed of in the Federal Cell, and LLW disposed of within the CAS. Alternatively, the applicant needs to modify the PA to account for all DU, LLW, and 11e.(2) wastes to be disposed of in the Federal Cell. Thirdly, the applicant needs to evaluate the impact of alternative disposal cell designs on the PA results, including 1) two separate disposal cells one for DU and LLW and the other for 11e.(2) waste and 2) three separate disposal cells one for DU, a second for LLW, and a third for 11e.(2) waste.

Energy*Solutions'* Response: Analysis of the design from the Class A West Embankment's ability to perform, as required, with disposal of Class A wastes has been assessed and approved as part of Energy*Solutions'* Class A West Amendment Application. "*Other wastes*" associated with the depleted uranium wastes (as noted in Section 2.3 of the Report) to be placed in the Federal Cell have been included in the depleted uranium Performance Assessment.

<u>Comment 8. PA Intent:</u> Section 2.1, page 21, states:

> *"…the intent of a PA is not necessarily to estimate actual long-term human health impacts or risks from a closed facility. Rather, the purpose of the Model is to provide a robust analysis that can examine and identify the key elements and components of the site, the engineered system, and the environmental setting that could contribute to potential long-term impacts."*

This statement should be revised to indicate that the intent of the PA is to demonstrate that disposal of DU at the Clive facility would meet the requirements of UAC R313-25-8 and the performance standards of 10 CFR Part 61, Subpart C.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

<u>Comment 9. Critical Group:</u> Section 4.1.2.10.1 describes the dose receptors and exposure pathways that are evaluated in the PA. The PA includes ranchers and recreationists (e.g., hunters, off-highway vehicle enthusiasts), but no residents. Resident receptors seem to have been excluded because there are currently no individuals living in close proximity to the site [i.e., the nearest resident is a caretaker at the eastbound Interstate 80 Grassy Mountain Rest Area at Aragonite, approximately 12 kilometers (km) (7.5 miles) northeast of the site]. In NUREG-1573, in response to public comments, the NRC's Performance Assessment Working Group (PAWG) recommended an approach to defining a critical group when there are currently no residents living nearby the disposal facility. Because there are no justifiable methods or procedures for forecasting human habits or lifestyles in the future (i.e., the very long term), the PAWG recommends that an analogue site, of comparable geology and climate, be identified and that the critical group be defined in terms of the analogue site. For example, for the Clive facility, the caretaker at the Interstate 80 Aragonite rest area [approximately 12 km (7.5 miles) to the northeast] might be used as an analogue site. The Final Report should document why it did not use the approach established by the PAWG.

Energy*Solutions'* Response: The discussion of Critical Group in Section 1.3 of the Compliance Report has been expanded.

<u>Comment 10. Analysis of Routine Operations and Likely Accidents:</u> Utah Radiation Control Rule R313-25-8(4)(c) states:

> *"Analysis of the protection of individuals during operations shall include assessments of expected exposures due to routine operations and likely accidents during handling, storage, and disposal of waste. The analysis shall provide reasonable assurance that exposures will be controlled to meet the requirements of R313-15."*

The Final Report should explain why these analyses were not included in the DU PA.

Energy*Solutions'* Response: Since its initial submittal, the Division has approved the design from the Energy*Solutions'* Class A West Amendment Application to Radioactive Material License UT2300249, demonstrating protection of individuals during operations. Management of depleted uranium and its disposal in the Federal Cell does not create any further "*unanalyzed conditions*" from those already approved.

Comment 11. Inconsistent Definitions: The Final Report frequently cites "peak mean" values. In some cases, identified in specific examples in Section 3.2, this terminology may not be correct. The document should be carefully reviewed to determine if the terms "peak," "mean," "peak of the mean," and "mean peak" are correctly and consistently used.

Energy*Solutions'* Response: Definitions cited are included in Section 3.2 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Comment 12. Incomplete Figures: Many of the graphs, including those identified in specific examples in Section 3.2, lack proper notation as to metrics for the x and y axes.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Comment 13. Incomplete Discussion of Sensitivity Plots: As indicated in the specific examples in Section 3.2, the various sensitivity and partial dependence plots are complex and should be discussed in greater detail in the text to ensure that the information they contain is sufficiently transparent.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Comment 14. Links to References: The file Report References AtoZ.zip (available from the Utah Division of Radiation Control's website: http://www.radiationcontrol.utah.gov/EnSolutions/performassess/duperfass.htm) contains the references used in the Final Report. Many of the references are given as Internet shortcuts, especially those that are copyrighted and/or must be purchased. To check the availability of these references, SC&A tested each Internet shortcut. With six exceptions, we successfully accessed the websites from which each reference could be obtained, although we did not actually purchase the references. The six Internet shortcuts that did not function as expected are shown below.

Internet Shortcut
Burnham and Anderson 2002
Efron and Tibshirani 1994
Link et al. 1999
Linsalata and Cohen 1980
MSUE 2011
NCRP 1988

Additionally, website links are embedded within the Final Report document itself. SC&A checked each of those links and found them to be active, except for those on pages 883 and 887 that link to the Neptune, Inc., website (i.e., neptuneinc.org), most of which require a usercode and password.

Energy*Solutions'* Response: At the time of its initial submittal (1 June 2011), links included in the depleted uranium Performance Assessment report were complete. Energy*Solutions* recognizes that as time passes from its initial submittal, texts will continue go out of print, authors will age and die, and internet links will continue to be changed. However, at the time of its submittal, the report was complete. As such, Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing. However, the Division should note that the accessibility of any updated references provided will likewise be time sensitive.

Comment 15. Federal vs. Agreement-State Regulations: In various sections of the appendices, e.g., Appendix A, Section 1.3, reference is made to Federal rules as though they have primacy for the Clive Facility. However, Utah is an agreement state under the Atomic Energy Act of 1954, as amended. Section 274 of the Act provides a statutory basis under which NRC has relinquished to Utah portions of its regulatory authority to license and regulate byproduct materials (radioisotopes), source materials (uranium and thorium), and certain quantities of special nuclear materials.

As an agreement state, Utah has developed its own rules, and it has primacy for administering the NRC agreement state regulatory program. It is the Utah rules, not Federal rules, that specifically govern regulated activities related to radioactive materials at the Clive Facility. Accordingly, all relevant appendices in the PA should be revised to discuss regulation primarily relative to Utah rule, rather than primarily Federal rule. Where Federal rules are referred to, the corresponding Utah rule should also be cited, and any differences in wording between the two should be described.

Energy*Solutions'* Response: Energy*Solutions* has revised the references in the main report, with preference given to Utah requirement (where available).

3.2 SPECIFIC COMMENTS

ES, page 2. The third paragraph states, "The model does not consider the effects of enhanced infiltration or radon diffusion from a compromised radon barrier." The Final Report should explain why the effects of a compromised radon barrier are not considered, since the durability of the radon barrier over time is problematic and as described in the Final Report, plant roots and burrowing animals are active at the Clive site and could compromise the radon barrier by creating "short-circuit" pathways.

Energy*Solutions'* Response: Infiltration and radon diffusion are discussed in the Executive Summary of Appendix A from revision 0. See also sections 3.4 and 3.5 of the Compliance Report for discussion of stability in near time and geologic time. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

ES, page 2. The last paragraph states, "The potentially significant cover degradation process of gully formation is evaluated using a simple modeling construct, in order to determine whether it warrants more sophisticated modeling approaches." The text should reference the section within the Final Report that contains the determination as to whether a more sophisticated modeling approach is warranted.

Energy*Solutions'* Response: Appendices 10 of Appendix A from revision 0 discusses the selection of gully methodology. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

ES, page 3. The last two sentences of the first paragraph state:

> *"No associated effects, such as biotic processes, effects on radon dispersion, or local changes in infiltration are considered. When gullies encounter DU waste, doses and uranium hazards are increased, but when wastes are buried sufficiently deep the gullies have essentially no effect on human exposures."*

The Final Report should provide the justification for not assuming that gully erosion will lead to increased infiltration.

Energy*Solutions'* Response: Appendices 10 of Appendix A from revision 0 discusses the selection of gully methodology. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

ES, page 3. The second paragraph states that typical NRC intrusion scenarios do not adequately describe likely human activities in the arid west and will usually underestimate the performance of the disposal system. The Final Report should explain why an underestimation is usual and under what unusual circumstances the performance will not be underestimated.

Energy*Solutions'* Response: Section 1.3 of the Compliance Report and Appendices 11 of Appendix A from revision 0 discuss NRC's intrusion scenarios. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

ES, page 4. The second-to-last paragraph states:

> *"In accordance with UAC Rule R313-25-8, doses are calculated within a 10,000 year compliance period and may be compared to a performance criterion of 25 mrem in a year for a MOP, and 500 mrem in a year for an inadvertent intruder."*

The Final Report should confirm that concentrations of radionuclides in the groundwater are only compared to the groundwater protection limits (GWPLs) and are not factored into the dose *assessment. It should also provide the rationale for assuming that the groundwater will never have beneficial uses and that potential exposure routes and receptors will not exist over the minimum 10,000-year compliance period.*

Energy*Solutions'* Response: Sections 3.1 and 3.6 of the Compliance Report describe compliance with the Ground Water Quality Discharge Permit and the 4 mrem/yr drinking water standard for the protection of the general public.

ES, page 5. The first sentence on the page states:

> *"These doses and the supporting contaminant transport modeling that provides the dose model with radionuclide concentrations in exposure media, are evaluated for 10,000 yr, in accordance with UAC R313-25-8(2)."*

This statement might at first appear to be inconsistent with the discussion in Section 6.1, where the groundwater concentrations are only evaluated for 500 years. Please discuss the basis for these apparently conflicting assumptions.

Energy*Solutions'* Response: Sections 3.1 and 3.6 of the Compliance Report describe compliance with the Ground Water Quality Discharge Permit and the 4 mrem/yr drinking water standard for the protection of the general public.

ES, page 6. The first paragraph states, "Consequently, six different models are considered for the dose and groundwater concentration endpoints." Since the erosion scenarios are claimed to not affect the groundwater modeling results, it seems that there would be only three groundwater concentration endpoints representing the three emplacement depths.

Energy*Solutions'* Response: The classifications of different models for dose and groundwater concentration endpoints are discussed in the Executive Summary of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Table ES-7. Footnotes 1, 2, and 3 are missing.

Energy*Solutions'* Response: Table ES-7 is a reproduction of Table 18 (page 87 of Appendix A from revision 0). The Division is pointed to the corresponding footnotes thereon.

Section 1.3, page 15. The last paragraph states that 10 CFR 61.42 defines ALARA; rather, the definition is given in 10 CFR 61.41.

Energy*Solutions'* Response: The definition of ALARA is provided in Section 1.3 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 1.3, page 16, paragraph 1; Section 4.1.2.11, page 39; Section 6.4, page 77, paragraph 1. When discussing the NRC's "options for discounting costs of human exposures over time," the

Final Report should describe the NRC's position on intergenerational impacts, as defined in NUREG/BR-0058, Section 4.3.5.

Energy*Solutions'* Response: Details from NUREG/BR-0058 are summarized in Section 1.3 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 1.3, page 16. The text should include a reference (NUREG-1530) for the NRC cost of $2,000 per person-rem.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 2.1, page 23. The second sentence on the page states:

> *"Note that there are 5,000 estimates of the peak of the mean for each receptor from the 5,000 simulations that are run. This is usually enough simulations to stabilize an estimate of the mean."*

The Final Report should reference the work that was performed to demonstrate that additional simulations will not significantly change the statistics.

Energy*Solutions'* Response: Appendices 15, 16, and 17 of Appendix A from revision 0 discuss the basis for the number of simulations chosen in the depleted uranium Performance Assessment.

Section 4.1.2.5, page 30. This section provides a number of assumptions regarding total dissolved solids, pH, solubilities, and other parameters. These assumptions should be supported with appropriate references.

Energy*Solutions'* Response: Detail and additional citations for geochemistry are provided in Appendix 6 of Appendix A from revision 0.

Section 4.1.2.6, page 31. The Final Report should provide the basis for establishing a point of compliance for groundwater at 27 meters (90 feet) from the edge of the embankment interior.

Energy*Solutions'* Response: Since its initial submittal, the Division has approved design from the Energy*Solutions'* Class A West Amendment Application to Radioactive Material License UT2300249. Justification and methodology of Sections 4.4, 5.4, 6.1, and Attachment 3 of this Amendment Application also apply to the location and distance between the Federal Cell and the Point of Compliance well.

Section 4.1.2.7, page 32. The Final Report should provide support for the statement in the third paragraph that "Accumulation on-site seems more likely."

Energy*Solutions'* Response: On-site accumulation is discussed in Section 4.1.2.7 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

<u>Section 4.1.2.8, page 32.</u> *The Final Report should provide support for the statement that the "…effect on radionuclide transport might be small".*

Energy*Solutions'* Response: Radionuclide transport is discussed in Section 4.1.2.8 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

<u>Section 4.1.2.8.2, page 34.</u> *The specific literature meant in the statement "Correlations reported in the literature" should be referenced.*

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

<u>Section 4.1.2.8.3, pages 34 and 35.</u> *This section discusses burrowing mammals and generally concludes that "…the burrows are sufficiently shallow that it is unlikely that they will have a significant impact on radionuclide transport." The Final Report should provide literature- and/or field-based support or justification for this statement and clarify whether this conclusion includes the "short-circuiting" effect that burrows would have for radon transport.*

Energy*Solutions'* Response: The Division approved Energy*Solutions'* Class A West Amendment Application to Radioactive Material License UT2300249, in which the Division accepted the analysis demonstrating that the approved cover design is capable of satisfying its performance objectives, including consideration of burrowing animals. The disposal of large volumes of depleted uranium in a Federal Cell with this same cover design (as contemplated in this depleted uranium Performance Assessment) has no impact on this Division-accepted cover design demonstration.

