State of Utah

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Department of
Environmental Quality

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*Executive Director*

DIVISION OF SOLID AND
HAZARDOUS WASTE
Scott T. Anderson
*Director*



February 28, 2014

Sean McCandless
Director of Permitting and Compliance
EnergySolutions, LLC
423 South 300 West, Suite 200
Salt Lake City, Utah 84101

RE: Depleted Uranium Performance Assessment (DUPA) for the Clive Facility
Round 1 Interrogatories
DRC Radioactive Materials License 2300249

Dear Mr. McCandless:

The Department of Environmental Quality has completed the Round 1 Interrogatory of the Depleted Uranium Performance Assessment for the EnergySolutions Clive LLRW Disposal Facility, Utah LLRW Disposal license – Condition 35 (RML UT 2300249), pertaining to:
Compliance Report (June 1, 2011), including Final Report, Version 1.0 (Appendix A), and Appendices 1–17 to Appendix A, and Compliance Report, Revision 1 (November 8, 2013).

The interrogatories are enclosed. Based on the scope of the interrogatories, we believe that a revision of the GoldSim probabilistic model is in order. Please provide a written response by March 31, 2014. We appreciate your cooperation.

If you have any questions, please call me at (801) 536-0215.

Sincerely,

Helge Gabert, Project Manager DU Contract
Division of Solid and Hazardous Waste

HG/STA/tjm

Enclosure: (CD) DSHW-2014-004182

(Over)

c: Rusty Lundberg, Director, DRC
Myron Bateman, EHS, MPA, Health Officer, Tooele County Health Department
Jeff Coombs, EHS, Environmental Health Director, Tooele County Health Department

# UTAH DIVISION OF RADIATION CONTROL: ENERGY*SOLUTIONS* CLIVE LLRW DISPOSAL FACILITY:

# UTAH LLRW DISPOSAL LICENSE – CONDITION 35 (RML UT 2300249)

# COMPLIANCE REPORT (JUNE 1, 2011) INCLUDING FINAL REPORT, VERSION 1.0 (APPENDIX A) AND APPENDICES 1–17 TO APPENDIX A AND COMPLIANCE REPORT, REVISION 1 (NOVEMBER 8, 2013)

# ROUND 1 INTERROGATORIES

## TABLE OF CONTENTS

## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| ALARA | as low as reasonably achievable |
| Am | americium |
| Ba | barium |
| bgs | below ground surface |
| BLM | Bureau of Land Management |
| BP | before present |
| CFR | *Code of Federal Regulations* |
| Ci/g | curie(s) per gram |
| CLSM | controlled low-strength material |
| cm/s | centimeter(s) per second |
| $cm^2/s$ | square centimeter(s) per second |
| cm/yr | centimeter(s) per year |
| Cs | cesium |
| DCF | dose conversion factor |
| DEQ | (Utah) Department of Environmental Quality |
| DF | decontamination factor |
| DOE | U.S. Department of Energy |
| DU | depleted uranium |
| DUF6 | depleted uranium hexafluoride |
| $DUO_2$ | depleted uranium dioxide |
| $DUO_3$ | depleted uranium trioxide |
| DWUR | drinking water unit risk |
| EPA | U.S. Environmental Protection Agency |
| EPRI | Electric Power Research Institute |
| FEP | feature, event, and process |
| g | gram(s) |
| $g/cm^3$ | gram(s) per cubic centimeter |
| g/s | gram(s) per second |
| GDP | gaseous diffusion plant |
| GWPL | groundwater protection limit |
| HI | Hazard Index |
| HQ | Hazard Quotient |
| I | iodine |
| ICRP | International Commission on Radiation Protection |
| IEM | Integrated Environmental Management, Inc., |
| IHI | inadvertent human intruder |
| in./yr | inch(es) per year |
| IRIS | Integrated Risk Information System |
| $K_d$ | soil/water partition coefficients |
| kg | kilogram(s) |
| ky | thousand years |
| kya | thousand years ago |
| LANL | Los Alamos National Laboratory |
| M | molar |

| | |
|---|---|
| MCL | maximum contaminant level |
| MDA | minimum detectable activity |
| mg/kg-day | milligram(s) per kilogram per day |
| mg/L | milligram(s) per liter |
| mg/m3 | milligram(s) per cubic meter |
| mm/yr | millimeter(s) per year |
| mrem | millirem |
| mrem/yr | millirem per year |
| mSv | millisievert |
| MT | metric tonne |
| MTU | metric tonne unit |
| My | million years |
| nCi/g | nanocurie(s) per gram |
| NCRP | National Council on Radiation Protection and Measurements |
| NNSS | Nevada National Security Site |
| Np | neptunium |
| NRC | U.S. Nuclear Regulatory Commission |
| NTS | Nevada Test Site |
| OHV | off-highway vehicle |
| OMB | Office of Management and Budget |
| PA | performance assessment |
| pCi/g | picocurie(s) per gram |
| $pCi/m^2$-s | picocurie(s) per square meter per second |
| ppb | part(s) per billion |
| Pu | plutonium |
| Ra | radium |
| REF | radiation effectiveness factor |
| RfD | reference dose |
| Rn | radon |
| SRS | Savannah River Site |
| TBD | to be determined |
| Tc | technetium |
| TDS | total dissolved solids |
| TEDE | total effective dose equivalent |
| U | uranium |
| $U_3O_8$ | triuranium octaoxide |
| UAC | Utah Administrative Code |
| $UF_6$ | uranium hexafluoride |
| µg/L | microgram(s) per liter |
| $UO_2$ | uranium dioxide |
| UZ | unsaturated zone |
| wt% | weight-percent |

**CATEGORIZATION OF INTERROGATORIES**

Cell and Cover Design: 27, 70, 71, 81, 84, 93, 109, 150, 154, 155, 160, 162, 168, 171, 173, 175, 179

Geochemistry: 54, 55, 64, 65, 66, 67, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149

Groundwater: 8, 20, 96, 97, 105, 106, 114, 117, 135, 156, 163, 182

Human Intrusion: 7, 11, 12, 29, 82, 83, 92, 172

Hydrology: 21, 59, 68, 69, 90, 91, 99, 100, 101, 103, 104, 112

Lake Formation/Sedimentation: 3, 14, 18, 19, 44, 86, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134

QA/QC: 4, 61, 62, 76, 77, 78, 80, 118, 152, 169, 181

Radon: 5, 16, 26, 28, 60, 110, 120, 151, 153

Regulatory: 24, 94, 164, 165, 180

Waste: 17, 23, 25, 30, 31, 32, 48, 49, 50, 51, 52, 89, 95, 113, 157, 158, 159, 161, 166, 167, 170, 174, 176

Miscellaneous: 1, 2, 6, 10, 13, 15, 22, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 45, 46, 47, 53, 56, 57, 58, 63, 72, 73, 74, 75, 79, 85, 87, 88, 98, 102, 107, 108, 111, 115, 116, 119, 177, 178

## INTERROGATORY CR R313-25-19-01/1: INTERGENERATIONAL CONSEQUENCES

### PRELIMINARY FINDING:

Refer to R313-25-19: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.*

### INTERROGATORY STATEMENT:

Please follow the policy of the U.S. Nuclear Regulatory Commission (NRC) in determining dollar values per person-rem and discount rates, or explain why that policy would not apply.

### BASIS FOR INTERROGATORY:

Section 6.4, pages 76–77, of the Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011 (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011) (FRV1) presents an "as low as reasonably achievable" (ALARA) analysis that implies that either an undiscounted value of $1,000 per person-rem or a discounted value of $2,000 per person-rem may be used, and it includes discount factors of 3% and 7%.

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

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

> *For certain regulatory actions, such as those involving decommissioning and waste disposal issues, the regulatory analysis may have to consider consequences that can occur over hundreds, or even thousands, of years. The OMB* [Office of Management and Budget] *recognizes that special considerations arise when comparing benefits and costs across generations. Under these circumstances, OMB continues to see value in applying discount rates of 3 and 7 percent. However, ethical and technical arguments can also support the use of lower discount rates. Thus, if a rule will have important intergenerational consequences, one should consider supplementing the analysis with an explicit discussion of the intergenerational concerns such as how future generations will be affected by the regulatory decision. Additionally, supplemental information could include a presentation of the values and impacts at the time in which they are incurred with no present worth conversion. In this case, no calculation of the resulting net value or value-impact ratio should be made. Also, one should consider a sensitivity analysis using a lower, but positive discount rate.*

FRV1 Sections 1.3, page 16; 4.1.2.11, page 39; and 6.4, pages 76–77, discuss the options for discounting costs of human exposures over time, but the report does not describe the NRC's position on intergenerational impacts, as defined in NUREG/BR-0058, Section 4.3.5.

**REFERENCES:**

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Nuclear Regulatory Commission, *Reassessment of NRC's Dollar Per Person-Rem Conversion Factor Policy*, NUREG-1530, Office of Nuclear Regulatory Research, December 1995.

U.S. Nuclear Regulatory Commission, *Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission*, NUREG/BR-0058, Office of Nuclear Regulatory Research, Revision 4, September 2004.

## INTERROGATORY CR R313-25-8(5)(A)-02/1: DEEP TIME

### PRELIMINARY FINDING:

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

### INTERROGATORY STATEMENT:

Provide further information on how the length of the deep time assessment (2.1 million years (My)) was determined.

### BASIS FOR INTERROGATORY:

In defining the length of the deep time assessment, the FRV1 Executive Summary, page 5, states the following:

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

In order to determine whether 2.1 My is the appropriate time for deep time assessment, the statement above needs to be clarified. First, decay products usually reach secular equilibrium with their principal parent, rather than the other way around. Second, the text should discuss how the value of 2.1 My was determined based on a half-life of $4.49\times10^{9}$ years for U-238 and the half-lives of its decay products (e.g., 244,500 years for U-234).

### REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0,* June 1, 2011. (Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

## INTERROGATORY CR R313-25-8(5)(A)-03/1: DEEP TIME – SEDIMENT AND LAKE CONCENTRATIONS

## PRELIMINARY FINDING:

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

Refer also to R313-19-13(2)(a)(i)(B): *(a) Exempt concentrations: (i) Except as provided in Subsection R313-19-13(2)(a)(iii) a person is exempt from Rules R313-19, R313-21 and R313-22 to the extent that the person receives, possesses, uses, transfers, owns or acquires products or materials containing: (B) diffuse sources of natural occurring radioactive materials containing less than 15 picocuries per gram radium-226.*

## INTERROGATORY STATEMENT:

1. Explain why FRV1 does not provide any health and environmental concentration limits for future lake water or sediments for comparison.
2. Resolve discrepancies between the concentration values given in Table 14 and the concentrations shown in FRV1 Figure 13.
3. Provide the basis for presenting only the U-238 sediment concentrations (rather than the full U-238 decay series), as well as the basis for concluding that these concentrations are "small."
4. Indicate why the soil criteria in 40 CFR Part 192 should not apply to the deep time assessment.

## BASIS FOR INTERROGATORY:

FRV1 Section 5.1.1, page 43, describes how the deep time model did not consider doses to receptors from future lake water and sediments but instead only predicted lake water and sediment concentrations. The report should provide appropriate environmental regulatory lake water and sediment concentration limits that can be used for compliance comparisons. Alternatively, the report should explain and justify why such health and environmental protection concentration limits are not needed.

FRV1 Section 5.1.8, page 45, describes how, after a future lake erodes the embankment and re-distributes the depleted uranium (DU) waste among lake sediments, the DU contaminants migrate into the lake water via diffusion. However, it does not mention how DU waste contaminants could enter the lake via a groundwater pathway. This apparent omission should be explained and justified, including why it is a conservative approach (protective of health and the environment).

FRV1 Section 6.5.2, page 81, provides in Table 14 and Figure 13 the U-238 lake sediment concentrations derived from successive lake events. However, the values given in Table 14 and shown in Figure 13 do not always agree. For example, the mean concentration in Table 14 is 1,500 or 1,600 picocuries per gram (pCi/g), but Figure 13 shows the mean concentration as always less than 1,000 pCi/g.

Section 7.1, page 84, states in the first full paragraph, "*Despite these possible conservatisms in the deep-time model, the lake water and lake sediment concentrations are small*." The full U-238 decay series is not provided and no other basis is given for concluding that the concentrations are "*small*." When considered in the context of regulations such as 40 CFR 192.12(a), the concentrations are not in fact small.

40 CFR 192.12(a) states the following:

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

Although 40 CFR 192.12 was developed specifically for the cleanup of uranium mill tailings sites under Title 1 of the Uranium Mill Tailings Radiation Control Act of 1978, the U.S. Environmental Protection Agency (EPA) has used the criteria in 40 CFR Part 192 when setting remediation goals at Comprehensive Environmental Response, Compensation, and Liability Act sites with radioactive contamination, and those criteria could be considered applicable to this facility.

A similar limit is included in Utah regulation R313-19-13(2)(a)(i)(B), which requires a radioactive material license for diffuse sources containing more than 15 pCi/g of Ra-226.

**REFERENCES:**

*Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 192, *Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings*.

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(4)-04/1: REFERENCES

### PRELIMINARY FINDING:

Refer to R313-25-8(4): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

*(b) Analyses of the protection of inadvertent intruders shall demonstrate a reasonable assurance that the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided.*

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

*(d) 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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

Refer also to R313-22-32(5): *In the application, the applicant may incorporate by reference information contained in previous applications, statements, or reports filed with the Director, provided the references are clear and specific.*

### INTERROGATORY STATEMENT:

Ensure that links to references online are working at the time of submittal and that they do not bring users to sites that require entry of a username and passcode.

### BASIS FOR INTERROGATORY:

Members of the public need to be able to access the references used in FRV1. With the understanding that Internet links can be broken over time, links should be accurate and working at the time of submittal, and links to documents on websites that require entry of a username and passcode are not considered publicly available.

**REFERENCES:**

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-7(2)-05/1: RADON BARRIER**

**PRELIMINARY FINDING:**

Refer to R313-25-7(2): *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.*

Refer also to R313-25-7(4): *Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.*

**INTERROGATORY STATEMENT:**

Explain why the model does not consider the effects of a compromised radon barrier.

**BASIS FOR INTERROGATORY:**

The FRV1 Executive Summary, page 2, states, "*The model does not consider the effects of enhanced infiltration or radon diffusion from a compromised radon barrier*." The effects of a compromised radon barrier should be considered, since the durability of the radon barrier over time is problematic. As described in FRV1, plant roots and burrowing animals are active at the Clive site and could compromise the radon barrier by creating "short-circuit" pathways. This issue is particularly sensitive since the performance assessment (PA) model must predict future site/embankment performance for more than 10,000 years, as called for in R313-25-8(5)(a).

**REFERENCES:**

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(2)-06/1: GULLY MODEL ASSUMPTIONS

### PRELIMINARY FINDING:

Refer to R313-25-7(2): *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.*

### INTERROGATORY STATEMENT:

Add a cross-reference in the Executive Summary to the discussion on gully model assumptions in the Erosion Modeling report.

### BASIS FOR INTERROGATORY:

The FRV1 Executive Summary, page 2, states, "*The potentially significant cover degradation process of gully formation is evaluated using a simple modeling construct, in order to determine whether it warrants more sophisticated modeling approaches*." The text should reference the section within FRV1 that contains the determination as to whether a more sophisticated modeling approach is warranted (i.e., Section 4.0 of the Erosion Modeling report).

### REFERENCES:

Neptune and Company, Inc., *Erosion Modeling for the Clive PA*, June 1, 2011. (Appendix 10 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(B)-07/1: APPLICABILITY OF NRC HUMAN INTRUSION SCENARIOS

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(b): *Analyses of the protection of inadvertent intruders shall demonstrate a reasonable assurance that the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided.*

### INTERROGATORY STATEMENT:

Identify the intrusion barriers in the disposal cell design and explain why typical NRC intrusion scenarios usually underestimate the performance of the disposal system and under what unusual circumstances the performance of the facility/site will not be underestimated. Evaluate other suggested scenarios in addition to the usual NRC intrusion scenarios.

### BASIS FOR INTERROGATORY:

The FRV1 Executive Summary, page 3, states that typical NRC intrusion scenarios do not adequately describe likely human activities in the arid west and will usually underestimate the performance of the disposal system. That is, we presume that modeling usual human intrusion scenarios will result in higher doses because such scenarios might not be reasonable in the arid West. The Dose Assessment report lists the exposure scenarios but does not explain why underestimation of performance the disposal system is usual.

Energy*Solutions* should explain and justify why each of the typical NRC intrusion scenarios were omitted from examination in FRV1, and identify the embankment features that constitute the intrusion barriers for the Clive facility.

In addition to the usual NRC intruder scenarios, Energy*Solutions* should also evaluate the following scenarios:

1. Future industrial occupation of Energy*Solutions*' abandoned buildings outside of Section 32.
2. Nearby industrial occupation for renewable energy development (e.g., solar farm, wind turbines).
3. Excavation for a transcontinental utility pipeline.
4. Surface mining of clay, sand, and gravel.

### REFERENCES:

Neptune and Company, Inc., *Dose Assessment for the Clive DU PA*, May 28, 2011. (Appendix 11 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(4)(A)-08/1: GROUNDWATER CONCENTRATION ENDPOINTS**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

**INTERROGATORY STATEMENT:**

Explain why six different models are considered for the dose and groundwater concentration endpoints rather than three.

**BASIS FOR INTERROGATORY:**

The FRV1 Executive Summary, page 6, states, "*Consequently, six different models are considered for the dose and groundwater concentration endpoints*." Since the erosion scenarios are claimed to not affect the groundwater modeling results, it seems that there would be only three groundwater concentration endpoints representing the three emplacement depths.

**REFERENCES:**

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-19-09/1: DEFINITION OF ALARA

### PRELIMINARY FINDING:

Refer to R313-25-19: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.*

### INTERROGATORY STATEMENT:

Change the citation for the definition of ALARA from 10 CFR 61.42 to 10 CFR 20.1003.

### BASIS FOR INTERROGATORY:

FRV1 Section 1.3, page 15, states that 10 CFR 61.42 defines ALARA; rather, the definition is given in 10 CFR 20.1003.

### REFERENCES:

*Code of Federal Regulations*, Title 10, *Energy*, Part 20, *Standards for Protection against Radiation*.

*Code of Federal Regulations*, Title 10, *Energy*, Part 61, *Licensing Requirements for Land Disposal of Radioactive Waste*.

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-22-32(2)-10/1: EFFECT OF BIOLOGICALS ON RADIONUCLIDE TRANSPORT**

**PRELIMINARY FINDING:**

Refer to R313-22-32(2): *The Executive Secretary may, after the filing of the original application, and before the expiration of the license, require further statements in order to enable the Executive Secretary to determine whether the application should be granted or denied or whether a license should be modified or revoked.*

**INTERROGATORY STATEMENT:**

Provide support for the statement that the severity of the *"…effect* [of plants, ants, and burrowing mammals] *on radionuclides transport might be small."*

**BASIS FOR INTERROGATORY:**

FRV1 Section 4.1.2.8, page 32, states that the severity of the effect of plants, ants, and burrowing mammals on radionuclide transport might be "*small*" because the impact will be limited largely to the top several meters. However, no discussion is provided to support this qualitative judgment of "*small*" effects. For example, what if burrowing occurs in gullies? We also note that the verb "*might*" typically connotes a considerable degree of uncertainty.

**REFERENCES:**

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-20-11/1: INADVERTENT HUMAN INTRUDER**

**PRELIMINARY FINDING:**

Refer to R313-25-20: *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.*

**INTERROGATORY STATEMENT**:

Ensure that the text correctly reflects the language of UAC R313-25-20.

**BASIS FOR INTERROGATORY:**

FRV1 Section 4.1.2.10.1, page 37, states that "*the IHI* [inadvertent human intruder] *is someone who intrudes onto the facility and may directly contact the waste (e.g., by well drilling, or basement construction)*." This statement requires revision or additional justification. Contrary to what is expressed here, UAC R313-25-20 does not restrict inadvertent intrusion scenarios to someone who directly contacts the waste. The rule speaks rather of "*any individuals inadvertently intruding into the disposal site and occupying the site or contacting the waste after active institutional controls over the disposal site are removed*." It is noted that an inadvertent intruder (1) inadvertently intrudes into the site, and either (2a) occupies the site, **or** (2b) contacts the waste, or both, after active institutional controls over the disposal site are removed.

**REFERENCES:**

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-20-12/1: SELECTION OF INTRUSION SCENARIOS

### PRELIMINARY FINDING:

Refer to R313-25-20: *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.*

### INTERROGATORY STATEMENT:

Address inadvertent human intruder exposure scenarios that are likely to result in the greatest doses to members of the public.

### BASIS FOR INTERROGATORY:

FRV1 Section 4.1.2.10.1, page 37, addresses only ranching and recreational scenarios for exposure. While each of these scenarios is likely, neither one is a scenario in which the greatest radioactive doses would likely occur, should the scenario come to pass. The PA should consider other likely scenarios in which the doses would likely be far greater. This will be more protective of inadvertent intruders and members of the public. At a minimum, these scenarios must include an industrial scenario, in which industrial activities, such as industrial waste disposal, are conducted on site. This may involve construction and use of buildings with basements, as well as use of groundwater from onsite wells for dust suppression, and other activities. The scenario may also involve digging of earthen materials for onsite cover use or some other beneficial purpose. Another scenario that should be considered is mining for sand and clay onsite (e.g., for road construction). Both types of activities have historically taken place on and/or near the site.

The following activities have been or are currently undertaken at or near the Clive site in an industrial setting and could serve as a basis for an inadvertent human intruder exposure scenario:

1. Drilling of wells – Personnel at industrial sites including the Clive site and a number of adjacent or nearby sites have drilled wells to moderate depths (e.g., several hundred feet); an inadvertent intruder in the future may likewise drill one or more wells and be exposed to radioactivity in cuttings, drilling mud, or gas emanating from a borehole.
2. Pumping of groundwater from wells – A number of wells at or near the Clive site have been pumped in the past to recover groundwater. The groundwater may be used for washing, cleaning, dust control, cooling, scrubbing, or other industrial purposes, as it historically has been used in the region. Any radioactivity within the groundwater (e.g., radon, Ra-226) may potentially be involved in a dose (via inhalation, skin contact, or other routes) to inadvertent intruders as receptors on the site.
3. Mining of clay and sand – This has been performed at Clive as well as at the Grassy Mountain facility and other nearby areas. Mining directly from embankments at the facility, such as for materials for road construction or waste embankments, could result in direct exposures to radioactivity without inadvertent intruders necessarily becoming aware of the hazard.

4. Development of areas where, because of ponding, leaking pipes, bad casing protection in wells, or some other reason, water locally infiltrates and results in mounding below the surface, as occurs at several places on the Clive site – This, in turn, may encourage rooting by deep-rooted plants that transpire water from the water table and capillary fringe and export radioactive substances to the surface.
5. Digging of foundations, basements of buildings, or roadcuts – This may potentially provide exposure to radioactive substances to one or more inadvertent intruders, not only during the time of digging but also at subsequent times when basements are used.

