UTAH LOW-LEVEL RADIOACTIVE WASTE

DISPOSAL LICENSE - CONDITION 35 (RML UT2300249)

COMPLIANCE REPORT

June 1, 2011

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

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EXECUTIVE SUMMARY

In early 2009, the U.S. Nuclear Regulatory Commission voted to initiate 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 Radiation Control Rule (URCR) Section R313-25-8(5) prohibits disposal of significant quantities of concentrated depleted uranium (more than one metric ton in total accumulation) after June 1, 2010, until the Utah Division of Radiation Control Executive Secretary's approves a performance assessment that demonstrates that Energy*Solutions* will meet the performance standards specified in 10 CFR Part 61 and corresponding provisions of Utah rules.

As required by URCR313-25-8(5) and in accordance with URCR313-25-8(2), Energy*Solutions* has competed and hereby submits to the Division's Executive Secretary for approval an in-depth site-specific performance assessment before disposal of depleted uranium. Once approved, it is Energy*Solutions*' objective to file documentation requesting its Radioactive Material License be amended to include disposal of depleted uranium.

Because of the processes, depleted uranium from the Savannah River Site also contains small quantities of waste fission products and transuranic elements. The estimated mass of depleted uranium from the Savannah River Site proposed for disposal at Energy*Solutions*' Clive Facility is 3,577 metric tons, (5,408 drums). Furthermore, this report 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 Executive Secretary 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* supports their claims of compliance with the license condition through the development and execution of a detailed, site-specific, 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 Radioactive Material License.

While also included in this Compliance Report as part of improving qualitative understanding of facility performance, Energy*Solutions* recognizes that events that are projected to broadly disrupt the disposal site region should generally be expected to drive human populations away from the affected areas. 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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ACRONYMS AND ABBEVIATIONS

Term	Definition
11e.(2)	Section 11e.(2) of the Atomic Energy Act of 1954, as amended
2008 LRA renewal	License Renewal Application dated 20 June 2005
ABC ALA	Application for License Amendment (Classes A, B & C waste), dated December 13,2000
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 ABBEVIATIONS (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 ABBEVIATIONS (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 ABBEVIATIONS (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
URCR	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, 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 the Clive Facility, located 85 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.

In early 2009, the U.S. Nuclear Regulatory Commission (NRC) voted to initiate rulemaking to require a site-specific analysis for the disposal of large quantities of depleted uranium (DU). Since that time, Energy*Solutions* has received 3,577 metric tons (5,408 drums) of uranium trioxide (DUO_3) waste that has been declared surplus from the Savannah River Site (SRS). In the future, Energy*Solutions* is also considering 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 potential Federal Cell as ultimate destination for depleted uranium. In accordance with Utah Radiation Control Rule (URCR) Section R313-25-8(2), Energy*Solutions* is required to complete and submit to the Division's Executive Secretary for approval an in-depth site-specific performance assessment for the disposal of depleted uranium. Once approved, it is Energy*Solutions'* objective to file documentation requesting its Radioactive Material License be amended to include disposal of depleted uranium.

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 85 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 (2008 RML renewal).

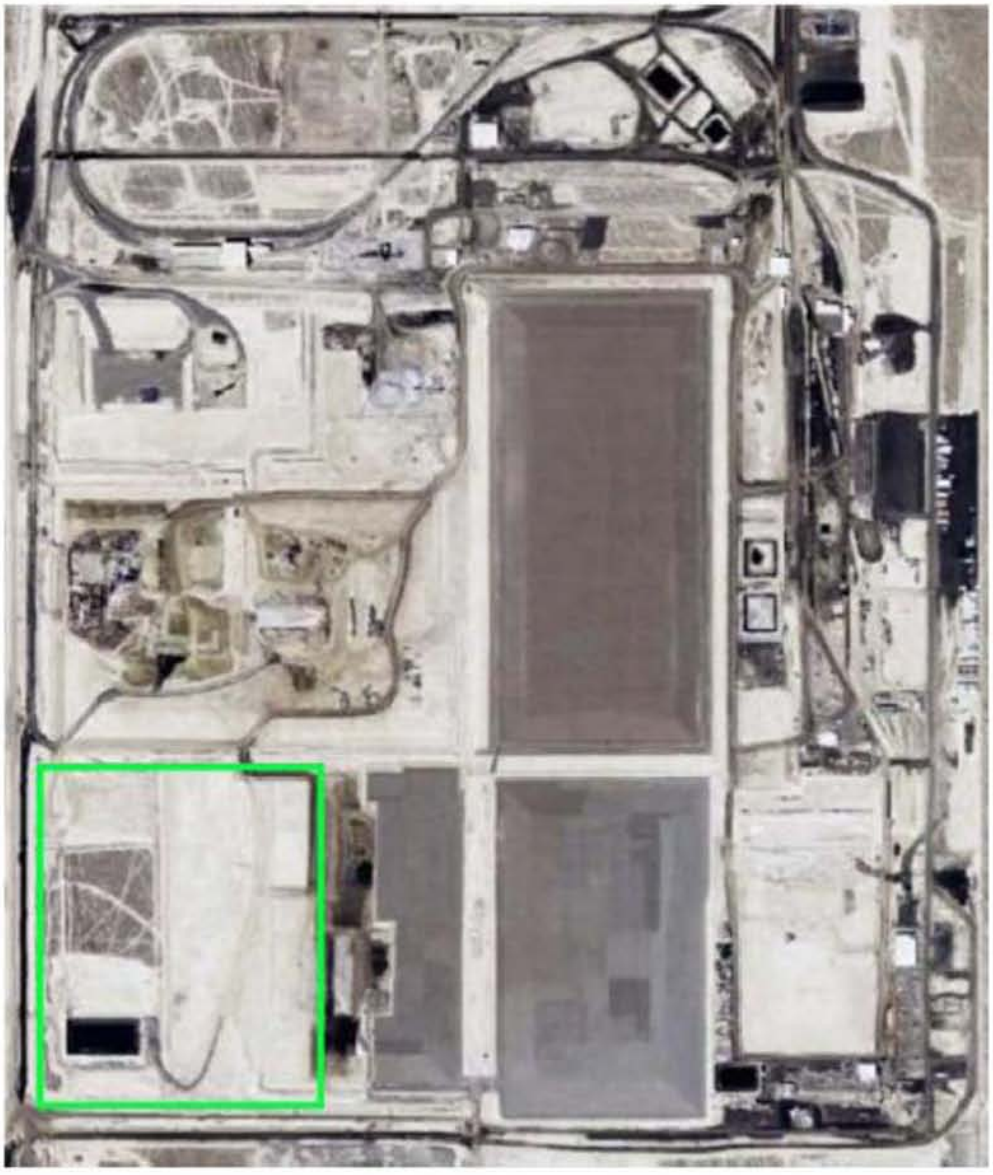

Figure 1-1, Energy*Solutions*' Proposed Depleted Uranium Disposal Location

Energy*Solutions* conducts other treatment and disposal operations in areas adjacent to its Class A embankments. These activities include mixed hazardous waste 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 Clive facility consists of a disposal cell, a treatment building, a storage building and an operations building. The treatment building is used for stabilization and solidification of certain waste streams and the operations building is used for alternative treatment technologies, such as macro-encapsulation and microencapsulation, as well as stabilization and storage of mixed waste.

Energy*Solutions* also disposes of uranium and thorium by-product material {11e.(2)} under a license issued by 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. Similarly, Energy*Solutions* also operates under Air Quality Approval Orders, issued by the Utah Division of Air Quality (UDAW).

1.2 Regulatory Summary

The Division regulates activities in the State of Utah that involve radioactive materials, some types of radioactive waste, and radiation. To assess whether Energy*Solutions*' Clive facility location and containment technologies are suitable for the disposal of depleted uranium and the continued protection of human health, specific performance objectives for land disposal of radioactive waste have been set forth in the URCR. Additionally, Energy*Solutions*' Clive facility is governed by the Department of Environmental Quality's groundwater and air regulatory requirements. Those rules potentially impacted by Energy*Solutions*' intent to dispose of depleted uranium include:

- "General Provisions" – URCR R313-12
- "Violations and Escalated Enforcement" – URCR R313-14
- "Standards for Protection Against Radiation" - URCR R313-15
- "Administrative Procedures" – URCR R313-17
- "Notices, Instructions and Reports to Workers by Licensees or Registrants—Inspections" – URCR R313-18
- "Requirements of General Applicability to Licensing of Radioactive Material" – URCR R313-19
- "Specific Licenses"- URCR R313-22
- "License Requirements of Land Disposal of Radioactive Waste" – URCR R313-25
- "Generator Site Access Permit Requirements for Accessing Utah Radioactive Waste Disposal Facilities" – URCR R313-26

- "Payments, Categories and Types of Fees" – URCR R313-70
- "Ground Water Quality Protection Rules" – Utah Administrative Code (UAC) Rule 317-6
- "Air Quality Protection Rules" – Utah Administrative Code Rule 307

1.3 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 1-2.

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.

[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.

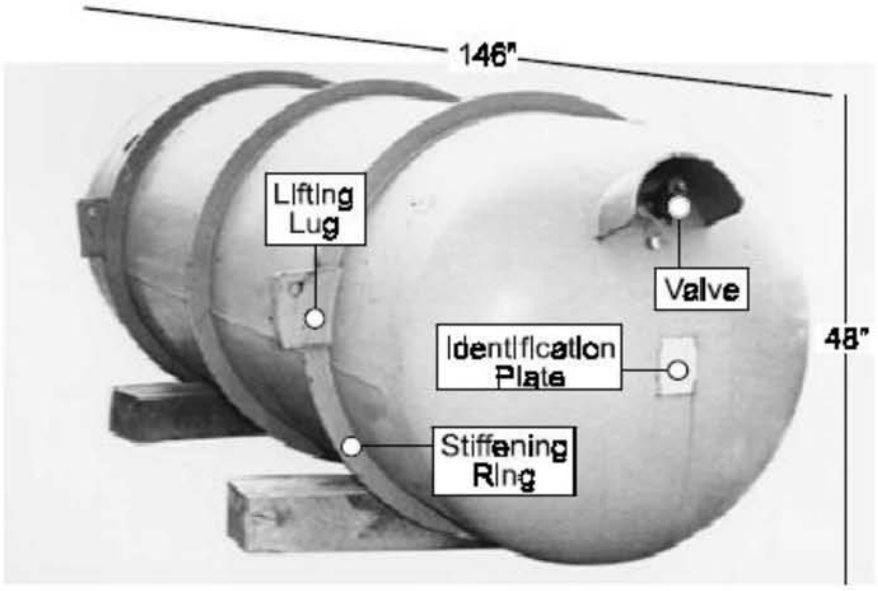

Figure 1-2, Typical Depleted Uranium Storage Cylinder (DOE, 1999)

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.