<u>Section 4.1.2.10.1, page 37.</u> *In the first paragraph of the section, the text states "…the IHI [inadvertent human intruder] is someone who intrudes onto the facility and may directly contact the waste (e.g., by well drilling, or basement construction)." This statement requires revision or additional justification. Contrary to what is expressed here, UAC R313-25-20 does not restrict inadvertent intrusion scenarios to someone who directly contacts the waste. The rule speaks rather of "any individuals inadvertently intruding into the disposal site and occupying the site or contacting the waste after active institutional controls over the disposal site are removed". It is noted that an inadvertent intruder (1) inadvertently intrudes into the site, and EITHER (2a) occupies the site, OR (2b) contacts the waste, or both, after active institutional controls over the disposal site are removed. The Final Report should clarify whether there is ever any exposure assumed for obtaining water from a well (e.g., for dust suppression, cleaning, etc.).*

Energy*Solutions'* Response: The inadvertent intruder is discussed in Section 1.3 of the main report has been clarified. Even so, Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

<u>*Section 4.1.2.10.1, page 27, addresses only a ranching scenario and a recreational scenario.*</u> *While each of these scenarios is likely, neither one is a scenario in which the greatest radioactive*

doses would likely occur, should the scenario come to pass. The PA should consider other likely scenarios in which the doses would likely be far greater. This will be more protective of inadvertent intruders and members of the public. These scenarios include an industrial scenario, in which industrial activities, such as industrial waste disposal, are conducted on site. This may involve construction and use of buildings with basements, as well as use of groundwater from onsite wells for dust suppression, etc. The scenario may also involve digging of materials for onsite cover use. Another scenario that should be considered is mining for sand and clay onsite, e.g., for road construction. Both types of activities have historically taken place on and/or near the site.

Energy*Solutions'* Response: The inadvertent intruder discussion in Section 1.3 of the main report has been clarified. Even so, Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 4.1.2.12, page 39. The correct, updated reference for the groundwater discharge permit is missing. It should be Ground Water Quality Discharge Permit No. UGW450005 (UWQB 2012), not (UWQB 2010) as given in the body of the text on page 39, and not UWQB (State of Utah, Division of Water Quality, Utah Water Quality Board), 2009. Ground Water Quality Discharge Permit No. 450005, 23 Dec 2009, as listed in the PA References, and found on page 90.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 4.1.2.12, page 40. The text says, "The main concern for the PA model is the potential for transport of ^{99}Tc, a contaminant in the DU waste, to the point of compliance." The text should provide a reference to a section in the PA that fully discusses transport of technetium in groundwater at the site and tells what steps will be taken to mitigate its presence in groundwater at concentrations in excess of Utah limits.

Energy*Solutions'* Response: Appendices 4, 5, and 7 of Appendix A from revision 0 discuss technicium-99 transport in the groundwater. Additional analysis can also be found in Attachment 3 of the Class A West Amendment Application (McCandless, 2012) and is directly applicable to the Federal Cell.

Section 4.1.2.12, page 40. The text says, "Note that according to the Permit, groundwater at Clive is classified as Class IV, saline ground water, according to UAC R317-6-3 Ground Water Classes, and is highly unlikely to serve as a future water source. The underlying groundwater in the vicinity of the Clive site is of naturally poor quality because of its high salinity and, as a consequence, is not suitable for most human uses, and is not potable for humans."

The text claims that "groundwater in the vicinity of the Clive site is of naturally poor quality because of its high salinity and, as a consequence, is not suitable for most human uses, and is not potable for humans." This statement is missing important context relative to use of the groundwater following suitable treatment. That context should be provided in the text and *accommodated in the model. A number of countries throughout the world regularly treat saline water of approximately the same or even greater average TDS content than at Clive (i.e., about 40,500 mg/L) to make the water potable for their citizens to drink or employ for other "human uses." Desalination of Mediterranean sea water (e.g., with TDS at about 37,000–39,000 mg/L) is currently expected to provide up to 80% of the needs of Israel as of next year (Sales 2013). Desalination along the Persian Gulf (with TDS content commonly ranging between 41,000 and 48,000 mg/L) provides potable water for citizens of a number of countries. Kennecott Utah currently desalinates saline groundwater in nearby Jordan Valley and provides the treated, potable water via a distributor to about 14,000 people each year. Regionally, Arizona and California either use or plan to use reverse osmosis to provide potable water from saline or brackish water sources. As population soars over hundreds, thousands, tens of thousands, hundreds of thousands, or millions of years, as the need for drinkable water rises, and as water treatment technology continues to advance, treatment of saline water via desalination is expected to increase over time. Groundwater at Clive is found at depth as well as in the shallow aquifer, and such groundwater can potentially be produced at rates sufficient to provide, after desalination, potable water for a small community. Whether that is done depends on whether there is sufficient economic incentive to do so. The water, from a technology standpoint, can be made potable. The PA should discuss the potential to treat uncontaminated groundwater and mention the logistical, economic and regulatory difficulties of attempting to treat groundwater contaminated by radionuclides.*

Energy*Solutions'* Response: The discussion of the groundwater beneath the Federal Cell in Sections 1.3, 3.1, and 3.6 of the Compliance Report has been expanded to address the Division's Interrogatory.

A 4-inch diameter extraction well, completed in the shallow water-bearing unit at the Clive Facility, produces less than 40 gallons per hour, with the pump running less than half-time to prevent cavitation. By comparison:

- Israel Desalination Enterprises' Sorek Desalination Plant will provide 7 million gallons of water per hour when completed. The source of water is the Mediterranean Sea.

- The Carlsbad Desalination Project in San Diego will produce 2.1 million gallons of water per hour. The source of water is the Pacific Ocean.

Kennecott Utah Copper Company (KUCC) is remediating contaminated groundwater in the Salt Lake Valley. The project is part of a Natural Resource Damage Claim filed by the State of Utah under CERCLA against KUCC for damages to deep groundwater in the Southwest Salt Lake Valley due to historic mining practices. There are concerns about the levels of selenium and mercury in the discharge from the treatment facility.

It is inappropriate to use city-scale desalination of ocean water and state-mandated remediation systems as practical examples of desalination of Clive facility groundwater. The shallow water-bearing zone is not capable of yielding sufficient quantities of water to a treatment system. Also, naturally occurring levels of radium, uranium, selenium, arsenic, and thallium in shallow groundwater at Clive can exceed UAC R317-6-2 Groundwater Quality Standards.

Perhaps most significantly, the postulated scenario is not reasonable when one considers that it attempts to "force" groundwater extraction and desalination onto a site with poorer background quality and considerably lower yield than the surface water of the Great Salt Lake, not far distant. Clearly, if desalination was desired to supplement water resources in Utah, this large surface water body would be the resource utilized first.

Section 4.1.2.13, page 40. The Final Report should provide a reference for the statement, "Given that long-term climatic cycles of 100 ky are considered very likely…."

Energy*Solutions'* Response: Long-term climatic cycles are discussed in Section 4.1.2.13. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 4.1.2.13, page 42. The text indicates that "…an assumption that the sediments completely mix is expedient, and probably leads to conservative results". The Final Report should indicate under what conditions mixing of the sediments does not lead to conservative results.

Energy*Solutions'* Response: The stochastic analysis includes simulations of a shallow lake reworking disposed depleted uranium material (thereby including a full range of mixing scenarios and distributions). Additional detail regarding sedimentation mixing is present in Appendix 13 of Appendix A from revision 0. However, Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 5.1.1, page 43. The text says, "For the deep-time model, there are no receptors that are considered, and doses are not calculated. Instead, concentrations of radionuclides are estimated in lake water and in lake sediment in the general vicinity of the CAS embankment."

Please provide additional discussion of how the PA accounts for radionuclide concentrations in lake water and lake sediment as a function of time. Also please provide further explanation as to why the PA does not perform a quantitative analysis of doses to persons exposed to radioactivity from the wastes in the embankment as a function of time as the embankment erodes.

In addition, please provide the rationale for not performing a qualitative assessment of the time to peak dose, since this determination is required by UAC R313-25-8(5)(a).

Energy*Solutions'* Response: Qualitative assessment detail of varied radionuclide concentrations within deep time is addressed in Appendix 13 of Appendix A from revision 0. Additional detail regarding the qualitative assessment of deep time has been added to Sections 1.3 and 3.5 of the Compliance Report.

Section 5.1.1, page 43. This section identifies compliance points for the dose assessment and the GWPLs, but not for uranium chemical toxicity.

Energy*Solutions'* Response: Uranium toxicity is available in Appendix 6 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 5.1.3, page 44. This section describes three potential disposal configurations. In each configuration, there are 27 layers within the disposal cell. In the first configuration, DU waste is disposed of in 21 layers; in the second configuration, DU waste is disposed of in 17 layers; and in the third configuration, DU waste is disposed of in 7 layers. The Final Report should describe the type of material that will be used to fill the layers and spaces not filled with DU waste.

Energy*Solutions'* Response: Waste other than depleted uranium to be placed in the Federal Cell is discussed in Section 2.4 of the main report and Appendix 3 of Appendix A from revision 0. Furthermore, demonstration of the Federal Cell's ability to satisfy the regulatory required performance objectives for this non-depleted uranium waste was previously submitted to and approved by the Division as part of the same design for the Class A West Amendment Application (Lundberg, 2012).

Section 5.1.7, page 45. The text provides well drilling and basement construction as examples of inadvertent intrusion, but then states that "such direct activities are unlikely at this site," implying that there was no need to analyze them. Such activities would be unlikely at any well-sited disposal site; therefore, the fact that these activities are unlikely is not a reason to preclude their analysis, and an analysis of these activities thus should be included in the PA. Please provide additional rationale for excluding these activities since they would be unlikely at any well-sited disposal site but are typically included as part of the analysis.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 5.2, page 45. In discussing distribution averaging, the Final Report states:

> *"In addition, these types of models are characterized by differential equations and multiplicative terms. Averaging is a linear construct that does not translate directly in non-linear systems. Again, care needs to be taken to capture the appropriate systems-level effect when dealing with differential equations and multiplicative terms."*

SC&A agrees with this statement. The Final Report should clarify what "cares" were taken in this PA "to capture the appropriate systems-level effect."

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 5.4.4, page 49. The text at the end of the first paragraph states:

> *"As the model progresses through time, these radionuclides migrate into other parts of the physical system, and eventually are found in environmental media (air, water, soils) that receptors will encounter."*

The Final Report should provide additional information on how the water pathway is considered in the dose assessment.

Energy*Solutions'* Response: The discussion of groundwater in Sections 1.3, 3.1, 3.5, and 3.6 of the Compliance Report have been expanded. Additionally, groundwater detail is already available in Appendices 5 and 7 of Appendix A from revision 0.

Section 6.1.1, page 55. *The caption in Figure 5 appears to be incorrect. These are plots of calculated Tc 99 concentrations as a function of time for each realization and are not "mean peak" values.*

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 6.1.1, page 57. *Similarly, the caption for Figure 6 should be "Statistical Summary of Tc_{99} Concentrations as a Function of Time."*

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 6.1.2, page 58. *The x and y axes on the right-hand graph in Figure 7 should be labeled. The corresponding text should explain the development and interpretation of partial dependence plots, an example of which for 99Tc is shown on the right-hand side of Figure 7.*

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 6.1.2, page 58. *The Final Report should list which parameters were varied in the sensitivity analysis.*

Energy*Solutions'* Response: Appendix 15 of Appendix A from revision 0 discusses the parameters involved in the sensitivity analysis.

Section 6.2.1, page 60. *The document states that "other [waste configuration] options could also be considered." The Final Report should identify which waste configuration EnergySolutions intends to use.*

Energy*Solutions'* Response: Depleted uranium waste disposal configurations under consideration by Energy*Solutions* are described in Section 2.4 of the main report.

Section 6.2.2, page 63. *The x and y axes in Figure 8 should be labeled.*

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 6.2.2, page 64. *The x and y axes in Figure 9 should be labeled. The text should provide more discussion on how to interpret Figures 7, 8, and 9.*

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 6.2.2, page 65. The term "sensitivity index (SI)" on line 8 should be defined.

Energy*Solutions'* Response: A definition for the term sensitivity index is already provided on page 3 of Appendix 15 of Appendix A from revision 0.

Section 6.2.2, page 67. The relationship between burrowing animals and the radon escape/ production ratio, if any, should be discussed.

Energy*Solutions'* Response: Burrowing animals is discussed in Section 6.2.2 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 6.3, page 67. The term "hazard quotient" should be defined.

Energy*Solutions'* Response: EPA defines Hazard Quotient as, "*The ratio of the potential exposure to the substance and the level at which no adverse effects are expected. If the HQ is calculated to be equal to or less than 1, then no adverse health effects are expected as a result of exposure. If the HQ is greater than 1, then adverse health effects are possible. The HQ cannot be translated to a probability that adverse health effects will occur and it is unlikely to be proportional to risk. It is especially important to note that an HQ exceeding 1 does not necessarily mean that adverse effects will occur.*"[5]

Section 6.3, page 67. The Final Report should identify which exposure pathways were evaluated when determining the uranium hazard quotients.

Energy*Solutions'* Response: Appendices 1, 2, 3, 5, 6, 7, and 11 of Appendix A from revision 0 discuss the exposure pathways incorporated for analysis of uranium hazard quotients.

Section 6.3.1, page 68. The text and Table 7 appear to be inconsistent. The text (line 1) refers to "mean…hazard quotient," while the title of Table 7 refers to "peak mean" and the body of Table 7 refers to "peak."

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 6.3.1, page 68-69. By definition, Hazard Quotient (HQ) is the ratio of exposure dose (mg/kg-day or mg/m3) divided by RfD mg/kg-day or RfC mg/m3 for the various exposure route. Since there are multiple exposure routes (ingestion, inhalation, dermal contact), their respective HQ must be summed to produce a Hazard Index (HI). It appears that Tables 7 and 8 present HIs rather than HQs, as they are labeled. Please clarify what the HQs (or HIs) in Tables 7 and 8

[5] U.S. EPA, "National-Scale Air Toxics Assessments: Glossary of Terms." Air Toxics Web site (http://www.epa.gov/ttn/atw/natamain/gloss1.html) accessed 30 October 2013, U.S. Environmental Protection Agency.

signify, for each receptor indicated, which exposure pathways were included in the HI and which pathways were excluded, and why.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 6.3.2, page 70. The x and y axes in Figure 10 should be labeled. The text should provide more discussion of how the partial dependence plots are interpreted and the type of information that can be abstracted from them.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 6.3.2, page 71. The document should discuss the significance of the reference to "uranium parents" in the second paragraph. Does this refer to the parents of uranium or the uranium parents of the decay products?

Energy*Solutions'* Response: Uranium parents are discussed in Section 6.3.2 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 6.3.2, page 72. The x and y axes in Figure 11 should be labeled.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 6.4, Table 11, page 76. Both the table title and the right-hand column title identify the dose as the "peak" population dose. Since population doses are summed over all years, the document should clarify what is meant by "peak."

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.*Section 6.5, page 77. The document indicates that 2.1 My was selected as the time for the deep time assessment based on the half-life of the U-238 decay products; however, the U-238 decay products are not included in the deep time assessment. The text should resolve this discrepancy by providing the rationale for the selected approach.*

Energy*Solutions'* Response: The source term incorporated into the deep-time assessment is described in Appendix 13 of Appendix A from revision 0.