Energy*Solutions* should also justify why other industrial pursuits were not considered, including, but not limited to, aquaculture for biofuels production and solar energy farms.

**REFERENCES:**

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7-13/1: REFERENCE FOR LONG-TERM CLIMATIC CYCLES

### PRELIMINARY FINDING:

Refer to R313-25-7: *The application shall include certain technical information. The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25:*

*(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

### INTERROGATORY STATEMENT:

Provide a reference for the statement about the likelihood of long-term climatic cycles of 100 thousand years (ky).

### BASIS FOR INTERROGATORY:

FRV1 Section 4.1.2.13, page 40, states, *"Given that long-term climatic cycles of 100 ky are considered very likely…."* This statement needs to be supported by a reference from technical literature subject to professional peer review.

### REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(4)(D)-14/1: SEDIMENT MIXING**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(d)): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

**INTERROGATORY STATEMENT:**

Clarify the statement *"probably leads to conservative results"* to indicate those cases in which conservative results would not be obtained.

**BASIS FOR INTERROGATORY:**

FRV1 Section 4.1.2.13, page 42, states that "*an assumption that the sediments completely mix is expedient, and probably leads to conservative results*." Section 3.4, pages 10–11, of the Deep Time Assessment report discusses the sedimentation accumulation rate but does not discuss the mixing of sediments. More information is needed on cases in which conservative results would not be obtained in order to permit full evaluation of the conservatism of the approach.

**REFERENCES:**

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R317-6-6.3(Q)-15/1: URANIUM CHEMICAL TOXICITY

### PRELIMINARY FINDING:

Refer to R317-6-6.3(Q): *Ground Water Quality Protection Regulations – Applications Requirements for a Ground Water Discharge Permit – Other Information Required.*

### INTERROGATORY STATEMENT:

Provide the spatial compliance points for uranium chemical toxicity.

### BASIS FOR INTERROGATORY:

FRV1 Section 5.1.1, page 43, identifies compliance points for the dose assessment and the groundwater protection limits (GWPLs), but not for uranium toxicity. The Geochemical Modeling report discusses geochemical modeling related to uranium but does not address toxicity. Spatial compliance points for uranium chemical toxicity are needed.

### REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(A)-16/1: RADON PRODUCTION AND BURROWING ANIMALS

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a)): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

### INTERROGATORY STATEMENT:

Discuss the relationship between burrowing animals in the cover system and the radon escape/production ratio, if any. Provide the values used in the Conceptual Site Model with regard to the waste form, porosity, and surface area and escape/production ratios for both the Savannah River Site (SRS) and gaseous diffusion plant (GDP) waste sources of DU.

### BASIS FOR INTERROGATORY:

FRV1 Section 6.2.2, page 67, should discuss the relationship between burrowing animals and the radon escape/production ratio, if any. For example, gullies where the rip rap has been disturbed might be more accessible to burrowing animals and would represent a shorter pathway to the waste.

Section 9.2.3, page 51, of the Conceptual Site Model report describes the relationship between the waste form, porosity, and surface area and the escape/production ratios. Energy*Solutions* should provide the values used in the model for both the SRS and GDP waste sources of DU.

### REFERENCES:

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R317-6-6.3(Q)-17/1: URANIUM PARENTS**

**PRELIMINARY FINDING:**

Refer to R317-6-6.3(Q): *Ground Water Quality Protection Regulations – Applications Requirements for a Ground Water Discharge Permit – Other Information Required.*

**INTERROGATORY STATEMENT:**

Clarify the reference to "*uranium parents.*"

**BASIS FOR INTERROGATORY:**

FRV1 Section 6.3.2, page 71, states that "*no other radionuclides except uranium parents (of which there are very few) could influence this endpoint.*" It is not clear whether this refers to the parents of uranium or the uranium parents of the decay products. The text should specify what elements and nuclides are meant, whether natural uranium isotopes or man-made transuranic radionuclides that decay to a uranium isotope.

**REFERENCES:**

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(5)(A)-18/1: SEDIMENT ACCUMULATION**

**PRELIMINARY FINDING:**

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

**INTERROGATORY STATEMENT:**

Resolve the discrepancy between the values for sediment accumulation cited in FRV1 and the Deep Time Assessment report.

**BASIS FOR INTERROGATORY:**

FRV1 Section 6.5, page 78, states that sediment accumulated at a rate of about 17 meters per 100 ky. Section 6.3, page 24, of the Deep Time Assessment report states that the sedimentation rate for large lakes (i.e., lakes that reach the elevation of the Clive site) has a log-normal distribution, with a geometric mean of 120 millimeters/ky and a geometric standard deviation of 1.2. This geometric mean is equivalent to 12 meters per 100 ky. The differing values cited in FRV1 and the Deep Time Assessment report should be reconciled. Lower sedimentation rates could lead to less isolation of the waste from the surface environment upon lake recession.

**REFERENCES:**

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(5)(A)-19/1: REFERENCE FOR SEDIMENT CORE RECORDS**

**PRELIMINARY FINDING:**

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

**INTERROGATORY STATEMENT:**

Provide a reference from technical peer-reviewed literature for the sediment core records.

**BASIS FOR INTERROGATORY:**

FRV1 Section 6.5, page 78, states that "*Sediment core records show significant mixing of sediment….*" However, no reference is provided for these records.

**REFERENCES:**

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R317-6-2.1-20/1: GROUNDWATER CONCENTRATIONS

### PRELIMINARY FINDING:

Refer to R317-6-2.1: *The following Ground Water Quality Standards as listed in Table I are adopted for protection of ground water quality.*

Refer also to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

### INTERROGATORY STATEMENT:

Explain why groundwater concentrations are not identical with and without the formation of gullies in the cover system.

### BASIS FOR INTERROGATORY:

FRV1 Section 7.1, page 83, states that *"Once gullies are involved, the doses increase (ground water concentrations do not change noticeably)."* If groundwater concentrations are not identical with and without the gullies (i.e., if they change, even if it is not *"noticeable"*), the text should explain why.

### REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(4)(D)-21/1: INFILTRATION RATES**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(d)): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

**INTERROGATORY STATEMENT:**

Explain why infiltration rates may be overestimated.

**BASIS FOR INTERROGATORY:**

FRV1 Section 7.2, page 85, states that *"Infiltration rates might be overestimated…."* The text should discuss and justify why the estimates for infiltration rates may be too high.

**REFERENCES:**

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-7-22/1: DEFINITION OF FEPS**

**PRELIMINARY FINDING:**

Refer to R313-25-7: *The application shall include certain technical information. The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25:*

*(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

*(2) 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.*

*(3) Descriptions of the principal design criteria and their relationship to the performance objectives.*

*(4) Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.*

**INTERROGATORY STATEMENT:**

Clarify the distinction between *"features, events, and processes"* (FEPs) and *"technical performance objectives."*

**BASIS FOR INTERROGATORY:**

Section 4.1.1, page 5, of the FEP Analysis report lists FEPs said to be mentioned in 10 CFR Part 61. However, it is not clear that the items listed are FEPs, since Section 4.1.2, page 5, refers to similar items as *"technical performance objectives."* State the difference between FEPs and technical performance objectives. Is the intent of Section 4.1.2 to indicate that FEPs and the listed technical performance objectives are identical? If so, the text should explain how they are identical.

**REFERENCES:**

*Code of Federal Regulations*, Title 10, *Energy*, Part 61, *Licensing Requirements for Land Disposal of Radioactive Waste.*

Neptune and Company, Inc., *FEP Analysis for Disposal of Depleted Uranium at the Clive Facility,* May 28, 2011. (Appendix 1 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

## INTERROGATORY CR R313-25-7(2)-23/1: CANISTER DEGRADATION AND CORROSION

### PRELIMINARY FINDING:

Refer to R313-25-7(2): *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.*

### INTERROGATORY STATEMENT:

Provide a specific cross-reference to the evaluation of canister degradation and corrosion in the Conceptual Site Model.

### BASIS FOR INTERROGATORY:

In Section 5, page 21, of the Conceptual Site Model Report and in Section 6.0, page 9, of the FEP Analysis report, the sections on "*Containerization*" state that "*two key components of containerization were identified as FEPs: containment degradation and corrosion*." They note that canister degradation, including corrosion, could result in containment failure and that these processes are evaluated in the conceptual site model. However, no cross-reference to this evaluation in the Conceptual Site Model report is provided; the text should be revised to include the appropriate reference(s).

### REFERENCES:

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *FEP Analysis for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 1 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-15-101(1)-24/1: UTAH REGULATIONS

### PRELIMINARY FINDING:

Refer to R313-15-101(1)): *Each licensee or registrant shall develop, document, and implement a radiation protection program sufficient to ensure compliance with the provisions of Rule R313-15. See Section R313-15-1102 for recordkeeping requirements relating to these programs.*

### INTERROGATORY STATEMENT:

Frame the discussion in the context of the governing Utah rule and correct errors in quoting Utah rules.

### BASIS FOR INTERROGATORY:

Section 1, page 1, of the Conceptual Site Model report mentions a federal rule (10 CFR Part 61, Subpart C) relative to the radiological PA. However, it does not mention the controlling rule(s) of the State of Utah, created and administered by the State of Utah as an NRC Agreement State (i.e., those listed at www.radiationcontrol.utah.gov/EnSolutions/depleteduranium/performassess/duparules.htm). The text should frame the discussion within the context of the governing Utah rule.

This problem is also repeated several times in FRV1 and its appendices. Energy*Solutions* should either state both the NRC and corresponding state rule or simply use the state citation alone.

Errors in quoting Utah rules should also be corrected, including those in FRV1 Section 1.3, page 15, and Section 4.2.1, page 17, of the Conceptual Site Model report.

### REFERENCES:

*Code of Federal Regulations*, Title 10, *Energy*, Part 61, *Licensing Requirements for Land Disposal of Radioactive Waste.*

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility,* May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0,* June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-7(9)-25/1: DISPOSITION OF CONTAMINANTS IN $UF_6$**

**PRELIMINARY FINDING:**

Refer to R313-25-7(9): *Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal facility.*

**INTERROGATORY STATEMENT:**

Provide a reference for the discussion of the results occurring when contaminated uranium hexafluoride ($UF_6$) is introduced to the cascade.

**BASIS FOR INTERROGATORY:**

Section 6, page 22, of the Conceptual Site Model report states that "*If uranium hexafluoride derived from irradiated reactor returns is introduced to the cascade, the associated fission products and actinides migrate to the depleted end of the cascade, with the-U 238.*" A reference for this statement is needed.

It is our understanding that the lighter fission products such as Tc-99 will migrate with U-235 toward the product side of the cascade. According to BJC/PGDP-167, Section 3, page 40, about 85% of the Tc-99 would transfer to the $UF_6$ and be fed into the cascade. It would be withdrawn in small quantities along with the enriched $UF_6$ product. Hightower et al. (2000) note in Appendix C that most of the nuclides introduced to the cascades are not expected to reach the tails. This is because most of the volatile Tc-99 species are removed through the GDPs' purge cascade or report to the product stream.

**REFERENCES:**

Bechtel Jacobs Company, LLC, *Recycled Uranium Mass Balance Project Paducah Gaseous Diffusion Plant Site Report*, BJC/PGDP-167, June 14, 2000.

Hightower, J.R., L.R. Dole, D.W. Lee, G.E. Michaels, M.I. Morris, D.G. O'Conner, S.J. Pawel, R.L. Schmoyer, L.D. Trowbridge, and V.S. White, *Strategy for Characterizing Transuranics and Technetium Contamination in Depleted UF6 Cylinders*, ORNL/TM-2000/242, UT-Battelle, Oak Ridge National Laboratory, Oak Ridge, Tennessee, October 2000.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(A)-26/1: RADON DIFFUSION IN THE UNSATURATED ZONE

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

### INTERROGATORY STATEMENT:

Clarify whether diffusion of radon in the air phase in the unsaturated zone is included in the PA model. If it is not, justify why its omission is protective of human health and the environment. Also, describe and justify what site-specific investigation was performed at Clive to determine the applicable air phase tortuosity model.

### BASIS FOR INTERROGATORY:

Section 6.6, page 26, of the Conceptual Site Model report states that *"The transport of radon in both the saturated and unsaturated zones will be included in the PA model."* Section 7.1.1.1, page 27, states that *"Diffusion in the air phase within the UZ below the facility will not be modeled, since the only diffusive species would be radon…."* The text should resolve these apparently contradictory statements.

Page 6 of the *Implementation of Diffusion in GoldSim* attachment to the Embankment Modeling report explains that three different models returned three different values for air phase tortuosity and then states that "*Which model is most appropriate for a given material is a matter of site-specific investigation.*" The text should describe and justify what site-specific investigation was performed at Clive to determine the applicable air phase tortuosity model.

### REFERENCES:

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Embankment Modeling for the Clive DU PA Model*, May 28, 2011. (Appendix 3 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(4)(A)-27/1: DIFFUSION PATHWAY MODELING**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

**INTERROGATORY STATEMENT:**

Clarify how the PA model accounts for the impact of diffusion pathways.

**BASIS FOR INTERROGATORY:**

Section 7.1.3.1, page 28, of the Conceptual Site Model report states that *"Over time, cracks, fissures, animal burrows, and plant roots can also provide preferential diffusion pathways that reduce the effectiveness of the engineered barrier."* Although the Embankment Modeling report outlines how diffusion in air and water is to be implemented in GoldSim models that include diffusion in the unsaturated zone, neither this appendix nor the Air Modeling report discusses how diffusion pathways reduce the effectiveness of the radon barrier. The text in Section 7.1.3.1 should indicate how the PA model accounts for such pathways reducing the effectiveness of the engineered barrier, particularly with respect to the potential release of radon to the surface. If such preferential pathways are not included in the PA, the text should discuss and justify why this modeling aspect was not included.

**REFERENCES:**

Neptune and Company, Inc., *Atmospheric Transport Modeling for the Clive DU PA,* May 28, 2011. (Appendix 8 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

Neptune and Company, Inc., *Embankment Modeling for the Clive DU PA Model,* May 28, 2011. (Appendix 3 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(4)(A)-28/1: BIOTURBATION EFFECTS AND CONSEQUENCES**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

**INTERROGATORY STATEMENT:**

Provide references to support the statement that bioturbation and homogenization of the radon barriers will probably occur very slowly relative to the 10,000-year time frame for the PA, and address other effects and consequences of biointrusion and bioturbation.

**BASIS FOR INTERROGATORY:**

Section 8.2, page 45, of the Conceptual Site Model report describes processes that drive potential changes in evapotranspiration and lateral drainage as the cap evolves. The third bullet states, "*On balance, the evidence suggests that bioturbation and homogenization of the radon barriers will probably occur very slowly relative to the 10,000-year time frame for the PA.*" However, the text provides no supporting references or justification for this claim. In addition, homogenization of the radon barriers is not the only result of biointrusion and bioturbation. Reduction of the diffusion path length should also be considered. The text should be expanded to address other results, and any assertions made should be well explained and justified.

In addition, Section 3.1.6, page 3-5, of the 2013 Compliance Report, Revision 1, states, "*Burrowing animals at the site include jackrabbits, mice, foxes, and ants.*" This statement needs to be reconsidered since jackrabbits do not burrow, per se. Black-tailed jackrabbits (*Lepus califonicus*) found at the site cannot properly be described as burrowing mammals: "*Jackrabbits are not true rabbits at all, but are actually hares…hares use only forms or surface nests, whereas most rabbits retreat to burrows when alarmed*" (McAdoo and Young 1980). The PA should clarify the information about jackrabbits on or near the site.

Potential bioturbation effects from other burrowing animals that are not referenced in Section 3.1.6 should also be considered. For example, SWCA Environmental Consultants (SWCA) (2012) states that (1) coyote burrows, while not seen in the limited number of plots studied at the site, were observed near or close to the plots, indicating the potential for coyotes to burrow in an embankment on the site, (2) badger burrows were observed in two of the plots, (3) badgers themselves were photographed moving about during the sampling event, and (4) burrowing owls were also observed on site and photographed. Coyotes and badgers are documented to dig more deeply than the planned Class A South rip rap cover system depth of 5.5 feet (Lindzey 1976, McKenzie et al. 1982, Hampton 2006). SWCA (2012) reports that "*the presence of the badgers…in the study area indicates the potential for large volume soil bioturbation within the existing vegetation communities and soil types.*"

Kit foxes, which are found in western Utah, either create or use dens as deep as 2.5 meters (8.2 feet) (Tannerfeldt et al. 2003, referencing O'Neal et al. 1987). This is considerably deeper than the design depth of the top of the radon barrier at the site and considerably deeper than the design depth of the top of the bulk waste. The DU PA should definitely account for fox burrowing into bulk Class A waste.

SWCA (2012) reports on the species of ground squirrels observed onsite: *Spermophilus spp*. Suter (1993) and Suter et al. (1993) report ground squirrel burrowing to depths of at least 1.4 meters (4.6 feet) but do not mention species. If ground squirrels get into bulk Class A waste, they may become surficially contaminated by radioactive particles and may spread these radioactive particles to other parts of the environment. Additionally, radioactive materials consumed by the ground squirrels may subsequently adversely impact the environment via excretion of ground squirrels' urine, feces, or other bodily fluids, or through decomposition.

The PA mentions mice but does not provide sufficient detail about deer mice. According to the SWCA (2011, 2012), 83 deer mice and one kangaroo rat were trapped during a single biological survey on site. This indicates the potential for extensive burrowing on site.

Arthur et al. (1986, 1987; see also Bowerman and Redente 1998) note that deer mice penetrated an Idaho National Environmental Laboratory cover system having a thickness of 2.4 meters (7.9 feet). Many of the mice are reported to have received relatively high radiation doses, some of which are said to have been lethal.

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

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

Many seeds, smaller plants, and burrowing mammals may be able to penetrate a rock armor cover by migrating through the large interstices or voids existing between its cobbles. Larger, stronger, fossorial mammals, such as badgers, may be able to remove some or all of the smaller cobbles by digging or burrowing. Dwyer et al. (2007) suggest that to prevent a mammal of concern from moving a cobble, the cobble should weigh at least 1.5 times more than the animal.

The PA should account for this in the model and also document the potential for deep burrowing by badgers.

A rock armor cover may or may not by itself provide adequate protection from biointrusion, especially for extremely strong animals like badgers. Hakonson (1986) is one of the very few careful studies undertaken on this topic. The cover system needs to provide a high level of protection from intrusion by burrowing animals, including ground squirrels. The PA should account for this in the model and in the descriptions.

**REFERENCES:**

Arthur, W.J. III, O.D. Markham, C.R. Groves, and D.K. Halford, *Radiation dose to small mammals inhabiting a solid-radioactive-waste disposal area*, Journal of Applied Ecology, Vol. 23, pp. 13–26, 1986.

Arthur, W.J. III, O.D. Markham, and C.R. Groves, *Radionuclide export by deer mice at a solid radioactive waste disposal area in southeastern Idaho*, Health Physics, Vol. 52, pp. 45–53, 1987.

Bowerman, A.G., and E.F. Redente, *Biointrusion of protective barriers at hazardous waste sites*, Journal of Environmental Quality, Vol. 27, pp. 625–632, 1998.

Dwyer, S.F., R.E. Rager, and J. Hopkins, *Cover System Design Guidance and Requirements Document*, LA-UR-06-4715, EP2006-0667, Environmental Programs-Environmental Restoration Support Services, Los Alamos National Laboratory, NM, April 2007.

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Hakonson, T.E., *Evaluation of Geologic Materials to Limit Biological Intrusion into Low-Level Radioactive Waste Disposal Sites*, LA-10286-MS, UC-70B, Los Alamos National Laboratory, NM, February 1986.

Hampton, N.L., *Biological Data to Support Operable Unit 7-13/14: Modeling of Plant and Animal Intrusion at Buried Waste Sites*, INEEL/EXT-01-00273, Revision 1, Project No. 23378, Idaho Cleanup Project, January 2006.

Landeen, D.S., and R.M. Mitchell, *Invasion of radioactive waste burial sites by the Great Basin Pocket Mouse (*Perognathus parvus*)*, in International Symposium on Migration in the Terrestrial Environment of Long-Lived Radionuclides from the Nuclear Fuel Cycle, Knoxville, TN, July 27, 1981.

Lindzey, F.G., *Characteristics of the natal den of the badger*, Northwest Science, Vol. 50, pp. 178–180, 1976.

McAdoo, J.K., and J.A. Young, *Jackrabbits*, Rangelands, Vol. 2, pp. 135–138, August 1980.

McKenzie, D.H., L.L. Cadwell, L.E. Eberhardt, W.E. Kennedy, Jr., R.A. Peloquin, and M.A. Simmons, *Relevance of Biotic Pathways to the Long-Term Regulation of Nuclear Waste Disposal*, NUREG/CR-2675, Prepared for the U.S. Nuclear Regulatory Commission by Pacific Northwest Laboratory, Richland, WA, 1982.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level*

*Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

O'Neal, G.T., J.T. Flinders, and W.P. Clary, *Behavioral ecology of the Nevada kit fox (*Vulpes macrotis nevadensis*) on a managed desert rangeland*, pp. 443–481 in H.H. Genoways, ed., Current Mammalogy, Vol. 1, Plenum Press, New York, NY, 1987.

Suter, G.W., *Ecological Risk Assessment*, 2nd Edition, CRC Press, Boca Raton, FL, 1993.

Suter, G.W., R.J. Luxmoore, and E.D. Smith, *Compacted soil barriers at abandoned landfill sites are likely to fail in the long term*, J. Environ. Qual., Vol. 22, pp. 217–226, 1993.

SWCA Environmental Consultants, *Field Sampling of Biotic Turbation of Soils at the Clive Site, Tooele County, Utah*, Prepared for Energy*Solutions*, January 2011.

SWCA Environmental Consultants, *Vegetated Cover System for the EnergySolutions Clive Site: Literature Review, Evaluation of Existing Data*, *and Field Studies, Summary Report*, Prepared for Energy*Solutions*, August 2012.

Tannerfeldt, M., A. Moehrenschlager, and A. Angerbjörn, *Den ecology of swift, kit and Arctic foxes: a review*, pp. 167–181 in Sovada, M. and Carbyn, L., eds., The Swift Fox: Ecology and Conservation of Swift Foxes in a Changing World, Canadian Plains Research Centre, University of Regina, Regina, Saskatoon, 2003.

**INTERROGATORY CR R313-25-8(5)(A)-29/1: LIMITATION TO CURRENT CONDITIONS OF SOCIETY AND THE ENVIRONMENT**

**PRELIMINARY FINDING:**

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

Refer also to R313-25-23(3): *Within the region where the facility is to be located, a disposal site should be selected so that projected population growth and future developments are not likely to affect the ability of the disposal facility to meet the performance objectives of R313-25.*

**INTERROGATORY STATEMENT:**

Explain and justify why Bureau of Land Management (BLM) restrictions should be included in the inadvertent intruder analysis, given the likelihood that they will change over the compliance period of the PA (i.e., 10,000 years). Explain why other future land uses and FEPs were omitted.