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.

1.4 Basis for Performance Assessment

URCR R313-25-8 requires that a performance assessment be performed and approved by the Department of Environmental Quality prior to the disposal of significant quantities of depleted uranium. The required performance assessment must meet the provisions of section 2(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 performance of the required performance assessment, it is useful to consider the guidance the 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). More recent guidance is contained in NUREG-1854, (NRC, 2007).

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

Section 2 (a) addresses the time period for compliance. It states:

> *"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."*

From a compliance period perspective, 10,000 years is the time period for a quantitative analysis and is consistent with Federal rules and guidance. Given the nature of depleted uranium, a qualitative analysis out to the peak dose period is also warranted to inform the performance assessment. Use of the 10,000 year time period for compliance is consistent with federal regulations (e.g., 40 CFR 191) and NRC guidance. Extending the analysis qualitatively until peak dose 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.

Consequently, for purposes of applying the performance standards for protection of the general public (URCR313-25-19) and for protection of individuals from inadvertent intrusion (URCR313-25-20), the Division should chosen to use the 10,000 year compliance period with a qualitative analysis to cover the period beyond to the peak dose.

The performance standard for protection of the general public (URCR313-25-19) is based on the 1959 standards of International Commission on Radiological Protection (ICRP) Publication 2 methodology. URCR313-15 rules are based on newer ICRP guidance in Publications 26 and 30. Part 20 uses the total effective dose equivalent (TEDE) rather than the whole body dose. NRC has recognized the inconsistency between the dose methodologies and has issued guidance to allow the use of newer guidance. This approach was taken for Yucca Mountain in 10 CFR Part 63, NUREGs -1854 and 1573, and in the NRC Decommissioning Criteria for West Valley. As noted 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)."

Consequently, the Division should use for purposes of applying the performance standards for protection of the general public (URCR313-25-19) the total effective dose equivalent rather than the whole body dose.

The performance standard for protection of individuals from inadvertent intrusion (URCR313-25-20) 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 Part 61 has been issued, the standard used by NRC and others for low-level radioactive waste disposal licensing has been an intruder standard of 500 mrem/yr. The 500 mrem standard is also used in DOE's waste determinations implementing the Part 61 performance objectives (NUREG-1854). It is noted that 500 mrem/yr was also the standard proposed in Part 61 in 1981 (46 FR 38081, July 24, 1981). Additionally, 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, DRC should use for purposes of applying the performance standard for protection of individuals from inadvertent intrusion (URCR313-25-20) a 500 mrem/yr threshold for the intruder dose.

The performance standard for stability requires the facility 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.

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 right next 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 beyond 1,000 years.

Consequently, the Division should use for purposes of applying the performance standard for stability of the disposal site after closure (URCR313-25-22) an approach consistent with past standard setting practice.

Energy*Solutions* has demonstrated that its disposal site design and closure will provide reasonable assurance that long-term stability will be achieved 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.

URCR Rule 313-25-8(2), as amended, requires Energy*Solutions* to demonstrate to the Division that 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 facility's performance objectives and the Division's regulatory requirements. Toward that end, Energy*Solutions* has conducted a detailed, site-specific, 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 demonstrates Energy*Solutions*' compliance with the URCR 313-25-8(2) and those other regulatory requirements affected by the proposed depleted uranium disposal.

2. REGULATORY COMPLIANCE AND PERFORMANCE OBJECTIVE SATISFACTION

As part of the renewal of its Radioactive Material License in 2008 (RML UT2300249), the Division certified that Energy*Solutions'* is in compliance with all applicable regulatory requirements (2008 RML renewal). As such, activities conducted at Energy*Solutions'* Clive site are designed to protect the health and safety of facility 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.

Additionally, Energy*Solutions* continues to demonstrate that it is financially capable to carry out all licensed activities. Energy*Solutions* provides financial assurances sufficient to fund the safe closure of the facility, as well as the long-term monitoring and maintenance of the facility. Energy*Solutions* also provides information about the required qualifications of those persons who will operate the facility and about its existing training program.

For the majority of applicable regulatory requirements, disposal of depleted uranium 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 URCR Rule 313-25-8(2), Energy*Solutions* has conducted a detailed, site-specific, probabilistic performance assessment to demonstrate to the Division that:

1) its proposed methods for disposal of depleted uranium will ensure that future operations, institutional control, and site closure will continue to be conducted safely,
2) the site will continue to comply with its performance objectives, and
3) it will continue to be in compliance with applicable Division requirements.

In addition to URCR R313-25-8(2), other regulatory requirements affected by the proposed depleted uranium disposal with which Energy*Solutions* must also demonstrate compliance are listed in Table 2-1 and addressed in further detail in this Section.

- Standards for Protection Against Radiation" - URCR R313-15
- Notices, Instructions and Reports to Workers by Licensees or Registrants" – URCR R313-18
- License Requirements of Land Disposal of Radioactive Waste" – URCR R313-25
- Ground Water Quality Protection Rules – R317-6
- Air Quality Protection Rules – R307

Table 2-1

Applicable Requirements Potentially Impacted by the Disposal of Depleted Uranium

URCR	REASON
R313-15-101	Radiation Protection Programs
R313-15-201	Occupational Dose Limits for Adults
R313-15-301	Dose Limits for Individual Members of the Public
R313-15-402	Radiological Criteria for Unrestricted Use
R313-15-601	Control of Access to High Radiation Areas
R313-15-801	Security and Control of Licensed or Registered Sources of Radiation
R313-15-902	Posting Requirements
R313-15-906	Procedures for Receiving and Opening Packages
R313-15-1002	Method for Obtaining Approval of Proposed Disposal Procedures
R313-15-1009	Waste Classification
R313-18-12	Instruction to Workers
R313-25-6(3)	General Information – Disposal Location and Expected Schedules
R313-25-7	Principal Design Features Potentially Impacted by the Disposal of Depleted Uranium (e.g., Waste Emplacement and Backfill, Land Disposal Facility Construction and Operation, and Classification and Specifications)
R313-25-8	Technical Analysis for the Protection of the General Population, Protection of Inadvertent Intruders, Protection during Normal and Abnormal Operations, and Demonstration of the Long-Term Disposal Site Stability.
R313-25-11	Requirements for Issuance of a License demonstrating no unreasonable risk to the General Public, Training and Qualification of Licensee Staff, Adequacy of Site to Protect the Public during operations and after closure, and the adequacy of financial resources to operate, close, and provide for appropriate institutional control of the facility.
R313-25-18	Licensee's facility shall be sited, designed, operated, closed, and controlled so that individual exposures are limited.
R313-25-19	Licensee's facility shall be sited, designed, operated, closed, and controlled so that general population exposures are limited.
R313-25-20	Licensee's facility shall be sited, designed, operated, closed, and controlled to limit exposures to individuals inadvertently intruding.
R313-25-21	Licensee's facility shall be sited, designed, and operated to limit exposures to individuals during operations.
R313-25-22	Licensee's facility shall be sited, designed, operated, closed, and controlled to achieve long-term stability of the site without ongoing active maintenance.
R313-25-23	Disposal Site Suitability Requirements for near-surface land disposal.
R313-25-24	Disposal site design requirements for near-surface land disposal.
R313-25-31	Licensee's assurance of financial capability to conduct necessary site closure and stabilization activities.
R313-25-32	Licensee's assurance of financial capability to conduct necessary institutional controls, following facility closure.

Table 2-1

Applicable Requirements Potentially Impacted by the Disposal of Depleted Uranium

URCR	REASON
R313-25-33	Specifies record keeping and reporting requirements of a person licensed for low-level radioactive waste disposal under URCR R313-25. As such, this is an issue for compliance monitoring rather than a criterion for granting a license amendment. However, the information and procedures provided in the 2008 LRA renewal and other submittals demonstrate that Energy*Solutions* intends to maintain information and records that are required by this regulation and that will be necessary to develop the required reports.
R313-25-34	Requires that Energy*Solutions* perform or allow the Executive Secretary to perform tests that the latter considers necessary. Tests may address any of (1) wastes, (2) facilities used for receipt, storage, treatment, handling or disposal of wastes, (3) radiation detection and monitoring instruments, and (4) other equipment and devices used in connection with the receipt, possession, handling, treatment, storage, or disposal of waste. As such, this is an issue for compliance monitoring rather than a criterion for initial licensing.
R313-25-35	Requires that Energy*Solutions* allow the Executive Secretary access to the disposal facility for facility and records inspections. As such, this is an issue for compliance monitoring rather than a criterion for granting a license amendment.
R313-R317-6	Groundwater protection limits

2.1 R313-15-101; Radiation Protection Programs

Requirement: Licensee shall develop, document, and implement a radiation protection program sufficient to ensure compliance, including operational procedures and engineering controls to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable. Licensee's Radiation Protection Program shall constrain air emissions of radioactive material from operations to the environment, excluding radon-222 and its decay products, such that a member of the public likely to receive the highest dose will not be expected to receive a total dose equivalent in excess of 10 mrem per year from these emissions.

Compliance Basis: Energy*Solutions*' 2008 RML renewal references several plans and program descriptions that control operational activities that are carried on at the facility and which constitute the facility's Radiation Protection Program, including the Waste Characterization Plan, CQA/QC Manual, Radiation Safety Manual, ALARA Plan, Health and Safety Plan, Emergency Response and Contingency Plan, Site Radiological Security Plan, Environmental Monitoring Plan, and Quality Assurance Manual. Management and disposal practices documented therein do not require alteration to accommodate depleted uranium in a manner compliance with the R313-15-101 ALARA standards. Similarly, the 2008 RML renewal includes models demonstrating that atmospheric-pathway doses to the general public during operations will remain below regulatory required levels. Furthermore, Energy*Solutions*' Environmental Monitoring Program includes provisions to actively measure atmospheric radioactive contaminant concentrations at their Clive facility property boundary and to notify the Division in the event these concentrations approach levels of non-compliance.