Section 6.5, page 78. The second paragraph states that sediment accumulates at about 17 meters (m) per 100 thousand years (ky). According to the Deep Time Assessment (Appendix 13, Section 6.3, page 24), the sedimentation rate for large lakes has a log-normal distribution with a geometric mean of 120 millimeters (mm)/ky and a geometric standard deviation of 1.2. This geometric mean is equivalent to 12 m per 100 ky. The differing values cited in the Final Report and Appendix 13 should be reconciled.

Energy*Solutions'* Response: Geometric standard deviations are discussed in Appendix 13 and Section 6.5 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 6.5, page 78. *The statement, "Sediment core records show significant mixing of sediments," in the third paragraph should be referenced.*

Energy*Solutions'* Response: Sediment core references are provided in Section 6.5 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 6.5.1, page 79. *The document should clarify the number meant by a "handful" in the statement in the first paragraph: "Intermediate lakes only occur a handful of times."*

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 6.5.1, page 80. *It might provide a useful perspective to compare the concentrations in Table 13 with the current GWPL for uranium.*

Energy*Solutions'* Response: While Energy*Solutions* appreciates the Division's suggestion as to what might be useful to the reader, Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 7.1, page 83. *The beginning of the fourth paragraph in the section states, "Once gullies are involved, the doses increase (groundwater concentrations do not change noticeably)." If groundwater concentrations are not identical with and without the gullies, then the text should explain why not.*

Energy*Solutions'* Response: The relationship between gullies and groundwater is addressed in Section 7.1 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 7.2, page 85. *The Final Report should provide justification for a 500-year compliance period for Tc-99. According to R313-25-8(5)(a), "for the purposes of this performance assessment," which applies to "the total quantities of concentrated depleted uranium and other wastes," "the compliance period shall be a minimum of 10,000 years," and "additional simulations shall be performed for the period where the peak dose occurs and the results shall be analyzed qualitatively." The first paragraph states that, "Because the groundwater concentration of 99Tc increases with time, the peak of the mean concentration occurs at 500 yrs." However, Figures 5 and 6 show the concentration of Tc-99 as still increasing at 500 years. The paragraph further states that "The 5,000 simulations provide 5,000 estimates of the peak of the mean concentrations." However, the 5,000 simulations provide 5,000 estimates of the Tc 99 concentration as a function of time from 0 to 500 years. From these 5,000 realizations, one can calculate the mean dose at any time. The highest mean dose will occur at 500 years, since the* *analysis was truncated at that time. SC&A does not believe that this is the generally accepted understanding of the peak of the mean concentration.*

Energy*Solutions'* Response: Sections 1.3, 3.1, and 3.6 of the main report reference groundwater protection limits associated with Energy*Solutions'* Ground Water Quality Discharge Permit (and UAC R317-6). Furthermore, these sections also discuss the implications associated with demonstration of compliance with the 4 mrem/year groundwater drinking standard of UAC R313-25-19.

Section 7.2, page 85. The second sentence in the second paragraph states, "Infiltration rates might be overestimated." The text should discuss why the estimates for infiltration may be too high.

Energy*Solutions'* Response: Infiltration rates are described in Section 7.2 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 7.2, page 85. The last paragraph states that "the MOP performance objectives are not exceeded in all cases." However, Table 17 shows that the 95th percentile ranch worker dose is 72.3 mrem/yr, which is greater than the 25 mrem/yr performance objective. The text should address this discrepancy.

Energy*Solutions'* Response: Doses summarized in Table 3-3 of the Compliance Report (which include 95-percentile doses of 110 mrem/year for the Industrial Worker and 72 mrem/year for the Rancher) are specifically associated with inadvertent intrusion scenarios and as such as comparable to the 500 mrem/year dose limit standard. Doses summarized in Table 3-1 of the Compliance Report (which cite 95-percentile doses of 16 mrem/year for the Industrial Worker and 11 mrem/year for the Rancher) are those specifically associated with the Division's referenced 25 mrem/year protection of the general public performance objective. Therefore, the statement from Section 7.2, page 85 is correct, as originally drafted.

4.0 REVIEW OF APPENDIX 1 – "FEP ANALYSIS FOR DISPOSAL OF DEPLETED URANIUM AT THE CLIVE FACILITY," MAY 28, 2011

4.1 GENERAL COMMENTS

Comment 1. Definition of Features, Events, and Processes (FEPs)

For document clarity, the text should include some discussion as to how FEPs are defined.

Energy*Solutions'* Response: Determination and definition for FEPs is included in Appendix 1 of Appendix A from revision 0.

4.2 SPECIFIC COMMENTS

Section 4.1.1, page 5. The discussion lists FEPs said to be mentioned in 10 CFR Part 61; however, it is not clear that the items listed are FEPs. Section 4.1.2 refers to similar items as "technical performance objectives." A clear distinction should be made between FEPs and technical performance objectives.

Energy*Solutions'* Response: FEPS are described in Section 4.1.1. of Appendix 1 of Appendix A from revision 0 Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 4.2, page 7. The discussion states that the PA reflects post-closure conditions, and FEPs related to operations are not considered relevant. It is not clear that this approach is consistent with UAC R315 25-8(4)(c), which states:

> *"Analysis of the protection of individuals during operations shall include assessments of expected exposures due to routine operations and likely accidents during handling, storage, and disposal of waste."*

In light of this requirement, the document needs to explain, in greater detail, why the protection of individuals during operations was not considered.

Energy*Solutions'* Response: As is discussed in Section 3.3 of the main report, demonstration of protection of individuals during operations has been previously submitted and approved by the Division as part of design from Energy*Solutions'* Class A West Amendment Application (McCandless, 2012). Disposal of depleted uranium in the Federal Cell requires no revision to existing and approved procedures currently protecting the general public.

Section 6.0, page 9. The text should provide a specific cross-reference to the evaluation of canister degradation and corrosion in the conceptual site model.

Energy*Solutions'* Response: Canister degradation and corrosion are discussed in Section 6.0 of Appendix 1 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

5.0 REVIEW OF APPENDIX 2 – "CONCEPTUAL SITE MODEL FOR DISPOSAL OF DEPLETED URANIUM AT THE CLIVE FACILITY," MAY 28, 2011

5.2 SPECIFIC COMMENTS

Pages vi and vii. Some of the page references for the figures and the table in the table of contents are incorrectly stated.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 1, page 1. The second paragraph mentions a Federal rule (10 CFR 61) relative to radiological performance assessment, but it does not mention the controlling Utah rule(s), created and administered by Utah as an NRC agreement state. The text should frame the discussion within the context of governing Utah rule.

Energy*Solutions'* Response: Citation to Utah rules has been given preference in the Compliance Report. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 1, page 1. The third paragraph states that the "PA model is intended to…support environmental decision making in light of inherent uncertainties." The text should clarify whether the PA is a National Environmental Policy Act (i.e., NEPA) document or a nuclear licensing document.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 1, page 2. The third paragraph states that the quantitative probabilistic PA model is based on projecting current societal conditions "up to 10,000 years." Utah rule UAC R313-25-8(5)(a) requires quantitative modeling for a minimum of 10,000 years, not a maximum of 10,000 years. Please provide text and modeling, as needed, to address this discrepancy.

Energy*Solutions'* Response: Regulatory context for a quantitative assessment up to 10,000 years has been added to Section 1.3 of the Compliance Report.

Section 2, page 3. The third paragraph states that the "…focus of the uncertainty analysis in the PA model will be parameter uncertainty." The paragraph should also state how parameter variability was addressed.

Energy*Solutions'* Response: The method of parameter uncertainty analysis is presented in Appendices 11, 13, and 16 of Appendix A from revision 0.

Section 2, page 5. The first paragraph on the page says, "However, it is very important to capture correlations between variables in a multiplicative model. Otherwise, system uncertainty is not adequately constrained. GoldSim provides some limited capability to introduce correlation into a PA model, but steps will be taken to evaluate the correlation effects of some variables." The text should provide a reference to the section in the PA where these steps are discussed.

Energy*Solutions'* Response: Parameter correlation is described in Appendices 3 through 11 and 14 of Appendix A from revision 0.

Section 3, page 5. The second paragraph states that, "Pending the findings of the PA, DU waste will be stored in a permanent above-ground engineered disposal embankment that is clay-lined with a composite clay and rock cap." The term "pending," as a preposition, means "while awaiting," or "during." The quoted statement is not correct, since DU waste will not be stored as described while awaiting or during "findings of the PA." Assuming that the PA is approved, *DU waste may then potentially be disposed, perhaps as described above. However, before DU is disposed of at the Clive facility, a license amendment (of which the PA is a part) must be approved by the Utah Division of Radiation Control.*

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing. Although the Performance Assessment evaluates disposal both above- and below-grade, depleted uranium will be disposed below grade to enhance assurance of continued isolation under geologic-time events such as the return of a large lake inundating Clive. Figure 1-2 of the Compliance Report demonstrates that the entire depleted uranium inventory evaluated can be disposed in such a manner.

Section 3.4.2.2, page 11. The last paragraph of this section states that the groundwater "is not potable for humans." The text should clarify whether there are any non-humans for which the groundwater may be potable.

Energy*Solutions'* Response: Potability is discussed in Section 1.3 of the Compliance Report. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 4.1.2, page 15. Discussions between the DRC and EnergySolutions have resulted in verbal agreements to limit doses to the general public to 25 mrem/yr TEDE. A discussion of these TEDE limits should be added to the information contained in this section.

Energy*Solutions'* Response: Discussion of the application of a 25 mrem/year TEDE for the general public has been added to Section 1.3 of the Compliance Report.

Section 4.1.4, page 16, of the PA says, "In addition to protecting any member of the public, 10 CFR 61 requires additional assurance of protecting individuals from the consequences of inadvertent intrusion. An inadvertent intruder is someone who is exposed to waste without meaning to, and without realizing it is there (after loss of institutional control). This is distinct from the intentional intruder, who might be interested in deliberately disturbing the site, or extracting materials from it, or who might be driven by curiosity or scientific interest."

This discussion should be framed in the context of applicable Utah rule, not 10 CFR 61. Utah rule UAC R313-25-20, entitled "Protection of Individuals from Inadvertent Intrusion" says, "Design, operation, and closure of the land disposal facility shall ensure protection of any individuals inadvertently intruding into the disposal site and occupying the site or contacting the waste after active institutional controls over the disposal site are removed." While not directly applicable, 10 CFR 61 says essentially the same thing. Therefore, it is not correct to define an inadvertent intruder as someone who is exposed to waste, per se. An inadvertent intruder may "inadvertently" intrude "into the disposal site and" occupy "the site" and be exposed to radiation without direct contact with the waste. In addition to inadvertently intruding into the disposal site, an inadvertent intruder, under Utah rule, is one who is "occupying the site" OR "contacting the waste."

While the intentional intruder, relative to the site, may be interested in "extracting materials from it, or who might be driven by curiosity or scientific interest," so might an inadvertent intruder. In fact, resource exploitation is one of the common classes of actions considered by the federal government in developing inadvertent intruder scenarios. The discussion in the PA should account for the possibility of inadvertent intruders engaging in resource exploitation (e.g., mining of clay, sand or aragonite materials).

Energy*Solutions'* Response: Justification and discussion of protection of the Inadvertent Intruder has been added to Section 1.3 of the Compliance Report.

Section 4.1.4, page 16. *The last paragraph of this section asserts that, "because the definition of inadvertent intruders encompasses exposure of individuals who engage in normal activities without knowing that they are receiving radiation exposure, there is no practical distinction made here between a member of the public (MOP) and inadvertent intruders with regard to exposure/ dose assessment."*

A review of UAC R313-25-19 and UAC R313-25-20 enables making such a practical distinction. Under UAC R313-25-19, entitled "Protection of the General Population from Releases of Radioactivity," reference is made to releases of "radioactive material" "to the general environment in ground water, surface water, air, soil, plants or animals." And under UAC R313-25-20, protection is extended to "any individuals inadvertently intruding into the disposal site and occupying the site or contacting the waste." In the former, radioactive materials or radioactivity is released to the general environment, which in many cases could be offsite, whereas in the latter, individuals must come into the disposal site itself and either occupy it or contact the waste, and it would be there that they could receive a dose of radioactivity. MOPs, unlike inadvertent intruders, do not need to enter the site. MOPs, unlike inadvertent intruders, may be aware of the potential for radioactive exposure, but still receive it. Inadvertent intruders do not have to be exposed to releases of radioactive materials to the environment, but, unlike members of the public, they may expose themselves directly to unreleased sources or shine from unreleased sources as well as releases of radioactive materials to the environment. The text should clarify these significant differences.

Energy*Solutions'* Response: Justification and discussion of protection of the Inadvertent Intruder has been added to Section 1.3 of the Compliance Report.

Section 4.2.1, page 17. *The last paragraph claims to reproduce the new section for R313-25-8 as follows:*

> *"(2)(a) Any facility that proposes to land dispose of significant quantities of depleted uranium, more than one metric ton in total accumulation, after June 1, 2010, shall submit for the Executive Secretary's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such*

performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period will be a minimum of 10,000 years. Additional simulations will be performed for an analysis for the period where peak dose occurs and the results shall be analyzed qualitatively."

This is not correct. The correct new section in R313-25-8 is designated as R313-25-8(5)(a), not as R313-25-8(2)(a). The correct new section is also reproduced properly as follows:

"(5)(a) Notwithstanding R313-25-8(1), any facility that proposes to land dispose of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, shall submit for the Director's review and approval a performance assessment that demonstrates that the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules will be met for the total quantities of concentrated depleted uranium and other wastes, including wastes already disposed of and the quantities of concentrated depleted uranium the facility now proposes to dispose. Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC. For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively."

The main difference between the two versions, other than the numbering, is that the correct, up-to-date version refers to "significant quantities of concentrated depleted uranium" (adding the word concentrated). Note that this rule applies to the facility as a whole, not simply to a particular embankment. The text should include the correct reproduction of the rule as well as the correct numbering.

Energy*Solutions'* Response: There corresponding references in Section 1.3 of the Compliance Report have been updated to current UAC citations. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

<u>Section 4.2.2, page 18.</u> This section refers to Utah rule R313-15-1008 as being "Classification and Characteristics of Low-Level Radioactive Waste." Figure 5 refers also to R313-15-1008. The rule numbers are not correct. The correct rule that should be referenced is UAC R313-15-1009.