**BASIS FOR INTERROGATORY:**

Section 10.3.1, page 57, of the Conceptual Site Model report states that *"Inputs for developing exposure parameter values under the ranching scenario include…restrictions related to BLM leases…."* The document should explain why it is appropriate to include BLM restrictions, given the potential for BLM policies to change over the next 10,000 years or more.

Section 11, page 62, of the Conceptual Site Model report states that the model will use current conditions of society and the environment to project future conditions, and that potential receptors are based on present-day use of the general area. This approach should be explained and justified, given the performance modeling objective of R313-25-8(5)(a) of 10,000 years or more.

Section 4.2, page 7, of the FEP Analysis report suggests that certain land use assumptions be eliminated for calculation of future human exposures (i.e., urban settlement, residential use, farming, and aquaculture). The text should explain and justify why seawater aquaculture could not be undertaken at Clive and future industrial land uses should not be considered in the PA model.

Table C, page 43, of the FEP Analysis report eliminates many FEPs. Energy*Solutions* should provide further explanation and justification for their exclusion. These include the following:

1. Resource extraction (quarrying and surface mining; FEP ID 910, page 45) – It is difficult to conceive that this will not happen in the future, in light of historic and current surface mining activities of clay, sand, and gravel resources near Clive by both government and private entities.
2. Water resource management (FEP ID 611, page 46) – In the case of future industrial land use, the text should explain why groundwater supply wells could not be a resource to support an industrial pursuit.

**REFERENCES:**

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *FEP Analysis for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 1 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(5)(A)-30/1: INCLUSION OF SRS-2002 DATA IN THE SENSITIVITY ANALYSIS

### PRELIMINARY FINDING:

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

### INTERROGATORY STATEMENT:

Provide a cross-reference in the text to the results of DU waste characterization, including the SRS-2002 data (Beals et al. 2002), in the sensitivity analysis.

### BASIS FOR INTERROGATORY:

Section 3.3, page 17, of the Waste Inventory report states that *"The effect of the inclusion of these data has been tested during model evaluation and is reported as part of the sensitivity analysis."* The text should provide a specific cross-reference indicating where the results of DU waste characterization, including the SRS-2002 data (Beals et al. 2002), are discussed. FRV1 Sections 6.1.2, 6.2.2, and 6.3.2 address the sensitivity analysis but they do not mention the SRS-2002 data specifically. Note that other interrogatories related to these analyses will also require resolution before the cross-references can be provided.

### REFERENCES:

Beals, D.M., S.P. LaMont, J.R. Cadieux, C.R. Shick, Jr., and G. Hall, *Determination of Trace Radionuclides in SRS Depleted Uranium (U),* WSRC-TR-2002-00536, Westinghouse Savannah River Company, Aiken, SC, November 19, 2002.

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0,* June 1, 2011. (Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA,* May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(5)(A)-31/1: TC-99 CONTENT IN THE WASTE AND INCLUSION IN THE SENSITIVITY ANALYSIS

### PRELIMINARY FINDING:

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

### INTERROGATORY STATEMENT:

Indicate whether (and where) the expectation that the concentration of Tc-99 will be a sensitive parameter was tested. Alternatively, explain and justify what other evidence is available that led to this conclusion. Perform additional characterization of the SRS waste proposed for disposal in terms of Tc-99 content and provide the results for agency review, or explain and justify why additional sampling and laboratory analysis are not needed.

### BASIS FOR INTERROGATORY:

Section 3.3, page 19, of the Waste Inventory report states that *"Given the mobility of $^{99}$Tc and the width of the input distribution defined above, it is reasonable to expect that concentration of $^{99}$Tc will be a sensitive parameter."* The text should indicate whether this expectation was tested and, if so, where the results are reported. Alternatively, the text should explain and justify what other evidence is available that led to this conclusion.

Note that FRV1 Section 6.1.1, page 55, states that *"In the case of $^{99}$Tc there are concerns over both the inventory concentration distribution, the concentration of $^{99}$Tc in the GDP waste, and the infiltration modeling. The $^{99}$Tc inventory concentration distribution is derived from three datasets that suggest very different concentrations. Consequently, the input distribution covers more than one order of magnitude of possible $^{99}$Tc concentrations. With more data or better information, it is reasonable to expect that this uncertainty could be reduced."*

Also note that the three sources of waste characterization data (i.e., Beals et al. 2002, GEL Laboratories 2010, Johnson 2010) include a total of 217 individual Tc-99 laboratory results. Unfortunately, as noted in Section 2.2.2, page 5, of the Waste Inventory report, the SRS samples were taken from a set of 3,300 drums, and it is not known if this is the same drum population as the more than 5,000 drums now in storage at Energy*Solutions*. Further, Section 2.2, page 4, of the Waste Inventory report states that the SRS DU waste stream consists of 36,000 drums. Therefore, it would appear that additional sampling and analysis are required to adequately characterize the SRS waste proposed for disposal. Energy*Solutions* should explain how this additional characterization will be done and provide results for agency review, or explain and justify why additional sampling and laboratory analysis are not needed.

**REFERENCES:**

Beals, D.M., S.P. LaMont, J.R. Cadieux, C.R. Shick, Jr., and G. Hall, *Determination of Trace Radionuclides in SRS Depleted Uranium (U)*, WSRC-TR-2002-00536, Westinghouse Savannah River Company, Aiken, SC, November 19, 2002.

GEL Laboratories, GEL Work Order 243721, laboratory reports dated January 12, January 19, and April 8, 2010.

Johnson, R., Utah Department of Environmental Quality, Memorandum, Subj: *Savannah River Depleted Uranium Sampling*, 2010.

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(4)(A)-32/1: EFFECT OF OTHER POTENTIAL CONTAMINANTS ON PA**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

**INTERROGATORY STATEMENT:**

State how the PA confirmed that other potential contaminants in the DU did not contribute significantly to doses and indicate whether they were included in the sensitivity analysis.

**BASIS FOR INTERROGATORY:**

Section 3.4, page 20, of the Waste Inventory report states the following:

> *As noted in Section 2.1, there are other potential contaminants in the SRS DU, including decay, activation and fission products (see Table 3). Given the only source of data for these radionuclides* [is] *SRS-2002, the concentrations are very low, and are unlikely to significantly contribute to the PA, however, input distributions for the mean concentrations of each of these radionuclides are developed and included in the PA to confirm that this is the case.*
>
> *The measurement of other radionuclides is reported only in the SRS-2002 dataset. These include $^{241}$Am, $^{226}$Ra, $^{137}$Cs, $^{90}$Sr, $^{237}$Np, $^{238}$Pu, $^{239}$Pu, $^{240}$Pu, $^{241}$Pu and $^{129}$I. Distributions of these values are shown in Figure 5. With the exception of the plutonium isotopes, all measurements were below the detection limit.*

To test the supposition that the contaminant radionuclides are unlikely to significantly contribute to the PA, it could be supposed that doses were assessed with and without these contaminants. However, the text does not indicate whether such a comparison was made, and the SRS-2002 data are not specifically addressed in FRV1 Sections 6.1.2, 6.2.2, and 6.3.2, which discuss sensitivity analyses.

In addition, the statement that only the plutonium isotopes were at detectable concentrations in the SRS results reported in Beals et al. (2002) is without support, since Table 15 of Beals et al. (2002) gives only six of the 33 samples as non-detects for Np-237 (Nos. 1, 3, 24, 26, 29, and 31).

Energy*Solutions* should indicate whether these other contaminant radionuclides were included in the reported sensitivity analysis and revise the sensitivity analysis to include them if they were not. Based on their low soil/water partitioning coefficients, of the other radionuclides, at minimum neptunium (Np)-237 and iodine (I)-129 must be simulated for the 10,000-year compliance period.

**REFERENCES:**

Beals, D.M., S.P. LaMont, J.R. Cadieux, C.R. Shick, Jr., and G. Hall, *Determination of Trace Radionuclides in SRS Depleted Uranium (U),* WSRC-TR-2002-00536, Westinghouse Savannah River Company, Aiken, SC, November 19, 2002.

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0,* June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA,* May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R315-101-5.3(6)-33/1: CLARIFICATION OF THE PHRASE "PROOF-OF-PRINCIPLE EXERCISE" AND SENSITIVITY TO URANIUM ORAL REFERENCE DOSE FACTORS

### PRELIMINARY FINDING:

Refer to R315-101-5.3(6): *Identification of toxicity information gathered for all identified hazardous constituents for carcinogenic, slope factors and weight-of-evidence classification, noncarcinogenic effects, chronic reference doses (RfDs) and critical effects associated with RfDs from, in order of preference, the Integrated Risk Information System (IRIS), Health Effects Assessment Summary Tables (HEAST), Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles, Environmental Criteria and Assessment Office (ECAO), or other scientifically accepted listings. The source and date of the toxicological information must be identified and be acceptable to the Director.*

### INTERROGATORY STATEMENT:

Clarify the meaning of the phrase *"proof-of-principle exercise"* with regard to the uranium toxicity analysis and explain how the sensitivity of the PA to different uranium oral reference dose factors was determined.

### BASIS FOR INTERROGATORY:

Section 3.4.5, page 25, of the Dose Assessment report refers to the evaluation in the PA of the potential non-radiation related toxicity of DU at the Clive facility as a *"proof-of-principle"* exercise. However, this phrase is not defined in the text. This issue was initially raised as a preliminary completeness comment to which Energy*Solutions* responded in its November 8, 2013, letter (CD13-0302) as follows:

> *As is noted in Section 3.4.5 of Appendix 11 of Appendix A from revision 0, the term "proof-of-principle exercise" relates to the potential non-radiation related toxicity of depleted uranium. Oral toxicity criteria for uranium are published by EPA in relation to the Superfund Program (EPA, 2011) and by EPA's Office of Water in relation to drinking water standards (EPA, 2000). However, since there is a five-fold difference between these criteria, both were employed in the depleted uranium Performance Assessment to determine the sensitivity of uranium health effect results to differences in these recommended toxicity criteria for uranium. As part of the analysis reported in Appendix A from revision 0, the validity of this assumption is confirmed.*

It is not clear how both criteria were actually applied to determine the sensitivity of uranium health effects, since, as noted in Table 1 of the Dose Assessment report, the two oral reference dose factors were assigned equal probability. Independent simulations were not run with each reference dose and the results then compared. In addition, it is not clear how to interpret the statement: "*As part of the analysis reported in Appendix A from revision 0, the validity of this assumption is confirmed.*" The specific analysis referred to in Appendix A of revision 0 and the assumption for which the validity was confirmed should be identified.

### REFERENCES:

Neptune and Company, Inc., *Dose Assessment for the Clive DU PA*, May 28, 2011. (Appendix 11 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Rogers, V., Energy*Solutions*, Letter to H. Gabert, Utah Department of Environmental Quality, *Subject: License No: UT2300249; #UT2300249 – Condition 35 Compliance Report, Revision 1: Responses to Task 1 Preliminary Completeness Review (CD13-0302)*, November 8, 2013.

**INTERROGATORY CR R313-25-8(5)(A)-34/1: INTENT OF THE PA**

**PRELIMINARY FINDING:**

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

**INTERROGATORY STATEMENT:**

Revise the text to correct the statement about the intent of the PA.

**BASIS FOR INTERROGATORY:**

FRV1 Section 2.1, page 21, states the following:

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

However, the intent of the PA is to demonstrate that disposal of DU at the Clive facility would meet the performance standards of 10 CFR Part 61, Subpart C, and the corresponding provisions of Utah rules. The text should be revised accordingly.

**REFERENCES:**

*Code of Federal Regulations,* Title 10, *Energy,* Part 61, *Licensing Requirements for Land Disposal of Radioactive Waste.*

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0,* June 1, 2011. (Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

## INTERROGATORY CR R313-25-19-35/1: REFERENCE FOR COST PER PERSON-REM

### PRELIMINARY FINDING:

Refer to R313-25-19: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.*

### INTERROGATORY STATEMENT:

Add the reference for the cited NRC estimate of the cost per person-rem.

### BASIS FOR INTERROGATORY:

FRV1 Section 1.3, page 16, states that the NRC suggests a value of $2,000 per person-rem, with a possible range of $1,000 to $6,000. However, the text does not cite a reference for these values. The reference should be added; we believe it is NUREG-1530. If other references are appropriate, they should be included as well.

### REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Nuclear Regulatory Commission, *Reassessment of NRC's Dollar Per Person-Rem Conversion Factor Policy*, NUREG-1530, Office of Nuclear Regulatory Research, December 1995.

## INTERROGATORY CR R313-25-8(4)(A)-36/1: ANT NEST EXTRAPOLATIONS

## PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

## INTERROGATORY STATEMENT:

Specify the documents meant in the phrase *"reported in the literature"* with regard to ant nest characteristics.

## BASIS FOR INTERROGATORY:

FRV1 Section 4.1.2.8.2, page 34, refers to correlations *"reported in the literature"* between total ant nest depth and volume and mound surface dimensions. However, the text does not cite specific references to the literature. The source(s) of the correlations used to extrapolate total nest depth and volume from mound surface dimensions must be provided.

## REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(5)(A)-37/1: DISTRIBUTION AVERAGING**

**PRELIMINARY FINDING:**

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

**INTERROGATORY STATEMENT:**

Describe the means of capturing "*the appropriate systems-level effect*" from the use of differential equations and multiplicative terms in the PA and describe what specific steps, model inputs, and model assumptions were modified for this purpose.

**BASIS FOR INTERROGATORY:**

FRV1 Section 5.2, page 45, discusses distribution averaging and states the following:

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

The text should clarify what *"care"* was taken in the PA to *"capture the appropriate systems-level effect"* and identify and justify what specific steps, model inputs, and model assumptions were modified for this purpose.

**REFERENCES:**

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(5)(A)-38/1: FIGURES 5 AND 11 IN FRV1

### PRELIMINARY FINDING:

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

### INTERROGATORY STATEMENT:

Correct the caption for Figure 5 to reflect the nature of the plots and describe how Figure 5 demonstrates compliance with R313-25-8(5)(a).

### BASIS FOR INTERROGATORY:

In FRV1 Section 6.1.1, page 56, the caption for Figure 5 appears to be incorrect. The figure provides plots of calculated Tc-99 concentrations as a function of time for each realization; they are not *"mean peak"* values. We believe that the caption should read, *"Tc-99 concentrations as a function of time for all realizations."*

In addition, explain and justify why a 500-year simulation for the groundwater pathway, shown in Figure 5, complies with the minimum 10,000-year mandate in R313-25-8(5)(a).

On Figure 11 in the Conceptual Site Model report, the exposure media column (far right) omits offsite groundwater as a means of possible human exposure. This point is important, since R313-25-8(5)(a) requires Energy*Solutions* to simulate disposal facility performance for 10,000 years. The figure should be revised to include offsite groundwater as a pathway.

### REFERENCES:

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(5)(A)-39/1: FIGURE 6 CAPTION

### PRELIMINARY FINDING:

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

### INTERROGATORY STATEMENT:

Correct the caption for Figure 6 to reflect the nature of the plots.

### BASIS FOR INTERROGATORY:

In FRV1 Section 6.1.1, page 57, the caption for Figure 6 appears to be incorrect, as it does not reflect *"mean peak"* values. The caption should read, *"Statistical Summary of $^{99}$Tc Concentrations as a Function of Time."*

### REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(5)(A)-40/1: FIGURES 7, 8, 9, 10, AND 11**

**PRELIMINARY FINDING:**

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

**INTERROGATORY STATEMENT:**

Label the axes for Figures 7, 8, 9, 10, and 11 and provide more discussion in the text on how to interpret the figures.

**BASIS FOR INTERROGATORY:**

In FRV1 Sections 6.1.2, 6.2.2, and 6.3.2, pages 58, 63, 64, 70, and 72, labeling is needed for the x and y axes in Figures 7, 8, 9, 10, and 11, respectively. The corresponding text should provide more discussion on how to interpret these figures, including the development and interpretation of partial dependence plots (an example of which for Tc-99 is shown on the right-hand side of Figure 7). The text should discuss how the partial dependence plots are interpreted and the type of information that can be abstracted from them.

**REFERENCES:**

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R315-101-5.3(6)-41/1: TABLE 7**

**PRELIMINARY FINDING:**

Refer to R315-101-5.3(6): *Identification of toxicity information gathered for all identified hazardous constituents for carcinogenic, slope factors and weight-of-evidence classification, noncarcinogenic effects, chronic reference doses (RfDs) and critical effects associated with RfDs from, in order of preference, the Integrated Risk Information System (IRIS), Health Effects Assessment Summary Tables (HEAST), Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles, Environmental Criteria and Assessment Office (ECAO), or other scientifically accepted listings. The source and date of the toxicological information must be identified and be acceptable to the Director.*

**INTERROGATORY STATEMENT:**

Resolve the discrepancy between the descriptive text and the title and content of Table 7.

**BASIS FOR INTERROGATORY:**

FRV1 Section 6.3.1, page 68, refers to *"mean…hazard quotient,"* while the title of Table 7 refers to *"peak mean…hazard quotient"* and the body of Table 7 refers to *"peak…hazard quotient."* Clarification should be provided on what is shown in Table 7 and the text and table should be made consistent.

**REFERENCES:**

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R315-101-5.3(6)-42/1: HAZARD QUOTIENT IN TABLES 7 AND 8

### PRELIMINARY FINDING:

Refer to R315-101-5.3(6): *Identification of toxicity information gathered for all identified hazardous constituents for carcinogenic, slope factors and weight-of-evidence classification, noncarcinogenic effects, chronic reference doses (RfDs) and critical effects associated with RfDs from, in order of preference, the Integrated Risk Information System (IRIS), Health Effects Assessment Summary Tables (HEAST), Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles, Environmental Criteria and Assessment Office (ECAO), or other scientifically accepted listings. The source and date of the toxicological information must be identified and be acceptable to the Director.*

### INTERROGATORY STATEMENT:

Resolve the discrepancy between the titles and content of Tables 7 and 8, in terms of whether they present the Hazard Quotient (HQ) or the Hazard Index (HI) and clarify what they signify for each receptor, the exposure pathways included and excluded, and the rationale for including or excluding them.

### BASIS FOR INTERROGATORY:

In FRV1 Section 6.3.1, pages 68–69, the titles and column headings in Tables 7 and 8 indicate that the tables provide the *"Hazard Quotient."* However, by definition (EPA 1989), HQ is the ratio of exposure dose (mg/kg-day or $mg/m^3$) divided by reference dose mg/kg-day or reference concentration $mg/m^3$ for the various exposure routes. Since there are multiple exposure routes (i.e., ingestion, inhalation, dermal contact), their respective HQ must be summed to produce an HI. It appears that Tables 7 and 8 present HIs rather than HQs. Clarification is needed with regard to whether Tables 7 and 8 contain HQs or HIs, what they signify for each environmental medium receptor indicated, which exposure pathways were included and which were excluded, and why.

### REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Environmental Protection Agency, *Risk Assessment Guidance for Superfund Volume I, Human Health Evaluation Manual (Part A)*, Interim Final, EPA/540/1-89/002, Office of Emergency and Remedial Response, Washington, DC, 1989.

## INTERROGATORY CR R313-25-19-43/1: PEAK DOSE IN TABLE 11

### PRELIMINARY FINDING:

Refer to R313-25-19: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.*

### INTERROGATORY STATEMENT:

Clarify the meaning of the term *"peak"* in the context of Table 11. Explain why this information has relevance to the regulatory requirement in R313-25-19, which sets dose limits for "*any member of the public*" (i.e., in the singular).

### BASIS FOR INTERROGATORY:

In FRV1 Section 6.4, page 76, the titles for Table 11 and its right-hand column identify the dose as the *"peak"* population dose. Since population doses are summed over all years, the document should clarify what is meant by *"peak"* in this context. In addition, the text should explain why this information is relevant, since R313-25-19 refers to dose limits for "*any member of the public*" (i.e., in the singular).

### REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(5)(A)-44/1: OCCURRENCE OF INTERMEDIATE LAKES**

**PRELIMINARY FINDING:**

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

**INTERROGATORY STATEMENT:**

Clarify the number meant by the term *"handful"* when referring to the occurrence of intermediate lakes. Describe intermediate lakes in terms of past or future total surface area and potential inundation of the Clive site.

**BASIS FOR INTERROGATORY:**

FRV1 Section 6.5.1, page 79, states that *"intermediate lakes only occur a handful of times."* The text should indicate what number is meant by the term *"handful."* It should also describe intermediate lakes in terms of past or future total surface area and potential to inundate the Clive site. The text should describe the duration of team each of the past lakes persisted and their frequency.

**REFERENCES:**

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-7(2)-45/1: INACCURATE CROSS-REFERENCE**

**PRELIMINARY FINDING:**

Refer to R313-25-7(2): *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.*

**INTERROGATORY STATEMENT:**

Change the text to cite the correct location for the list of relevant radionuclides.

**BASIS FOR INTERROGATORY:**

Section 4.2.2, page 18, of the Conceptual Site Model report states that the wastes under consideration for disposal potentially contain *"some radionuclides listed in the tables shown in Figure 7 in addition to the Ra-226 added by Utah (Figure 5)."* However, Figure 7, page 40, is the Whittaker Biome Diagram and does not contain any tables. As noted in the first paragraph on page 18 and the caption for Figure 5, Figure 5 is the list of radionuclides from UAC R313-15-1008, containing those in Table 1 of 10 CFR 61.55 plus Ra-226. The text should be revised to correctly identify the location of the information referenced.

**REFERENCES:**

*Code of Federal Regulations*, Title 10, *Energy*, Part 61, *Licensing Requirements for Land Disposal of Radioactive Waste.*

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

## INTERROGATORY CR R313-25-7(1)-46/1: TORNADOS

### PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

### INTERROGATORY STATEMENT:

Provide complete and accurate information on tornados in Utah and discuss their potential impact on the long-term integrity of the embankment cover.

### BASIS FOR INTERROGATORY:

Section 5, page 20, of the Conceptual Site Model report states that "*a tornado occurred in Salt Lake City in 1999, which was the first tornado in Utah in over 100 years*." However, numerous tornados have been reported in Utah; one web site lists 120 tornados between 1953 and 2012 (www.tornadohistoryproject.com/tornado/Utah/table; see also www.tornadoproject.com/alltorns/uttorn.htm).

Table B, page 41, of the FEP Analysis report notes that tornados are possible in the area. Further, Section 3.6.2, pages 12–13, of the Conceptual Site Model report notes the following:

> *It is possible, however, that the rip rap may be displaced or degraded by processes such as unusual weather events (e.g., tornadoes), animal activity, or human activities after the loss of institutional control. These events may result in damage to the rip rap and cap, though the damage is likely to be localized. This could result in gully erosion, and possibly the exposure of deeper parts of the cap or the waste itself. Details are provided in the Erosion Modeling white paper*.

However, tornados are not discussed in the Erosion Modeling report. Either the Erosion Modeling report or the Conceptual Site Model report should be revised to address these issues.