2.2 R313-15-201; Occupational Dose Limits for Adults

Requirement: Licensee shall control the occupational dose to individual adults, except for planned special exposures, to the more limiting of a total effective dose equivalent of 5 rem or the sum of the deep dose equivalent and committed dose equivalent to any individual organ or tissue other than the eye of 50 rem. Furthermore, the Licensee shall control the occupational doses to the lens of the eye to 15 rem and skin to 50 rem of individual adults. Notwithstanding the annual dose limits, the Licensee shall limit the soluble uranium intake by an individual to 10 mg in a week in consideration of chemical toxicity.

Compliance Basis: Energy*Solutions*' 2008 RML renewal references several plans and program descriptions that control exposures from operational activities that are carried on at the facility, including the Radiation Safety Manual, ALARA Plan, Health and Safety Plan, Emergency Response and Contingency Plan, and Environmental Monitoring Plan. Management and disposal practices documented therein do not require alteration to accommodate depleted uranium in a manner compliance with the R313-15-201 occupational standards. As is documented therein, Energy*Solutions* regularly monitors and reports to the Division occupational exposures. Energy*Solutions*' Radiation Protection Program also includes provisions to notify the Division in the event these occupational exposures approach levels of non-compliance.

2.3 R313-15-301; Dose Limits for Individual Members of the Public

Requirement: Licensee shall conduct operations so that the annual total effective dose equivalent to individual members of the public during operations does not exceed 0.1 rem. Additionally, the dose in any unrestricted area from external sources does not exceed 2 mrem in any one hour.

Compliance Basis: Energy*Solutions*' 2008 RML renewal references several plans and program descriptions that control exposures to members of the public from operational activities that are carried on at the facility, including the Radiation Safety Manual, ALARA Plan, Health and Safety Plan, Emergency Response and Contingency Plan, Site Radiological Security Plan, and Environmental Monitoring Plan. Management and disposal practices documented therein do not require alteration to accommodate depleted uranium in a manner compliance with the R313-15-301 operational standards. As is documented therein, Energy*Solutions* regularly monitors and reports to the Division offsite contaminant concentrations and exposure levels. Energy*Solutions*' Radiation Protection Program also includes provisions to notify the Division in the event these occupational exposures approach levels of non-compliance.

2.4 R313-15-402; Radiological Criteria for Unrestricted Use

Requirement: By statute (R313-15-401), radiological criteria for unrestricted use apply to ancillary surface facilities that support radioactive waste disposal activities. As such, a site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a total effective dose equivalent to an average member of the critical group that does not exceed 25 mrem per year, including no greater than 4 mrem committed effective dose equivalent or total effective dose equivalent to an average member of the critical group from groundwater sources, and the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA).

Compliance Basis: Chapter 6.4 of Appendix A and Energy*Solutions*' 2008 RML renewal references policies and procedures for decommissioning and releasing of ancillary surface facilities used in support of disposal operations, including the CQA/QC Manual, Radiation Safety Manual, ALARA Plan, Health and Safety Plan, and Quality Assurance Manual. Energy*Solutions* is currently storing drums containing depleted uranium from Savannah River Site's operations in a Depleted Uranium Storage Building built after the 2008 RML renewal. Prior to its construction, the Division reviewed and approved the Storage Building construction plans, use management, and eventual decommissioning and unrestricted release plans. No additional information is required to demonstrate compliance.

2.5 R313-15-601; Control of Access to High Radiation Areas

Requirement: The Licensee shall ensure that each entrance or access point to a high radiation area has 1) a control device that, upon entry into the area, causes the level of radiation to be reduced below that level at which an individual might receive a deep dose equivalent of 0.1 rem in one hour at 30 centimeters from the source of radiation or from any surface that the radiation penetrates; 2) a control device that energizes a conspicuous visible or audible alarm signal so that the individual entering the high radiation area and

the supervisor of the activity are made aware of the entry; or 3) entryways that are locked, except during periods when access to the areas is required, with positive control over each individual entry.

Compliance Basis: Energy*Solutions*' 2008 RML renewal references unrestricted and restricted area access protocols and protections contained in the Radiation Safety Manual, ALARA Plan, Health and Safety Plan, Emergency Response and Contingency Plan, and Site Radiological Security Plan. As was submitted to the Division prior to their approval of its construction, Energy*Solutions* continues to apply building access restriction controls to their Depleted Uranium Storage Building. No further information is necessary to demonstrate compliance.

2.6 R313-15-801; Security And Control Of Licensed Or Registered Sources Of Radiation

Requirement: The licensee shall secure licensed radioactive material from unauthorized removal or access.

Compliance Basis: Energy*Solutions*' 2008 RML renewal references security protocols and protections for radioactive materials in unrestricted and restricted area contained in their Radiation Safety Manual, Health and Safety Plan, Emergency Response and Contingency Plan, and Site Radiological Security Plan. As was submitted to the Division prior to their approval of its construction, Energy*Solutions* continues to apply material security and access controls to their Depleted Uranium Storage Building. No further information is necessary to demonstrate compliance.

2.7 R313-15-902; Posting Requirements

Requirement: The licensee shall post each radiation area with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIATION AREA."

Compliance Basis: Energy*Solutions*' 2008 RML renewal references radiation sign posting protocols and procedures for radioactive materials in unrestricted and restricted area contained in their Radiation Safety Manual. In compliance with these posting protocols and procedures, Energy*Solutions* has posted the required caution signs on its Depleted Uranium Storage Building. No further information is necessary to demonstrate compliance.

2.8 R313-15-906; Procedures for Receiving and Opening Packages

Requirement: The Licensee shall monitor the external surfaces of a labeled package for radioactive contamination, monitor the external surfaces of a labeled package for radiation levels, and monitor all packages known to contain radioactive material for radioactive contamination and radiation levels if there is evidence of degradation of package integrity, such as packages that are crushed, wet, or damaged.

Compliance Basis: Energy*Solutions*' 2008 RML renewal references waste receipt policies and procedures for radioactive materials received via rail and truck as contained in their Waste Characterization Plan, Radiation Safety Manual, ALARA Plan, and Health and Safety Plan. The Savannah River Site depleted

uranium drums currently in storage in Energy*Solutions'* Depleted Uranium Storage Building and any future depleted uranium packages will continue to be received and inspected according to these approved procedures.

2.9 R313-15-1002; Method for Obtaining Approval of Proposed Disposal Procedures

Requirement: The Licensee shall apply to the Executive Secretary for approval of proposed procedures to dispose of licensed or registered material.

Compliance Basis: Energy*Solutions*' 2008 RML renewal references waste disposal policies and procedures for radioactive materials contained in their CQA/QC Manual. Disposal of depleted uranium will be conducted according to these approved procedures. No further information is required to demonstrate compliance.

2.10 R313-15-1009; Waste Classification

Requirement: The Licensee shall only disposal of waste classified as "Class A", as defined by the procedures contained in this requirement. The definitions in this section are essentially identical to those in 10 CFR 61.55, with one exception: Utah adds Ra_{226} to the list of long-lived radionuclides in the regulations' Table I with a concentration limit of 100 nanoCuries per gam (nCi/g). Additionally, on April 13, 2010, the Utah Radiation Control Board approved a Depleted Uranium Performance Assessment Rule, R313-25-8, "Technical Analysis." The rule allows, subject to approval of the information contained in this Compliance Report, the Licensee to accept and disposal of depleted uranium as Class A waste.

Compliance Basis: URCR R313-15-1009 defines specific classifications (e.g., Class A, Class B, and Class C), based on a waste's source term. The Division has included Ra_{226} to the list of long-lived radionuclides in this regulations, with a concentration limit of 100 nCi/g (Utah, 2010). Since Ra_{226} is a decay product of uranium-238 (U_{238}), the principal component of depleted uranium, it is of direct relevance to the disposal of depleted uranium waste. Energy*Solutions*' Clive facility is licensed by the Division to dispose of Class A waste and has disposed of small quantities of depleted uranium waste under that license. However, as is presented in Table 2-2, the Savannah River Site wastes under consideration for disposal in this Compliance Report contain more than isotopes of uranium. In particular, the depleted uranium contains technetium-99 (Tc_{99}) and strontium-90 (Sr_{90}). Because of this, R313-15-1009 dictates that the determination of waste classification is driven not by the presence of uranium, but by the presence of radionuclides identified in the regulatory requirement. Based on the relative concentrations of isotopes other than uranium, the Savannah River Site wastes are Class A. Future shipments of other depleted uranium wastes that also contain isotopes other than uranium will be evaluated for waste classification purposes in accordance with the Radioactive Material License and Waste Characterization Plan, with wastes that are greater than Class A to be rejected for receipt.

Table 2-2

Savannah River Site Depleted Uranium Drum Waste Concentrations

Radionuclide	Mean Concentration (pCi/g)*	Standard Deviation (pCi/g)
Sr_{90}	47	75
Tc_{99}	23,800	11,000
$_{129}I$	19	9
$_{137}Cs$	12	4
$_{226}Ra$	317	110
$_{233}U$	5,290	480
$_{234}U$	33,100	2,170
$_{235}U$	2,970	750
$_{236}U$	4,910	1,170
$_{238}U$	272,000	6,640
$_{237}Np$	6	7
$_{238}Pu$	0.2	0.3
$_{239}Pu$	1	1
$_{240}Pu$	0.3	0.3
$_{241}Pu$	4	4
$_{241}Am$	14	5

* Radionuclide Concentrations in Savannah River Site drums in storage at Energy*Solutions* are generally normally distributed – See Appendix A, Chapter 9 for development methodology.