The PA says that "Ra-226, a decay product of uranium-238, the principal component of DU, is of direct interest to the disposal of DU waste." However, Ra-226 is also one of the many "other wastes" mentioned in UAC R313-25-8(5)(a) for which modeling must be performed during not only the compliance period of a minimum of 10,000 years, but also during an extended period of time beyond that, i.e., for a time sufficient for the peak dose to be evaluated through the model, with the results then being analyzed and discussed qualitatively. The text should discuss *ramifications for modeling associated with the Utah rule that includes in-growth of Ra-226 in determining LLW classification and characteristics.*

Classification for most radioactive substances involves those whose activity concentrations are maximums at the time of initial classification, and decline via radioactive decay thereafter. However, activity concentrations for Ra-226 are not maximum at the time of LLW classification, but they continue to grow through time until secular equilibrium is attained with the uranium parent(s). This is a situation not analyzed for in the original development of the classification tables. This is a point of importance in considering whether the Director of the DRC should allow for DU disposal at Clive in Utah, where radioactive materials having a classification above Class A are not permitted to be disposed of by law. This factor needs to be discussed in depth. The text should accordingly reference the section of the PA that provides modeling results for Ra-226 and that indicates the point at which the activity concentrations of Ra-226, through radioactive in-growth associated with depleted DU, exceed Class A concentrations, and also the point, if any, at which activity concentrations of Ra-226 exceed Class C concentrations. The text should also provide justification as to why Utah should permit disposal of materials producing substances that, even though initially passing Class A limits, will ultimately lead to the anomalous condition of Ra-226 activity concentrations exceeding Class A limits, and possibly even Class C limits, over time.

Energy*Solutions'* Response: The corresponding references in Section 1.3 of the Compliance Report have been updated to current UAC citations. The concentration limits in R313-15-1009 apply to classification at the time of disposal. The radiological characteristics (i.e., in-growth) of Ra-226 were well-established at the time its classification limit was set; and once disposed, waste is commingled with other wastes and fill materials, reducing initial concentration. Therefore, hypothetical classification exercises add no value to an assessment of the safety implications of depleted uranium disposal.

Section 4.2.2, page 18. The second paragraph states, "…some radionuclides listed in the tables shown in Figure 7 in addition to the Ra-226 added by Utah (Figure 5)." However, there are no tables in Figure 7; Figure 5 includes a single table. The text should be revised to clarify.

Energy*Solutions'* Response Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 4.2.3, page 19, says, "Note that according to the Permit, groundwater at Clive is classified as Class IV, saline ground water, according to UAC R317-6-3 Ground Water Classes, and is highly unlikely to serve as a future water source. As noted in Section 3.4.2.2 , the underlying groundwater in the vicinity of the Clive site is of naturally poor quality because of its high salinity and, as a consequence, is not suitable for most human uses, and is not potable for humans."

It is true that the Permit states that groundwater at Clive is classified as Class IV groundwater, which is saline. However, it is not true that "according to the Permit, groundwater at Clive . . . is highly unlikely to serve as a future water source." The permit does not appear to speak to that *speculation. The Licensee should provide appropriate justification for this claim, or make modifications as needed.*

The claims that groundwater at Clive, because of its natural high salinity, "…is not suitable for most human uses, and is not potable for humans" are simply not correct. Water of comparable salinity is currently being used, after appropriate treatment, in many Middle Eastern countries as potable water, and it is employed there for many human uses. Saline water is also currently used to provide potable water for people in other parts of the world, including the local region. Saline water is currently being used, for example, here in Utah by Kennecott and a local water distributor to provide potable water for people in the Jordan Valley. Regionally, it is being used in Arizona and California. The text should provide more appropriate, extended discussion of this issue, or it should justify the original statements.

Energy*Solutions'* Response: The discussion of groundwater classifications have been added to Section 1.3 of the Compliance Report.

Section 5, page 20, first paragraph. Information in the meteorology section appears to be incomplete and in error. Numerous tornados have been reported in Utah; one web site lists 120 tornados between 1953 and 2012 (http://www.tornadohistoryproject.com/tornado/Utah/table). Please provide complete and accurate information.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 5, page 20, last paragraph. Information about seismic activity section appears to be incomplete and in error. (See also Section 4.2.) Please provide complete and accurate information.

Energy*Solutions'* Response: Seismicity has been included in Section 5 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 5, page 21, Containerization. The text states that canister degradation and corrosion are evaluated in the conceptual model. The document should provide a specific cross-reference to this discussion.

Energy*Solutions'* Response: Canister degradation and corrosion is discussed in Section 5 of Appendix 2 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 5, page 22, Human Processes. The text states that anthropogenic climate change is among the human process FEPs identified for assessment. The text should provide a specific cross-reference to this assessment.

Energy*Solutions'* Response: Section 6.0 of Appendix 1 of Appendix A from revision 0 provides detail as to the manner in which the anthropogenic climate change FEP was assessed.

<u>Section 6, page 22.</u> The text states that the "scope of this CSM is limited to the disposal of DU wastes…." This statement appears to conflict with UAC R313-25-8(5)(a), which requires the PA to demonstrate that performance standards will be met for "depleted uranium and other wastes, including wastes already disposed of…." Please reconcile this apparent inconsistency.

Energy*Solutions'* Response: As is described in Section 1.2 of the Compliance Report, a Performance Assessment modeling waste already disposed of in the Class A West Embankment has been submitted and approved by the Division as part of Energy*Solutions'* Class A West Amendment Application (McCandless, 2012). Because it employs the same Division-approved cover design, McCandless (2012) also demonstrates compliance with Class A Waste placed above any depleted uranium in the Federal Cell. Additionally, "o*ther wastes*" within the depleted uranium canisters (as discussed in Section 2.3 of the Compliance Report and Appendix 4 of Appendix A from revision 0) is included in the depleted uranium Performance Assessment.

<u>Section 6, page 22.</u> The first paragraph describes DU oxides to be produced from GDPs, but the information is not complete on this matter. Please provide it.

Energy*Solutions'* Response: Depleted uranium oxides are discussed in Section 6 of Appendix 2 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

<u>Section 6, page 22.</u> The text should provide a reference for the statement in the third paragraph, "If uranium hexafluoride derived from irradiated reactor returns is introduced to the cascade, the associated fission products and actinides migrate to the depleted end of the cascade, with the U 238."

Energy*Solutions'* Response: Uranium hexafluoride is discussed in Section 6 of Appendix 2 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

<u>Section 6.3, page 24.</u> This section refers to depleted uranium oxide from gaseous diffusion plants. The section, however, does not describe the types and quantities of uranium oxide(s) produced or expected to be produced from de-conversion of DUF6 at these plants. This section needs to reference one or more other section(s) in the PA where detailed information about these oxides are presented in the PA, since chemical properties and environmental behavior differ depending on the type of oxide and its relative fractional contribution to the DU waste.

Energy*Solutions'* Response: Detailed descriptions of the depleted uranium waste projected to be disposed of (and included in the depleted uranium Performance Assessment) is discussed in Appendix 4 of Appendix A from revision 0.

<u>Section 6.4, page 25.</u> Depleted uranium already disposed of at the Clive Facility is not accounted for in the DU PA Model. However, Utah code requires demonstration within the PA that performance standards will be met for "depleted uranium and other wastes, including wastes already disposed of…." [UAC R313-25-8(5)(a)]. Reference should be made here to that section

of the PA where depleted uranium already disposed of at the Clive Facility is discussed and evaluated. If such a section does not currently exist, then it needs to be created.

Energy*Solutions'* Response: As is described in Section 1.2 of the main report, a Performance Assessment modeling waste disposed of in the Class A West Embankment (including depleted uranium) has already been submitted and approved by the Division as part of Energy*Solutions'* Class A West Amendment Application (McCandless, 2012). Additionally, authorization for historically-disposed depleted uranium was already approved by the Division with the Performance Assessment submitted in support of condition 6 of Energy*Solutions'* 22 October 1998 License 2300249 (limiting the depleted uranium within a container as 3.7e+05 pCi/g upon receipt).

Section 6.6, page 26. The second paragraph states that, "The transport of radon in both the saturated and unsaturated zones will be included in the PA model." However, radon is not mentioned in the saturated zone modeling appendix (Appendix 7); the text should provide a specific cross-reference to the discussion of radon transport under saturated conditions.

Energy*Solutions'* Response: Radon transport is discussed in Appendices 5, 7, and 8 of Appendix A from revision 0.

Section 7.1.1.1, page 27. The third paragraph states that "Diffusion in the air phase within the UZ below the facility will not be modeled, since the only diffusive species would be radon...." However, Section 6.6 states that "The transport of radon in both the saturated and unsaturated zones will be included in the PA model." The text should resolve these apparently contradictory statements.

Energy*Solutions'* Response: Radon diffusion is discussed in Section 7.1.1.1 of Appendix 2 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 7.1.1.2, page 27. The second paragraph states that "A range of values will allow the sensitivity analysis (SA) to determine if this is a sensitive parameter...." The text should provide a specific cross-reference to the discussion of this sensitivity analysis.

Energy*Solutions'* Response: Sensitivity is discussed in detail in Appendices 14, 15, and 16 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 7.1.3.1, page 28. The first paragraph states that "Over time, cracks, fissures, animal burrows, and plant roots can also provide preferential diffusion pathways that reduce the effectiveness of the engineered barrier." The document should indicate how this was accounted for in the PA model, particularly with respect to the potential release of radon to the surface.

Energy*Solutions'* Response: Modeling of the impact of the diffusion pathways is described in Appendices 3 and 8 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 7.1.4, page 31, *says, "However, in areas where precipitation does not infiltrate to groundwater, black greasewood will not form taproots and will maintain a more shallowly rooted growth form. Excavations of several greasewood plants at the Clive site by SWCA (2011) found roots that did not exceed one meter in depth."*

SWCA (2011) explains that these greasewood roots went down to a compressed clay layer located at that shallow depth, and then spread out laterally. Where there locally is a perching layer such as this clay layer appears to be, one that traps moisture at a shallow level and makes it available for roots, such shallow plant rooting behavior is expected. However, where such a perching layer does not exist, it is expected that greasewood roots may extend to great depths in search of groundwater or capillary-fringe water. As Neptune and Associates (2011) says of the site, "The vegetative survey of the Clive site found that the majority of greasewood plants are less than one meter tall . . . Still, larger plants do occupy parts of the Clive site, especially where precipitation runoff is concentrated, and these plants may extend taproots to exploit deeper water."

As the PA implies, greasewood is a phreatophyte. Its scientific name is Sarcobatus vermiculatus. Maxwell et al. (2007) state that greasewood is an obligate phreatophyte, whose roots almost always grow into groundwater. Waugh (1998) states of greasewood that it "is an obligate phreatophyte requiring a permanent ground-water supply, and can transpire water from aquifers as deep as 18 meters below the land surface (Nichols 1993)." Nichols (1993) reports greasewood taproots growing to depths equivalent to about 60 feet. Meinzer (1927) states that "Near Grandview, Idaho, H. T. Stearns observed roots of greasewood penetrating the roof of a tunnel 57 feet below the surface." White (1932) reports greasewood growing at localities where the depth to groundwater is 50 to 60 feet. WSDNR (2011) states that "Sarcobatus vermiculatus is an obligate phreatophyte and is able to tap into groundwater at great depth (>10 meters)." Chimner and Cooper (2004) report that xylem water from greasewood plants overlying a groundwater table at a depth of about 13 meters (43 feet) was isotopically similar to xylem water from greasewood at other sites where depth to groundwater ranged from 2 to 13 meters (6 to 43 feet). Harr and Price (1972) report maximum greasewood rooting depths of at least 12.7 m (42 feet).

When natural soils in the area are disturbed during excavation to procure cover-system materials, these cover-system materials will no longer possess an intact compressed natural clay layer at a depth of 1 meter that acts to pond infiltrating water and limit deeper greasewood rooting. While the radon barrier may provide some local resistance, the radon barrier is susceptible to damage over time via plant rooting, animal burrowing, water-based and wind-based erosion, and violent meteorological events, such as tornados and microbursts. This section should discuss the potential for deeper rooting by greasewood.

Energy*Solutions'* Response: Expanded discussion of greasewood bioturbation has been added to Section 2.1.11 of the Compliance Report and is already found in Appendices 8 and 9 of Appendix A from revision 0.

Section 7.1.5, page 32. The first paragraph states that "site-specific information about the utilization of the site by specific animal species is likewise limited." The PA does not include much information relative to burrowing mammals. Such information, however, can be found specifically for the site in SWCA (2011; 2012). SWCA in particular describes burrowing mammals on site, or very near the site, such as coyotes, badgers, kit foxes, burrowing owls, ground squirrels, and deer mice. Additional generic and case-study information is available in the literature. Much more analysis on the potential for burrowing mammals to impact site rock and soil materials is needed, since burrowing mammals may play an important role in cover-system degradation over time. The PA should include extensive analysis about this important topic, including additions to modeling to show effects of burrowing on site conditions.

Dwyer et al. (2007) state that, "…biointrusion can lead to increased infiltration and preferential flow of surface water through the cover system as well as contribute to the change in the soil layer's hydraulic properties." Hakonson (1999; 2002) and Hakonson et al. (1982) indicate that biointrusion by mammals can be problematic at disposal sites and that pocket gophers, for example, can increase rates of infiltration by 200% to 300%. Breshears et al. (2005) report that burrows made by pocket gophers in simulated landfills dramatically increased infiltration rates, i.e., by about one order of magnitude. Badger burrows at the Hanford site are reported to have captured much runoff and allowed the runoff to infiltrate into soils deeper than elsewhere on site. Measurements by researchers of moisture in soils under the burrows after artificial rainfall events demonstrated this impact. "These measurements confirmed that larger mammal burrows can and do cause the deep penetration of precipitation-generated runoff at Hanford" (Link et al. 1995). Hakonson (2002) says, "Erosion and percolation increase dramatically when the vegetation cover is absent in the presence of burrowing." According to SWCA Environmental Consultants (2012), "A bioturbation barrier will likely be needed that is designed to exclude large and small burrowing mammals (i.e., mice, rats, hares, badgers)." The text should clarify whether additional site-specific information about use of the site by animals and also biointrusion is going to be collected, and if not, document why the limited available site-specific information is sufficient for the PA and the license amendment.

Energy*Solutions'* Response: Site-specific information on the impact of burrowing animals has been included in Appendices 3, 9, and 10 of Appendix A from revision 0. In response to the Division's future Round 1 Interrogatories, this information will be supplemented with SWCA (2012), which was written during the 2.5 years between when the PA was submitted and this completeness review.

Section 7.1.5, page 32. The PA does not mention coyotes inhabiting the site. SWCA (2012) noted that, while coyote burrows or dens were not observed directly on the several plots used for their limited sampling events, evidence of coyotes was noted nearby. The presence of coyotes on or near the site indicates the potential for cover damage by the coyotes.