### REFERENCES:

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Erosion Modeling for the Clive PA*, June 1, 2011. (Appendix 10 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *FEP Analysis for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 1 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

TornadoHistoryProject.com, *Tornadoes in Utah*, accessed January 3, 2014. (www.tornadohistoryproject.com/tornado/Utah/table; data within this database has been pulled from the Storm Prediction Center's (SPC) historical tornado data file at www.spc.noaa.gov/wcm/#data)

TornadoProject, accessed January 2014 at www.tornadoproject.com/alltorns/uttorn.htm.

## INTERROGATORY CR R313-25-7(1)-47/1: SELECTION OF BIOME

### PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

### INTERROGATORY STATEMENT:

Correct the placement of the X on the Whittaker Biome Diagram to accurately represent site conditions.

### BASIS FOR INTERROGATORY:

In Section 7.2.1.5, page 40, of the Conceptual Site Model report, Figure 7 depicts the Whittaker Biome Diagram. The X on the diagram is supposed to represent site conditions. However, it appears to be placed too high. In its current location, the scaled precipitation value for the X appears to be in the range of 27–30 cm/yr (10.63–11.81 in./yr). However, Section 3.2.2 of the report states that the average precipitation at Clive is 8.62 in./yr (about 21.9 cm/yr). Moving the location of the X may change the biome in which the Clive site falls.

### REFERENCES:

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(9)-48/1: SOURCE AND COMPOSITION OF DU WASTE

### PRELIMINARY FINDING:

Refer to R313-25-7(9): *Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal facility.*

### INTERROGATORY STATEMENT:

Clarify the source of the DU waste considered in the analysis and how the PA accounts for potentially different radionuclide species compositions. Address concerns with the three sources of information on the characteristics of the DU waste.

### BASIS FOR INTERROGATORY:

With regard to the reported inventory, Section 9.1.1, page 47, of the Conceptual Site Model report states that *"Based on laboratory analysis of the contents of DU waste (including all radionuclides in the containers), the species in the disposed inventory include (Beals et al. 2002; Energy*Solutions *2009b; Johnson 2010):…."* However, it is not clear which waste this statement refers to – all DU waste expected to be disposed of, including in the future; all DU waste currently disposed of; DU waste from SRS; or DU waste from the GDPs. Each of these will have different DU-waste species compositions.

In addition, detailed review of these three information sources has resulted in the following concerns:

1. Beals et al. (2002) – This DOE SRS report dated November 19, 2002, provided 33 DU sample results for 14 analytes (Tc-99, Am-241, Ra-226, Cs-137, Sr-90, I-129, Pu-239, Pu-240 (also Pu-239+420, Pu-241[1], Pu-242, Np-237, U-238, U-235+236, U-234[2]).
    - Few SRS samples. Section 2.2.2, page 5, of the Waste Inventory report indicates that 33 SRS samples were collected from a population of 3,300 drums at SRS (1% sampling rate). The text should explain and justify why these 33 samples are representative of the 36,000 SRS DU drums in need of disposal, as cited on page 4 of the Waste Inventory report.
    - SRS reporting of minimum detectable activity (MDA) limits. Several nuclides were expressed in terms of the MDA value for each sample and not by sample activity concentrations (e.g., Ra-226 in Table 7, Sr-90 in Table 9, and I-129 in Table 10 of Beals et al. (2002)). Reliable, representative activity concentration data are needed for at least two of these: Ra-226 is needed for estimation of short-term radon emanation from the disposal cell, and I-129 is needed because it is a mobile isotope in groundwater and is easily leached from the DU waste. The text should provide activity concentration data

[1] SRS analyzed only three $DUO_3$ waste samples for PU-242.
[2] The report notes on page 22 that no U-233 concentrations were observed during mass spectrometry in the selected samples.

for these two isotopes in the SRS DU waste or explain and justify why these are not needed or could be conservatively replaced by an analog nuclide. For any future Ra-226 sampling and analysis, the MDA should be ≤15 pCi/g.

- Lack of SRS uranium isotope activity concentration data. We agree that the SRS uranium data cannot be reconciled into activity concentrations for input into the PA model because they were reported in units of atom% and activity% and not in units of activity per mass (pCi/g) or activity per volume (pCi/cm$^3$). As a result, the total numbers of uranium data from the three data sources used in FRV1 have been reduced from 59 to only 26 samples (all collected by Energy*Solutions*), thus making the uranium activity data statistically weaker than many of the other DU waste analytes considered.
- Lack of SRS reconciliation of uranium data. Energy*Solutions* should explain why it did not ask DOE to resolve the problem with uranium analysis reporting units. Alternatively, Energy*Solutions* should ask SRS to collect new representative samples and provide adequate analytical results for the uranium isotopes to be disposed in Utah.

2. EnergySolutions 2009b – These data were summarized in Tables 14 and 15 of the Waste Inventory report and include 26 different DU waste samples collected at Clive in January 2010 (11 samples) and April 2010 (15 samples). These were analyzed for five different analytes (Tc-99[3], total uranium, U-238, U-235+236, and U-233+234). Section 2.2.1, page 5, of the Waste Inventory report indicates that these samples were taken from a small portion of the 5,408 SRS drums now in storage at Clive.
   - Few Energy*Solutions* samples. Energy*Solutions* should explain and justify why the 26 Energy*Solutions* samples are representative of the 5,408 DU drums in Clive storage now and of the 36,000 SRS drums in total needing land disposal, for all analytes reported.
   - Artificial Neptune uranium isotope data. Given the concern that the 26 Energy*Solutions* uranium samples are not statistically representative of the 5,408 DU drums in storage at Clive or the 36,000 drums of SRS DU needing burial, the artificially generated Neptune uranium concentration data also raise concerns. Energy*Solutions* should explain and justify how mathematical generation of uranium isotope concentrations for the DU waste from only 26 Energy*Solutions* samples can be reliable, representative, and produce conservatively high uranium concentrations for the PA model. This concern should be addressed in terms of individual artificial data values, the mean population concentration, and the full range of possible concentrations (distribution) for each of the uranium isotopes in question.
3. Johnson 2010 – This document includes Utah Division of Radiation Control (DRC) sampling and analytical results for 173 samples for Tc-99 only (see Tables 9 and 16 of the Waste Inventory report). No other analyte was sampled or analyzed in this work. In determining the number of samples from the 5,300 SRS drums at Clive at the time needed for statistical power, the state relied on EPA Resource Conservation and Recovery Act waste sampling guidance (EPA 2002). Therefore, it should be explained why 33 samples or less, as collected

[3] No Energy*Solutions* sampling for Tc-99 was done in the April 2010 sampling event (see Table 4 of the Waste Inventory report). Therefore, only 11 Tc-99 samples are available from this report, compared to the other analytes reported.

by SRS and Energy*Solutions*, could be statistically meaningful and representative of the entire SRS DU waste inventory of 36,000 drums needing disposal.

The text should clarify and justify the DU waste sources and analytical data considered and indicate how the PA model accounts for the potentially different species compositions and isotopic distributions for both the SRS $DUO_3$ waste and future DU waste from GDPs.

**REFERENCES:**

Beals, D.M., S.P. LaMont, J.R. Cadieux, C.R. Shick, Jr., and G. Hall, *Determination of Trace Radionuclides in SRS Depleted Uranium (U),* WSRC-TR-2002-00536, Westinghouse Savannah River Company, Aiken, SC, November 19, 2002.

Energy*Solutions*, *Radioactive Waste Profile Record,* EC-0230, Rev. 7, plus attachments (Form 9021-33), Clive, Utah, 2009.

Johnson R., State of Utah, Department of Environmental Quality, Memorandum, *Subject: Savannah River Depleted Uranium Sampling,* April 6, 2010.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility,* May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA,* May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Environmental Protection Agency, *RCRA Waste Sampling Draft Technical Guidance, Planning, Implementation, and Assessment*, EPA 530-D-02-002, August 2002.

**INTERROGATORY CR R313-25-7(9)-49/1: COMPOSITION OF MATERIAL MASS**

**PRELIMINARY FINDING:**

Refer to R313-25-7(9): *Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal facility.*

**INTERROGATORY STATEMENT:**

Clarify the material comprising masses discussed in the text.

**BASIS FOR INTERROGATORY:**

Section 2.2.2, page 6, of the Waste Inventory report states that the SRS waste manifests provide a weight of *"total of 7,886,738 pounds, corresponding to a mass of 3,577 Mg."* However, it does not indicate whether this is 3,577 Mg of DU, $DUO_3$, or $DUO_2$. When the inventory cites a material mass, the type of material comprising the mass should be stated.

**REFERENCES:**

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(9)-50/1: SAMPLES COLLECTED

### PRELIMINARY FINDING:

Refer to R313-25-7(9): *Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal facility.*

### INTERROGATORY STATEMENT:

Correct the numbers given in the text for samples collected in January and April 2010 to match the corresponding tables.

### BASIS FOR INTERROGATORY:

Section 2.2.2, page 6, of the Waste Inventory report states the following:

> *In January of 2010 Energy*Solutions *collected 15 samples that were analyzed for uranium isotopes (Table 14, in the Appendix). In April 2010 Energy*Solutions *collected 11 samples that were analyzed for uranium isotopes and* $^{99}$*Tc (Table 15, in the Appendix).*

However, Table 14 shows 11 samples for January 2010, and Table 15 shows 15 samples for April 2010.

### REFERENCES:

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(9)-51/1: NATURE OF CONTAMINATION

### PRELIMINARY FINDING:

Refer to R313-25-7(9): *Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal facility.*

### INTERROGATORY STATEMENT:

Refer to other existing analyses for information on the nature and extent of contamination within the contaminated DU population for the GDPs.

### BASIS FOR INTERROGATORY:

In reference to the composition of DU from the GDPs, Section 2.3.2, page 7, of the Waste Inventory report states that *"Little information is available at this time regarding the exact nature and extent of the contamination within the contaminated DU population."* Section 3.5.2.2, page 22, of the Waste Inventory report states that "*Given the lack of definitive information about the degree of contamination, it is assumed that contaminated DU from the GDPs shares the same composition as the DU from SRS.*" However, information does exist, including that in DOE/SO-0003, BJC/PGDP-167, and Hightower et al. (2000), for example. These documents and their supporting references may contain useful information on the levels of actinides and fission product contaminants in materials at the three GDPs. The Waste Inventory report should be revised to include all available waste composition data available to date, and any statistical distributions for waste source term input to the PA model should be updated or modified. Alternatively, Energy*Solutions* should explain and justify why these three references are of no value or not applicable to the DU PA model project.

### REFERENCES:

Bechtel Jacobs Company LLC, *Recycled Uranium Mass Balance Project Paducah Gaseous Diffusion Plant Site Report*, BJC/PGDP-167, June 14, 2000.

Hightower, J.R., L.R. Dole, D.W. Lee, G.E. Michaels, M.I. Morris, D.G. O'Conner, S.J. Pawel, R.L. Schmoyer, L.D. Trowbridge, and V.S. White, *Strategy for Characterizing Transuranics and Technetium Contamination in Depleted UF6 Cylinders*, ORNL/TM-2000/242, UT-Battelle, Oak Ridge National Laboratory, Oak Ridge, Tennessee, October 2000.

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

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

## INTERROGATORY CR R313-25-7(9)-52/1: MEASUREMENT TYPES FOR SAMPLING EVENTS

### PRELIMINARY FINDING:

Refer to R313-25-7(9): *Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal facility.*

### INTERROGATORY STATEMENT:

Clarify the reference for *"different measurement types between sampling events."*

### BASIS FOR INTERROGATORY:

Section 3.1.2, page 10, of the Waste Inventory report states, *"However, different sampling events for $^{99}$Tc and U indicate potentially different measurement types between sampling events."* The meaning of this statement is not clear, in terms of what is meant by *"different measurement types"* and on what basis this judgment was made. Energy*Solutions* should indicate which of the three data sources (i.e., Beals et al. 2002, Energy*Solutions* 2009b, or Johnson 2010) are indicated by this statement or whether this statement relates to some other source of data.

### REFERENCES:

Beals, D.M., S.P. LaMont, J.R. Cadieux, C.R. Shick, Jr., and G. Hall, *Determination of Trace Radionuclides in SRS Depleted Uranium (U),* WSRC-TR-2002-00536, Westinghouse Savannah River Company, Aiken, SC, November 19, 2002.

Energy*Solutions*, *Radioactive Waste Profile Record,* EC-0230, Rev. 7, plus attachments (Form 9021-33), Clive, Utah, 2009.

Johnson R., State of Utah, Department of Environmental Quality, Memorandum, *Subject: Savannah River Depleted Uranium Sampling,* April 6, 2010.

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(9)-53/1: SUBSCRIPTS IN EQUATION 1

### PRELIMINARY FINDING:

Refer to R313-25-7(9): *Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal facility*.

### INTERROGATORY STATEMENT:

Correct the subscripts in the denominator of equation 1.

### BASIS FOR INTERROGATORY:

In Section 3.2.1, page 12, of the Waste Inventory report, the subscripts in equation 1 should all be "$i$" and not "$j$," based on the explanations of the variables in the equation.

### REFERENCES:

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(9)-54/1: PARTITIONING IN THE SENSITIVITY ANALYSIS

### PRELIMINARY FINDING:

Refer to R313-25-7(9): *Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal facility.*

### INTERROGATORY STATEMENT:

Provide a specific cross-reference to the discussion of partitioning in the sensitivity analyses.

### BASIS FOR INTERROGATORY:

With regard to the partitioning of U-233+234 and U-235+236, Section 3.2.1, page 12, of the Waste Inventory report states that *"In general, the differences this causes in uranium activity concentrations are fairly small relative to the likely effect on the PA model results, however, this will be tested in the model evaluation and sensitivity analysis."* The text should provide a specific cross-reference to the discussion of this issue in the sensitivity analyses.

### REFERENCES:

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(5)(A)-55/1: URANIUM ISOTOPE DISTRIBUTIONS

### PRELIMINARY FINDING:

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

### INTERROGATORY STATEMENT:

Indicate whether analyses were conducted to determine if the uranium isotope distributions significantly affected the results of the PA.

### BASIS FOR INTERROGATORY:

Section 3.2.3, page 16, of the Waste Inventory report states, *"If, given these relatively broad distributions, the uranium isotopes are not sensitive to any PA model endpoint, then the need to refine these distributions will be less."* The text should indicate whether any analyses were conducted to determine if the uranium isotope distributions significantly affected the results of the PA. The response should be prepared after all other interrogatories related to the Waste Inventory report have been resolved.

### REFERENCES:

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-7(9)-56/1: INTERPRETATION OF BOX PLOTS**

**PRELIMINARY FINDING:**

Refer to R313-25-7(9): *Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal facility*.

**INTERROGATORY STATEMENT:**

Interpret the information contained in the box plots in Figures 3 and 5, including the statistical parameters they display.

**BASIS FOR INTERROGATORY:**

Sections 3.3 and 3.4, pages 18 and 21, of the Waste Inventory report should describe how the Tc-99 information contained in the box plots in Figures 3 and 5 should be interpreted. This should include an indication of the specific statistical parameters displayed in the boxes. The symbols used in the figures should be defined.

**REFERENCES:**

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-7(9)-57/1: DASHED LINES IN FIGURE 4**

**PRELIMINARY FINDING:**

Refer to R313-25-7(9): *Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal facility*.

**INTERROGATORY STATEMENT:**

Explain the purpose of the dashed lines in Figure 4.

**BASIS FOR INTERROGATORY:**

In Section 3.3, page 20, of the Waste Inventory report, the caption for Figure 4 should define the purpose of the dashed lines, as it does for the red lines.

**REFERENCES:**

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-7(9)-58/1: REFERENCE FOR PERSONAL COMMUNICATION**

**PRELIMINARY FINDING:**

Refer to R313-25-7(9): *Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal facility*.

**INTERROGATORY STATEMENT:**

Provide complete information for personal communication citations in the reference list.

**BASIS FOR INTERROGATORY:**

Section 3.5.2.3, page 23, of the Waste Inventory report cites *"personal communication, Tammy Stapleton, April 2011."* This citation is also given on page 24. However, this item is not included in the reference list in Section 4.0, pages 27–28. Complete information on the citation is needed in the reference list.

**REFERENCES:**

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(2)-59/1: BATHTUB EFFECT

### PRELIMINARY FINDING:

Refer to R313-25-7(2): *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.*

### INTERROGATORY STATEMENT:

Clarify why, after the upper flow barriers are compromised, water will not collect above the clay liner and drive infiltration rates above those predicted by models.

### BASIS FOR INTERROGATORY:

Section 4.1, page 5, of the Unsaturated Zone Modeling report states, *"Since the upper filter layer is assumed to have been silted up and is therefore ineffective at diverting infiltrating water, it is assigned a lateral flow of 0 cm/yr (0 in/yr)."* The document should clarify why, after the upper flow barriers are compromised, water will not collect above the top clay liner ("bathtub effect") and provide a driving force to increase the infiltration rates above those predicted by HELP and UNSAT-H.

### REFERENCES:

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-7(3)-60/1: MODELED RADON BARRIERS**

**PRELIMINARY FINDING:**

Refer to R313-25-7(3): *Descriptions of the principal design criteria and their relationship to the performance objectives.*

**INTERROGATORY STATEMENT:**

Provide additional justification for the modeled post-installation upper and lower radon barriers.

**BASIS FOR INTERROGATORY:**

Sections 5.1.5 and 5.1.6, page 27, of the Unsaturated Zone Modeling report describe hydraulic conductivity values for the modeled post-installation field permeability of the upper ($5x10^{-8}$ cm/s) and lower ($5 \times 10^{-6}$ cm/s) radon barriers. However, the values used for the lower barrier are orders of magnitude lower than those indicated as being appropriate in NRC guidance, such as NUREG/CR-7028. The text should provide additional justification for the model parameters chosen, with emphasis on natural phenomenon including, but not limited to, frost damage, burrowing insects and animals, and desiccation.

**REFERENCES:**

Benson, C.H., Albright, W.H., Fratta, D.O., Tinjum, J.M., Kucukkirca, E., Lee, S.H., Scalia, J., Schlicht, P.D., and Wang, X., *Engineered Covers for Waste Containment: Changes in Engineering Properties and Implications for Long-Term Performance Assessment*, Volume 1, NUREG/CR-7028, NRC Office of Nuclear Regulatory Research, December 2011.

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(A)-61/1: MASS-BALANCE INFORMATION

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

### INTERROGATORY STATEMENT:

Provide the mass-balance information for both the flow and contaminant transport from the model simulations.

### BASIS FOR INTERROGATORY:

Section 8.0, page 30, of the Unsaturated Zone Modeling report should provide the mass-balance information for both the flow and contaminant transport from the model simulations. A mass balance is an application of the conservation of mass to the analysis of physical systems. In numerical models, as a result of numerical approximations (truncation and rounding errors), the conservation of mass is not always ensured; thus, it needs to be verified for each application. (Silling, 1983; ASTM, 2002). This information should be submitted for review by the Utah Department of Environmental Quality.

### REFERENCES:

American Society for Testing and Materials, *Standard Guide for Describing the Functionality of a Groundwater Modeling Code*, D6033-96, reapproved 2002.

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Silling, S.A., *Final Technical Position on Documentation of Computer Codes for High-Level Waste Management*, NUREG-0856, NRC Office of Nuclear Material Safety and Safeguards, June 1983.

## INTERROGATORY CR R313-25-7(2)-62/1: NUMERICAL TESTING OF RUNGE-KUTTA METHOD

### PRELIMINARY FINDING:

Refer to R313-25-7(2): *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.*

### INTERROGATORY STATEMENT:

Provide a reference for the statement about numerical testing with regard to the Runge-Kutta method and describe the bases for the conclusion that stable solutions were produced.

### BASIS FOR INTERROGATORY:

Section 8.3, page 37, of the Unsaturated Zone Modeling report states, *"Numerical testing demonstrated that the geometric zoning produces stable solutions for the top slope and side slope models with the Runge-Kutta method up to flow rates of 5 cm/year."* The text should provide a specific reference with regard to this numerical testing work and describe the bases for the conclusion that stable solutions were produced.

### REFERENCES:

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(A)-63/1: AIR-PHASE ADVECTION

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

Refer also to R313-25-7(1) and (4): *(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

*(4) Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.*

### INTERROGATORY STATEMENT:

Provide additional explanation and justification for the exclusion of air-phase advection from the PA model.

### BASIS FOR INTERROGATORY:

Section 9.2.1, page 49, of the Unsaturated Zone Modeling report states that *"Air-phase advection is not included in the Clive DU PA Model. It is assumed that the advective flux of gases is negligible compared to the diffusive gas flux."* The document should provide additional justification for this statement, since it is a major assumption in predicting radon flux back to the surface. If a total pressure gradient exists in a soil as a result of external forces (e.g., atmospheric pumping or diurnal temperature changes), gases, especially when considering dispersion, will experience net flow from points of higher to lower pressure. Furthermore, it has been shown that relatively small gradients in total pressure can result in advective gas fluxes that are much larger than diffusive gas fluxes (Thorstenson and Pollock, 1989; Massmann and Farrier, 1992; Weisbrod et al., 2009; Ganot et al., 2012).

### REFERENCES:

Ganot, Y., M.I. Dragila, and N. Weisbrod, *Impact of thermal convection on air circulation in a mammalian burrow under arid conditions*, Journal of Arid Environments, Vol. 84, pp. 51–62, 2012.

Massmann, J. and D.F. Farrier, *Effects of atmospheric pressures on gas transport in the vadose zone*, Water Resour. Res., Vol. 28, pp. 777–791, 1992.

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Thorstenson, D.C., and D.W. Pollock, *Gas transport in unsaturated porous media: The adequacy of Fick's law*, Rev. Geophys., Vol. 27, pp. 61–78, 1989.

Weisbrod, N., M.I. Dragila, U. Nachshon, and M. Pillersdorf, *Falling through the cracks: The role of fractures in Earth-atmosphere gas exchange*, Geophys. Res. Lett., 36, L02401, doi:10.1029/2008GL036096, 2009.

## INTERROGATORY CR R313-25-8(4)(A)-64/1: YUCCA MOUNTAIN STUDIES

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

Refer also to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

### INTERROGATORY STATEMENT:

Consider more recent Yucca Mountain information in preparing the Geochemical Modeling report.

### BASIS FOR INTERROGATORY:

The Geochemical Modeling report uses data developed for the Yucca Mountain Site Characterization Project's Total System Performance Assessment to define solubilities for several species. The source document cited is LA-13262-MS (LANL, 1997). However, more recent Yucca Mountain studies on solubilities exist that should be considered, such as ANL-WIS-MD-000010.

### REFERENCES:

Bechtel SAIC Company, LLC, *Dissolved Concentration Limits of Radioactive Elements*, ANL-WIS-MD-000010, Revision 05, for U.S. Department of Energy, July 2005, retrieved September 2013 at www.osti.gov/scitech/servlets/purl/883412.