2.11 R313-18-12; Instruction to Workers

Requirement: All individuals who in the course of employment with the Licensee are likely to receive in a year an occupational dose in excess of 100 mrem a) shall be kept informed of the storage, transfer, or use of sources of radiation in the licensee's or registrant's workplace; b) shall be instructed in the health protection considerations associated with exposure to radiation or radioactive material to the individual and potential offspring, in precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed; c) shall be instructed in, and instructed to observe, to the extent within the worker's control, the applicable provisions of these rules and licenses for the protection of personnel from exposure to radiation or radioactive material; d) shall be instructed as to their responsibility to report promptly to the licensee or registrant a condition which may constitute, lead to, or cause a violation of the Act, these rules, or a condition of the licensee's license or unnecessary exposure to radiation or radioactive material; e) shall be instructed in the appropriate response to warnings made in the event of an unusual occurrence or malfunction that may involve exposure to radiation or radioactive material; and f) shall be advised as to the radiation exposure reports which workers shall be furnished.

Compliance Basis: Energy*Solutions*' 2008 RML renewal references employee training requirements for their plans and program descriptions that control operational activities that are carried on at the facility and which constitute the facility's Radiation Protection Program, including the Waste Characterization Plan, CQA/QC Manual, Radiation Safety Manual, ALARA Plan, Health and Safety Plan, Emergency Response and Contingency Plan, Site Radiological Security Plan, Environmental Monitoring Plan, and Quality Assurance Manual. Energy*Solutions*' Employee Training Program for management and disposal practices documented therein does not require alteration to accommodate depleted uranium.

2.12 R313-25-6(3); General Information - Expected Schedules

Requirement: The general information shall include the expected schedules for construction, receipt of waste, and first emplacement of waste at the existing land disposal facility.

Compliance Basis: As has been documented herein, Energy*Solutions* is currently in possession of depleted uranium from DOE's Savannah River Site, waiting a final disposal solution. It is Energy*Solutions*' target within 120 days of acceptance by the Division's Executive Secretary of the Performance Assessment (as documented herein), to apply for its Radioactive Material License be amended to include disposal of the depleted uranium wastes currently in storage at their Clive Facility. Within 120 days following successfully amending their Radioactive Material License, Energy*Solutions* intends to begin disposing of the Savannah River Site depleted uranium. Furthermore, subject to ongoing contract negotiations with DOE, Energy*Solutions* expects to receive and dispose of depleted uranium from the deconversion plants within one year of regulatory approval.

2.13 R313-25-7; Specific Technical Information - Principal Design Features: Descriptions, Design Criteria, Justification, and Codes

Requirement: The regulatory requirements of URCR R313-25-7(2) , -7(3) , -7(4) , and -7(5) form a system of requirements that apply to numerous principal design features at the existing low-level radioactive waste disposal facility and ensure that they will continue to perform adequately with the disposal of depleted uranium to achieve the performance objectives stated in URCR R313-25-18 through 26. The Licensee shall include the following information to determine whether or not they can continue to meet the performance objectives and the applicable technical requirements of URCR R313-25 in disposing of depleted uranium.

Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures. [URCR R313-25-7(2)] Descriptions of the principal design criteria and their relationship to the performance objectives. [URCR R313-25-7(3)] Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria. [URCR R313-25-7(4)] Descriptions of codes and standards which Energy*Solutions* has applied to the design, and will apply to construction of the land disposal facilities. [URCR R313-25-7(5)]

Compliance Basis: Energy*Solutions* recognizes that the safe storage and disposal of depleted uranium waste is essential for mitigating releases of radioactive materials and reducing exposures to humans and the environment. Energy*Solutions*' Clive Facility design features are described in detail in the 2008 RML renewal. In its acceptance of Energy*Solutions'* 2008 RML renewal, the Division has determined that the principal design features identified perform the required functions (meaning that at least one required function is performed by each principal design feature). The principal design features potentially impacted by the intended disposal of depleted uranium, and for which satisfactory functional performance must herein be addressed are Waste Placement and Backfill, Land Disposal Facility Construction and Operation, and Classification and Specifications.

As they are potentially impacted by the intended disposal of depleted uranium, Waste Placement and Backfill, Land Disposal Facility Construction and Operation, and Classification and Specifications are described below, their design criteria identified, justification that they will perform as required is presented, and the codes and standards applicable are summarized. In review of the principal design features, the required functions that the principal design features must perform, as identified in URCR R313-25-7(2), include:

- Minimize infiltration of water.
- Ensure integrity of covers for disposal units.
- Ensure structural stability of backfill, wastes, and covers.
- Minimize contact of wastes with standing water.

- Provide disposal site drainage.
- Ensure disposal site closure and stabilization.
- Eliminate to the extent practicable long-term disposal site maintenance.
- Protect against inadvertent intrusion
- Limit occupational exposures.
- Provide for disposal site monitoring.
- Provide a buffer zone for monitoring and potential mitigative measures.

Waste Emplacement and Backfill - Description of Design Feature

Requirement: Descriptions of the design features of the land disposal facility and of the disposal units for near-surface disposal of depleted uranium shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures. [URCR R313-25-7(2)]

Compliance Basis: Energy*Solutions* proposes to dispose of depleted uranium in the western fraction of the Federal Cell. The eastern section is occupied by the 11e.(2) cell, which is dedicated to the disposal of uranium processing by-product waste, and which is not considered in the analysis. The general design aspect is that of a hipped cover, with relatively steep sloping sides nearer the edges. The upper part of the embankment has a more moderate slope than the sides. Only the top slope region is modeled in Appendix A, since no depleted uranium will be placed beneath the embankment's side slopes.

The 2008 LRA renewal addresses the pertinent characteristics of the principal design features for general waste placement and backfill including the waste types to be disposed in the existing embankments. Waste included in this analysis may take a variety of physical forms, including soil or soil-like material, compressible debris, incompressible debris, oversized debris, containerized Class A LLRW, and depleted uranium. Liquid waste may not be disposed in the embankments. Revisions to the waste placement management program for placement of depleted uranium are addressed in Chapters 4 and 6 of Appendix A and will be conducted in accordance with the CQA/QC Manual. As with other wastes, depleted uranium will be are disposed at Energy*Solutions*' Disposal Embankments in accordance with the provisions of the CQA/QC Manual. However, depleted uranium placement is expected to be subject to controls and license conditions.

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 Performance Assessment examined three different options for configuration of the depleted uranium waste within the embankment. The volume within the embankment that is available for waste disposal is 44.3 ft deep below the engineered cover. No depleted uranium waste is modeled beneath the embankment's side slopes in the Performance Assessment.

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
   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

These options cover a fairly wide range of possible disposal options, from disposal below grade only to disposal throughout most of the system, exploring the range of possible options for disposal of depleted uranium waste.

The design of the facility enables isolation of each embankment after it has been filled and covered. Thus, once the embankment is closed, it will not be disturbed by continuing operations at the site. The final embankment cover integrates long-term water and erosion control methods into the overall design, thus eliminating the need for active maintenance of a closed embankment. Compliance with this requirement has therefore been sufficiently demonstrated.

Waste Emplacement and Backfill - Principal Design Criteria

Requirement: Descriptions of the principal design criteria and their relationship to the performance objectives. [URCR R313-25-7(3)]

Compliance Basis: The principal design criteria pertinent to the design of the depleted uranium waste placement and backfill are justified in Chapter 4 of Appendix A. A key design criterion is the limitation of allowable distortion in the cover to less than 0.02 ft/ft. That is, the depleted uranium waste placement and backfill must not result in a magnitude of differential settlement within the Disposal Embankment that would contribute to a distortion that exceeds 0.02 ft/ft in the cover. Practically, this means that cover system settlement is acceptable so long as it is less than 1 foot of vertical displacement in less than any 50-foot horizontal distance. Based on the foregoing summary of information contained in the 2008 RML renewal and the fact that waste placement procedures will not change, this report documents Compliance

by Energy*Solutions* with the requirements of URCR R313-25-7(3)) as they pertain to the disposal of depleted uranium in the disposal embankments.

Waste Emplacement and Backfill - Design Basis Conditions and Design Criteria Justification

Requirement: Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria. [URCR R313-25-7(4)]

Compliance Basis: In development of the projected performance of the depleted uranium waste placement and backfill as presented and justified in Appendix A, Energy*Solutions* utilized applicable guidance issued by the NRC, including those described in SECY-08-0147, NRC NUREG-1199 and NUREG-1200, pertaining to normal, abnormal, and accident (where applicable) conditions that should be considered during design of NRC-licensed low-level radioactive waste disposal facilities. Chapter 4 of Appendix A summarizes the conditions considered in the design of the depleted uranium waste placement and backfill principal design feature and the relationship between the normal, and abnormal, and accident (as applicable) conditions evaluated to the principal design criteria.

Factors of safety associated with all of the normal and abnormal conditions evaluated represent the design criteria distortion of 0.02 ft/ft divided by the calculated distortions. Overall, the average safety factor associated with the three normal conditions and the average safety factor associated with the five abnormal conditions were ascertained. The safety factor is greater than or equal to 1.00 under abnormal conditions.

Based on the foregoing summary of information, this Report demonstrates Energy*Solutions*' compliance with requirements of URCR R313-25-7(4), as they pertain to the depleted uranium waste emplacement and backfill of the disposal embankment.

Waste Emplacement and Backfill - Applicable Codes and Standards

Requirement: Descriptions of codes and standards which Energy*Solutions* has applied to the design, and will apply to construction of the land disposal facilities. [URCR R313-25-7(5)]

Compliance Basis: The 2008 RML renewal provides a summary of the codes, standards, and guidelines that Energy*Solutions* considered and applied to the design. The primary standards considered by Energy*Solutions* in the design of the depleted uranium waste placement and backfill are those codified in URCR R313-25-24 and R313-25-25. Energy*Solutions* has also incorporated by reference minimum design criteria safety factors of 1.5 for static conditions and 1.2 for dynamic conditions from Utah Statutes and Administrative Rules for Dam Safety, Rule R625-11-6.

The CQA/QC Manual provides specifications for constructing the Class A Disposal Embankments (including sections associated with the disposal of depleted uranium). The CQA/QC Manual also includes QC and QA procedures to be used during its construction.

Based on the foregoing summary of information, this Report demonstrates Energy*Solutions*' compliance with requirements of URCR R313-25-7(5), as they pertain to the waste emplacement and backfill of the disposal embankment.