Coyotes are capable of deep burrowing. In one study, it is reported that minimum depth of 17 dens ranged from 2 to over 5 meters (6 to 16 feet), with an average depth of 2.5 m (8 feet) (Way et al. 2001). This depth is much greater than the depth of the proposed cover system (6.5 feet), so a risk from biointrusion into radon barriers and bulk waste exists.

Biointrusion by coyotes can badly damage cover systems, possibly allowing a direct path for water to percolate into waste, and permitting the release of radon into the atmosphere, increasing risk to people and the environment. If coyotes get into waste, they may become surficially contaminated by radioactive particles and may spread these radioactive particles to other parts of the environment. Additionally, radioactive materials within the coyotes (e.g., from eating other fossorial mammals) may subsequently adversely impact the environment via excretion of coyotes' urine, feces or other bodily fluids, or, when the coyotes die, through decomposition of their flesh. The cover system needs to provide a high level of protection from intrusion by burrowing animals, including coyotes. The PA should account for this and also document the potential for deep burrowing by coyotes.

Energy*Solutions'* Response: Site-specific information on the impact of burrowing animals (including coyotes) has been included in Appendices 3, 9, and 10 of Appendix A from revision 0. In response to the Division's future Round 1 Interrogatories, this information will be supplemented with SWCA (2012), which was written during the 2.5 years between when the PA was submitted and this completeness review.

Section 7.1.5, page 32. *The PA does not mention badgers inhabiting the site. SWCA (2012) shows photos documenting that badgers live at the site, and this reference also reports badger burrows at the site. McKenzie et al. (1982) is said to give a burrowing depth for badgers that is greater than 2.0 meters, or 6.6 feet (Hampton 2006). Based on a study of a couple of badgers in Utah and Idaho, Lindzey (1976) reports that one badger observed in the study burrowed to a depth of 2.3 meters (7.5 feet). Reported burrowing depths of 6.6 to 7.5 feet are significantly greater than the depth of the proposed DU cover system soil and rip rap. It is estimated in Eldridge (2004) that each badger creates or enlarges up to 1,000 to 1,700 burrows or pits each year. Badgers do this primarily while searching for fossorial mammals (e.g., ground squirrels, kangaroo rats or deer mice) to eat. Since each pit lasts, on average, about 4 years (see Eldridge 2004), one badger may be responsible for the presence of 4,000 to 6,800 relatively large pits being in existence each year.*

Biointrusion by badgers can potentially cause a number of problems. Biointrusion can potentially damage cover systems, allow too much water to percolate into LLW, and permit release of radon into the atmosphere, increasing radioactive doses to humans and the environment. If badgers get into LLW, they may become contaminated by radioactive particles and may spread them throughout the environment. Badgers may also ingest radioactive materials by eating other fossorial mammals impacted by waste. They may then spread radioactivity through the environment via urine, feces, and other bodily fluids, and, when the badgers die, via decomposing flesh.

Rock armor cover may by itself provide minimal biointrusion protection. Many plants and burrowing mammals may be able to penetrate a rock armor cover by migrating through the large interstices or voids existing between its cobbles. Larger fossorial mammals, such as badgers, may be able to remove some or all of the smaller cobbles by digging or burrowing. The PA should account for this and also document the potential for deep burrowing by badgers.

Energy*Solutions'* Response: Site-specific information on the impact of burrowing animals (including badgers) has been included in Appendices 3, 9, and 10 of Appendix A from revision 0. In response to the Division's future Round 1 Interrogatories, this information will be supplemented with SWCA (2012), which was written during the 2.5 years between when the PA was submitted and this completeness review.

Section 7.1.5, page 32. The PA does not mention kit foxes inhabiting the site. Kit foxes, which are found in western Utah, among other places, either create or use (in some cases) dens as deep as 2.5 meters (8.2 feet; Tannerfeldt et al. 2003, referencing O'Neal et al. 1987). This depth is considerably deeper than the design depth of the top of radon barrier, and even considerably deeper than the design depth of the top of the bulk waste. Foxes are mentioned on page 3-4 of Section 3.1.6 of the EnergySolutions PA for blended and processed resin LLW, which states, "Other burrowing animals at the site include jackrabbits, mice, and foxes." Jackrabbits do not burrow. The PA, however, should account for fox burrowing into bulk waste.

Energy*Solutions'* Response: Site-specific information on the impact of burrowing animals (including kit foxes) has been included in Appendices 3, 9, and 10 of Appendix A from revision 0. In response to the Division's future Round 1 Interrogatories, this information will be supplemented with SWCA (2012), which was written during the 2.5 years between when the PA was submitted and this completeness review.

Section 7.1.5, page 32. The PA does not mention burrowing owls. The EnergySolutions PA for blended waste says, "Furthermore, the presence of badgers and a large family of burrowing owls indicates that the biota can potentially move large volumes of soil." SWCA (2012) also mentions them, and shows a photograph. The PA should document the potential for deeper burrowing by burrowing owls.

Energy*Solutions'* Response: Site-specific information on the impact of burrowing animals (including burrowing owls) has been included in Appendices 3, 9, and 10 of Appendix A from revision 0. In response to the Division's future Round 1 Interrogatories, this information will be supplemented with SWCA (2012), which was written during the 2.5 years between when the PA was submitted and this completeness review.

Section 7.1.5, page 32. SWCA Environmental Consultants (SWCA 2012) reports on the species of ground squirrels observed onsite: Spermophilus spp. Suter (1993) and Suter et al. (1993) report ground squirrel burrowing to depths of at least 1.4 meters (4.6 feet), but do not mention species. HERD (1998) reports that ground squirrels in California burrow to depths of at least 66 inches (1.7 meters, or 5.5 feet). These data indicate that the potential depth to which ground squirrels may burrow may be nearly as deep as the proposed cover system soil thickness and *deeper than the top of the radon barrier. These data indicate the potential for ground squirrels to biointrude through at least some of the cover-system soils at the site.*

Biointrusion by ground squirrels can badly damage cover systems, possibly allowing for more water to percolate into waste, and facilitating the release of radon into the atmosphere, increasing risk to people and the environment. The cover system needs to provide a high level of protection from intrusion by burrowing animals, including ground squirrels. The PA should account for this.

Energy*Solutions'* Response: Site-specific information on the impact of burrowing animals (including ground squirrels) has been included in Appendices 3, 9, and 10 of Appendix A from revision 0. In response to the Division's future Round 1 Interrogatories, this information will be supplemented with SWCA (2012), which was written during the 2.5 years between when the PA was submitted and this completeness review.

<u>*Section 7.1.5, page 32.*</u> *The PA does not talk extensively about deer mice. Yet, according to the SWCA (SWCA 2011; 2012), 83 deer mice and 1 kangaroo rat were trapped during a single biological survey on site.*

Kenagy (1973) reports on the depth of nests of the kangaroo rat, Dipodomys merriami, at a site in Owens Valley between the Mohave Desert and the Great Basin. Maximum depth of kangaroo rats that could be located by tracking devices used at this site is reported to have been 1.75 m (5.7 feet). However, many of the kangaroo rats are reported to have stayed in their burrows during the study at considerably greater depths than this maximum depth to which the tracking devices used in the study could read a signal and track them. Different species of kangaroo rats may burrow more deeply or less deeply. The species of kangaroo rat found at the site is not mentioned in the PA. The kangaroo rat captured by SWCA Environmental Consultants (2012) is thought to have been an Ord's Kangaroo rat (see page 23 of SWCA 2012b).

Arthur and Markham (1986, 1987; see also Bowerman and Redente 1998) note that deer mice penetrated an Idaho National Environmental Laboratory (INEL) cover system having a thickness of 2.4 meters. Many of the mice are reported to have received relatively high radiation doses, some of which are said to have been lethal.

Landeen and Mitchell (1981) found that other types of mice (i.e., pocket mice) at the Hanford site burrowed about 79% deeper in disturbed soils than in native soils. This indicates that, for combinations of some mammals and some soils, biointrusion may be deeper in disturbed soils than in non-disturbed soils.

Based on the foregoing, it appears that the potential for biointrusion exists for both kangaroo rats and deer mice at the site. Kangaroo rats are noted in field observations to have burrowed down to soil depths of at least 1.75 meters (5.7 feet). It is not known how species variation affects burrowing depth. Deer mice can burrow down to at least 2.4 meters (7.9 feet). These are depths for which actual field samples are relatively few. Therefore, greater depths of burrowing could be expected if an entire population were to be evaluated. Furthermore, as reported for one *species in one soil by Landeen and Mitchell (1981), burrowing depths may possibly tend to be greater in disturbed soil.*

For the Licensee-preferred cover design at the site (see pages 12 and 15), the proposed cover-system soil thickness is several feet. Both kangaroo rats and deer mice have been reported to burrow down into soil fairly deeply. This indicates the potential for biointrusion at the site. The PA should include discussion of the potential for this from mice and kangaroo rats, and the effects of biointrusion by mice and kangaroo rats, and all other potential biointrusions, should be accounted for in the PA model.

Energy*Solutions'* Response: Site-specific information on the impact of burrowing animals (including deer mice) has been included in Appendices 3, 9, and 10 of Appendix A from revision 0. In response to the Division's future Round 1 Interrogatories, this information will be supplemented with SWCA (2012), which was written during the 2.5 years between when the PA was submitted and this completeness review.

Section 7.2, page 35. Even though predictions of dose in deep time involve much uncertainty, doses can be discussed qualitatively under certain assumptions. This approach has value in assisting regulators and the general public in understanding how radioactivity values of DU's daughter products (and therefore their potential contribution to dose) tend to increase over time. A simple bounding assumption that could be used would be to assume that site conditions do not deteriorate at all. Annual dose could then be estimated, for example, for an inadvertent intruder working 8 hours per day, 5 days per week, in a basement of a building located over the embankment. The results, though based on quantitative numbers, would need to be assessed qualitatively, because there would be, in fact, dramatic uncertainty associated with the result, and this set of criteria can be communicated to the reader of the PA. Determination of dose at the time of peak dose and qualitative discussion of the results is mandated by Utah rule, and it should be included as one of the PA results.

Energy*Solutions'* Response: Regulatory discussion of the nature of the qualitative assessment is included in Section 1.3 of the Compliance Report and Appendix 13 of Appendix A from revision 0.

Section 7.2.1.4, page 39. This section discusses the indirect effects of volcanism in diverting the Bear River from Idaho to the Bonneville basin. The effects of volcanism on the Clive area should be included, or the text should document that there is no possibility for impacts of volcanism on the Clive area over the next 10,000 years.

Energy*Solutions'* Response: Multiple effects that may potentially impact the Federal Cell, including volcanism, are considered in Appendix 13 of Appendix A from revision 0.

Figure 7.2.1.5, page 40. The X on the Whittaker biome diagram (which is supposed to represent site conditions) appears to be too high. As it currently is depicted, the scaled precipitation value for the X appears to be in the range of 27–30 cm/yr. Yet average precipitation at Clive is 8.62 in/yr (about 21.9 cm/yr). This appears to change the biome depicted for the site conditions. The *placement of the data point for site conditions as presented by the X on the diagram should be modified in the PA.*

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 7.2.2, page 42. The document says, "When the first lake returns at or above the elevation of Clive, the waste embankment will be treated as destroyed." This interpretation of results may, under many circumstances, be reasonable. However, if all waste and cover-system materials are located below natural grade level, then it is not likely that the waste would be redistributed into the environment nearly as readily, if at all. The PA model should be re-run under this scenario, with the top of the cover at natural grade level, and the results presented in the text.

Energy*Solutions'* Response: Deep time is addressed in Section 7.2.2 of Appendix 2 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 8.1, page 44. The last sentence of the section states that, "All wastes are assumed to have the characteristics of local Unit 3 sandy soil." The text should provide the basis for making this assumption, rather than assuming that the DU waste would have the characteristics of DUO3 from SRS and DU3O8 and DUO2 associated with de-conversion of UF6.

Energy*Solutions'* Response: Waste characteristics for depleted uranium and the conservatisms of the statement referenced are discussed in Appendices 3 and 4 of Appendix A from revision 0.

Sections 8.2 and 8.3, page 44. The text should provide a brief description of the liners and cap or provide a specific cross-reference to where descriptions may be found.

Energy*Solutions'* Response: The liner and cover design approved for the Class A West Embankment is described in detail in Section 3 of the Class A West Amendment Application (McCandless, 2012). This same Division-approved design is planned for use in the Federal Cell.

Section 8.2, page 45. Paragraph three of the first bulleted item says, "The measured moisture content in the Cover Test Cell at the site provides evidence for an evaporative zone depth greater than 18 in (Envirocare 2005)." However, the DRC in its 2012 report on the covered test cell, clearly demonstrated a lack of substantive evidence for an evaporative zone depth greater than 18 in exists. Substantial evidence, in fact, exists to show that in many studies, coarse-grained material (such as rip rap) placed at the surface of a soil layer acts as an inorganic mulch and greatly reduces or, in some instances, nearly eliminates evaporation. The PA should be modified to account for this.

Energy*Solutions'* Response: The impacts of evaporation on the Class A West Embankment has been included in the Performance Assessment submitted and approved by the Division in Attachment 3 of the Class A West Amendment Application (McCandless, 2012). Because the same Division-approved design is planned for the Federal Cell, this analysis also supports the performance of the Federal Cell. Similar GoldSim representation within the depleted uranium Performance Assessment was modeled (see Appendices 3 and 8 of Appendix A from revision 0).

Section 8.3, page 45. The suppositions in the second bullet about the behavior of smaller mammals and ants should be supported by appropriate references.

Energy*Solutions'* Response: Small mammals and ants are described in Section 8.3 of Appendix 2 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 8.2, page 45. The third bulleted item says, "On balance, the evidence suggests that bioturbation and homogenization of the radon barriers will probably occur very slowly relative to the 10,000-year time frame for the PA." No justification is provided for this claim. Moreover, homogenization of the radon barriers is not the only result of biointrusion and bioturbation. This bulleted item should be expanded, and any assertions made should be justified.

Energy*Solutions'* Response: Bioturbation of the radon barrier is discussed in Section 8.2 of Appendix 2 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 8.2, page 46, says, "Freeze/thaw cycles will also tend to degrade performance of the cap. This process is anticipated in the design, however, which includes a sacrificial layer to accommodate it (Whetstone, 2000)." However, the sacrificial layer is not necessarily of sufficient thickness in its current design to withstand sustained cold winter temperatures.

At the Cover Test Cell previously built and tested on site, freezing temperatures occurred at a depth of 30 inches for January 2004, which was not an exceptionally cold month. Neither was the month before an exceptionally cold month. In very cold winters, it stands to reason that the zone of freezing may extend even deeper than 30 inches, and this may necessitate even greater design soil layer thickness above the radon barrier to protect it.