Los Alamos National Laboratory, *Summary and Synthesis Report on Radionuclide Retardation for the Yucca Mountain Site Characterization Project*, LA-13262-MS, 1997.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R317-6-6.3(Q)-65/1: COLLOID TRANSPORT

### PRELIMINARY FINDING:

Refer to R317-6-6.3(Q): *Ground Water Quality Protection Regulations – Applications Requirements for a Ground Water Discharge Permit – Other Information Required.*

Refer also to R313-25-7(1) and (4): *(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

*(4) Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.*

### INTERROGATORY STATEMENT:

Discuss the potential for other types of colloids and colloidal-forming constituents in the waste (e.g., ligands). Explain how these phenomena might affect $K_d$ coefficients in GoldSims and justify how and why the $K_d$ values used are representative of or conservatively low for the actual site conditions.

### BASIS FOR INTERROGATORY:

Section 5.0, page 17, of the Geochemical Modeling report states that *"The potential for colloidal transport of actinides at the Clive facility is not incorporated into the PA model."* To support this decision, the text then refers to actinide intrinsic colloids, which comprise one type of colloid. The text should discuss the potential for the actinides and progeny to form colloids with other constituents in the waste (e.g., ligands). In addition, it should explain how these phenomena might affect radionuclide soil-water partitioning ($K_d$) coefficients in the GoldSims modeling effort. In light of these possible factors, Energy*Solutions* should justify how and why the $K_d$ values used are representative of or conservatively low for the actual site conditions.

In addition, Section 5.0, page 18, of the Geochemical Modeling report states the following:

> *Retention of colloids is favored at high ionic strength, low pH and in impermeable rock. The high ionic strength conditions in the saturated zone at Clive are counter to conditions considered favorable for colloid transport.*

The text should provide citations for the statement that retention of colloids is favored in solutions of high ionic strength. The text should also discuss any specific conditions under which exceptions may occur.

### REFERENCES:

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(4)(A)-66/1: COLLOID RETENTION**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

Refer also to R313-25-7(1) and (4): *(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

*(4) Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.*

**INTERROGATORY STATEMENT:**

Provide references from technical, peer-reviewed publications to support the statement that retention of colloids is favored in solutions of high ironic strength.

**BASIS FOR INTERROGATORY:**

Section 5.0, page 18, of the Geochemical Modeling report states that *"Retention of colloids is favored at high ionic strength, low pH and in impermeable rock. The high ionic strength conditions in the saturated zone at Clive are counter to conditions considered favorable for colloid transport."* The text should provide citations from technical, peer-reviewed publications for the statement that retention of colloids is favored in high ionic strength solutions.

**REFERENCES:**

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(A)-67/1: SOLUBILITY AND SPECIATION OF RADIONUCLIDES

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

Refer also to R313-25-7(1) and (4): *(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

*(4) Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.*

### INTERROGATORY STATEMENT:

Consider the solubility and speciation work with radionuclides in high ironic strength brines performed to support the Waste Isolation Pilot Plant. If it is not relevant, explain how solubility and speciation in high ionic strength brines are addressed.

### BASIS FOR INTERROGATORY:

Section 5.0, page 18, of the Geochemical Modeling report states the following:

> *In many cases the solubility of radionuclide species used in the transport model was based to some extent on the data provided in the proposed Yucca Mountain Project (LANL 1997) and the Nevada National Security Site (NNSS, formerly the Nevada Test Site) (Sandia 2001) modeling.*

The discussion should also include the solubility and speciation work with radionuclides in high ionic strength brines that has been performed (and is currently ongoing) to support the Waste Isolation Pilot Plant (e.g., LCO-ACP-08 and LCO-ACP-10). If this information does not correlate directly to the Clive shallow groundwater, Energy*Solutions* should explain how it addresses solubility and speciation in high ionic strength brines.

**REFERENCES:**

Borkowski, M., J.F. Lucchini, M.K. Richmann, and D.T. Reed, *Actinide (III) Solubility in WIPP Brine: Data Summary and Recommendations*, LCO-ACP-08, Revision 0, LANL/ACRSP Report, LA-UR-09-03222, Los Alamos: Los Alamos National Laboratory, 2009.

Los Alamos National Laboratory, *Summary and Synthesis Report on Radionuclide Retardation for the Yucca Mountain Site Characterization Project*, LA-13262-MS, 1997.

Lucchini, J.-F., H. Khaing, M. Borkowski, M.K. Richmann, and D.T. Reed, *Actinide (VI) Solubility in Carbonate-free WIPP Brine: Data Summary and Recommendations,* LCO-ACP-10, LANL\ACRSP Report, LA-UR-10-00497, Los Alamos: Los Alamos National Laboratory, 2010.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Sandia National Laboratories, *Compliance Assessment Document for the Transuranic Wastes in the Greater Confinement Disposal Boreholes at the Nevada Test Sites*, Volume 2: *Performance Assessment*, Version 2.0, 2001.

## INTERROGATORY CR R313-25-8(4)(A)-68/1: DISTRIBUTION OF HYDRAULIC GRADIENTS

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

Refer also to R313-25-7(1) and (4): *(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

*(4) Descriptions of the natural events or phenomena on which the design is based and their relationship to the principal design criteria.*

### INTERROGATORY STATEMENT:

Provide any factors considered when developing the magnitude and distribution of hydraulic gradients from off-normal conditions.

### BASIS FOR INTERROGATORY:

Section 3.3, page 4, of the Saturated Zone Modeling report should discuss any factors taken into consideration when developing the distribution of hydraulic gradients from off-normal conditions. These could include impacts by increased infiltration due to climatic changes; gully erosion; plant or animal penetration of the cover system; or accumulation of snow melt and stormwater runoff in clay, sand, and gravel pits already authorized by Tooele County in areas adjoining Section 32 that remain unreclaimed upon facility closure.

### REFERENCES:

Neptune and Company, Inc., *Saturated Zone Modeling for the Clive DU PA*, May 28, 2011. (Appendix 7 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(A)-69/1: LONGITUDINAL DISPERSIVITY

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

### INTERROGATORY STATEMENT:

Provide the longitudinal dispersivity value used in the model and references for any studies or calculations that demonstrate the GoldSim model grid spacings are sufficiently small. Provide the mass-balance information for both the flow and contaminant transport from the model simulations. Indicate the length and location of the horizontal domain used for groundwater flow and transport modeling in the GoldSim simulations.

### BASIS FOR INTERROGATORY:

Section 4.2, page 11, of the Saturated Zone Modeling report states that *“Only longitudinal dispersion will be considered for this discussion because of the geometry of the transport pathway.”* The longitudinal dispersivity value used in the model must be provided and justified. Energy*Solutions* should also provide any studies (e.g., grid convergence) or calculations that demonstrate the GoldSim model grid spacings are sufficiently small.

The text must also provide the mass-balance information for both the flow and contaminant transport from the model simulations.

The Saturated Zone Modeling report should be revised to indicate the length of the horizontal domain used for groundwater flow and transport modeling in the GoldSim simulations. The text should also indicate whether this model distance was fixed and if so describe where this domain is located relative to the proposed DU waste source term, nearby point of compliance monitoring well(s), the DU disposal cell’s buffer zone, and outer boundaries of property owned and controlled by Energy*Solutions*.

### REFERENCES:

Neptune and Company, Inc., *Saturated Zone Modeling for the Clive DU PA*, May 28, 2011. (Appendix 7 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(2)-70/1: GULLY SCREENING MODEL

### PRELIMINARY FINDING:

Refer to R313-25-7(2): *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.*

Refer also to R313-25-23(2): *The disposal site shall be capable of being characterized, modeled, analyzed and monitored.*

### INTERROGATORY STATEMENT:

Explain and justify why a more sophisticated erosion model than the initial screening-type gully model is not needed and why gully formation is restricted to locations only on the cover system and does not include other locations.

### BASIS FOR INTERROGATORY:

Section 4.0, pages 4–5, of the Erosion Modeling report states the following:

> *The purpose of the initial gully model in the Clive PA model is to determine whether gullies and fans are significant contributors to dose and whether a more sophisticated erosion model is needed. A simple screening-type gully model was developed with the advice of Dr. Willgoose.*

Similarly, FRV1 Section 4.1.2.9, page 36, states the following:

> *The gully model is a simplistic model of gully erosion and landscape evolution. For example, the model assumes that 1) a gully forms instantly and doesn't change with time, 2) that between 1 and 20 gullies only are allowed to form, and 3) that gullies do not interact with other model processes such as biotic transport (e.g., no plants grow in a gully). This stylized model was used to provide a basis for discussion of whether or not gully formation is an important consideration in this waste disposal system, and to evaluate the consequences of human activities that inadvertently cause doses to future humans.*

FRV1 Section 6.2.1 shows that the presence of gullies increases the peak mean dose to a rancher from 4.37 mrem/yr total effective dose equivalent (TEDE) in Table 3 (page 59) to 20.9 mrem/yr TEDE in Table 4 (page 61). This increase is due to thinning of the cover layers (cap and fill materials) and possible direct exposure of the DU waste. Based on this information, it would appear that gully formation is an important consideration in evaluating the long-term performance of the waste disposal system. Therefore, the report should explain why a more sophisticated erosion model is not needed, including justification for how and why the assumed 1 to 20 gullies can be reconciled with the actual number of gullies expected to form during a minimum of 10,000 years. The text should explain why gully formation is restricted to locations only on the cover system and why a gully could not form in a nearby excavation, away from the disposal cell, and by head-cutting processes that later erode the side and top slope areas of the cover. If a more sophisticated erosion model is developed, the report needs to describe the new model, including how it will be implemented in the PA and its effect on the peak mean dose to a rancher or to any other member of the public in any other relevant scenarios.

**REFERENCES:**

Neptune and Company, Inc., *Erosion Modeling for the Clive PA*, May 28, 2011. (Appendix 10 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(A)-71/1: BIOTIC PROCESSES IN GULLY FORMATION

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

### INTERROGATORY STATEMENT:

Provide additional rationale for excluding potentially important biological processes when considering gully formation.

### BASIS FOR INTERROGATORY:

Section 4.0, page 5, of the Erosion Modeling report should provide additional rationale for and justify why potentially important biotic intrusion processes were excluded when considering gully formation. Such processes, including burrowing of animals within gullies, could penetrate the waste more readily than in areas free of gullies.

### REFERENCES:

Neptune and Company, Inc., *Erosion Modeling for the Clive PA*, May 28, 2011. (Appendix 10 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(4)(A)-72/1: DE MINIMIS DOSE VALUE**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

**INTERROGATORY STATEMENT:**

Provide the justification for proposing a de minimis (i.e., below regulatory concern) dose value.

**BASIS FOR INTERROGATORY:**

Section 3.3.1, page 16, and Section 3.3.3, page 18, of the Dose Assessment report develop a de minimis dose value based on EPA's de minimis risk level and dose equivalence. However, the Energy Policy Act of 1992 contained provisions revoking the NRC's 1986 and 1990 Below Regulatory Concern Policy Statements. Therefore, the report must provide a clear and defensible justification for proposing a de minimis (i.e., below regulatory concern) dose value.

**REFERENCES:**

*Energy Policy Act of 1992*, Pub. L. No. 102-486, http://thomas.loc.gov/cgi-bin/query/z?c102:H.R.776.ENR:.

Neptune and Company, Inc., *Dose Assessment for the Clive DU PA*, May 28, 2011. (Appendix 11 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Nuclear Regulatory Commission, *Radioactive Waste Below Regulatory Concern: Policy Statement*, Federal Register, Vol. 51, No. 168, pp. 30839–30847, August 29, 1986.

U.S. Nuclear Regulatory Commission, *Below Regulatory Concern: Policy Statement*, *Federal Register*, Vol. 55, No. 128, pp. 27522–27537, July 3, 1990.

**INTERROGATORY CR R313-25-19-73/1: ALARA CONCEPT**

**PRELIMINARY FINDING:**

Refer to R313-25-19: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.*

**INTERROGATORY STATEMENT:**

Ensure that the information provided on the ALARA concept is consistent with that in International Commission on Radiological Protection (ICRP) Publication 101b.

**BASIS FOR INTERROGATORY:**

Section 1, page 1, and Section 2, page 2, of the Decision Analysis Methodology report cite U.S. Department of Energy (DOE) and NRC documents and ICRP Publication 26 with regard to the ALARA concept. In addition, ICRP Publication 101b provides a good description of the ALARA concept, including a history of its evolution. ICRP Publication 101b describes ALARA as an "*optimization*" process. It should be confirmed that the information contained in the Decision Analysis Methodology is consistent with ICRP Publication 101b.

**REFERENCES:**

International Commission on Radiological Protection, *Recommendations of the International Commission on Radiological Protection*, Publication 26, Ann. ICRP 1 (3), 1977.

International Commission on Radiological Protection, *The Optimisation of Radiological Protection – Broadening the Process*, Publication 101b, Ann. ICRP 36 (3), 2006.

Neptune and Company, Inc., *Decision Analysis Methodology for Assessing ALARA Collective Radiation Doses and Risks*, May 30, 2011. (Appendix 12 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(5)(A)-74/1: TAILORED DISCUSSION OF SENSITIVITY ANALYSIS

### PRELIMINARY FINDING:

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

### INTERROGATORY STATEMENT:

Expand on the Sensitivity Analysis report to discuss the sensitivity index and the partial dependence plots for specific parameters modeled in the Clive DU PA.

### BASIS FOR INTERROGATORY:

The Sensitivity Analysis report provided is a generic presentation describing various approaches to sensitivity analyses. As such, it is not a useful document by itself to support the sensitivity analyses described in FRV1 Section 6.0. Instead, the sensitivity analysis methods report should be expanded to clearly discuss and justify the sensitivity index and the partial dependence plots for specific parameters modeled in the Clive DU PA.

### REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Machine Learning for Sensitivity Analysis of Probabilistic Environmental Models*, May 29, 2011. (Appendix 15 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-7(9)-75/1: BRANCHING FRACTIONS**

**PRELIMINARY FINDING:**

Refer to R313-25-7(9): *Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal facility*.

**INTERROGATORY STATEMENT:**

Provide a reference list with complete information for Tuli, 2005.

**BASIS FOR INTERROGATORY:**

In Section 4.1, page 7, of the Model Parameters report, the text of Figure 1 indicates that the branching fractions were obtained from *"the Nuclear Wallet Cards (Tuli, 2005)."* However, the report does not provide a reference list entry with complete information for this reference.

**REFERENCES:**

Neptune and Company, Inc., *Model Parameters for the Clive DU PA Model*, May 28, 2011. (Appendix 16 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-7(10)-76/1: QUALITY ASSURANCE PROJECT PLAN SIGNATURE PAGE**

**PRELIMINARY FINDING:**

Refer to R313-25-7(10): *Descriptions of quality assurance programs, tailored to low-level waste disposal, including audit and managerial controls, for the determination of natural disposal site characteristics and for quality control during the design, construction, operation, and closure of the land disposal facility and the receipt, handling, and emplacement of waste.*

**INTERROGATORY STATEMENT:**

Provide a complete signature page for the Quality Assurance Project Plan and its appendices.

**BASIS FOR INTERROGATORY:**

The signature pages of the Quality Assurance Project Plan and its appendices do not include the indicated signatures of Neptune and Company officials. The document should indicate and identify that all necessary Utah approvals have been obtained.

**REFERENCES:**

Neptune and Company, Inc., *Quality Assurance Project Plan Performance Assessment Model Clive, Utah*, undated. (Appendix 17 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-7(10)-77/1: QUALITY ASSURANCE PROJECT PLAN PAGE NUMBERING**

**PRELIMINARY FINDING:**

Refer to R313-25-7(10): *Descriptions of quality assurance programs, tailored to low-level waste disposal, including audit and managerial controls, for the determination of natural disposal site characteristics and for quality control during the design, construction, operation, and closure of the land disposal facility and the receipt, handling, and emplacement of waste.*

**INTERROGATORY STATEMENT:**

Provide page numbers in the Quality Assurance Project Plan.

**BASIS FOR INTERROGATORY:**

Although the table of contents of the Quality Assurance Project Plan makes reference to page numbers, no page numbers are included for the body of the plan. The document must include page numbers.

**REFERENCES:**

Neptune and Company, Inc., *Quality Assurance Project Plan Performance Assessment Model Clive, Utah*, undated. (Appendix 17 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(10)-78/1: GOLDSIM MODEL CALIBRATION

### PRELIMINARY FINDING:

Refer to R313-25-7(10): *Descriptions of quality assurance programs, tailored to low-level waste disposal, including audit and managerial controls, for the determination of natural disposal site characteristics and for quality control during the design, construction, operation, and closure of the land disposal facility and the receipt, handling, and emplacement of waste.*

Refer also to R313-25-23(2): *The disposal site shall be capable of being characterized, modeled, analyzed and monitored.*

### INTERROGATORY STATEMENT:

Describe the role of model calibration in substantiating that GoldSim adequately simulates the physical, chemical, and biological processes at the Clive site.

### BASIS FOR INTERROGATORY:

The PA Quality Assurance Project Plan describes quality assurance for modeling services and the development of the GoldSim model. However, the only GoldSim model calibration appears to be that done to counteract numerical dispersion on air diffusion in Section 9.4.3, pages 55–56, of the Unsaturated Zone Modeling report. The Quality Assurance Project Plan should discuss the role that model calibration has taken in substantiating that GoldSim adequately simulates the physical, chemical and biological site processes. The purpose of the model calibration is to make sure that the model is simulating the actual field parameters correctly. For example, soil layer water content should be measured in the field and the assigned infiltration rate in the model should yield the measured water content.

### REFERENCES:

Neptune and Company, Inc., *Quality Assurance Project Plan Performance Assessment Model Clive, Utah*, undated. (Appendix 17 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

## INTERROGATORY CR R313-25-7(10)-79/1: CRITICAL TASKS AND SCHEDULE

### PRELIMINARY FINDING:

Refer to R313-25-7(10): *Descriptions of quality assurance programs, tailored to low-level waste disposal, including audit and managerial controls, for the determination of natural disposal site characteristics and for quality control during the design, construction, operation, and closure of the land disposal facility and the receipt, handling, and emplacement of waste.*

### INTERROGATORY STATEMENT:

Update the schedule and completion dates for the critical tasks.

### BASIS FOR INTERROGATORY:

In Section 5.0 of the PA Quality Assurance Project Plan, Table 2 lists the critical tasks for meeting project objectives and their scheduled deliverable dates. However, several of these dates are listed as TBD, and it is not clear whether tasks with *"scheduled"* completion dates have actually been completed. The table should be updated to indicate actual or scheduled completion dates for items that were TBD and to note the completion of other tasks with specific scheduled completion dates.

### REFERENCES:

Neptune and Company, Inc., *Quality Assurance Project Plan Performance Assessment Model Clive, Utah*, undated. (Appendix 17 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(10)-80/1: TESTING OF GOLDSIM ABSTRACTIONS

### PRELIMINARY FINDING:

Refer to R313-25-7(10): *Descriptions of quality assurance programs, tailored to low-level waste disposal, including audit and managerial controls, for the determination of natural disposal site characteristics and for quality control during the design, construction, operation, and closure of the land disposal facility and the receipt, handling, and emplacement of waste.*

Refer also to R313-25-23(2): *The disposal site shall be capable of being characterized, modeled, analyzed and monitored.*

### INTERROGATORY STATEMENT:

Provide information on the verification and benchmarking exercises that were designed to test the GoldSim abstractions against results obtained from process-level analytical and/or numerical models.

### BASIS FOR INTERROGATORY:

Appendix B, Section 2.6, page 8, of the PA Quality Assurance Project Plan provides a general description of model validation/verification and benchmarking. However, specific written information should be given on the verification and benchmarking exercises that were designed to test the GoldSim abstractions against results obtained from process-level analytical and/or numerical models. This should include, but not be limited to, all such testing results related to all of the simulated fate and transport pathways, input/output links to external models (e.g., HELP, atmospheric modeling), probabilistic components, and dose assessments.

### REFERENCES:

Neptune and Company, Inc., *Quality Assurance Project Plan Performance Assessment Model Clive, Utah*, undated. (Appendix 17 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(2) AND 7(6)-81/1: COMPARISON OF DISPOSAL CELL DESIGNS

### PRELIMINARY FINDING:

Refer to R313-25-7(2): *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.*

Refer to R313-25-7(6): *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 R313-25.*

### INTERROGATORY STATEMENT:

Provide a detailed annotated comparison of (1) the design of the Class A South embankment design[4] described in FRV1 and upon which the DU PA dated June 1, 2011, was based, (2) the Division-approved Class A West embankment design discussed in the 2013 Compliance Report (Revision 1, 2013) and (3) the Federal Cell design now proposed for DU disposal. The comparison should include design features and design criteria that are common to the three cells, as well as those that are different among the three designs. The comparison should include such factors as physical dimensions, materials used, types of waste, infiltration rates, depth of waste burial, waste depth compared to native grade, design life of the cell, liner and cover system specifics and other assumptions used in groundwater modeling, such as soil layer porosity and permeability, soil/water partition coefficients ($K_d$ values) and solubilities. Explain and justify why the Class A West Cell design is relevant and applicable to the new DU disposal cell to be constructed in the far southwest corner of Section 32.

Also explain and justify why current construction specifications and quality assurance/quality control requirements used at the Class A West Cell (or any other Clive disposal cell) have relevance to the DU PA, now that DU Waste disposal is to be examined for at least 10,000 years.

Provide a single, stand-alone engineering design report, including drawings and construction specifications, for the cell where DU waste will be disposed. Include detailed cross-sections to clearly identify the specific below-grade depth interval that the DU waste will occupy, as well as

[4] At a minimum, this would include both *Amendment Request Class A South/11e.(2) Embankment*, Revision 0, dated January 4, 2008 (Energy*Solutions* 2008), and *Class A South/11e.(2) Embankment Revised Application & Response to Completeness Review*, dated June 9, 2009 (Energy*Solutions* 2009).

design elevations for all pertinent site and disposal embankment features. If Energy*Solutions* plans to implement any evapotranspirative cover design for the DU cell, provide specific, discrete, and detailed engineering plans and specifications for the cell where this disposal will take place. Explain the current status in obtaining approval from DRC of an evapotranspirative cover design for the Class A West Cell.

Describe the types, forms, and locations of intruder barriers that will be provided for the DU waste in the disposal cell selected. Elaborate on how these barriers can and will endure across deep time periods (i.e., at least 10,000 years).

**BASIS FOR INTERROGATORY:**

Sections 1.2, 2.2, 2.3, 2.5, and 3.1.3 of the 2013 Compliance Report, Revision 1, and the Embankment Modeling report make frequent reference to the division-approved Class A West embankment and the fact that it is similar to the Federal Cell. By inference, the Federal Cell should perform the same as the Class A West embankment. For example, Section 1, page 1-1, of the 2013 Compliance Report, Revision 1, states the following:

> *As is illustrated in Figure 1-1, Energy*Solutions *has evaluated a new Federal Cell, using the Division-approved and licensed Class A West Embankment cover design, as the ultimate destination for the large volumes of depleted uranium.*

Although Energy*Solutions* speaks of a "*new Federal Cell, using the Division-approved and licensed Class A West Embankment cover design,*" the licensee should make clear that no design has yet been submitted for the Federal Cell, and that, although the proposed Federal Cell may use a design for a cover that is similar to that approved for the Class A West embankment cell, no design for the Federal Cell embankment has yet been submitted to nor approved by DRC. The Federal Cell will have a different location, different dimensions, different geometry, different waste, and different waste containers within it as compared to the Class A West embankment cell. Moreover, its performance must be demonstrated for 10,000 years.