Land Disposal Facility Construction and Operation

Requirement: The Licensee shall provide certain technical information. The following information is needed to determine whether or not Energy*Solutions* can meet the performance objectives and the applicable technical requirements of URCR R313-25: Descriptions of the construction and operation of the land disposal facility. The description shall include as a minimum the methods of construction of disposal units; waste emplacement; the procedures for and areas of waste segregation; types of intruder barriers; onsite traffic and drainage systems; survey control program; methods and areas of waste storage; and methods to control surface water and ground water access to the wastes. The description shall also include a description of the methods to be employed in the handling and disposal of wastes containing chelating agents or other non-radiological substances which might affect meeting the performance objectives of URCR R313-25. [URCR R313-25-7(6)]

Compliance Basis: This Report demonstrates Compliance with the requirements of URCR R313-25-7(6) have been met. Energy*Solutions*' methods for constructing and operating the depleted uranium disposal embankment are those already approved as part of the 2008 RML renewal. Construction of the disposal unit will involve a continuous cut, backfill, and cover construction. To ensure that the depleted uranium disposal embankment is built to design requirements, construction activities will be performed under a QA/QC program and conform to the requirements of the CQA/QC Manual. The primary activities involved in construction of the disposal embankment (as target location for depleted uranium) include:

- Excavation.
- Preparation of the disposal area Foundation
- Construction of liner.
- Construction of run-on and runoff protection.
- Waste emplacement and backfill
- Construction of Temporary Cover over completed portions of disposal embankments
- Settlement monitoring to determine compliance with waste compaction / stability requirements. May include surcharging efforts to ensure embankment is stable for final cover,
- Construction of Final Cover, as per CQA/QC Manual requirements, and
- Construction of permanent drainage ditches surrounding the disposal unit(s).

Of particular interest is the placement of depleted uranium waste. Depleted uranium procedures for waste emplacement are the same as those already described in the 2008 RML renewal. After the Liner has been constructed over a specific area of the disposal embankment, at least 12 inches of debris-free soil will be placed on top of the liner; followed by another 12-inches of waste as a protection to the integrity of the liner. Both of these layers of protective soil will be compacted with rubber tired equipment.

The protection of inadvertent intruders from radiation exposures during facility operations focuses on prevention of inadvertent intrusion. Depleted uranium operational areas will be surrounded by fencing as described in Energy*Solutions*' CQA/QC Manual. Additional security features are presented in the Energy*Solutions'* Site Radiological Security Plan. Several features of the facility design have the effect of protecting an inadvertent intruder from exposure to the disposed depleted uranium materials and the effects of radiation. These features include:

- Lack of nearby residential population
- Embankment cover system

Onsite earth-roadways are continuously changing to meet the demands of current disposal needs. As the height of an active disposal cell increases, as the activity in a portion of the embankment decreases, or as the activity for a new portion of the embankment increases, access roads are constructed or removed to facilitate safe hauling and disposal of materials. Roadways are constructed to ensure that water properly drains off from them, thus minimizing ponding or ponded road conditions. Haul roads to disposal units generally are sloped at no greater than 3:1 in accordance with safety guidelines.

Energy*Solutions* describes the onsite drainage systems in the 2008 RML renewal. Energy*Solutions* has developed a berm system to direct water flow from precipitation, winter runoff, away from the site and stored materials. It also has developed an embankment drainage system surrounding each embankment to help minimize any water accumulation. The drainage systems are constructed of an erosion barrier rock of the same type used to cover the embankments. The design of the berms is sufficient to withstand the Probable Maximum Flood (PMF) without overtopping. The ditches will have triangular cross sections with side slopes of 1:5, and will have gentle longitudinal slopes, with depths great enough to carry the runoff from the 100-year, 1-hour storm event without exceeding their bounds.

Surveys at the disposal site will be tied to both the United States Geological Survey (USGS) survey of Section 32 T1S, R11E and to the state plane coordinate system. Energy*Solutions* performs an annual as-built survey of each embankment which is accomplished by a Utah licensed land surveyor. Survey control is the responsibility of the licensed land surveyor, in accordance with Utah licensing standards.

Energy*Solutions'* plans for controlling the access of surface water to the depleted uranium wastes are those already authorized as part of the 2008 RML renewal. The vertical minimum separation between the bottom of the disposed depleted uranium and the historic high water table is determined as being 13 feet. This value is based on: 1) the groundwater contour map, and 2) the minimum depth from the base of the liner to the groundwater below the liner for the disposal embankment over the past five years is approximately 13 feet.

Based on the information summarized above, this Report documents Energy*Solutions*' regulatory compliance in its methods for emplacing the depleted uranium waste in the disposal embankment.

Classification and Specifications

Requirement: The application shall include certain technical information. The following information is needed to determine whether or not Energy*Solutions* can meet the performance objectives and the applicable technical requirements of URCR R313-25: Descriptions of the kind, amount, classification and specifications of the radioactive material expected to be received, possessed, and disposed of at the land disposal facility. [URCR R313- 25-7(9)]

Compliance Basis: The information contained in Chapter 9 of Appendix A demonstrate that the requirements of URCR R313-25-7(9) have been met. Appendix A also describes the types and volumes of depleted uranium waste to be received for disposal, including the physical, chemical, and radiological properties of the waste. All depleted uranium waste accepted for disposal will be at or below the Class A concentration limits. Radionuclide release characteristics of the depleted uranium waste may vary, but the radionuclide release rates in the performance assessment are modeled in a conservative manner that does not take credit for package or improved waste forms.

In summary, the waste information presented are sufficiently complete and detailed to support the necessary calculations and analyses to show that the facility will meet the depleted uranium performance objectives and the applicable technical requirements of URCR R313-25.

2.14 R313-25-8; Technical Analysis

General Population Protection

Requirement: The Licensee's specific technical information shall include the following analyses needed to demonstrate that the performance objectives of URCR 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 URCR R313-25-19 [URCR R313-25-8(1)].

Compliance Basis: The information contained in Appendix A 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. The principal sources of information for the exposure assessment are Sections 4, 6, and 9 of Appendix A. Original evaluations contained in Energy*Solutions*' 2008 RML renewal demonstrate continued compliance for exposures from normal operating conditions and accident scenarios.

Air Pathway

Analysis conducted in support of the 2008 RML renewal 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 Performance Assessment documented in Chapters 4, 6, and 9 of Appendix A projects potential releases of depleted uranium through the air pathway have been assessed for the facility far below regulatory limits. As stated in the 2008 RML renewal, Energy*Solutions*' engineering and operational controls prevent the resuspension and dispersion of particulate depleted uranium 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.

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 disposal embankment, the facility design prevents any further migration of radioactivity through the air pathway because all waste will be beneath a thick earthen cover. Analysis presented in Chapter 6 of Appendix A demonstrates that the maximum dose to a member of the public following site 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 cover design includes a clay radon barrier designed to limit the surface radon flux to less than 20 pCi/m^2-s, resulting in potential radon exposures well within limits. The 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).

For accident conditions, depleted uranium dust or particulate matter could be released to the atmosphere and inhaled by individuals. The 2008 RML renewal and the analysis documented in Chapter 6 of Appendix A 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 disposal site boundary.

Soil Pathway

As summarized in Chapter 6 of Appendix A, the soil pathway involves the exposure of the public to contaminated depleted uranium from the facility. 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 design of the disposal embankment also contributes to minimizing exposures to contaminated soil by members of the public. After closure of the embankment, all depleted uranium waste will be covered in the disposal cells. The 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.

During operation, the facility will be monitored as described in the 2008 RML renewal and Environmental Monitoring Program, to ensure that no releases or doses have occurred via the soil pathway.

Groundwater Pathway

As is described in Chapters 4 and 6 of Appendix A, the groundwater pathway is assessed using EPA's Hydrologic Evaluation of Landfill Performance (HELP) model and 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 embankment to the compliance well.

Several embankment design features provide additional protection of the public from exposure to depleted uranium via the groundwater pathway. The cover system to be placed over the disposal waste allows very little water to flow into the disposed waste. This limits the contamination of the groundwater by minimizing the contact of water with the depleted uranium waste. Another design feature of the disposal embankment 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 embankment cover uses calculations with EPA's Hydrologic Evaluation of Landfill Performance (HELP) model (Schroeder et al., 1994) as a guide to defining the vertical and lateral flow rates in the individual layers of the cover, as a function of time. Additionally, annual water balances for the disposal embankment have been computed with the HELP model. By using HELP as input to GoldSim, Energy*Solutions* demonstrates 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. All other radionuclide concentrations are 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 waste 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 disposal facility. 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 under side slopes. 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. Groundwater protection levels are met for all radionuclides present in the depleted uranium wastes.

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. The disposal embankment design features also minimize the potential for releases by the surface water pathway. Embankment design includes drainage ditches around the waste disposal areas. After precipitation events, these ditches divert runoff from the disposal cell cover to areas away from the disposal cells.

Vegetation

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 Clive facility, 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 embankment, releases and doses through the plant pathway are limited by the design, operation, and maintenance of the facility. 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 embankment because of natural site characteristics and design features of the embankment. 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.

Design features of the facility also help limit exposures via the plant uptake pathway. A thick earthen cover will be placed over the disposal cells to make the waste less accessible to plant roots after closure of the facility. 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 earthen cover will offer an inhospitable environment for extension of these types of roots into the waste.

Burrowing Animals Pathway

In the arid environment of the Clive Facility, 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 at the Clive site. 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-specific or inter-specific 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 contaminant using the following three steps:

1. Identification of which ant species overwhelmingly contribute to the rearrangement of soils near the surface at Clive.
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. The first deterrent to burrowing animals is the rip-rap erosion barrier. While this may be only partially effective in deterring animals, the primary protective barrier is the clay radon barrier. The burrowing species at the site are not known to dig to such a depth that their burrows could penetrate through the entire cover and into the waste. During operation of the facility, releases and doses from the burrowing animal pathway will be prevented by the design, operation, and maintenance of the facility.

Burrowing animals will be prevented from contacting the waste materials. After final placement of the cover, the design features of the facility, primarily the thick soil 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 and exhuming waste 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.

Doses to the Public

Chapter 6 of Appendix A shows that doses to members of the public will be within established regulatory limits. The groundwater pathway is not viable because of the high salinity and general poor quality of the groundwater; however, it was evaluated via the groundwater modeling and found to be less than 4 mrem/yr.