In the Cover Test Cell that month, while freezing occurred at a depth of about 30 inches, temperatures only slightly above freezing (e.g., 2°C, or about 36°F) were noted even at a depth of 42 inches, at or near the top of the radon barrier. During that month, mean monthly low air temperatures are reported as having been 11.35°F (see http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?utdugw). However, meteorological records show that, in the 56 years between 1951 and 2006, inclusive, there were 13 years (23%) in which mean monthly low air temperatures for January dropped to values lower than 11.35°F (http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?utdugw), and sometimes much lower. Likewise, about 25% of December monthly low air temperatures between 1951 and 2006 were colder than those in December 2003, and sometimes much colder. It follows that test results for freezing of the Cover Test Cell in 2004 are not conservatively representative of all freezing temperatures experienced over time.

In January, 1989, monthly low air temperatures plummeted to 0.39°F, which is nearly 11 degrees cooler than in January 2004. With a similar drop of 11 degrees in monthly low air temperature *in the future compared to January 2004, it is possible that a radon barrier at the DU embankment could be subjected to below-freezing temperatures, with consequent severe damage.*

The PA should discuss the potential for freezing of the radon barrier, which could cause it to undergo severe damage through frost heave.

Energy*Solutions'* Response: The adequacy of modeling the impacts of freeze/thaw cycles on the Class A West Embankment have been included in the Performance Assessment submitted and approved by the Division in Attachment 3 of the Class A West Amendment Application (McCandless, 2012). Because the same Division-approved design is planned for the Federal Cell, the analysis demonstrates compliance. Consideration of the disposal of depleted uranium does not impact the Division-approved cover design.

Section 8.2, page 46. *As stated in the document, "Subsidence is not expected to be an important process at the Clive facility, since the waste is aggressively compacted in order to prevent this occurrence (EnergySolutions, 2009c). However, the subsidence described in the EnergySolutions reference does not refer to compaction of DU in its drums or canisters, which may behave very differently in the embankment from, for example, compacted bulk waste. Drums of DU-related LLW from SRS or canisters of DU-related LLW from GDPs may have headspace within the associated containers that may not respond to compaction efforts at Clive. However, this headspace may become important as the containers deteriorate over long periods of time, perhaps decades or hundreds of years, and as the headspace is filled in by overlying waste, resulting in differential subsidence. What is missing from the PA is an analysis of stability conditions as this compaction occurs. The analysis is required under UAC R313-25-22 and analysis should be part of the PA.*

Energy*Solutions'* Response: The impact of waste subsidence on the Class A West Embankment ability to satisfy its performance objectives has been included in the Performance Assessment submitted and approved by the Division in Sections 3.3.3 and 4.3 and Attachment 5 of the Class A West Amendment Application (McCandless, 2012). Because the same Division-approved design is planned for use in the Federal Cell, this analysis also supports the Federal Cell's performance. In accordance with existing CQA/QC Manual requirements for LLRW disposal, depleted uranium containers, regardless of the type, will require any headspace void to be filled. Energy*Solutions* does not propose to vary this requirement, in order to provide assurance that embankment stability evaluations remain bounding. Consideration of the disposal of depleted uranium does not impact the use of the Division-approved Class A West Embankment design in the Federal Cell.

Section 9.1.1, page 47. *The document states, "Based on laboratory analysis of the contents of DU waste (including all radionuclides in the containers), the species in the disposed inventory include (Beals et al. 2002; EnergySolutions 2009b; Johnson 2010): . . " This statement is unclear as to which waste it is referring. Does it refer to all DU waste expected to be disposed of including that in the future, or to currently disposed of DU waste, or to DU waste from SRS, or to DU waste from GDPs? Each of these will have different DU-waste species compositions. How is this accounted for in the model? This section needs clarification.*

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 9.1.2, page 47. The text should describe how "spontaneous fission" is modeled in the PA such that it is "accounted for in terms of [its] dose effects on humans."

Energy*Solutions'* Response: Modeling of doses is described in Appendices 4 and 11 of Appendix A from revision 0.

Section 9.2, page 51. It is stated that, "The disposed DU waste is assumed to be uncontainerized, since standard operations at the site include significant compaction of disposed waste." This appears to be an incorrect assumption. Planned disposal practices at the site include disposal of SRS drums and GDP canisters as well as the DU waste that each type of container holds. Correct information about containers needs to be supplied for the model and for the text in this section. This information is important in considering physical stability of the waste, since any headspace in the containers will eventually allow for partial collapse of the waste and cover above it.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 9.3, page 52. This section discusses use of partition coefficients in the model. However, the text, and presumably the model, either openly or implicitly assume that sorption and exchange processes occur:

(1) Under equilibrium conditions, rather than non-equilibrium or time-dependent conditions
(2) Linearly, rather than nonlinearly
(3) Reversibly, rather than irreversibly
(4) Independently of pH, Eh, temperature, and other physical and chemical characteristics of the external environment, rather than dependently

While choosing such an approach to sorption and exchange processes may be considered by the modeler(s) to be necessary to keep the model sufficiently simple and workable, and data acquisition minimal, it is well known that there are some rather severe limitations to the accuracy of such an approach with respect to radionuclides. For example, as stated by Cygan et al. (2001), "linear and reversible sorption (i.e., KD approach) is rarely observed in soils and groundwaters because of complex geochemical factors that can significantly affect radionuclide transport mechanisms and kinetics (e.g., pH, fluid composition, ionic strength, mineral substrate structure and composition, organic complexation)."

There is thus a great deal of uncertainty involved in model results based on an application of the partition coefficient approach, such as occurs in the PA model. This section should either provide a discussion of this inherent uncertainty, or provide a reference to a relevant discussion found elsewhere in the PA. The discussion of uncertainty should attempt to quantify it. Another section of the PA should address model sensitivity to the value of the partition coefficient used.

Energy*Solutions'* Response: The selection of sorption coefficients has been previously submitted to and approved by the Division as part of the Attachment 3 to the Class A West Amendment Application (McCandless, 2012). Since the applicable environment considered therein is also applicable to the Federal Cell, the Division's acceptance of the sorption coefficients is also supported for the Federal Cell. Uncertainty in sorption coefficients is discussed in Appendices 4, 5, 6, 7, and 14 of Appendix A from revision 0.

Section 9.3, page 52. The text provides the partition coefficient concept. It should also provide details on how the retardation factor was calculated and specifically whether moisture content or porosity is used in the unsaturated zone transport calculation.

Energy*Solutions'* Response: Calculation of retardation factor has been previously submitted to and approved by the Division as part of the Attachment 3 to the Class A West Amendment Application (McCandless, 2012). Since the applicable environment considered therein is also applicable to the Federal Cell, the Division's acceptance of the retardation factors is also supported for the Federal Cell. Additional discussions are present in Appendices 4, 5, and 7 of Appendix A from revision 0.

Section 10.3, page 56. The text states that "Potential activities of interest…are based on the predominant present day uses of the general area…." As we described in Section 3.1, General Comment 9, the PAWG (see NRC 2000a) expects that an analogue site would be used when there are currently no nearby residents. The applicant should provide the basis for not using an analogue site.

Energy*Solutions'* Response: Nearby industrial residents are described Section 1.3 of the main report.

Section 10.3.1, page 57. The second paragraph states that "Inputs for developing exposure parameter values under the ranching scenario include…restrictions related to BLM leases…." The document should explain why it is appropriate to include Bureau of Land Management (BLM) restrictions, given the potential for BLM policies to change in the future over the next 10,000 years.

Energy*Solutions'* Response: BLM leases are discussed in Section 10.3.1 of Appendix 2 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 11, page 62. The first paragraph states that "…process-level models may be developed." The text should clarify whether process-level models were, in fact, developed and integrated fully into the overall model; it should describe how the conceptual site model was actually implemented.

Energy*Solutions'* Response: Process modeling is addressed in Appendices 5, 6, 7, 8, 9, and 13 of Appendix A from revision 0.

ENERGYSOLUTIONS

6.0 REVIEW OF APPENDIX 4 – "RADIOACTIVE WASTE INVENTORY FOR THE CLIVE DU PA," MAY 28, 2011.

6.1 GENERAL COMMENTS

Comment 1. Clarification of Metrics: When the appendix cites a material mass, the material comprising the mass should be stated. For example, on page 6 (line 2), the text states, "…weight (total of 7,886,738 pounds corresponding to a mass of 3,577 Mg)." The document should indicate whether this is 3,577 Mg of DU, DUO3, or DUO2.

Energy*Solutions'* Response: Energy*Solutions* appreciates the recommendation. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Comment 2. Overlooked Reference: The list of references does not include the following document (DOE 2003):

Recycled Uranium, United States Production, Enrichment and Utilization. DOE/SO-0003. U.S. Department of Energy. May 2003.

This document and its supporting references may contain useful information on the levels of actinides and fission product contaminants in materials at the three gaseous diffusion plants.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

6.2 SPECIFIC COMMENTS

Section 2.2.2, page 5. The first paragraph mentions samples analyzed by the Savannah River Technology Center (SRTC) and by BWXT Services, Inc., for uranium, fission, and transuranic radionuclides. The last sentence of the paragraph provides the references for the results from SRTC, but not for BWXT Services, Inc.; the document should also provide a specific cross-reference to the results of the BWXT analysis.

Energy*Solutions'* Response: Results from the BWXT assessment are included in Appendix 4 of Appendix A from revision 0.

Section 2.2.2, page 6. The document states that "In January of 2010 EnergySolutions collected 15 samples that were analyzed for uranium isotopes (Table 14, in the Appendix). In April 2010 EnergySolutions collected 11 samples that were analyzed for uranium isotopes and 99Tc (Table 15, in the Appendix)." The number of samples should be reversed; Table 14 shows 11 samples for January 2010, and Table 15 shows 15 samples for April 2010.

Energy*Solutions'* Response: Energy*Solutions* appreciates the recommendation. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 2.3.2, page 7. *The document states that "Little information is available at this time regarding the exact nature and extent of the contamination within the contaminated DU population." Based on Comment 2 above (see DOE 2003), SC&A believes that this statement is not accurate. Additional information is available to augment the analysis.*

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 3.1.2, page 10. *The text states, "However, different sampling events for 99Tc and U indicate potentially different measurement types between sampling events." The meaning of this statement is not clear. What are different measurement types? How is this judgment made?*

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 3.2.1, page 12. *We believe that the subscripts in the denominator of equation 1 should be i (eye).*

Energy*Solutions'* Response: Energy*Solutions* appreciates the recommendation. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 3.2.2, page 14. *The document states:*

"In general, the differences this causes in uranium activity concentrations are fairly small relative to the likely effect on the PA model results, however, this will be tested in the model evaluation and sensitivity analysis."

The text should provide a specific cross-reference to the sensitivity analyses.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 3.2.3, page 16. *The text states:*

> *"If, given these relatively broad distributions, the uranium isotopes are not sensitive to any PA model endpoint, then the need to refine these distributions will be less."*

The text should indicate whether any analyses were conducted to determine if the uranium isotope distributions significantly affected the PA results.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 3.3, page 17. *The text states:*

> *"The effect of the inclusion of these data has been tested during model evaluation and is reported as part of the sensitivity analysis."*

The text should provide a specific cross-reference indicating where the results are reported.

Energy*Solutions'* Response: Sections 6.1.2, 6.2.2, and 6.3.2 of Appendix A from revision 0 address results of the sensitivity analysis. Energy*Solutions* appreciates the recommendation. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 3.3, page 18. The text should describe how the information contained in the box plots in Figure 3 (and later in Figure 5) should be interpreted. What statistical parameters do the boxes display?

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 3.3, page 19. The document states:

> *"Given the mobility of 99Tc and the width of the input distribution defined above, it is reasonable to expect that concentration of 99Tc will be a sensitive parameter."*

The text should indicate whether this expectation was tested and, if so, where the results are reported.

Energy*Solutions'* Response: Sections 6.1.2, 6.2.2, and 6.3.2 of Appendix A from revision 0 address results of the sensitivity analysis. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 3.3, page 20. The intent of the dashed lines in Figure 4 should be defined.

Energy*Solutions'* Response: Energy*Solutions* appreciates the recommendation. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 3.4, page 20. The introductory paragraph in this section states:

> *"As noted in Section 2.1, there are other potential contaminants in the SRS DU, including decay, activation and fission products (see Table 3). Given the only source of data for these radionuclides in SRS-2002, the concentrations are very low, and are unlikely to significantly contribute to the PA, however, input distributions for the mean concentrations of each of these radionuclides are developed and included in the PA to confirm that this is the case."*

To test the supposition that the contaminant radionuclides are unlikely to significantly contribute to PA, one might suppose that doses were assessed with and without these contaminants. The text does not indicate whether such a comparison was made. The document should state how the PA confirmed that the contaminants did not contribute significantly to the PA.

Energy*Solutions'* Response: Sections 6.1.2, 6.2.2, and 6.3.2 of Appendix A from revision 0 address results of the sensitivity analysis. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 3.5, page 21. It is stated here:

> *"The exact nature of the DU oxides that will be generated by the deconversion plants at Portsmouth and Paducah will not be known until their production, so this PA relies on the best information available to develop estimates. What is known is that the oxides will be primarily U3O8, and that they will be shipped and disposed in used DUF6 cylinders, some of which will contain residual contamination from reactor returns."*

It is assumed by the Licensee within the PA that the radioactive waste from GDPs will primarily be U_3O_8*. However, the exact nature of the oxides produced at the GDPs, as stated, is not known. A number of sources suggest that the deconverted DU material may also contain* UO_2*. At an NRC Website (NRC 2012), it says, "What will happen to the waste products from the de-conversion process? De-conversion permits the recovery of fluoride compounds . . . as the fluorine is extracted, the uranium is converted to an oxide (either U3O8 or UO2)." Even the PA (2011), on page 21 of Appendix 4, says, "Note that UO2 . . . may make up a small amount of the GDP DU."*

UO2 formed by some processes is known to be pyrophoric when finely divided. Finely divided uranium oxide materials may be created during processing, or they may form as a result of movement and abrasion during shipping and waste emplacement.

Pyrophoric wastes, of course, may present some hazards. Disposal of pyrophoric wastes, unless they are treated, prepared and packaged to be nonflammable, is forbidden by rule in Utah [R313-15-1009(2)(a)(vii)].

An ORNL document (Thein and Bereolos 2000) says, "UO2 may even be pyrophoric when the particle size is very fine." A U.S. Air Force translation of Budnikov et al. (1963) says, "Finely dispersed UO2 has pyrophoric properties, it burns to U3O8." Clayton and Aronson (1958) indicate that whether or not UO2 is pyrophoric depends on the process used in chemically preparing it. Eidson and Beals (2010) state, "Finely divided UO2 is pyrophoric, oxidizing in air to a variety of oxide phases including U3O8 as the most stable phase."