Energy*Solutions* should more explicitly identify proposed elevations, or heights above and depths below native grade. Depths given in the PA below the base of the top slope engineered cover are not sufficient for review when the elevation of the base of the top slope engineered cover is not given explicitly or clearly.

Section 1.3.2.3, page 1-16, of the 2013 Compliance Report, Revision 1, states, "*Since there is no change being proposed for construction of the Federal Cell for ultimate disposal of depleted uranium in the types of waste or necessary administrative controls that will be managed,….*" Energy*Solutions* should explain and justify this statement. The types of waste are considerably different.

Section 1.3.2.4, page 1-17, of the 2013 Compliance Report, Revision 1, refers to the Class A West Embankment and states, "*As such, this depleted uranium Performance Assessment model of a Federal Cell using the Division-approved Class A West Embankment cover design does not trigger the need to conduct additional stability analysis*." However, the nature, containerization and geometry of most of the DU waste and containers proposed for disposal in the Federal Cell are highly different from those of most other waste disposed of at the Class A West cell, and it may affect stability differently. Moreover, site dimensions differ. Energy*Solutions* should justify its claim using an appropriate stability analysis.

Section 1.3.2.5, page 1-17, of the 2013 Compliance Report, Revision 1, states, "*Part I.C.1 of the* [Ground Water Quality Discharge Permit UGW450005] *specifies that GWPLs shall be used for the Embankment.*" However, the permit does not refer directly to the Federal Cell embankment.

Section 2.1, page 2-1, of the 2013 Compliance Report, Revision 1, states that "*Depleted uranium waste will be disposed below native grade in the permanent near surface engineered disposal Federal Cell….*" Energy*Solutions* needs to also place below native grade radon protection layers, which would lie above the DU waste. Otherwise, destruction of the above-ground portion of the cell would simply provide for easier exposure to radioactivity from the DU waste.

Because information on the various designs is located piece-meal in several documents, it is not possible to develop a coherent view of the differences and similarities of the designs. This lack of transparency is further complicated by reference to an alternative evapotranspirative cell. It is not clear whether or not some of the favorable PA outcomes cited in the 2013 Compliance Report, Revision 1, are attributable to that alternative design.

**REFERENCES:**

Energy*Solutions*, *Amendment Request Class A South/11e.(2) Embankment*, Revision 0, January 4, 2008.

Energy*Solutions*, *Class A South/11e.(2) Embankment Revised Application & Response to Completeness Review*, June 9, 2009.

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Neptune and Company, Inc., *Embankment Modeling for the Clive DU PA Model*, May 28, 2011. (Appendix 3 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-20-82/1: LIMITATION ON INADVERTENT INTRUDER SCENARIOS**

**PRELIMINARY FINDING:**

Refer to R313-25-20: *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.*

**INTERROGATORY STATEMENT**:

Explain and justify why the language of R311-25-7(8) limits the types of intrusion scenarios to be considered.

**BASIS FOR INTERROGATORY:**

Section 1.3.2.2, page 1-13, of the 2013 Compliance Report, Revision 1, states the following:

> *While an unlimited number of inadvertent intruder scenarios can be developed, Division requirements limit such developments to include, 'Identification of the known natural resources at the disposal site whose exploitation could result in inadvertent intrusion into the wastes after removal of active institutional control.' UAC R313-25-7(8).*

DRC does not agree with this interpretation of the regulation. The full section of R313-25-7, of which R313-25-7(8) is a sub-section, describes specific technical information that the applicant must provide: "*The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25:….*" Nothing in the regulatory language suggests that DRC plans to limit intrusion scenarios to those related to the exploration and exploitation of natural resources. Certainly, if there are known natural resources, DRC will likely wish to ensure the consideration of intruder scenarios involving their exploration and exploitation. More to the point, the definition of "inadvertent intruder" does not limit the DRC Director to only considering discovery and exploitation of natural resources. Instead, as stated in R313-25-2―

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

Hence, the emphasis is not only on natural resources but also on human activities and pursuits at the disposal site after facility closure.

We agree that the inadvertent intruder requirements in the rules of the NRC and Utah DRC are in some ways confusing and open to interpretation. The NRC staff has also acknowledged the confusion and attempted to add clarity in several writings, including in SECY-08-0147 (NRC 2008):

> *…since the requirement to conduct an inadvertent intruder analysis similar to that conducted to develop the § 61.55 waste classification tables is not specifically identified in Part 61 and may not be well understood.… applicants or*

> *licensees could misinterpret the regulations to only require compliance with the concentration limits in the waste classification tables for ensuring protection of the intruder….* [p. 6]
>
> *At the time of development of Part 61, it was envisioned that LLW in a disposal facility would decay, in a maximum of 500 years, to activity levels that would not pose a significant risk to an inadvertent intruder, and that there would not be significant quantities of long-lived isotopes which would pose unacceptable long-term risks to the public from releases from the facility.…The disposal site included a buffer zone around the disposal area, where the disposal area circumscribed the disposal units (NRC, 1982). An appropriate buffer zone was expected to extend approximately 100 m (330 feet [ft]) from the disposal area, although buffer zones up to 1,000 m (3,300 ft) were considered.* ***A receptor engaging in activities on the disposal site, rather than outside the buffer zone, was regarded as the inadvertent intruder. A receptor engaging in activities at the edge of the buffer zone was regarded as a member of the public.*** [Enclosure 1, p. 4; emphasis added]

We also acknowledge that the NRC is currently revising 10 CFR Part 61 and that upon completion of that effort there may be better clarity in what constitutes the "inadvertent intruder" and how to best protect that person(s). In the meantime, we suggest that the Division and Energy*Solutions* meet to discuss this issue in detail and establish a path forward.

**REFERENCES:**

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report,* Revision 1, November 8, 2013.

U.S. Nuclear Regulatory Commission, *NRC Response to Commission Order CLI-05-20 Regarding Depleted Uranium*, SECY-08-0147, October 7, 2008.

**INTERROGATORY CR R313-25-20-83/1: INTRUDER-DRILLER AND NATURAL RESOURCE EXPLORATION SCENARIOS**

**PRELIMINARY FINDING:**

Refer to R313-25-20: *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.*

**INTERROGATORY STATEMENT:**

Explain why a lack of subsurface mineral resources renders the intruder-driller scenario inapplicable. Evaluate inadvertent intrusion at locations within the facility's buffer zone and determine all exposure pathways and doses to a member of the public.

Explain the reason for excluding the intruder-driller scenario from this PA, taking into account the fact that the guidance in NUREG/CR-4370 refers to an intruder drilling for water, not mineral resources, and the fact that such a scenario was included in a prior site-specific PA.

**BASIS FOR INTERROGATORY:**

Section 1.3.2.2, page 1-14, of the 2013 Compliance Report, Revision 1, states, "*However, lacking the precursory subsurface mineral resources (NRC 1986, Section 4.2.1), the intruder-driller scenario is inapplicable to the Federal Cell*." The text refers to NUREG/CR-4370 (NRC, 1986) as the basis for the argument for inapplicability. However, the intruder-driller scenario as described in NUREG/CR-4370, Section 4.2.1, refers to a scenario that involves drilling for water; it is not related to subsurface mineral resources:

> *It is assumed in this scenario that, some time after the end of operations at the disposal facility, institutional controls temporarily break down and an intruder inadvertently decides to have a house built on the disposal facility. In order to do so, however, he must first install a well to secure an adequate supply of water for his living needs.*

This discrepancy with the argument given in the 2013 Compliance Report needs to be explained or corrected.

In addition, the intruder-driller scenario was included in a prior PA submitted by Energy*Solutions* related to waste disposal at the Clive Facility (October 8, 2012). That report stated the following:

> *That potable groundwater is not present below the floor of the Great Salt Lake Desert where the disposal site is located is common knowledge today. However, there is a very remote but finite chance that someone in the future might drill a well to determine whether potable groundwater exists at the Clive, UT site. Even if this were to occur, it is also highly unlikely that a drilling rig would be sited upon the rip rap cap of the embankment, rather than on the flat-lying landscape surrounding the disposal facility. Nevertheless, the initiating scenario of intruder-drilling suggested as an example in NRC (1986) is evaluated in the IHI dose assessment*. [Appendix B, p. 23]

An explanation should be provided for excluding the intruder-driller scenario from this PA, when it was included in a prior related PA. The analysis should also include the exploitation of other natural resources that may be available near the disposal site. At a minimum, it should evaluate inadvertent intrusion at locations within the facility's buffer zone and determine all exposure pathways and doses to a member of the public.

Furthermore, the Federal Cell geology is similar to the geology of the rest of the site, which contains valuable clay and sand used in construction of waste cells for the facility. These are of great value to the facility as they prevent a need to import similar construction materials from a distance and thus materially reduce costs. Workers at the Utah Test and Training Range have dug for and have used local native soils for disposal at Landfill No. 5 and for other applications. Clean Harbors Grassy Mountain Facility, north of the Clive low-level waste disposal facility, uses local native soils for various purposes. Intruders on the Clive site in the future may likewise dig for clay and/or sand for a variety of purposes, possibly including disposal of waste or creating basements for buildings. Thus, the assumption that the Federal Cell's geology holds no mineral resources of value is not accurate.

The site also contains natural resources other than minerals. Saline water is a potentially valuable resource, in that it can help grow beneficial halophytic plants or algae for cooking oils, and may contain minerals of value, such as lithium. Sunshine in the West Desert is also an important natural resource in great abundance at the site. It may be harvested in the future, such as to create large amounts of solar energy at solar farms in and about the Clive area. Solar farms are currently being implemented throughout the country, including nearby areas in the region. It is reported, for example, that a massive solar farm is currently being planned in the region at a location near Delta, Utah (see, for example, Maffly 2013).

The fact that the Federal Cell's current practices and county zoning limit use of the area to industrial purposes means that the site can indeed be used for industrial purposes, even if someone in the future happens to be aware of the zoning laws, and if they are still enforced. Thus, an inadvertent intrusion scenario related to industrial use should therefore be developed.

Recreational pursuits can also be considered, but these are not believed to be nearly as likely to cause significant, chronic dose to inadvertent intruders as the intruder-industrial or the intruder-resource-user scenarios, which need to be analyzed in the PA.

**REFERENCES:**

Energy*Solutions, Utah Low-Level Radioactive Material License (RML UT2300249) Updated, Site Specific Performance Assessment,* October 8, 2012.

Energy*Solutions, Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report,* Revision 1, November 8, 2013.

Maffly, Brian, *Massive solar farm to be planted near Delta*, The Salt Lake Tribune, September 19, 2013, access at www.sltrib.com/sltrib/news/56893328-78/state-energy-solar-utah.html.csp.

U.S. Nuclear Regulatory Commission, *Update of Part 61 Impacts Analysis Methodology,* NUREG/CR-4370, Volume 1, *Methodology Report*, January 1986.

**INTERROGATORY CR R313-25-7(6)-84/1: BELOW-GRADE DISPOSAL OF DU**

Refer to R313-25-7(6): *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 R313-25.*

Refer also to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

**INTERROGATORY STATEMENT:**

Explain how Figure 1-2 demonstrates that the entire inventory of DU can be disposed below grade. Provide calculations demonstrating that below-grade disposal will be achieved in the Federal Cell and that the burial depth is sufficient to protect the DU waste.

Indicate the drum/cylinder dimensions and orientation after placement on the respective waste lifts. Indicate the container packing arrangement (e.g., cubic, rhombic, octhahederal) and the minimum, maximum, and average distance that will be left between DU containers. Explain how a degraded embankment would continue to adequately control radiation dose to a member of the public and describe the types, forms, and locations of intruder barriers and how they will endure for a period of 10,000 years or more.

**BASIS FOR INTERROGATORY:**

Section 1, page 1-3, of the 2013 Compliance Report, Revision 1, states the following:

> *…depleted uranium will be disposed below grade to enhance assurance of continued isolation under geologic-time events such as the return of a large lake inundating Clive. Figure 1-2 below demonstrates that the entire depleted uranium inventory evaluated can be disposed in such a manner.*

Figure 1-2, page 1-4, shows that the below-grade capacity of the Federal Cell is 44,712 DU cylinders (21,962 cylinders in a single layer and 22,750 cylinders in a double layer). However, Table 1 of the Waste Inventory report indicates that 57,122 cylinders are available for disposal, and the B&W Conversion Services deconversion Web site states that more than 63,000 cylinders are stored at Paducah and Portsmouth. These values are higher than the Federal Cell capacity of 44,722 cylinders cited in Figure 1-2.

The report should indicate the drum/cylinder dimensions and orientation after placement on the respective waste lifts. It should also indicate the container packing arrangement (e.g., cubic, rhombic, octhahederal) and the minimum, maximum, and average distance that will be left between DU containers.

In addition, Table 1 of the Embankment Modeling reports an average original grade elevation of 4,272 feet above mean sea level and an average elevation at the bottom of the waste of 4,264.17 feet above mean sea level. Thus, the distance from the original grade to the bottom of the waste is 7.83 feet (4,272-4264.17). Figure 1-2 of the 2013 Compliance Report, Revision 1, shows that a double stack of DU cylinders is 7.3 feet high. This means that the double stack of $DUF_6$ cylinders would be only a few inches below grade. Energy*Solutions* should indicate whether this very small increment is consistent with its definition of below grade, and justify whether that small amount of below-grade cover will prevent the DU waste from being impacted by an encroaching pluvial lake, or prevent excessive radiological exposure to a receptor located above the cover (e.g., in a houseboat).

Energy*Solutions* should also explain and justify how, after an erosion event has occurred and the pluvial lake has receded, the degraded embankment would continue to adequately control radiation dose to a member of the public. At a minimum, this analysis must include evaluation of the degraded radon controls, prevention of stormwater erosion, and increased infiltration and contaminant leachate discharges to groundwater.

Energy*Solutions* should also describe the types, forms, and locations of intruder barriers that will be provided for the DU waste in the disposal cell selected. Detail should be provided on how these barriers can and will endure across deep time periods of at least 10,000 years.

**REFERENCES:**

B&W Conversion Services, LLC, *The DUF6 Process*, accessed January 3, 2014. (www.bwconversionservices.com/our-process)

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report,* Revision 1, November 8, 2013.

Neptune and Company, Inc., *Embankment Modeling for the Clive DU PA Model*, May 28, 2011. (Appendix 3 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(A)-85/1: UNCERTAINTY DISTRIBUTIONS ASSIGNED TO DOSE CONVERSION FACTORS

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

### INTERROGATORY STATEMENT:

When discussing the uncertainty associated with the risk coefficients in Federal Guidance Report 13, the discussion should include the work performed by Pawel et al. (2007), which was an update of the uncertainty analysis in Federal Guidance Report 13 for the cases of inhalation and ingestion of radionuclides and expands the analysis to all radionuclides addressed in that report. In addition, reference should be made to the guidance provided in NCRP, 1996; NCRP, 1998; NCRP, 2007; NCRP, 2009; NCRP, 2012; and Puncher and Harrison, 2013.

### BASIS FOR INTERROGATORY:

The Dose Assessment report documents the variability and uncertainty in many of the input parameters and assumptions used to model the exposure scenarios and pathways attendant to the disposition of DU at the Clive site. Among the important parameters it addresses are the dose conversion factors (DCFs). A careful review of the material provided in the report, especially Sections 3.4.3 and 4.4 and Appendix I, reveals that the uncertainty analysis of the DCFs is limited to the uncertainty in the radiation effectiveness factors (REFs), which contribute to only a part of the uncertainty in the DCFs. Specifically, the REF is the part of a DCF that converts the absorbed dose to the effective dose, and the analysis does an excellent job in addressing the contribution of the uncertainty in the DCFs that is due to uncertainty in the REFs. However, with respect to internal exposures, the uncertainty analysis provides a very limited discussion and analysis of the uncertainty in the models, parameters, and assumptions used to convert radionuclide intake (becquerel) to absorbed dose (rad or gray), which is the other component of a DCF that contributes to uncertainty.

The uncertainty analysis of the DCFs in the Dose Assessment report should (1) disclose that the uncertainty analysis is limited the contribution of the uncertainty in the REFs to the overall uncertainty in the DCFs, (2) summarize the literature that discusses the other factors that contribute to uncertainty in the DCFs, and (3) either explicitly address these other sources of uncertainty or provide a more complete explanation of the reasons for not including these other sources of uncertainty in the DCFs.

**REFERENCES:**

National Council on Radiation Protection and Measurements, *A Guide for Uncertainty Analysis in Dose and Risk Assessments Related to Environmental Contamination,* NCRP Commentary No. 14, 1996.

National Council on Radiation Protection and Measurements, *Evaluating the Reliability of Biokinetic and Dosimetric Models and Parameters used to Assess Individual Doses for Risk Assessment Purposes,* NCRP Commentary No. 15, 1998.

National Council on Radiation Protection and Measurements, *Uncertainties in Internal Radiation Dose Assessment,* NCRP Report No. 164, 2009.

National Council on Radiation Protection and Measurements, *Uncertainties in the Estimation of Radiation Risks and Probability of Disease Causation,* NCRP Report No. 171, 2012.

National Council on Radiation Protection and Measurements, *Uncertainties in the Measurement and Dosimetry of External Radiation,* NCRP Report No. 158, 2007.

Neptune and Company, Inc., *Dose Assessment for the Clive DU PA,* May 28, 2011. (Appendix 11 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Pawel et al., *Uncertainties in Cancer Risk Coefficients for Environmental Exposure to Radionuclides: An Uncertainty Analysis for Risk Coefficients Reported in Federal Guidance Report No. 13,* U.S. Environmental Protection Agency and Oak Ridge National Laboratory, ORNL/TM-2006/583, January 2007.

Puncher, M. and J.D. Harrison, *Assessing the Reliability of Dose Coefficients for Ingestion and Inhalation of Radionuclides by Members of the Public,* Health Protection Agency, Center for Radiation, Chemical and Environmental Hazards, Chilton, Didcot, Oxfordshire OX11 0RQ, HPA-CRCE-048, ISBN 978-0-85951-741-6, April 2013.

**INTERROGATORY CR R313-25-8(5)(A)-86/1: CONSEQUENCES OF SEDIMENTATION ON DISPOSAL CELL**

**PRELIMINARY FINDING:**

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

**INTERROGATORY STATEMENT:**

The deep time assessment needs to consider the relative rates of progeny in-growth and pluvial lake sedimentation. It should determined if there are points in time when individual exposures can be greater than at the time of peak activity, due to the influence of sedimentation on reducing surface concentrations of contamination or of wavecutting increasing access to waste and doses received by receptors.

**BASIS FOR INTERROGATORY:**

FRV1 Section 4.1.2.13, page 42, asserts that "*Overall sediment concentrations decrease over time because the amount of waste does not change other than through decay and ingrowth, whereas more sediment is added over time*." This statement is misleading. In-growth of uranium progeny is an important consideration that was not included in the deep time assessment. The PA should qualitatively discuss relative rates of radionuclide in-growth and net sediment accumulation over long periods of geologic time (e.g., until peak doses are attained for all radionuclides potentially having a human health consequence, which may be longer than 1 My years). The PA should also assess how geological changes through time may affect net rates of sediment accumulation (considering relative rates of sediment erosion as well as deposition). At the time that wave action cuts into the embankment, some or all of the low-level waste (including DU) in the embankment or in wave-cut sediments may be present in a form that has relatively high concentrations of progeny and that allows for human exposure prior to the redistribution of sediment throughout the lake. Human exposure during this intermediate time is not analyzed in the model or text. This scenario needs to be considered in the model and documented in the text.

**REFERENCES:**

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R315-101-5.3(6)-87/1: ORAL TOXICITY PARAMETERS

### PRELIMINARY FINDING:

Refer to R315-101-5.3(6): *Identification of toxicity information gathered for all identified hazardous constituents for carcinogenic, slope factors and weight-of-evidence classification, noncarcinogenic effects, chronic reference doses (RfDs) and critical effects associated with RfDs from, in order of preference, the Integrated Risk Information System (IRIS), Health Effects Assessment Summary Tables (HEAST), Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles, Environmental Criteria and Assessment Office (ECAO), or other scientifically accepted listings. The source and date of the toxicological information must be identified and be acceptable to the Director.*

### INTERROGATORY STATEMENT:

The approach used in the Dose Assessment report with regard to oral toxicity should be revised based on the established drinking water standard for uranium and a review of recent literature on hazards from uranium ingestion. The report should also explain how the oral toxicity factors used in the PA were derived, as they may understate risk.

### BASIS FOR INTERROGATORY:

As is noted in Section 3.4.5, page 25, of the Dose Assessment report, the term "*proof-of-principle exercise*" relates to the potential non-radiation-related toxicity of DU. EPA published oral toxicity criteria for natural uranium in relation to the Superfund Program (EPA, 2002) and in relation to drinking water standards (EPA, 2000). Given the five-fold difference between these criteria, the DU PA employed both to determine the sensitivity of uranium health effects results to differences in these criteria. Specifically, Table 1 of the Dose Assessment report indicates that a discrete distribution was used as input for this parameter, where 50% of the realizations were assigned an oral RfD of 0.0006 mg/kg-day and 50% were assigned 0.003 mg/kg-day.

It is noteworthy that the drinking water standard for uranium is 30 µg/L (EPA, 2000). The Dose Assessment report should explain how it derived a drinking water standard expressed as 0.003 mg/kg-day. Assuming a 70-kilogram adult drinks 2 liters per day, the maximum contaminant level (MCL) for uranium of 30 µg/L is converted into units of mg/kg-day as follows:

$$30\ \mu g/L \times 1E\text{-}3\ mg/kg \times 2\ L/day \div 70\ kg = 8.5E\text{-}4\ mg/kg\text{-}day$$

This calculation yields lower results than cited in EPA's drinking water standards (R317-6-2, Table 1).

Inspection of the IRIS Web site (EPA, 2002) reveals that Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997 and that, as of December 1998, EPA was reassessing uranium under the IRIS program. Hence, the MCL is the EPA standard currently applicable for the control of exposures to uranium in drinking water, which includes consideration of both the chemical and radiological toxicity of uranium ingestion. Since the radiological risks associated with uranium are explicitly addressed elsewhere in the PA, the question is whether the discrete distributions delineated in Table 1 of the Dose Assessment report represent a valid characterization of the uncertainty in the non-radiological risks associated with the ingestion of uranium in the form of DU oxide in water (and presumably food).

A vast body of literature has been compiled on the chemical toxicity of DU, especially following the Persian Gulf War in 1990–1991, where DU munitions were introduced into the battlefield in a significant way (Briner, 2010). Briner (2010) cites nearly 400 authoritative reports that address the toxicity of DU as of the time of publication of his article in the *International Journal of Research in Public Health*. The article emphasizes the inhalation of fine airborne particles of DU and not DU in drinking water. However, the article and the literature cited in the article address the chemical toxicity of DU once it is absorbed into the bloodstream, and the article does cite literature where rats were administered DU in drinking water. The article provides a detailed description the toxic effects of both acute and chronic uptakes of DU, which are not repeated here. However, it is worth noting that chronic low uptakes of DU that do not produce classic signs of renal toxicity and failure are suspected of producing other detrimental effects as a result of protracted low-level exposures at subclinical levels, similar in many respect to exposure to lead. For example, exposures to pregnant experimental animals at levels that were not observed to cause renal damage resulted in neurodevelopmental effects, smaller litter size, small offspring, increased offspring mortality, skeletal abnormalities, and a number of behavioral changes indicative of neurodevelopment effects.