Protection of Inadvertent Intruders

Requirement: The specific technical information shall also include the following analyses needed to demonstrate that the performance objectives of URCR R313-25 will be met: Analyses of the protection of inadvertent intruders shall demonstrate a reasonable assurance that the depleted uranium waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided. [URCR R313-25-8(2)]

Compliance Basis: Analyses of radiation exposure doses to inadvertent intruders were assessed by Energy*Solutions'* GoldSim model. Based upon current and reasonably anticipated future land uses, two future use exposure scenarios were identified: ranching and recreation. After institutional controls are no longer maintained, it is expected that exposures to contamination in the ranching and recreation scenarios could occur on the Clive facility site. The primary exposure routes for the ranching and recreation scenarios include ingestion, inhalation, and external irradiation. Chapter 6 of Appendix A discusses the design performance objectives of the facility 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
- Embankment cover system
- Waste Form

Operations specific features include:

- Fences
- Buffer zone
- Security plan
- Post-Closure specific features include:
- Granite markers

Exposure Assessment

Requirement: The specific technical information shall also include the following analyses needed to demonstrate that the performance objectives of URCR R313-25 will be met: Assessments of expected exposures due to routine operations and likely accidents during handling, storage and disposal of depleted uranium waste. The analysis shall provide reasonable assurance that exposures will be controlled to meet the requirements of URCR R313-15. [URCR R313-25-8(3)]

Compliance Basis: The information contained Chapters 4 and 6 of Appendix A indicate that the requirements of URCR R313-25-8(3) have been met. The Radiation Protection Program that is required by URCR R313-15-101(1) outlines the facility's radiation protection program. 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. Included therein are descriptions of Energy*Solutions'* ALARA program, including dose goals that are significantly below the regulatory dose criteria for workers.

Long-Term Stability of Disposal Site

Requirement: The specific technical information shall also include the following analyses needed to demonstrate that the performance objectives of URCR R313-25 will be met: Analyses of the long-term stability of the disposal site shall be based upon analyses of active natural processes including erosion, mass wasting, slope failure, settlement of wastes and backfill, 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 ongoing active maintenance of the disposal site following closure. [URCR R313-25- 8(4)]

Compliance Basis: The description and justification of the principal design features of the facility are provided in Section 3.0 of the 2008 RML renewal. These principal design features have been designed to perform their required functions over the period of hundreds of years such that the facility will not require ongoing active maintenance following facility closure. Further discussion of these features is presented under URCR R313-25-7(2) through URCR R313-25-7(5) in sections dealing with the waste placement and backfill. Design features other than those discussed in this Compliance Report do not require alteration to accommodate the disposal of depleted uranium.

Geologic-Time Stability of Disposal Site

Requirement: The specific technical information shall also include the following analyses needed to demonstrate that the performance objectives of URCR 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. [URCR R313-25- 8(5)]

Compliance Basis: While included in this Compliance Report as part of improving qualitative understanding of facility 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 Clive Facility'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 facility during geologic-time frames have also been evaluated (see Chapters 6 and 9 of Appendix A). 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 facility will not require further design changes or ongoing active maintenance following facility closure.

2.15 R313-25-10; Financial Qualifications to Carry Out Activities

Requirement: This information shall demonstrate that the applicant is financially qualified to carry out the activities for which the license is sought. The information shall meet other financial assurance requirements of URCR R313-25. [URCR R313-25-10(1)] A license for the receipt, possession, and disposal of waste containing radioactive material will be issued by the Executive Secretary upon finding that the financial or surety arrangements meet the requirements of URCR R313-25. [URCR R313-25-

11(9)] The applicant shall show that it either possesses the necessary funds, or has reasonable assurance of obtaining the necessary funds, or by a combination of the two, to cover the estimated costs of conducting all licensed activities over the planned operating life of the project, including costs of construction and disposal. [URCR R313-25-30(1)]

Compliance Basis: As required by License condition 73, Energy*Solutions* submits annual revised cost estimates from facility closure. In conjunction with the Surety Review, Energy*Solutions* submits annual revisions to a Letter of Credit complying with the requirements of URCR R313-25-10(1), 25-11(9), and 25-30(1). No revisions to Energy*Solutions*' current Letter of Credit are required as a result of the targeted disposal of depleted uranium.

2.16 R313-25-11; Requirements For Issuance Of A License

Risk to Health and Safety

Requirement: A license for the receipt, possession, and disposal of depleted uranium waste containing radioactive material will be issued by the Executive Secretary upon finding that the issuance of the license will not contribute an unreasonable risk to health and safety of the public [URCR R313-25-11(1)]

Compliance Basis: The information contained in Appendix A demonstrates that the requirements of URCR R313-25-11(1) have been or will be met. The analysis contained therein shows that the groundwater protection requirements will be met for at least 500 years, as required. Doses to offsite members of the public will be below the 25 mrem/yr limit.

Training and Experience

Requirement: A license for the receipt, possession, and disposal of waste containing radioactive material will be issued by the Executive Secretary upon finding that the applicant is qualified by reason of training and experience to carry out the described disposal operations in a manner that protects health and minimizes danger to life or property (URCR R313-25-11(2)].

Compliance Basis: No additional training and experience will be required as a result of the acceptance and disposal of depleted uranium. Once the Radioactive Material License has been amended to allow the disposal of depleted uranium, employee training and experience requirements of URCR R313-25-11(2) will continue to be met. Energy*Solutions'* training program contains detail about required worker experience, qualifications and training.

Protection to Public Health and Safety

Requirement: A license for the receipt, possession, and disposal of waste containing depleted uranium material will be issued by the Executive Secretary upon finding that the applicant's disposal site, disposal design, land disposal facility operations, including equipment, facilities, and procedures, disposal site

closure, and post-closure institutional control, are adequate to protect the public health and safety as specified in the performance objectives of URCR R313- 25-19 [URCR R313-25-11(3)]

Compliance Basis: The information contained in Appendix A of this Compliance Report indicate Energy*Solutions* will continue to comply with the requirements of URCR R313-25-11(3) as a result of accepting and disposing of depleted uranium. Energy*Solutions*' Clive Disposal site, disposal design, land disposal facility operations, including equipment, facilities, and procedures, disposal site closure, and post-closure institutional control features are addressed under several other requirements. Appendix A shows that the groundwater protection requirements will be met for at least 500 years, as required. Doses to offsite members of the public will be below the 25 mrem/yr limit, as described in Appendix A.

Health and Safety Performance Objectives

Requirement: A license for the receipt, possession, and disposal of depleted uranium waste will be issued by the Executive Secretary upon finding that the applicant's disposal site, disposal site design, land disposal facility operations, including equipment, facilities, and procedures, disposal site closure, and post-closure institutional control are adequate to protect the public health and safety in accordance with the performance objectives of URCR R313-25-20 [URCR R313-25-11(4)]

Compliance Basis: The information contained in Appendix A indicates that Energy*Solutions*' Clive disposal site, disposal site design, land disposal facility operations, including equipment, facilities, and procedures, disposal site closure, and post-closure institutional control are adequate to protect the public health and safety in accordance with requirements of URCR R313-25-11(4). The basis for this affirmative finding is presented in the description and justification of the design of the intruder barrier. The basis is presented under findings contained in this Compliance Report for Requirements URCR R313-25-7(2) through URCR R313-25-7(5) and are addressed in Appendix A.

Land Disposal Facility Operations, Including Equipment, Facilities, and Procedures

Requirement: A license for the receipt, possession, and disposal of depleted uranium waste containing radioactive material will be issued by the Executive Secretary upon finding that the applicant's proposed land disposal facility operations, including equipment, facilities, and procedures, are adequate to protect the public health and safety in accordance with R313-15 (URCR R313-25-11(5)]

Compliance Basis: In Appendix A, Energy*Solutions* projects that radiation exposures to members of the general public in unrestricted areas and to facility workers will not exceed the limits during facility operations. Furthermore, Energy*Solutions* will reduce radiation exposures to the extent reasonably achievable under the company's ALARA program. Energy*Solutions* has submitted operational procedures and descriptions of facilities which incorporate features to protect worker and public health and safety. These requirements are discussed further under requirements URCR R313-25-8(1) through URCR R313-25-8(3).

Long-Term Stability

Requirement: A license for the receipt, possession, and disposal of waste containing depleted uranium radioactive material will be issued by the Executive Secretary upon finding that the applicant's disposal site, disposal site design, land disposal facility operations, disposal site closure, and post-closure institutional control plans are adequate to protect the public health and safety in that they will provide reasonable assurance of the long-term stability of the disposed waste and the disposal site and will eliminate to the extent practicable the need for continued maintenance of the disposal site following closure. [URCR R313-25-11(6)]

Compliance Basis: As is repeated in Appendix A, Energy*Solutions* demonstrates that the disposal site, disposal site design, land disposal facility operations, disposal site closure, and post-closure institutional control plans are adequate to protect the public health and safety in that they will provide reasonable assurance of the long-term stability of the disposed waste and the disposal site and will eliminate to the extent practicable the need for continued maintenance of the disposal site through the 10,000 year compliance period following closure in accordance with the requirements of URCR R313-25-11(6). The basis for this affirmative finding is presented in the description and justification of the design of the principal design features planned for the disposal facility. These principal design features have been designed to perform their required functions over an appropriate period of time such that the facility will meet applicable performance objectives without the need for ongoing active maintenance following facility closure. The basis for this Compliance demonstration is presented under URCR R313-25-7(2) through URCR R313-25-7(5), URCR R313-25-8(4), and URCR R313-25-22(1).

Reasonable Assurance

Requirement: A license for the receipt, possession, and disposal of waste containing depleted uranium radioactive material will be issued by the Executive Secretary upon finding that the applicant's demonstration provides reasonable assurance that the requirements of URCR R313-25 will be met. [URCR R313-25-9(7)]

Compliance Basis: Energy*Solutions* demonstrates that the requirements of URCR R313-25 have been or will be met, as described and justified in this document. This finding is a global rollup of all the requirements contained in URCR R313-25. The basis for this demonstration of compliance is contained in the individual sections addressed in this Report.