Gupta and Singh (2003) warn, "When dealing with uranium powder or some other powder in a finely divided form, it should be borne in mind that one is handling pyrophoric materials and that it is absolutely necessary to exercise the corresponding control and implement precautions in every stage of production and processing . . ."

Either the Licensee must make provisions for exclusion of UO2 from the waste, or the PA should justify disposal of waste containing UO2 at the site. Factors to consider include development of finely divided particles and possible pyrophorism during physical transport by rail or road, placement in an embankment, or geochemical modification subsequent to burial.

Energy*Solutions'* Response: As part of its Class A West Amendment Application (and condition 16.D of the associated License UT 2300249), Energy*Solutions* is prohibited from managing pyrophoric radioactive waste. Licensing of a Federal Cell with the Division-approved Class A West Embankment design does not alter the appropriateness of this condition. Development and submission of the depleted uranium Performance Assessment does not change this limitation.

Section 3.5.2.3, page 23. Please provide a complete reference for "(personal communication, Tammy Stapleton, April 2011)."

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

7.0 REVIEW OF APPENDIX 5 – "UNSATURATED ZONE MODELING FOR THE CLIVE PA," MAY 28, 2011

7.2 SPECIFIC COMMENTS

Section 2, page 7. The Final Report (first paragraph, page 55) states that "the waste is more concentrated [when placed lower in the embankment] since it is arranged into a smaller volume, thereby decreasing the duration of breakthrough at the well, and increasing its amplitude." Appendix 5 should provide a schematic similar to Appendix 7, Figure 1, for the saturated zone modeling that shows the different arrangements of the wastes as a function of the three burial depths.

Energy*Solutions'* Response: Energy*Solutions* appreciates the Division's recommendation. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 3.1, page 11. The text indicates that the distribution of recharge rates is based on 18 years of historical data. The text should explain the rationale for not adjusting the distribution to include potential climatic changes (wetter) and subsequent impacts to precipitation. Studies at Yucca Mountain have suggested significant climate changes over the next 10,000 years (e.g., BSC 2004).

Energy*Solutions'* Response: While included in this Compliance Report as part of qualitatively informing the Performance Assessment of the Federal Cell, Energy*Solutions* agrees with NRC cautions and recognizes that regulatory compliance should include limited,

> "*consideration given to the issue of evaluating site conditions that may arise from changes in climate or the influences of human behavior should be limited so as to avoid unnecessary speculation*"(NRC, 2000).

Furthermore,

> "*[t]hese events are envisaged as broadly disrupting the disposal site region to the extent that the human population would leave affected areas as the ice sheet or shoreline advances. Accordingly, an appropriate assumption under these conditions would be that no individual is living close enough to the facility to receive a meaningful dose.*" (NRC, 2000).

As such, Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 3.2, page 15. The text at the end of the fourth paragraph states, "Since the upper filter layer is assumed to have been silted up and is therefore ineffective at diverting infiltrating water, it is assigned a lateral flow of 0 cm/yr (0 in/yr)." The document should clarify why, after the upper flow barriers are compromised, water will not collect above the clay liner ("bathtub effect") and provide a driving force to increase the infiltration rates above those predicted by HELP and UNSAT-H.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 5.1.5 and 5.1.6, page 27. Please provide additional justification for the modeled post-installation upper and lower radon barriers since the values used are orders of magnitude lower than that indicated as being appropriate in NUREG guidance (see Benson et al., 2011).

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 8.0, page 30. The document should provide the mass-balance information for both the flow and contaminant transport from the model simulations.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 8.3, page 37. The last sentence in the section states, "Numerical testing demonstrated that the geometric zoning produces stable solutions for the top slope and side slope models with the Runge-Kutta method up to flow rates of 5 cm/year." The text should provide a specific reference to where this work is presented.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 9.2.1, page 49. The text states, "Air-phase advection is not included in the Clive DU PA Model. It is assumed that the advective flux of gases is negligible compared to the diffusive gas flux." The document should provide additional justification for this statement, since it is a major assumption in predicting radon flux back to the surface. If a total pressure gradient exists in a soil as a result of external forces, such as atmospheric pumping or diurnal temperature changes, gases, especially when considering dispersion, will experience net flow, e.g., from points of *higher to lower pressure. Furthermore, it has been shown that relatively small gradients in total pressure can result in advective gas fluxes that are much larger than diffusive gas fluxes (Thorstenson and Pollock 1989; Massmann and Farrier 1992; Weisbrod et al. 2009; Ganot et al. 2012).*

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

8.0 REVIEW OF APPENDIX 6 – "RADIONUCLIDE GEOCHEMICAL MODELING FOR THE CLIVE DU PA," MAY 28, 2011

8.1 GENERAL COMMENTS

<u>Comment 1. Up-to-Date References:</u> Appendix 6 uses data developed for the Yucca Mountain Site Characterization Project's Total System Performance Assessment to define solubilities for several species. The source document is LANL 1997. There are more recent Yucca Mountain studies that should be considered to be sure that the most current sources are considered. This includes "Dissolved Concentration Limits of Radioactive Elements," ANL-WIS-MD-000010, Revision 05, July 2005 (Bechtel SAIC 2005).

Energy*Solutions'* Response: Energy*Solutions* appreciates the suggestion. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

<u>Comment 2. Reactions with Water:</u> This appendix does not consider reactions of depleted uranium oxides with water. Please provide justification for not considering reactions of depleted uranium oxides with water. Particularly due to the potential to create flammable, explosive or pressurizing gases, such as hydrogen DUO3 is an example of depleted uranium oxide that is potentially prone to production of pressurizing gases, even at ambient temperatures. As stated by Thein and Bereolos (2000):

There has been a continuing concern that moisture and other volatiles theoretically can produce pressurizing gases during long-term, sealed storage via radiolysis. Reduction of this potential source of pressurization is a primary reason for treating the uranium oxides. Heating uranium oxide will reduce moisture content to less than 0.5 wt % and similarly reduce equivalent quantities of residual species (e.g., hydrates), which might produce pressurizing gases. The 0.5 wt % specification is a generally accepted limit that is reasonable to achieve and for which no negative effects have been identified. Reducing the amount of moisture present also reduces the potential for and rate of container corrosion.

Free water is eliminated during heating at temperatures above 100°C (i.e., simple evaporation in a vented vessel). The three principal uranium oxides (UO2, UO3, and U3O8) all form hydrates. However, UO2 and U3O8 form hydrates only when prepared via a precipitation reaction. On the *other hand, UO3 can form hydrates directly through reaction with H2O between temperatures of 5 and 75°C (Vdovenko 1960).*

It is not presently known if DUO2 and DU3O8 present in the proposed LLW will be formed during de-conversion at the GDPs via a precipitation reaction and therefore be susceptible to hydrate formation and gas production if buried in containers at Clive. However, it is known that the SRS depleted uranium LLW is in the form of UO3. It can therefore presumably "form hydrates directly through reaction with H2O between temperatures of 5 and 75°C (Vdovenko 1960)." Subsurface temperatures at Clive are expected to be between temperatures of 5°C and 75°C. If UO3 is buried at Clive, it will ultimately be exposed to soil moisture. This could occur in the unsaturated portion of the vadose zone, the saturated portion of the vadose zone (i.e., the capillary fringe, which, in fine-grained materials such as fine silts or clays, may be as high as 5–10 feet above the water table), or the saturated zone (located beneath the water table). During prolonged inundation, as during a large-scale intermontane lake level rise, the porous media surrounding buried UO3 would ultimately be saturated. This would occur even in the initially unsaturated portion of the vadose zone, which would become saturated over time. Since exposure to moisture leads to hydrate formation, and hydrate formation is associated with production of potentially hazardous gases via radiolysis, it follows that the PA should discuss how this problem can be obviated.

Energy*Solutions'* Response: As part of the application of Energy*Solutions'* current Division-approved procedure for waste disposal in the Class A West Embankment with CLSM, disposal of depleted uranium in the Federal Cell will not be sealed in an air-tight condition. Therefore, any gases that may be formed after disposal of depleted uranium will be allowed to diffuse through the Federal Cell without the risk of increase pressurization or accumulation.

Comment 3. DU Solubility in Water and SRS Waste: *The DU oxide DUO_3, under oxidizing conditions, is moderately soluble in water (Weiner 2008). DUO_3 dissolved in groundwater will move offsite given enough time. Complexes of uranium with water and some other minerals such as sulfate and carbonate can also be fairly mobile in groundwater. The Utah limit on uranium in groundwater is 30 ug/L, comparable to about 27 pCi/L. The uranium in a plume that has moved downgradient from the embankment over time will decay to form radon-222 in areas where no cover-system exists to protect the general public or inadvertent intruders from exposure. As such, DUO3 in general, and SRS waste specifically, does not appear to be suitable for long-term subsurface burial at Clive. The PA should discuss this issue and justify why UO3 should be allowed to be disposed of at the Clive LLW Disposal Facility.*

Energy*Solutions'* Response: The mobility of depleted uranium under various geochemical conditions is considered in Appendix 6 of Appendix A from revision 0. Additionally, radon pore-space diffusion has been shown to be approximately 4 orders of magnitude lower in the presence of highly saturated media (Figure 5 of NUREG/CR-3409). Because the aquifer is in a saturated condition, it is extremely unlikely that radon formed within the aquifer would upwardly diffuse into the atmosphere.

In a related study by Schramke, Janet (2006), it was concluded that,

> *"if the uranium oxides U_3O_8 or UO_2 are placed in [the Class A West Embankment], interaction with infiltrating water is likely to result in replacement of the oxide phases by more-stable, less-soluble secondary solids. . . Therefore, as a consequence of the formation of increasingly stable phases, the uranium solids present in the [Class A West Embankment] would be expected to become less soluble with time. The solubilities of these phases would provide an upper limit for uranium concentrations in the leachate regardless of the total mass of uranium in the disposal cell. The [Class A West Embankment] is located above the water table in an arid environment. The [Class A West Embankment] design includes a clay liner and leachate collection system that will minimize the transport of waste constituents to the site groundwater. The site soils consist of fine-grained materials that are dominated by clay and carbonate minerals. Uranium in solution is known to be attenuated by sorption on clay minerals (Giblin 1980, Ames et al. 1983, Giammar 2001), carbonate minerals (Voudrias and Means 1993, Brown et al. 1999) and soil organic matter (Meunier et al 1989), which will limit the concentration of uranium in leachate that reaches the groundwater below the[Class A West Embankment]. Once the leachate travels to the groundwater, the uranium concentration will be decreased by dilution and dispersion as well as by sorption on the clay minerals, carbonates, organic matter, and other minerals present in the aquifer solids. In summary, the following processes at the [Class A West Embankment] would substantially reduce uranium concentrations at a groundwater point of exposure to levels considerably below the solubility of U_3O_8:*
>
> *• Formation of more-stable, less-soluble uranium phases within the disposal cell;*
>
> *• Uranium adsorption by clays, carbonates, and organic matter in the vadose zone;*
>
> *• Dilution by mixing of leachate with native groundwater; and*
>
> *• Uranium adsorption on aquifer materials in the saturated zone."*

8.2 SPECIFIC COMMENTS

Section 1.0, Table 3, page 2. *The notation "U" should be defined. SC&A presumes it refers to a uniform distribution with the indicated minimum and maximum.*

Energy*Solutions'* Response: Energy*Solutions* appreciates the Division's recommendation. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 2.0, page 2. *Please provide clarification as to whether the fill placed between the waste containers before the cell is closed would be radioactive bulk LLW or non-radioactive earthen material.*

Energy*Solutions'* Response: As is discussed in Section 2.4 of the Compliance Report and Appendices 2, 3, and 4 of Appendix A from revision 0, the Federal Cell will accept Class A low level radioactive waste (including some of the same backfill as described in Section 4.3 of the Class A West Amendment Application). Section 3.3 of the Compliance Report describes how containers of depleted uranium will be disposal in CLSM within the Federal Cell so that voids within and between the containers are filled.

Section 4.1.11, page 15. *Please provide a reference to the section of the PA that covers transport of technetium in groundwater at the site. Please also provide additional information on the role that waste acceptance criteria may play to exclude sources of DU having elevated concentrations of technetium-99.*

Energy*Solutions'* Response: Groundwater migration of technetium-99 from the Division-approved Class A West Embankment has been addressed in Attachment 3 of the Class A West Amendment Application (McCandless, 2012) and from the Federal Cell in Appendices 5, 6, and 11 of Appendix A from revision 0. Additionally, Section 3.1.3 of the Compliance Report suggests that, "*since the technetium-99 disposal concentrations are already limited to 1,720 pCi/g under the Class A West side slope, EnergySolutions proposes similar limitations be applied to the Federal Cell to include a disposal concentration limit for Tc99 of 23,800 pCi/g under the Federal Cell top slope.*"

Section 5.0, page 17. *The first sentence of the last paragraph states, "The potential for colloidal transport of actinides at the Clive facility is not incorporated into the PA model." The text then refers to actinide intrinsic colloids, which comprise one type of colloid. The text should discuss the potential for other types of colloids and colloidal-forming constituents in the waste (e.g., ligands).*

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 5.0, page 18. *The last two sentences of the first paragraph state:*

> *"Retention of colloids is favored at high ionic strength, low pH and in impermeable rock. The high ionic strength conditions in the saturated zone at Clive are counter to conditions considered favorable for colloid transport."*

The text should provide citations for the statement that retention of colloids is favored in high ionic strength solutions.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 5.0, page 18. *The first sentence in the second paragraph states:*

> *"In many cases the solubility of radionuclide species used in the transport model was based to some extent on the data provided in the proposed Yucca Mountain Project (LANL 1997) and the Nevada National Security Site (NNSS, formerly the Nevada Test Site) (Sandia 2001) modeling."*

The discussion should also include the solubility and speciation work with radionuclides in high ionic strength brines that has been performed (and is currently ongoing) to support the Waste Isolation Pilot Plant.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

9.0 REVIEW OF APPENDIX 7 – "SATURATED ZONE MODELING FOR THE CLIVE DU PA," MAY 28, 2011

9.1 GENERAL COMMENTS

Comment 1. Vertical Hydraulic Conductivity and Gradient: Please provide additional discussion on how vertical components of hydraulic conductivity and vertical gradients are considered in the PA.

Energy*Solutions'* Response: Vertical conductivity and gradients are addressed in Appendices 3, 5, and 7 of Appendix A from revision 0.