In light of the extent of the relatively recent published literature, it might be prudent to survey the published literature to confirm that the non-radiological effects associated with chronic intakes of DU are bounded by the drinking water standards as adopted for use in the PA. Also, it appears that the discrete distributions adopted in the PA for uranium non-radiological toxicity are somewhat arbitrary and require reconsideration. Since IRIS does not currently report a value for oral toxicity, the approach taken in the Dose Assessment report of equal weighting of IRIS data and the drinking water standards is questionable and understates the oral toxicity risk.

**REFERENCES:**

Briner, W., *The Toxicity of Depleted Uranium*, Int. J. Res. Public Health, Vol. 7, No. 1, pp. 303–313, January 25, 2010.

Neptune and Company, Inc., *Dose Assessment for the Clive DU PA*, May 28, 2011. (Appendix 11 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Environmental Protection Agency, *Integrated Risk Information System*, Office of Research and Development and National Center for Environmental Assessment, Electronic Database, entry for Uranium, natural (CASRN 7440-61-1), available online at www.epa.gov/iris/subst/0259.htm, last updated August 9, 2002, accessed January 16, 2014.

U.S. Environmental Protection Agency, *National Primary Drinking Water Regulations; Radionuclides; Final Rule*, Federal Register, Volume 65, No. 236, December 7, 2000.

## INTERROGATORY CR R313-25-19-88/1: COLLECTIVE DOSE AND ALARA

### PRELIMINARY FINDING:

Refer to R313-25-19: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.*

### INTERROGATORY STATEMENT:

Confirm that the population (collective) doses over 10,000 years presented in FRV1 Table 11 are not in error, underestimating those doses by about a factor of 10. If the doses are correct, explain and justify why it should stand as written.

### BASIS FOR INTERROGATORY:

FRV1 Section 6.4, Section 3 of the Dose Assessment Report, and Section 2 of the Decision Analysis report analyze compliance with 10 CFR 61.41 with respect to the requirement that "*Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable*." The analysis describes (1) the regulatory requirements and guidelines pertaining to an ALARA analysis of the design and operation of the facility, (2) the criteria used in the PA for judging compliance with cost/benefit criteria used to perform an ALARA analysis (i.e., $1,000 per person rem averted), (3) the methods used to perform such an analysis, and (4) the calculation of the collective dose over a 10,000-year time period. The PA appropriately addresses the applicable regulatory requirements and guidelines, selects an appropriate cost/benefit criterion, and uses appropriate mathematical models and assumption to derive collective doses. The detailed analysis in the PA provides a high level of assurance that the doses are very small. However, the actual quantitative analysis of the collective doses, expressed in units of person rem, appears to have underestimated dose by about a factor of 10. It appears that a calculation error has been made, and the values for the population (collective) doses over 10,000 years, as provided in FRV1 Table 11, page 76, should be re-evaluated.

### REFERENCES:

*Code of Federal Regulations*, Title 10, *Energy*, Part 61, *Licensing Requirements for Land Disposal of Radioactive Waste*.

Neptune and Company, Inc., *Decision Analysis Methodology for Assessing ALARA Collective Radiation Doses and Risks*, May 30, 2011. (Appendix 12 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Dose Assessment for the Clive DU PA*, May 28, 2011. (Appendix 11 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(9)-89/1: CONTAMINATION LEVELS IN $DUF_6$

### PRELIMINARY FINDING:

Refer to R313-25-7(9): *Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal.*

### INTERROGATORY STATEMENT:

Review the basis for setting contamination levels in the DU PA and consider the substantial amount of contamination information available from the GDPs in lieu of surrogate data based on DU from SRS. Direct particular attention to contamination remaining in the heels of the $DUF_6$ cylinders. Describe in the PA how Energy*Solutions* will ensure that the cylinders shipped to Clive do not contain contaminated heels resulting from introduction of recycled uranium into the GDP process streams.

Revise the PA report to do the following:

1. Incorporate the new technical literature information for nuclide activity in the GDP DU waste.
2. Explain and justify why the already buried nuclear inventory for Clive was not included in the DU PA model, as required by R313-25-8(5)(a).

### BASIS FOR INTERROGATORY:

In the DU PA, contamination in the $DUF_6$ associated with recycled uranium processed through the GDPs was estimated using surrogate assays from $DUO_3$ produced at SRS. Based on information specifically from the GDPs, it appears that the contamination in the $DUF_6$ and its containment cylinders may have been significantly underestimated.

Table 1 of the Waste Inventory report assumes that there were 686,500 MT of $DUF_6$ stored in 57,122 cylinders at the GDPs, based on information available from the Depleted Uranium Hexafluoride Information Network (DOE, 2014). On page 24, the report further assumes that between 1,946 and 2,619 cylinders contained contamination from recycled uranium, based largely on information derived from Henson (2006). Figure 6 indicates that the number of contaminated cylinders was assigned a normal distribution, with the $1^{st}$, $50^{th}$, and $99^{th}$ percentiles being 1,946, 2,266 and 2,619 cylinders, respectively.

The Tc-99, plutonium, and Np-237 contents of the contaminated $DUF_6$ stored at the GDPs were assumed to be the same as the contaminated $DUO_3$ from SRS. Using several sets of assays of the SRS $DUO_3$, Table 5 shows a mean Tc-99 concentration of 23.8 nCi/g U for the contaminated oxide. Table 6 shows a mean Np-237 concentration of 5.68 pCi/g U and a mean plutonium (Pu-238, Pu-239, Pu-440, and Pu-241) concentration of 5.87 pCi/g.

The specific activity of Tc-99 is 1.7E-02 Ci/g (IEM, 2014) or 1.7E+07 nCi/g Tc-99. Thus, the mean Tc-99 concentration in the contaminated cylinders would be 13.9 E-07 g Tc/g U (23.8 nCi/g U ÷ 1.7 E+07 nCi/g Tc). The average mass of uranium in a cylinder is 8.17 MTU (686,500 x 238/352 MTU ÷ 57,122 cylinders). If the mean estimate is 2,266 contaminated cylinders, then the mean total amount of Tc-99 in the $DUF_6$ inventory would be 25,700 g Tc (2,266 × 8.17 MTU × $10^6$ g U/MTU × 13.9 E-07 g Tc/g U) or 25.7 kg Tc-99. Expressed in total activity of GDP DU waste to be shipped to Clive, over the coming years, this would equate to a total of 436.9 Ci Tc-99 to be disposed.

The specific activity of Np-237 is 6.9E-04 Ci/g Np (IEM, 2014) or 6.9 E+08 pCi/g Np, fixing the neptunium concentration at 0.82 E-08 g Np/g U (5.68 pCi/g U ÷ 6.9 E+08 pCi/g Np) or 8.2 parts per billion (ppb). The total Np-237 inventory would be 152 g (2,266 × 8.17 MTU × $10^6$ g U/MTU × 8.2 E-09 g Np/g U).

Based on the mix of plutonium isotopes in Table 6 and their specific activities, the total mass of plutonium is 0.4 g.

However, the DU PA did not consider, for example, a study by Hightower et al. (2000) characterizing the contamination in $DUF_6$ cylinders from processing at the GDPs. Information in Table C.2 of Appendix C to that report indicates that approximately 98,400 MTU as recycled $UO_3$ was delivered to the GDPs. Of this, about 95,600 MT $UF_6$ was fed into the cascades. Included in the recycled uranium was 872 kg of Tc-99 delivered to the $UF_6$ feed preparation facilities at the GDPs, of which 804 kg were delivered to the cascades, 709 kg were fed into the cascades, and 95 kg remained in the cylinder heels. Table 1 provides details on the composition of the feed cylinder heels (Hightower et al. 2000, Appendix C, Table C.6).

**Table 1. Estimated Upper Bound Quantities of Pu-239, Np-237, and Tc-99 Remaining as Heels in Reactor Returns Feed Cylinders**

| Plant | Pu (g)[a] | Np (kg)[b] | Tc (kg)[c] |
|---|---|---|---|
| ORGDP | 21 | 0.73 | 21 |
| PGDP | 2.9 | 11.1 | 57 |
| PORTS | No data | No data | 17 |
| Total | 24 | 11.8 | 95 |

a – 99.9% of Pu remains in feed cylinder
b – 60% of Np remains in feed cylinder
c – 20% of Tc remains in feed cylinder

Hightower et al. (2000) (Appendix C, Table C-9, page C-9) concluded that the **bounding** concentrations for these contaminants based on the limits of detection in the $DUF_6$ tails were as follows:

- Pu – 0.01 ppb U
- Np – 5 ppb U
- Tc-99 – 10 ppb U

Conservatively assuming that each of the contaminants is at the bounding concentration, Table 2 presents the estimated quantities in the heels and in the $DUF_6$ tails. Note that the plutonium content is in grams, while the Np-237 and Tc-99 contents are in kilograms.

**Table 2. Contaminants in $DUF_6$**

| $DUF_6$ (MT) | Tc-99 in Heels (kg) | Tc-99 in $DUF_6$ (kg) | Np in Heels (kg) | Np in $DUF_6$ (kg) | Pu in Heels (g) | Pu in $DUF_6$ (g) |
|---|---|---|---|---|---|---|
| 95,600 | 95 | 0.65[a] | 11.8 | 0.33 | 24 | 0.65 |

a – 95,600 MT $DUF_6$ × 238/352 MTU/MT $DUF_6$ × 10 parts Tc/$10^9$ parts U × $10^3$ kg/MT = 0.65 kg

As shown in Table 3, the quantity of Tc-99 estimated in Table 2 is a factor of 3.7 higher than that used in the DU PA ([95 kg in heels + 0.65 kg in $DUF_6$] ÷ 25.7 kg in DU PA). If the $DUF_6$ cylinders are cleaned as part of the de-conversion process, then it should be possible to substantially reduce the mass of the heels. Results of tests when washing the cylinders with an acidic solution indicated that contamination in the rinse solution was reduced by factors of 400–500 after four rinses (Hightower et al. 2000, Appendix C, page C-7).

**Table 3. Contaminants in DU PA Versus Contaminants Based on Hightower et al. (2000)**

| Contaminant | DU PA | Hightower | Hightower w/o heels |
|---|---|---|---|
| Tc-99 (kg) | 25.7 | 95.65 | 0.65 |
| Np-237 (kg) | 0.15 | 12.1 | 0.33 |
| Pu (g) | 0.4 | 24.6 | 0.65 |

However, current practice at the de-conversion plants is **not** to wash the emptied tails cylinders but rather to add potassium hydroxide to neutralize the heels. The neutralized residue is left in the cylinder and any liquid is assumed to absorbed in the de-converted uranium oxide.

If the heels are eliminated by washing, then Tc-99 would be reduced by a factor of 40 as compared to the DU PA, but Np-237 would still be a factor of 2 higher than the value in the DU PA and the plutonium would be a factor of 1.6 higher.

The quantities of contaminants listed in Table 3 above from the DU PA include only those contaminants from the GDPs. Table 4 below estimates the contaminants in the drummed SRS $UO_3$ already stored at Clive based on the following assumptions:

- Number of drums – 5,408
- Mass of SRS $DUO_3$ – 3,577 MT (2,977 MTU)
- Tc-99 activity concentration – 23,800 pCi/g
- Np-237 activity concentration – 5.68 pCi/g
- Pu activity concentration – 5.87 pCi/g

**Table 4. Mass of Contaminants in SRS $DUO_3$**

| Contaminant | Activity Concentration (pCi/g U) | Mass of SRS $UO_3$ (MTU) | Specific Activity (pCi/g) | Mass of Contaminant (g) |
|---|---|---|---|---|
| Tc-99 | 23,800 | 2,977 | 1.7E+10 | 4,196 |
| Np-237 | 5.68 | 2,977 | 6.9E+08 | 24.7 |
| Pu | 5.87 | 2,977 | various | 0.07 |

Note that all calculated masses in Table 4 are in grams. Comparing Tables 3 and 4, it can be seen that the SRS $DUO_3$ accounts for about 16% of the total Tc-99 mass included in the DU PA modeling.

Energy*Solutions* should revise the PA report to (1) incorporate the new technical literature information for nuclide activity in the GDP DU waste and (2) explain and justify why the already buried nuclide inventory for Clive was not included in the DU PA modeling analysis, as required by R313-25-8(5)(a).

**REFERENCES:**

Henson Technical Projects, LLC, *Contents Categorization of Paducah DUF6 Cylinders Using Cylinder History Cards – Phase II*, DUF6-G-G-STU-003, Draft for UDS Review, Uranium Disposition Services, LLC, Lexington, KY, September 30, 2006 (file: DUF6-G-G-STU-003 Henson 2006.pdf).

Hightower, J.R., L.R. Dole, D.W. Lee, G.E. Michaels, M.I. Morris, D.G. O'Conner, S.J. Pawel, R.L. Schmoyer, L.D. Trowbridge, and V.S. White, *Strategy for Characterizing Transuranics and Technetium Contamination in Depleted UF6 Cylinders*, ORNL/TM-2000/242, UT-Battelle, Oak Ridge National Laboratory, Oak Ridge, Tennessee, October 2000.

Integrated Environmental Management, Inc., *Specific Activities*, available at *www.iem-inc.com*, accessed January 16, 2014, followed by searching for "specific activities."

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Department of Energy, *Depleted* $UF_6$ *Storage*, available at http://web.ead.anl.gov/uranium/mgmtuses/storage/index.cfm, accessed January 16, 2014.

## INTERROGATORY CR R313-25-7(1–2)-90/1: CALIBRATION OF INFILTRATION RATES

### PRELIMINARY FINDING:

Refer to R313-25-7(1–2): *(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

*(2) 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.*

### INTERROGATORY STATEMENT:

Explain how the infiltration rates predicted with HELP/UNSAT-H and HYDRUS were calibrated against actual field data. Explain and justify which infiltration rate should apply to the DU disposal embankment (Federal Cell) at Clive, addressing radon barrier damage via frost heave, root penetration, animal burrowing, insect burrowing, and desiccation.

### BASIS FOR INTERROGATORY:

According to Rogers (2007), the measured infiltration through the test cell averaged 0.0267 cm/yr (including the first year of monitoring data). At that time, the modeled infiltration rate was assigned a value an order of magnitude higher at 0.265 cm/yr. However, as discussed in a memorandum from a DRC staff member to the Director, there is evidence that the observed flux, at least up until that time, was not from infiltration (Edwards and Bishop 2011). If fully saturated, the cover system at the test cell (having very low-permeability radon barrier soil layers) would permit infiltrating water under a unit head to move through it in about 11 years. If not fully saturated (which it would not be under desert conditions), then the time for fluid migration would be much greater. At the time of review, the cover test cell had been in service about 11 years. The fluids observed, including those in the first year, were likely merely water added during construction and expressed during compaction. Whetstone (2007) predicted a net infiltration of 0.277 cm/yr and 0.287 cm/yr for the top and side slopes of the Class A South cell, respectively. For the Class A West cell, however, Whetstone (2011**)** predicted net infiltration rates of 0.09 cm/yr and 0.168 cm/yr for the top and side slopes, respectively. Since the modeled configurations all consist of the traditional rock-armored cover system, it is unclear why there is significant variability in the predicted infiltration rates.

EnergySolutions should explain and justify which infiltration rate should apply to the DU disposal embankment (Federal Cell) at Clive, addressing radon barrier damage via frost heave, root penetration, animal burrowing, insect burrowing, and desiccation.

Section 6.0 of the Quality Assurance Project Plan notes the following:

> *The quality objective for the model is to provide results that are consistent with the site characteristics, the waste characteristics, and the CSM. If data are available, the demonstration of consistency will be supported by available site monitoring data and other field investigations.*

The importance of model calibration is further stressed by conclusions reached in the Executive Summary, page xii, of NUREG/CR-6836:

> *For the numerical model [HYDRUS-2D] inputs and results, the largest source of uncertainty arose from the need to input estimated potential evapotranspiration. The uncertainty is propagated through the model's approach for calculating actual evapotranspiration (i.e., assumptions in plant water uptake and root distribution). Additional sources of uncertainty for the modeling results were due to incomplete knowledge of soil hydraulic properties.*

**REFERENCES:**

Edwards, D., and C. Bishop, Memorandum to Rusty Lundberg, Director, Utah Division of Radiation Control, through John Hultquist and Phil Goble, *Review and Audit of Energy*Solutions*' Cover Test Cell (CTC) Corrective Action Plan and Related Documents,* October 28, 2011.

Neptune and Company, Inc., *Quality Assurance Project Plan Performance Assessment Model Clive, Utah*, undated. (Appendix 17 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Rogers, V., *EnergySolutions*, Letter to D. Finerfrock, Utah Department of Environmental Quality*, Subject: Radioactive License No: UT2300249 – Comments on Draft License Renewal,* September 21, 2007.

U.S. Nuclear Regulatory Commission, *Comparing Ground-Water Recharge Estimates Using Advanced Monitoring Techniques and Models*, NUREG/CR-6836, Office of Nuclear Regulatory Research, September 2003.

Whetstone Associates, Inc., *Energy*Solutions *Class A South Cell Infiltration and Transport Modeling*, December 7, 2007.

Whetstone Associates, *Energy*Solutions *Class A West Disposal Cell Infiltration and Transport Modeling*, November 28, 2011.

## INTERROGATORY CR R313-25-7(2)-91/1: DESIGN CRITERIA FOR INFILTRATION

### PRELIMINARY FINDING:

Refer to R313-25-7(2): *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.*

### INTERROGATORY STATEMENT:

Include specific design criteria for infiltration into the Class A South Cell (subsequently called the Federal Cell) and explain how the Utah groundwater protection levels will be met for 10,000 years. Explain and justify which infiltration rate will apply to the DU disposal cell and how a 500-year PA analysis for the groundwater pathway is compliant with R313-25-8(5)(a) in terms of both model prediction time and determination of peak dose.

### BASIS FOR INTERROGATORY:

FRV1 Section 1.2, page 12, states that "*The disposal embankment is designed to perform for a minimum of 500 years based on requirements of 10 CFR 61.7, and hence provides a possible solution for the long-term disposal of DU.*" However, this statement appears to contradict the findings presented in Section 3.1.3, page 3-20, of the Energy*Solutions* Radioactive Material License Renewal Application, dated October 25, 2012, for low-level radioactive waste disposal with respect to the design criteria for infiltration required to meet groundwater protection standards as presented below:

> ***Design Criteria:*** *Average infiltration into the Embankment shall be less than or equal to 0.000079 inches per year (0.002 cm/year).*
>
> ***Design Criteria Justification:*** *Infiltration was modeled using the HYDRUS computer model. At the maximum average infiltration rates provided above, RESRAD modeling of the fate and transport of hazardous constituents within the waste disposed demonstrates that Ground Water Protection Levels will not be exceeded for at least 500 years for radiologic constituents and at least 200 years for heavy metals (Neptune, 2012).*

Since infiltration rates for the traditional rock-armored cover system are all predicted to exceed the design criteria necessary to meet groundwater protection levels (Whetstone, 2007, 2011), it does not appear possible to use the rock-armored cover system and still meet the groundwater protection standards.

Energy*Solutions* should explain and justify which infiltration rate will apply to the DU disposal cell. It should also describe and justify how a 500-year PA analysis for the groundwater pathway is compliant with R313-25-8(5)(a), in terms of both model prediction time and determination of peak dose.

**REFERENCES:**

Energy *Solutions, State of Utah Radioactive Material License Renewal Application (UT 2300249),* Revision 0, October 25, 2012.

Energy*Solutions, Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report,* Revision 0, June 2, 2011.

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Modeling Report: Fate and Transport of Contaminants from the Class A West Embankment and Exposure to a Post-Closure Traditional Inadvertent Human Intruder at the Energy*Solutions *Clive, Utah Facility (NAC-0009_R1)*, October 5, 2012.

Whetstone Associates, Inc., *Energy*Solutions *Class A South Cell Infiltration and Transport Modeling*, December 7, 2007.

Whetstone Associates, *Energy*Solutions *Class A West Disposal Cell Infiltration and Transport Modeling*, November 28, 2011.

**INTERROGATORY CR R313-25-20-92/1: INADVERTENT INTRUDER DOSE STANDARD AND SCENARIOS**

**PRELIMINARY FINDING:**

Refer to R313-25-20: *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.*

Refer also to R313-25-8(4)(b): *Analyses of the protection of inadvertent intruders shall demonstrate a reasonable assurance that the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided. Analyses of the protection of inadvertent intruders shall demonstrate a reasonable assurance that the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided.*

**INTERROGATORY STATEMENT:**

1. Justify why 25 mrem/yr should not be used as the dose limit for inadvertent intruders and instead why a 500 mrem/yr limit should be applied for inadvertent intruder analysis in unrestricted areas.
2. Include analysis in the PA for additional inadvertent intruder scenarios.

**BASIS FOR INTERROGATORY:**

1. Section 1.3.2.2, pages 1-15 to 1-16, of the 2013 Compliance Report, Revision 1, discusses the use of an intruder dose limit for inadvertent intruder analysis of 500 mrem/year.

We agree that when the NRC promulgated the 10 CFR Part 61 low-level radioactive waste (LLRW) rules in 1982 that the dose limit for the members of the public in unrestricted areas (10 CFR Part 20) was 500 mrem/yr. However, the NRC did not consider the shallow land disposal of large quantities of concentrated DU waste in the original 10 CFR Part 61 rulemaking. Consequently, it appears that use of a 500-mrem/yr dose limit in this case is without regulatory support.

Since its original promulgation of 10 CFR Part 61, the NRC has amended its rules in 10 CFR Part 20 to reduce the dose limit for exposure in unrestricted areas to 25 mrem/yr TEDE (see current 10 CFR 20.1402).[5] This same limit is reflected in the Utah rule at R313-15-402.

We also agree that the NRC license termination rules allow a 500 mrem/yr dose to public in unrestricted areas, should certain conditions be met. The corresponding Utah requirement is found in R313-15-403. Unfortunately, this Utah flexibility is restrained by R313-15-401(1), which imposes a key limiting criteria, in that "*For low-level waste disposal facilities (Rule R313-25, the criteria apply only to ancillary surface facilities that support radioactive waste disposal activities*." Our current interpretation of these rules leads us to find that a 500 mrem/yr dose standard in inadvertent intruder analysis should not be applied to the actual disposal

[5] For more information, see NRC RCPD 13-005, Enclosure, pages 9 and 27, as transmitted by email from Donald Saah (NRC) to Craig Jones (Utah Division of Radiation Control) on March 15, 2013.

embankment. However, we are willing to consider additional Energy*Solutions* arguments to the contrary.