Institutional Control Assurance

Requirement: A license for the receipt, possession, and disposal of waste containing radioactive material will be issued by the Executive Secretary upon finding that the applicant's proposal for institutional control provides reasonable assurance that control will be provided for the length of time found necessary to ensure the findings in URCR R313-25-11(3) through (6) and that the institutional control meets the requirements of URCR R313-25-28. [URCR R313-25-11(8)]

Compliance Basis: This Report demonstrates that reasonable assurance exists that control will be provided as necessary to ensure the findings in URCR R313-25-11(3) through (6) will be met. The information provided also indicates that reasonable assurance exists that the provisions for institutional control meet or will meet the requirements of URCR R313-25-28.

Financial or Surety Arrangements

Requirement: A license for the receipt, possession, and disposal of waste containing radioactive material will be issued by the Executive Secretary upon finding that the financial or surety arrangements meet the requirements of URCR R313-25. [URCR R313-25-9(9)]

Compliance Basis: As required by License condition 73, Energy*Solutions* submits annual revised cost estimates from facility closure. In conjunction with the Surety Review, Energy*Solutions* submits annual revisions to a Letter of Credit complying with the requirements of URCR R313-25-10(1), URCR R313-25-30(1), URCR R313-25-32(1), and URCR R313-32(2). No revisions to Energy*Solutions*' current Letter of Credit are required as a result of the targeted disposal of depleted uranium.

2.17 R313-25-18; Individual Exposure Assurance

Requirement: Land disposal facilities shall be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to individuals do not exceed the limits stated in URCR R313-25-19 through 25-22. [URCR R313-25-19(1)]

Compliance Basis: The information contained in this Report demonstrate that the requirements of URCR R313-25-18 will be met (as embodied in the Technical Analyses required in support of each and are presented individually for each of the cited regulatory requirements as follows:

- R313-25-19 in Requirement 2508-1,
- R313-25-20 in Requirement 2508-2,
- R313-25-21 in Requirement 2508-3, and
- R313-25-22 in Requirement 2508-4.

2.18 R313-25-19; Protection Of The General Population From Releases Of Radioactivity

Requirement: Concentrations of radioactive material which may be released to the general environment in groundwater, 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. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable. [URCR R313-25-19(1)]

From a compliance period perspective, 10,000 years is the time period for a quantitative analysis and is consistent with Federal rules and guidance. Given the nature of depleted uranium, a qualitative analysis out to the peak dose period is also warranted to inform the performance assessment. Use of the 10,000 year time period for compliance is consistent with federal regulations (e.g., 40 CFR 191) and NRC

guidance. Extending the analysis qualitatively until peak dose 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.

Consequently, for purposes of applying the performance standards for protection of the general public (URCR313-25-19) and for protection of individuals from inadvertent intrusion (URCR313-25-20), the Division should chosen to use the 10,000 year compliance period with a qualitative analysis to cover the period beyond to the peak dose.

The performance standard for protection of the general public (URCR313-25-19) is based on the 1959 standards of International Commission on Radiological Protection (ICRP) Publication 2 methodology. URCR313-15 rules are based on newer ICRP guidance in Publications 26 and 30. Part 20 uses the total effective dose equivalent (TEDE) rather than the whole body dose. NRC has recognized the inconsistency between the dose methodologies and has issued guidance to allow the use of newer guidance. This approach was taken for Yucca Mountain in 10 CFR Part 63, NUREGs -1854 and 1573, and in the NRC Decommissioning Criteria for West Valley. As noted 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)."*

Consequently, the Division should use for purposes of applying the performance standards for protection of the general public (URCR313-25-19) the total effective dose equivalent rather than the whole body dose.

Compliance Basis: The information contained in this Report demonstrates that the requirements of URCR R313-25-19(1) have been met. Appendix A of this Compliance Report present the results of extensive analyses addressing the potential radionuclide releases to media including groundwater, surface water, air, soil, plants and animals, and discuss potential exposure pathways resulting from these releases. Transport of releases from disposed wastes was evaluated. The annual doses resulting from the postulated releases for reasonably likely conditions were found to be within the regulatory limit of 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ. The annual doses are found to be in compliance with the regulations. The following text provides a discussion of releases to all environmental media and their corresponding doses. The information on releases and dose assessment is included in Appendix A and is qualitatively summarized below to demonstrate that the construction, operation, and closure Clive operations will satisfy all applicable regulatory dose limits.

As is noted in the Technical Analysis and has been accepted by the Division as a result of prior licensing activities, future intruder constructor, intruder agriculture, and off-site receptor scenarios are considered unreasonable. An intruder explorer would not receive a significant dose. Conclusions are based upon the poor water quality, arid conditions and institutional controls.

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 committed effective dose equivalents (CEDE). Energy*Solutions* actively reviews work practices, performs operational radiological surveys and has a functional ALARA review committee. The Division has recognized Energy*Solutions*' proactive approach that has resulted in successfully maintaining worker doses ALARA.

Maximum Dose

Table 2-3 presents the maximum dose to the general public at the Clive facility 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 member of the general public of 25 mrem in a year is clearly established for all three disposal configurations. The doses increase as waste is placed nearer the top of the embankment, but the more stringent protection of the general public performance objectives are not exceeded for all cases. Compliance is demonstrated.

Groundwater Pathway

The groundwater protection criteria are based on an annual dose of 4 mrem to an individual drinking groundwater. The expected 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 facility.

Table 2-4 summarizes the distribution of the peak groundwater concentrations at the compliance point within the 500-year regulatory limit. As is illustrated, the 3m and 5m Models comply with the GWPLs. However, for the 10m Model, the situation is not as clear. Because 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, it is reasonable to conclude that the 10m Model is not in compliance with the performance objective.

Table 2-3

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

Waste Model	Receptor	Mean	Median	95% Percentile
3m Model	Rancher	4.4	3.4	11.0
	Hunter	0.19	0.15	0.46
	OHV enthusiast	0.29	0.23	0.72
	I-80 receptor	0.00012	9.85e-5	0.00032
	Knolls receptor	0.0013	0.00099	0.0034
	Rail road receptor	0.00019	0.00016	0.0005
	Rest area receptor	0.0025	0.002	0.0063
	UTTR access road	0.062	0.049	0.166
5m Model	Rancher	0.60	0.47	1.5
	Hunter	0.026	0.021	0.063
	OHV enthusiast	0.039	0.032	0.095
	I-80 receptor	1.4e-5	1.20e-5	3.5e-5
	Knolls receptor	0.00015	0.00012	0.00038
	Rail road receptor	2.3e-5	1.9e-5	5.6e-5
	Rest area receptor	0.00029	0.00025	0.00073
	UTTR access road	0.0071	0.0059	0.018
10m Model	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

Table 2-4

Peak Groundwater Concentrations
(pCi/L within 500 years)

Waste Model	GWPL	Mean	Median	95% Percentile
3m Model:				
Sr_{90}	42	0	0	0
Tc_{99}	3,790	86	1.4e-5	210
I_{129}	21	0.053	7.7e-21	0.13
Th_{230}	83	4.9e-17	4.2e-37	1.7e-26
Th_{232}	92	5.1e-23	0	1.3e-32
Np_{237}	7	1.9e-28	0	0
U_{233}	26	4.8e-13	5.2e-33	5.1e-22
U_{234}	26	2.3e-12	3.3e-32	3.3e-21
U_{235}	27	1.4e-13	2.7e-33	3.1e-22
U_{236}	27	4.4e-13	4.7e-33	4.1e-22
U_{238}	26	1.9e-11	2.7e-31	2.8e-20
5m Model:				
Sr_{90}	42	0	0	0
Tc_{99}	3,790	440	0.0026	1,700
I_{129}	21	0.37	3.4e-16	1.8
Th_{230}	83	2.2e-21	5e-37	1.5e-26
Th_{232}	92	1.6e-27	0	1.3e-32
Np_{237}	7	3.9e-25	0	4.2e-38
U_{233}	26	4.4e-17	6.3e-33	3.9e-22
U_{234}	26	2.7e-16	3.7e-32	2.4e-21
U_{235}	27	2.9e-17	3.0e-33	2.1e-22
U_{236}	27	3.6e-17	5.2e-33	3.4e-22
U_{238}	26	2.2e-15	3.0e-31	2.0e-20

Table 2-4
(continued)

Peak Groundwater Concentrations
(pCi/L within 500 years)

Waste Model	GWPL	Mean	Median	95% Percentile
10m Model:				
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

Surface Water Pathway

Long-term surface water pathway doses are expected to be zero because of the absence of permanent surface water bodies at the site. The nearest stream channel is greater than five miles east of the facility. Surface water from precipitation is directed away from the waste disposal embankment by drainage ditches and berms. During facility 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.

Air Pathway

As are described in Chapters 4 and 9 of Appendix A, gaseous and particle-bound contaminants that have migrated to the surface soil layer are potentially subject to dispersion in the atmosphere. The effect of mechanical disturbance on human exposure to soil particulates is evaluated in the Performance Assessment based on the effect of off-highway vehicle use. However, although this mechanism may be consequential for human exposure, it is not a significant contributor to the overall rate of fine particulates emissions from the embankment over time. Aeolian (wind-related) disturbance is the primary cause of particulates emissions from the embankment. Because the model projects massive dilution for windblown sediments, this pathway results in insignificant offsite accumulation of transported radionuclides and associated exposures to the general public. Compliance is demonstrated for the regulatory requirements for protecting members of the general public from the atmospheric pathway.

Soil Pathway

Soil pathway doses involve exposure of the public to contaminated soil from the facility. If an exposure occurred, doses could result from external radiation or ingestion of soil on dirty hands. External radiation levels at the top of the final cover will be at or below background radiation for the site, so no doses are anticipated. During operation, the facility will be monitored to ensure that no releases or doses occur via the soil pathway.

Plant Pathway

The plant pathway is not expected to cause any doses to humans. Edible crops or animal forage are not expected to grow on the waste embankment. During operations all plants will be prevented from contacting the waste. After closure, the site's low precipitation and cell cover design will prevent crop production or growth of domestic animal forage on the embankment.

Animal Pathway

Ants fill a broad ecological niche in arid ecosystem of the Clive facility as predators, scavengers, trophobionts and granivores. However, it is their role as burrowers that is of main concern for the purposes of this Compliance Report. 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 at the Clive site. 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-specific or inter-specific 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. These attributes are described in this section, along with other considerations involving the impact of ant species and their inclusion in the Clive PA model.