9.2 SPECIFIC COMMENTS

Section 3.1, page 3. Typically, hydraulic conductivity has a log-normal distribution, as opposed to the normal distribution assigned in the model. The applicant should provide the Excel® spreadsheet prepared by R. Sobocinski, the random-effects analysis, and any other information that supports the derivation of normal distribution for the hydraulic conductivity.

Energy*Solutions'* Response: Distribution shape justification for the Federal Cell's saturated zone is documented in the Revised Hydrogeologic Report (Energy*Solutions*, 2012a).

Section 3.3, page 4. The applicant should provide any factors taken into consideration when developing the distribution of hydraulic gradients from off-normal conditions (e.g., impacts by increased infiltration due to climatic changes, or gully erosion/plant or animal penetration of the liner).

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 4.1, page 7. The text in the last paragraph on the page states:

> *"An aquifer thickness for each of the four locations was calculated as the difference between the recorded elevation of the water table and the elevation of the bottom of the shallow aquifer. Since the four locations do not quite form a square, triangulation was used to calculate an average thickness across the region."*

The document should explain the rationale for this approach and provide any information that supports the assumption that uniform mixing is likely to occur over the "aquifer thickness" described, i.e., to a depth of 16 or more feet beneath the waste unit. This assumption is important since there is a direct linear relationship between the thickness of the aquifer (vertical extent of plume) and the concentrations arriving at the monitoring well.

Energy*Solutions'* Response: Aquifer thickness beneath the Federal Cell's saturated zone have been documented in the Revised Hydrogeologic Report (Energy*Solutions*, 2012a). Even so, Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 4.2, page 11. *The text in the second paragraph states, "Only longitudinal dispersion will be considered for this discussion because of the geometry of the transport pathway." The applicant should provide the longitudinal dispersivity value used in the model, as well as any studies (e.g., grid convergence) or calculations that demonstrate the grid spacings are sufficiently small.*

The applicant should also provide the mass-balance information for both the flow and contaminant transport from the model simulations.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

10.0 REVIEW OF APPENDIX 10 – "EROSION MODELING FOR THE CLIVE PA," MAY 28, 2011

10.1 GENERAL COMMENTS

Comment 1. Below-Grade Disposal: *Please provide a discussion of how the performance of the system may change if the top of the cover system was set at or below natural grade, particularly with respect to gulley formation, radon releases, and the ability to meet groundwater GWPL's.*

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Comment 2. Gully Screening Model: *As stated in Section 4.0, "The purpose of the initial gully model in the Clive PA model is to determine whether gullies and fans are significant contributors to dose and whether a more sophisticated erosion model is needed. A simple screening-type gully model was developed with the advice of Dr. Willgoose." Similarly, the Final Report on the Clive DU PA states in Section 4.1.2.9, "The gully model is a simplistic model of gully erosion and landscape evolution. For example, the model assumes that 1) a gully forms instantly and doesn't change with time, 2) that between 1 and 20 gullies only are allowed to form, and 3) that gullies do not interact with other model processes such as biotic transport (e.g., no plants grow in a gully). This stylized model was used to provide a basis for discussion of whether or not gully* *formation is an important consideration in this waste disposal system, and to evaluate the consequences of human activities that inadvertently cause doses to future humans." In Section 6.2.1 of the Final Report, it is shown that the presence of gullies increases the peak mean dose to a rancher from 4.37 to 20.9 mrem/y TEDE, and is due to thinning of the cover layers (cap and fill materials) and possible direct exposure of the DU waste. Based on this information, it would appear that gully formation is an important consideration in evaluating the waste disposal system. The report should explain why a more sophisticated erosion model is not needed, including how the assumed 1 to 20 gullies can be reconciled with the actual number of gullies expected to form during a minimum of 10,000 years. If a more sophisticated erosion model is developed, the report needs to describe the new model, including how it will be implemented in the PA and its effect on the peak mean dose to a rancher or other relevant scenarios.*

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

10.2 SPECIFIC COMMENTS

<u>Section 4, page 5.</u> The text in the first bullet states, "Gullies are assumed to form instantaneously, from the time of loss of institutional control." In Section 5.1.2 of the Final Report (page 43), the text indicates that the institutional control period of 100 years is assumed for the dose calculations. The document should indicate when gullies are instantaneously formed for the PA.

Energy*Solutions'* Response: Energy*Solutions* agrees that the intent of the cited statement from Section 5.1.2 of Appendix A from revision 0 is that gullies are instantaneously formed following the loss of institutional control.

<u>Section 4, page 5.</u> Please provide additional rationale for excluding potentially important biological processes in considering gully formation. For instance, burrowing of animals within gullies since presumably the gullies could be penetrated more readily in areas of rip rap erosion.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

<u>Section 6.2, page 17.</u> The second sentence in the first paragraph states, "In the current Clive PA model, waste is buried only under the top slope, so the quantity of concern is the distance from the ridge that the gully gets into the waste." The text should clarify whether this is the case for all three burial scenarios.

Energy*Solutions'* Response: Energy*Solutions* agrees that the intent of the cited statement from Section 6.2 of Appendix 10 of Appendix A from revision 0 is that the depleted uranium Performance Assessment models burial of depleted uranium only beneath the top slopes for all three depth scenarios summarized in Section 2.4 of the main report.

11.0 REVIEW OF APPENDIX 11 – "DOSE ASSESSMENT FOR THE CLIVE DU PA," MAY 28, 2011

11.2 SPECIFIC COMMENTS

Section 3.1, page 10. To be consistent with other sections of the PA, "2.5 million years" should be changed to "2.1 million years."

Energy*Solutions'* Response: Energy*Solutions* agrees that the intent of the cited statement from Section 3.1 of Appendix 11 of Appendix A from revision 0 is 2.1 million years. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 3.1, page 11. The document should provide a basis for the statement that "the assumption that future land use and receptors will be similar to today's is likely conservative (i.e., protective)."

Energy*Solutions'* Response: Energy*Solutions* recognizes the Division's request for expanded discussion in Section 3.1 of Appendix 11 of Appendix A from revision 0. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 3.2, pages 12 and 13. The text states that "screening-level" calculations will be performed to determine what quantity of plant material and volume of water would need to be consumed to exceed the radiation dose performance objective. Provide a specific cross-reference to the results of these "screening-level" calculations.

Energy*Solutions'* Response: Screening level calculations addressing plant and water ingestion are discussed in Section 5.1.5, 5.1.6, and 5.4.5 and Appendices 1, 9, ad 11 of Appendix A from revision 0.

Section 3.3.1, page 16; Section 3.3.3, page 18. A de minimis dose value is developed based on EPA's de minimis risk level and dose equivalence. Given that the Energy Policy Act of 1992 contained provisions revoking the NRC's 1986 and 1990 Below Regulatory Concern Policy Statements, the applicant should provide the justification for proposing a de minimis (i.e., below regulatory concern) dose value.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 3.4.3, page 22. With regard to the dose conversion factors (DCFs), the text should clarify what is meant by the phrase "proof-of-principle uncertainty distributions."

Energy*Solutions'* Response: As is noted in Section 3.4.3 of Appendix 11 of Appendix A from revision 0, the term "*proof-of-principle uncertainty distributions*" related to evaluation of the appropriateness of use of the distribution and uncertainties of Kocher's radiation effectiveness factors to the depleted uranium Performance Assessment's use of dose conversion factors. In doing so, it was assumed that for the carcinogenic effects of radiation, that the radiation effectiveness factors are equivalent to the relative biological effectiveness, which is in turn equivalent to radiation weighting factors. Since the radiation effectiveness factors account for the fact that some types of radioactive decay result in more biological damage than others.

In the depleted uranium Performance Assessment, the radiation-type specific radiation effectiveness factors were used as modifying distributions to the dose conversion factor point estimates presented in NRC's FGR 13. As the radiation effectiveness factors are radiation type specific, they are generally applicable to the predominant radiation characteristics of the particular radionuclide of concern. As part of the analysis reported in Appendix A from revision 0, the validity of this assumption is confirmed. Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 3.4.5, page 25. With regard to the uranium toxicity analysis, the text should clarify what is meant by the phrase "a proof-of-principle exercise."

Energy*Solutions'* Response: As is noted in Section 3.4.5 of Appendix 11 of Appendix A from revision 0, the term "*proof-of-principle exercise*" relates to the potential non-radiation related toxicity of depleted uranium. Oral toxicity criteria for uranium are published by EPA in relation to the Superfund Program (EPA, 2011) and by EPA's Office of Water in relation to drinking water standards (EPA, 2000). However, since there is a five-fold difference between these criteria, both were employed in the depleted uranium Performance Assessment to determine the sensitivity of uranium health effect results to differences in these recommended toxicity criteria for uranium. As part of the analysis reported in Appendix A from revision 0, the validity of this assumption is confirmed.

Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 3.4.5, page 25. Instead of simply referencing EPA documents, the PA needs to provide a brief description of the Superfund and drinking water uranium RfDs. For example, are the RfDs for soluble or insoluble uranium salts, or both? This appendix states that there is a five-fold difference between the two RfDs; a brief description of why there is this difference would be helpful. Also, what was the basis for assigning a 50/50 probability to each RfD? Why not simply assign 100% probability to the Superfund RfD, since it is the more recent, or 100% probability to the drinking water RfD, since it is the more limiting?

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 4.5, page 30. The text does not describe how "non-standard" receptors (e.g., teenagers, children, infants, pregnant women, Native Americans) were addressed. The text should address such non-standard receptors or explain why they do not need to be addressed.

Energy*Solutions'* Response: Energy*Solutions* recognizes the Division's request for expanded discussion in Section 4.5 of Appendix 11 of Appendix A from revision 0. However, the comment does not identify incompleteness. If requested, Energy*Solutions* will consider expanding the discussion of Section 4.5 of Appendix 11 of Appendix A from revision 0 as part of its responses to the Division's future Round 1 Interrogatories.

12.0 REVIEW OF APPENDIX 12 – "DECISION ANALYSIS METHODOLOGY FOR ASSESSING ALARA COLLECTIVE RADIATION DOSES AND RISKS," MAY 30, 2011

12.2 SPECIFIC COMMENTS

Section 1, page 1. The third and fourth paragraphs refer to the "Exposure and Dose Documentation" white paper. The applicant should clarify which reference is meant; we assume it is the "Dose Assessment for the Clive DU PA" (May 28, 2011) white paper (Appendix 11). Please confirm or clarify.

Energy*Solutions'* Response: The reference, as clarified above, is correct.

Section 1, page 1. The fourth paragraph refers to the ALARA regulation as "a second decision rule;" however, a first decision rule has not been identified.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 1, page 1; Section 2, page 2. In addition to the DOE and NRC documents listed in Section 1 and ICRP Publication 26 (ICRP 1977) discussed in Section 2, ICRP Publication 101b (ICRP 2006) provides a good description of the ALARA concept, including a history of its evolution. ICRP 101b describes ALARA as an "optimization" process. It should be ascertained that the information contained in this appendix is consistent with ICRP 2006.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Section 2, page 3. As discussed in Section 3.1, General Comment 1 for the Final Report, the government has indicated that the use of discount factors other than the 3% and 7% may be necessary when intergenerational consequences are involved [see NUREG/BR-0058 (NRC 2004) and OMB Circular A-4 (OMB 2003)]. In addition, NUREG-1757 (NRC 2006) replaces NUREG-1727 (NRC 2000b), as stated in the abstract for NUREG-1757.

Energy*Solutions'* Response Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

13.0 REVIEW OF APPENDIX 15 – SENSITIVITY ANALYSIS METHODS ("MACHINE LEARNING FOR SENSITIVITY ANALYSIS OF PROBABILISTIC ENVIRONMENTAL MODELS," MAY 29, 2011)

13.1 GENERAL COMMENTS

Comment 1. Relevance to PA: The document, Machine Learning for Sensitivity Analysis of Probabilistic Environmental Models (May 29, 2011), is a generic presentation describing various approaches to sensitivity analyses. As such, it is not a useful document by itself to support the sensitivity analyses described in Section 6.0 of the Final Report. The sensitivity analysis methods report should be expanded to discuss the sensitivity index and the partial dependence plots for specific parameters modeled in the DU PA.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

14.0 REVIEW OF APPENDIX 16 – "MODEL PARAMETERS FOR THE CLIVE DU PA MODEL VERSION 1.0," MAY 28, 2011

14.2 SPECIFIC COMMENTS

Section 3.2, Table 5, page 5. The comment associated with Dose _Simulation _Duration states, "User can set this value, up to 10,000 yr, per UAC R313-28-8." UAC R313-25-8(5)(a) states that "the compliance period shall be a minimum of 10,000 years" (emphasis added), not a maximum of 10,000 years.

Energy*Solutions'* Response: The regulatory basis for use of a 10,000 year Period of Performance is addressed in Section 1.3 of the main report.

15.0 SECTION 4.1, FIGURE 1, PAGE 7. THE TEXT OF FIGURE 1 INDICATES THAT THE BRANCHING FRACTIONS WERE OBTAINED FROM "THE NUCLEAR WALLET CARDS (TULI, 2005)." THE REPORT SHOULD INCLUDE A REFERENCE SECTION, WITH A COMPLETE REFERENCE FOR TULI 2005.APPENDIX 17 – QUALITY ASSURANCE PROJECT PLAN

15.1 GENERAL COMMENTS

Comment 1. Missing Approvals: The signature page of Document No. 06245-001 available on the web is incomplete in that the indicated signatures are not provided and the signature page does not include approval by the State of Utah. The document should indicate that all necessary approvals have been obtained. This comment also applies to Appendices A, B, and C.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Comment 2. Lack of Page Numbers: There no page numbers in the document. Page numbers should be added.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Comment 3. GoldSim Model Calibration: The only GoldSim model calibration appears to be that done to counteract numerical dispersion on air diffusion (Appendix 5, Section 9.4.3). Please provide a discussion of the role that model calibration has taken in substantiating that GoldSim adequately simulates the physical, chemical and biological site processes.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

15.2 SPECIFIC COMMENTS

Section 5.0, Table 2. Several scheduled completion dates are listed as TBD. Please indicate when the tasks with TBD dates were completed and that other scheduled tasks with specific completion dates have been completed.

Energy*Solutions'* Response Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.

Appendix B. Section 2.6. Please provide the verification and benchmarking exercises that were designed to test the GoldSim abstractions against results obtained from process-level analytical and/or numerical models, including (but not limited to) all of the simulated fate and transport pathways, input/output links to external models (e.g., HELP, atmospheric modeling), probabilistic components and dose assessments.

Energy*Solutions'* Response: Energy*Solutions* does not consider this comment to be relevant to completeness. It will be addressed during the substantive review of the filing.