Other than ants, the burrowing animal pathway is not expected to cause any doses to humans. Burrowing animals at the site include jackrabbits, mice, and foxes. None of these species typically burrow deep enough to penetrate through the cover system and disturb the waste materials.

2.19 R313-25-20; Protection of Individuals From Inadvertent Intrusion

Requirement: 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. [URCR R313-25-20]

From a compliance period perspective, 10,000 years is the time period for a quantitative analysis and is consistent with Federal rules and guidance. Given the nature of depleted uranium, a qualitative analysis out to the peak dose period is also warranted to inform the performance assessment. Use of the 10,000 year time period for compliance is consistent with federal regulations (e.g., 40 CFR 191) and NRC guidance. Extending the analysis qualitatively until peak dose 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.

Consequently, for purposes of applying the performance standards for protection of the general public (URCR313-25-19) and for protection of individuals from inadvertent intrusion (URCR313-25-20), the Division should chosen to use the 10,000 year compliance period with a qualitative analysis to cover the period beyond to the peak dose.

The performance standard for protection of individuals from inadvertent intrusion (URCR313-25-20) 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 Part 61 has been issued, the standard used by NRC and others for low-level radioactive waste disposal licensing has been an intruder standard of 500 mrem/yr. The 500 mrem standard is also used in DOE's waste determinations implementing the Part 61 performance objectives (NUREG-1854). It is noted that 500 mrem/yr was also the standard proposed in Part 61 in 1981 (46 FR 38081, July 24, 1981). Additionally, 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, DRC should use for purposes of applying the performance standard for protection of individuals from inadvertent intrusion (URCR313-25-20) a 500 mrem/yr threshold for the intruder dose.

Compliance Basis: For purposes of demonstrating compliance, it is important to note that occupation of the site by inadvertent intruders after site closure is not likely due to a lack of natural resources in the area, particularly a lack of potable water. As such, contacting the waste after site closure by an onsite resident is not likely due to the lack of natural resources (no reason to drill or dig) and the design of the embankment cover system. The design features and operations will minimize radiation dose to inadvertent intruders, as well. Several design features provide the required protection. Overall features include:

- Lack of nearby residential population
- Embankment cover system

Operations specific features include:

- Fences
- Buffer zone
- Security plan

Post-Closure specific features include:

- Granite markers

While onsite occupation is unlikely, the impact on facility performance by inadvertent intruders is modeled in the 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 2-5 summarizes the maximum dose to the inadvertent intruder at the Clive facility 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.

Table 2-5

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

Waste Model	Receptor	Mean	Median	95% Percentile
3m Model	Rancher	21	11	72
	Hunter	0.8	0.47	2.6
	OHV enthusiast	1.2	0.73	4.0
5m Model	Rancher	0.60	0.44	1.4
	Hunter	0.024	0.02	0.063
	OHV enthusiast	0.037	0.03	0.090
10m Model	Rancher	0.0059	0.0046	0.015
	Hunter	0.00026	0.00020	0.00062
	OHV enthusiast	0.00039	0.00031	0.00096

2.20 R313-25-21; Protection of Individuals During Operation

Requirement: Operations at the land disposal facility shall be conducted in accordance with the standards for radiation protection set out in URCR R313-15, except for release of radioactivity in effluents from the land disposal facility, which are governed by URCR R313-25-19. Every reasonable effort shall be made to maintain radiation exposures as low as reasonably achievable, ALARA. [URCR R313-25-21]

Compliance Basis: The information contained in Appendix A of this report demonstrates that the requirements of URCR R313-25-21 will be met. NUREG-1199 describes the items that together encompass Conduct of Operations.

2.21 R313-25-22; Stability of the Disposal Site After Closure

Requirement: The disposal facility shall be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate, to the extent practicable, the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required. [URCR R313-25-21]

The performance standard for stability requires the facility 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.

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 right next 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 beyond 1,000 years.

Consequently, the Division should use for purposes of applying the performance standard for stability of the disposal site after closure (URCR313-25-22) an approach consistent with past standard setting practice.

Compliance Basis: Compliance with the regulatory requirements related to URCR R313-25-22 is addressed in this Report's sections for URCR R313-25-23(1) through URCR R313-25-23(11), URCR R313-25-7(2) through URCR R313-25-7(5), URCR R313-25-11(1) through URCR R313-25-11(5), URCR R313-25-8, and URCR R313-11(6) through URCR R313-25-11(9).

2.22 R313-25-24; Disposal Site Design For Near-Surface Land Disposal

Requirement: Site design features shall be directed toward long-term isolation and avoidance of the need for continuing active maintenance after site closure. [URCR R313-25-24(1)]

Compliance Basis: URCR R313-25-8 discuss the primary emphasis in determining disposal site suitability was given to isolation of depleted uranium wastes and to disposal site features that ensure that the long-term performance objectives will be met. URCR R313-25-7(1) through URCR R313-25-7(5) also demonstrate that the Principal Design Features have been designed to perform as intended for more than 500 years following the Institutional Control period without reliance on active ongoing maintenance.

2.23 R313-25-31; Funding for Disposal Site Closure and Stabilization

Requirement: The applicant shall provide assurances prior to the commencement of operations that sufficient funds will be available to carry out disposal site closure and stabilization, including: (a) decontamination or dismantlement of land disposal facility structures, and (b) closure and stabilization of the disposal site so that following transfer of the disposal site to the site owner, the need for ongoing active maintenance is eliminated to the extent practicable and only minor custodial care, surveillance, and monitoring are required.

Compliance Basis: The supporting documentation for the 2008 RML renewal indicates that the requirements of URCR R313-25-31, 25-32(1) , and 25-32(2) have been or will be met. Energy*Solutions* annually submits supplemental information to justify the financial assurances it proposes. These annual reports supplement sureties already provided for licensed activities, in an amount adequate to cover any additional costs attributable to closing, stabilizing, decontaminating, decommissioning, monitoring, and maintaining the depleted uranium disposal embankment.

Energy*Solutions* has provided a binding arrangement between Energy*Solutions*, the Division, and the Energy*Solutions*' fiduciary agent that ensures that sufficient funds will be available to cover the costs of

closing and stabilizing the depleted uranium disposal facility, and monitoring and maintaining it during the institutional control period.

The binding arrangement has been and continues to be periodically reviewed by the Executive Secretary to ensure that changes in inflation, technology, and disposal facility operations are reflected in the arrangements. Energy*Solutions* is required by regulation to support similar reviews on an annual basis. Any changes to the binding arrangement will be submitted to the Executive Secretary for review and approval before becoming effective.

2.25 R313-25-32; Financial Assurances For Institutional Control

Requirement: The applicant shall provide assurances prior to the commencement of operations that sufficient funds will be available to carry out disposal site closure and stabilization, including: (a) decontamination or dismantlement of land disposal facility structures, and (b) closure and stabilization of the disposal site so that following transfer of the disposal site to the site owner, the need for ongoing active maintenance is eliminated to the extent practicable and only minor custodial care, surveillance, and monitoring are required.

These assurances shall be based on Executive Secretary approved cost estimates reflecting the Executive Secretary approved plan for disposal site closure and stabilization. The Applicant's cost estimates shall take into account total costs that would be incurred if an independent contractor were hired to perform the closure and stabilization work. [URCR R313-25-31(1)]

Requirement: Prior to the issuance of the license, the applicant shall provide for Executive Secretary approval, a binding arrangement, between the applicant and the disposal site owner that ensures that sufficient funds will be available to cover the costs of monitoring and required maintenance during the institutional control period. The binding arrangement shall be reviewed annually by the Executive Secretary to ensure that changes in inflation, technology, and disposal facility operations are reflected in the arrangements. [URCR R313-25-32(1)]

Requirement: Subsequent changes to the binding arrangement specified in URCR R313-25-32(1) relevant to institutional control shall be submitted to the Executive Secretary for prior approval. [URCR R313-25-32(2)]

Compliance Basis: The supporting documentation in the 2008 RML renewal indicates that the requirements of URCR R313-25-31, 25-32(1) , and 25-32(2) have been or will be met. Energy*Solutions* annually submits supplemental information to justify the financial assurances it proposes. These annual reports supplement sureties already provided for licensed activities, in an amount adequate to cover any additional costs attributable to closing, stabilizing, decontaminating, decommissioning, monitoring, and maintaining the depleted uranium disposal embankment.

Energy*Solutions* has provided a binding arrangement between Energy*Solutions*, the Division, and the Energy*Solutions* fiduciary agent that ensures that sufficient funds will be available to cover the costs of closing and stabilizing the depleted uranium disposal facility, and monitoring and maintaining it during the institutional control period.

The binding arrangement has been and continues to be periodically reviewed by the Executive Secretary to ensure that changes in inflation, technology, and disposal facility operations are reflected in the arrangements. Energy*Solutions* is required by regulation to support similar reviews on an annual basis. Any changes to the binding arrangement will be submitted to the Executive Secretary for review and approval before becoming effective.

2.26 R317-6; Groundwater Protection Limits

Requirement: In addition to these radiological criteria, the Division imposes limits on groundwater contamination, as stated in the Ground Water Quality Discharge Permit (the Permit) (UWQB, 2011). Part I.C.1 of the Permit specifies that Ground Water Protection Limits (GWPLs) in Table 1A of the Permit shall be used for depleted uranium. Table 1A in 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.

Compliance Basis: It is noted 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. As presented in Appendix A, the Performance Assessment estimates groundwater concentrations at a virtual well near the depleted uranium disposal embankment for comparison with these GWPLs.

3. CONCLUSIONS

This report demonstrates Energy*Solutions*' continued regulatory compliance resulting from their proposed disposal of depleted uranium as Class A waste. As such, it is concluded that acceptance and disposal of depleted uranium produced at DOE's Savannah River Site can be completed compliant with URDR 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 their claims of compliance with URCR Rules through the development and execution of a detailed, site-specific, 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 URCR.

While included in this Compliance Report as part of improving qualitative understanding of facility 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).

4. REFERENCES

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APPENDIX A

Final Report for the Clive DU PA Model – version 1.0

[provided via attached digital DVD]