We also recognize the draft NRC rule changes for the Unique Waste Streams initiative at 10 CFR Part 61, which propose a 500 mrem/yr inadvertent intruder dose limit. Unfortunately, that draft rule has yet to be approved by the Commission, opened for public comment, or promulgated. Therefore, final NRC rulemaking is many months away, if not a year or more.

Further, the DRC Director has an obligation to determine a DU inadvertent intruder dose limit for the Clive facility that is legally defensible under current state rules. Currently, we believe that this dose limit should be 25 mrem/yr. In light of the above findings by the Utah Department of Environmental Quality (DEQ), Energy*Solutions* should explain and justify why the modern 25 mrem/yr value should not be used and instead the 500 mrem/yr limit be applied for inadvertent intruder analysis in unrestricted areas.

Alternatively, if Energy*Solutions* is intent on pursuing a 500 mrem/yr inadvertent intruder dose limit, at least three options are available, including, but not limited to, petitions before the Utah Radiation Control Board for the following:

- Exemption from the 25 mrem/yr dose limit for members of the public in unrestricted areas.
- Exemption from the current requirements in R313-25-401(1) that would, in turn, allow the Director to apply a 500 mrem/yr inadvertent intruder dose limit, should the conditions of R313-15-403 be met.
- Rulemaking to modify applicable requirements in either R313-15 or R313-25.

2. In addition, the PA model should include additional inadvertent intruder analysis to account for the following new intruder scenarios, and Table 3-3 of the 2013 Compliance Report, Revision 1, should be revised (or new tables provided) to describe peak inadvertent intruder dose under these new scenarios:

- Industrial Occupation of Energy*Solutions* Abandoned Structures Outside of Section 32 – where person(s) occupy or use buildings and facilities Energy*Solutions* plans to leave behind after site closure that border on the buffer zone.
- Nearby Industrial Occupation, Renewable Energy Development – where at some future time one or more persons build new structures on or near Section 32 to develop and operate waste disposal facilities, or alternative energy projects, such as solar farms and wind turbine farms, or to conduct saline aquaculture for bio-diesel.
- Excavation of a Transcontinental Pipeline – where a private company digs trenches for a transcontinental pipeline (or other utility) near the disposal embankment.
- Mining or Harvest of Soil and Gravel Materials – including removal of engineered gravels found in the Federal Cell cover system, or harvest of native clay, silt, or sand materials near the Clive disposal site.

**REFERENCES:**

*Code of Federal Regulations*, Title 10, *Energy*, Part 20, *Standards for Protection against Radiation*.

*Code of Federal Regulations*, Title 10, *Energy*, Part 61, *Licensing Requirements for Land Disposal of Radioactive Waste*.

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

U.S. Nuclear Regulatory Commission, RCPD 13-005, Enclosure, pages 9 and 27, as transmitted by email from Donald Saah (NRC) to Craig Jones (Utah Division of Radiation Control), March 15, 2013.

**INTERROGATORY CR R313-25-22-93/1: STABILITY OF DISPOSAL SITE AFTER CLOSURE**

**PRELIMINARY FINDING:**

Refer to R313-25-22: *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.*

**INTERROGATORY STATEMENT:**

1. Include long-term PA analysis for a scenario where wave-cut action from a pluvial lake breaches the Federal Cell cover system and DU waste. Alternatively, redesign the Federal Cell to locate the DU waste and its overlying radon barrier at an elevation that is below the native ground surface.
2. Revise the consideration of the span of time used in the PA modeling to go beyond the time period for which the disposal embankment maintains its designed condition and function, and explain and justify why the span of time used in the PA modeling for engineering design requirements was adequate to comply with the requirements of R313-25-8(4) and (5).

**BASIS FOR INTERROGATORY:**

1. Section 1.3.2.4, pages 1-16 to 1-17, of the 2013 Compliance Report, Revision 1, does not mention the effect of pluvial lakes on the Clive site. Because the current design may place part of the DU waste at an elevation that is above native ground surface, the amendment application and PA model should be revised to include long-term PA analysis for a scenario where wave-cut action from a pluvial lake breaches the Federal Cell cover system and DU waste. Alternatively, Energy*Solutions* may redesign the Federal Cell to locate the DU waste and its overlying radon barrier at an elevation that is below the native ground surface.
2. We agree that there is a limit to how long engineered structures will withstand natural forces. We do not disagree with your suggestion that this period might be as long as 1,000 years. However, we disagree that the Division should continue its past practice of limiting the PA analysis to the time period for which the disposal embankment maintains its designed condition and function. Because the disposal of large quantities of DU unique waste is a scenario completely outside the original assumptions underlying the NRC's 10 CFR Part 61 rulemaking in the early 1980s, it is now appropriate for Energy*Solutions* to re-tool its PA analysis.

Pursuant to R313-25-8(4)(a), the PA "*…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*." Hence, once the engineered embankment has failed, the site characteristics must come to bear to ensure "*…exposures to humans from the release of radioactivity will not exceed the limits set forth in R313-25-19*." The same requirement is set forth in 10 CFR 61.13(a).

This concept is further reinforced in NUREG-1573, Section 1.2, page 1-2, where the NRC states the following:

> *The* natural site *in which an LLW disposal facility is located consists of: (a) the geosphere and hydrosphere (i.e., geologic and hydrogeologic systems, including surface water); (b) the surrounding atmosphere; and (c) the biosphere. The natural characteristics of an LLW disposal site should promote disposal site stability and attenuate the transport of radionuclides away from the disposal site into the general environment. Although engineered barriers can be used to improve or enhance disposal site performance, the natural (geologic) setting must be relied on, in the long term, for safety.*

NUREG-1573, page 1-3, states the following:

> Engineered barriers *(both physical and chemical) are man-made structures or devices designed to improve or enhance the site's natural ability to isolate and contain waste, and to minimize releases of radionuclides to the environment. The engineered barrier system operates in conjunction with the characteristics of the natural site to form an integrated waste disposal system.*

The PA analysis should be revised accordingly, and the text should explain and justify why the span of time used in the PA modeling was adequate to comply with the requirements of R313-25-8(4) and (5).

**REFERENCES:**

*Code of Federal Regulations*, Title 10, *Energy*, Part 61, *Licensing Requirements for Land Disposal of Radioactive Waste*.

Energy*Solutions, Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

U.S. Nuclear Regulatory Commission, *A Performance Assessment Methodology for Low-level Radioactive Waste Disposal Facilities; Recommendations of NRC's Performance Assessment Working Group*, Office of Nuclear Material Safety and Safeguards, October 2000.

## INTERROGATORY CR R313-25-3(8)-94/1: ULTIMATE SITE OWNER

### PRELIMINARY FINDING:

Refer to R313-25-3(8): *The plan approval siting application shall provide evidence that if the proposed disposal site is on land not owned by state or federal government, that arrangements have been made for assumption of ownership in fee by a state or federal agency.*

Refer also to R313-25-9(2): *Evidence, if the proposed disposal site is on land not owned by the federal or a state government, that arrangements have been made for assumption of ownership in fee by the federal or a state agency. Evidence, if the proposed disposal site is on land not owned by the federal or a state government, that arrangements have been made for assumption of ownership in fee by the federal or a state agency.*

### INTERROGATORY STATEMENT:

Provide written evidence that the site owner shall be legally responsible for the Federal Cell, including all environmental liability that may develop for that disposal unit.

### BASIS FOR INTERROGATORY:

The 2013 Compliance Report, Revision 1, does not address Utah regulation R313-25-31(8). The ultimate site owner for the Federal Cell where DU waste will be disposed should be identified. Written evidence should be provided that the site owner shall be legally responsible for the Federal Cell, including all environmental liability that may develop for that disposal unit. This is particularly critical since disposal of large quantities of DU was not considered in the NRC's Final Environmental Impact Statement on 10 CFR Part 61 (NUREG-0945).

### REFERENCES:

Energy*Solutions, Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report,* Revision 1, November 8, 2013.

U.S. Nuclear Regulatory Commission, *Final Environmental Impact Statement on 10 CFR Part 61, 'Licensing Requirements for Land Disposal of Radioactive Waste,* NUREG-0945, 1982. (ADAMS Accession Nos. ML052590184, ML052920727, and ML052590187)

## INTERROGATORY CR R313-25-8(4)(A)-95/1: ESTIMATION OF I-129 CONCENTRATIONS

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

Refer also to R313-25-7(9): *Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal facility.*

### INTERROGATORY STATEMENT:

Consider an alternative approach to estimating I-129 concentrations in the waste and revise the PA accordingly. Alternatively, explain and justify why a proxy nuclide already in the PA model report could be used to account for the I-129 activity/dose in the environment near the Clive facility.

### BASIS FOR INTERROGATORY:

FRV1 Section 6.1.1, page 55, states that I-129 was not detected or identified in any sample, which suggests that I-129 does not exist in the SRS inventory. The text also states that the detection limit was used to create the I-129 inventory distribution. If fission occurred (and the presence of Tc-99 confirms that fission did occur), then, as a fission product, I-129 will be present. That said, using the detection limit to create an I-129 inventory may be too conservative. Considering that the SRS data (Beals et al. 2002, p. 4) involved a 1% sampling rate (33 samples) of a population of 3,300 drums, and that a total of 26,000 drums of SRS DU need disposition, a better method to estimate the I-129 inventory may be to use an I-129 to Tc-99 spent fuel ratio that is available from general industry documentation. For example, the I-129 to Tc-99 ratios given in EPRI NP-4037 could be used to estimate the DU I-129 inventory from the measured DU Tc-99 inventory. This better practice is important in that both Tc-99 and I-129 are mobile isotopes in water environments.

### REFERENCES:

Beals, D.M., S.P. LaMont, J.R. Cadieux, C.R. Shick, Jr., and G. Hall, *Determination of Trace Radionuclides in SRS Depleted Uranium (DU)*, WSRC-TR-2002-00536, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC, 2002.

Electric Power Research Institute, *Radionuclide Correlations in Low-Level Radwaste*, EPRI NP-4037, June 5, 1985.

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(A)-96/1: CURRENT AND FUTURE POTABILITY OF WATER

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

### INTERROGATORY STATEMENT:

Demonstrate that there will only be non-potable water at the Clive site for 10,000 years, considering the potential for desalination, reverse osmosis, and other water treatment activities and the potential for higher groundwater quality in deep aquifers. Provide reliable evidence that (1) groundwater near Clive will not improve in quality in the future, (2) currently available treatment technology cannot render Clive groundwater useable for municipal or industrial purposes, (3) no potable or treatable groundwater exists at Clive in deeper aquifers, and (4) there is no current or future treatment technology that could render saline waters suitable for culinary or industrial use.

### BASIS FOR INTERROGATORY:

In numerous places, the Conceptual Site Model report mentions the current lack of shallow potable water at the Clive site (e.g., Section 3.1, page 7; Section 3.4, page 11; Section 4.2.3, page 19; and Section 10.3, page 57). However, this may not be the case over the next 10,000 years, especially given the potential for water treatment technologies such as desalination and reverse osmosis, and/or tying in to sources of water to the east via pipeline.

Research by DRC (2014) shows that public water supply systems registered with the Utah Division of Drinking Water, including four facilities in Tooele County, near Clive, already rely on reverse osmosis treatment to supply culinary and industrial water from brackish and saline groundwater.

Energy*Solutions* has argued that all water resources near Clive are non-potable. However, there may be exceptions to this claim. For example, deep groundwater resources have been shown to be of better quality than the shallow aquifer, as noted by Bingham Environmental (1991). Bingham Environmental (1991) shows that three sets of nested monitoring wells do or have existed in Section 32, including (1) GW-19A and GW-19B, (2) I-1-30, I-1-50, and I-1-100, and (3) I-3-30, I-3-50, and I-3-100 (Figure 2). Upward native hydraulic gradients were observed in these well nests in 1991 (Bingham Environmental 1991, p. 26). However, downward gradients have been observed in GW-19A and GW-19B transiently since that time during mounding after high precipitation events and/or pond leakage. The table below summarizes historic and recent total dissolved solids (TDS) sampling and analysis from two nested well groups. Review shows that in 1991 TDS groundwater concentration in wells completed at depths of almost 100 feet below ground surface (bgs) had half the TDS concentration of those in the shallow aquifer. Further, in 2012, the shallow monitoring well GW-19A had a TDS content that was three times higher than nearby 1991 deep well sample in GW-19B.

| Well | Screen Interval, feet bgs | 1991 TDS mg/L[a] | 2012 TDS mg/L[b] |
|---|---|---|---|
| GW-19A | 18–28 | 45,000 | 69,000 |
| GW-19B | ~78–98 | 23,000 | |
| I-1-30 | 25–35[c] | n/a | n/a |
| I-1-100 | 90–100[c] | 21,000 | n/a |

[a] Bingham Environmental 1991, Appendices A and C
[b] Energy*Solutions* 2013
[c] DRC Summary Spreadsheet HYDROSTR.XLS (2000)

Therefore, it is possible that deeper aquifers near Clive could produce water for beneficial municipal and industrial uses and that, periodically, because of high precipitation events or pond or other leakage, could be locally impacted by the shallow aquifer. In order to support its current claims regarding lack of useable groundwater resources near Clive, both today and in the future, Energy*Solutions* should provide reliable evidence that (1) groundwater near Clive will not improve in quality in the future, (2) currently available treatment technology cannot render Clive groundwater useable for municipal or industrial purposes, (3) no potable or treatable groundwater exists at Clive in deeper aquifers, and (4) there is no current or future treatment technology that could render saline waters suitable for culinary or industrial use.

**REFERENCES:**

Bingham Environmental, *Hydrogeological Report Envirocare Waste Disposal Facility South Clive, Utah*, October 9, 1991.

Edwards, D., *Regional Use of Reverse Osmosis Technology in Areas near Clive, Utah to Treat Saline or Brackish Groundwater*, Memorandum to Rusty Lundberg, Laura Lockhart, John Hultquist and File, Utah Department of Environmental Quality, Division of Radiation Control, January 16, 2014.

EnergySolutions, *2012 Annual 11e.(2), LARW, Class A West, and Mixed Waste Groundwater Monitoring Report*, March 1, 2013.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011).

Utah Division of Radiation Control, Summary Spreadsheet *HYDROSTR.XLS* (last revised March 20, 2000), compiled from 12 different Energy*Solutions* hydrologic reports between January 1992 and June 1997. (Included in Edwards 2014.)

**INTERROGATORY CR R313-25-8(4)(A)-97/1: NEED FOR POTABLE AND/OR INDUSTRIAL WATER**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

**INTERROGATORY STATEMENT:**

Add a discussion of various existing and historical examples of the waste industry in the Clive area and explain how they address the potential need for potable and/or industrial water in the area. Provide reliable evidence to substantiate claims that no moderate- or high-yield aquifers exist at depth near Clive and evaluate economic considerations for current and future beneficial uses of deep groundwater.

**BASIS FOR INTERROGATORY:**

Section 3.1, page 7, of the Conceptual Site Model report states the following:

> *While the site is zoned for hazardous waste disposal by Tooele County, the lack of potable water at this site makes the surrounding area an unlikely location for any residential, commercial, or industrial developments (Baird et al. 1990).*

However, a number of industrial developments currently exist on and near the site, including the Energy*Solutions* low-level waste disposal facility, that are dedicated to various aspects of the waste industry. Other industrial facilities are, or have been, located nearby. The Division of Drinking Water (Edwards 2014) has indicated that a number of facilities to the west of the Great Salt Lake use regional groundwater having relatively high TDS content and treat it to make it potable. The treated groundwater has been used for drinking at some of these facilities. Appropriate treatment technology for saline water exists. It is simply a matter of whether sufficient economic incentive for it to be used exists at a given time.

DRC recognizes previous Energy*Solutions* arguments that aquifers at Clive are of such low yield that they could never serve for a major water supply. However, in 1996, Envirocare's construction contractor, Broken Arrow Inc., drilled a deep supply well near the southern margin of Section 29, at a distance of 500 feet from the northern margin of the Clive disposal site (Section 32) (DWR 2014, water right number 16-816). This supply well was installed to a depth of 620 feet bgs and found two significant water-bearing gravel layers at depths of 487–495 and 505–545 feet bgs (DWR 2014, well log number 11293). Therefore, it is possible that high-yield water-bearing strata can be found at Clive. Based on TDS groundwater quality evidence (Bingham Environmental 1991, HYDROSTR.XLS, and DRC summary spreadsheet TDS - Clive GW Monitoring Wells.xlsx in Edwards 2014), it is possible that higher water quality could exist at depths greater than any of the wells historically drilled in either Sections 29 or 32. If present, this deep groundwater could be called on for beneficial municipal and industrial uses. Energy*Solutions* should provide reliable evidence to substantiate its recent claims that no moderate- or high-yield aquifers exist at depth near Clive and evaluate economic considerations for current and future beneficial uses of deep groundwater.

**REFERENCES:**

Bingham Environmental, *Hydrogeological Report Envirocare Waste Disposal Facility South Clive, Utah*, October 9, 1991.

Edwards, D., *Regional Use of Reverse Osmosis Technology in Areas near Clive, Utah to Treat Saline or Brackish Groundwater*, Memorandum to Rusty Lundberg, Laura Lockhart, John Hultquist and File, Utah Department of Environmental Quality, Division of Radiation Control, January 16, 2014.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility,* May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011).

Utah Division of Radiation Control, Summary Spreadsheet *HYDROSTR.XLS* (last revised March 20, 2000), compiled from 12 different Energy*Solutions* hydrologic reports between January 1992 and June 1997.

Utah Division of Water Rights, water rights and well log database at http://waterrights.utah.gov/wrinfo/query.asp. Accessed February 7, 2014.

**INTERROGATORY CR R313-25-7(1)-98/1: MONTHLY TEMPERATURES**

**PRELIMINARY FINDING:**

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

**INTERROGATORY STATEMENT:**

Describe the nature of the "*monthly temperatures*" referenced in the Conceptual Site Model report.

**BASIS FOR INTERROGATORY:**

Section 3.2.1, page 8, of the Conceptual Site Model report states that "*Data from the Clive facility from 1992 through 2009 indicate that monthly temperatures range from about -2°C (29°F) in December to 26°C (78°F) in July (Whetstone, 2006).*" However, the text does not specify whether these are lowest monthly values to highest monthly values, monthly means, monthly medians, or some other parameter.

**REFERENCES:**

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

**INTERROGATORY CR R313-25-7(1)-99/1: EVAPORATION**

**PRELIMINARY FINDING:**

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

**INTERROGATORY STATEMENT:**

Clarify the meaning of the term "*evaporation*" as used in the Conceptual Site model report and provide documentation that evaporation exceeds precipitation.

**BASIS FOR INTERROGATORY:**

Section 3.2.2, page 8, of the Conceptual Site Model report states that "*The Clive facility is characterized as being an arid to semi-arid environment where evaporation greatly exceeds annual precipitation (Adrian Brown, 1997a).*" The meaning of the term "*evaporation*" as used here should be clarified to indicate whether the statement refers to evaporation or potential evaporation. Generally, evaporation itself cannot be measured directly; it is only estimated, if it is indeed segregated from transpiration, via modeling. The PA should document, if possible, that evaporation exceeds precipitation at Clive or amend the statement.

**REFERENCES:**

Adrian Brown Consultants, *LARW Infiltration Modeling Input Parameters and Results*, prepared for Envirocare of Utah, Report 3101B.970515, Volume 1, 41 pages plus tables, figures and attachments, May 15, 1997.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

## INTERROGATORY CR R313-25-7(1)-100/1: GROUNDWATER RECHARGE FROM PRECIPITATION

### PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

### INTERROGATORY STATEMENT:

Address considerations that would affect the amount of groundwater recharge due to precipitation and snow melt, such as concentration of water in topographic depressions, increase in cover-system hydraulic conductivity, and inhibition of evaporation because of large-grain materials.

### BASIS FOR INTERROGATORY:

Section 3.2.3, page 8, of the Conceptual Site Model report states that "*Because of the high evaporation rate, the amount of groundwater recharge due to precipitation is likely very small, except during high intensity precipitation events (Adrian Brown, 1997a).*" However, the discussion does not explicitly account for snow storage and subsequent melting, the post-precipitation concentration of water in topographic depressions, drainages, fractures, holes, or burrows in rock or soil cover materials that will likely develop over time and that may locally reduce effective evaporation rates and increase groundwater recharge. It also does not describe how cover-system hydraulic conductivity tends to greatly increase within a relatively short time after cover-system placement due to frost heave and other factors (Benson et al., 2011). Any of these features, processes, or events may potentially result in increased groundwater recharge. Neither does the text account for the inhibition or minimization of evaporation due to the presence of rip rap or natural rock or other large-grain materials at the surface, as has been documented in many technical studies. For example:

- Reith and Caldwell (1990) claim that a rock cover reduces evaporation from a cover system and makes more water present within the cover system.
- Kemper et al. (1994) show that 5 centimeters of gravel placed on top of soil significantly reduced evaporation and increased retention of water in the subsurface to about 80–85% of total precipitation.
- Poesen and Lavee (1994) indicate that the presence of a rock-fragment layer at the surface of a soil acts like a mulch to that soil, inhibiting capillary rise and evaporation. They attribute this to low unsaturated hydraulic conductivity of that rock-fragment layer at low suction values.

Such materials tend to act as a mulch, greatly reducing evaporation rates. The PA should address and resolve these considerations. Alternatively, Energy*Solutions* can provide other technical evidence and explain and justify why it supports the conclusions made in the Conceptual Site Model report.

**REFERENCES:**

Benson, C.H., W.H. Albright, D.O. Fratta, J.M. Tinjum, E. Kucukkirca, S.H. Lee, J. Scalia, P.D. Schlicht, and X. Wang, *Engineered Covers for Waste Containment: Changes in Engineering Properties and Implications for Long-Term Performance Assessment*, NUREG/CR-7028, Volume 1, U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, December 2011.

Adrian Brown Consultants, *LARW Infiltration Modeling Input Parameters and Results*, prepared for Envirocare of Utah, Report 3101B.970515, Volume 1, 41 pages plus tables, figures and attachments, May 15, 1997.

Kemper, W.D., A.D. Nicks, and A.T. Corey, *Accumulation of water in soils under gravel and sand mulches*, Soil Sci. Soc. Am. J., Vol. 58, pp. 56–63, 1994.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

Poesen, J. and H. Lavee, *Rock fragments in top soils: significance and processes*, Catena, Vol. 23, pp. 1-28, 1994.

Reith, C.C. and J.A. Caldwell, *Vegetative covers for UMTRA project disposal cells*, Jacobs Engineering Group, Albuquerque, New Mexico, February 1990.

**INTERROGATORY CR R313-25-7(1)-101/1: NATURE OF UNITS 1 AND 2**

**PRELIMINARY FINDING:**

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

**INTERROGATORY STATEMENT:**

Indicate how the thickness of Unit 1 is accounted for in the numerical GoldSim model, and describe the nature of the confining unit. Provide information about local downward components of hydraulic gradient at the site that result in groundwater mounding.

**BASIS FOR INTERROGATORY:**

Section 3.3.1, page 9, of the Conceptual Site Model report states the following:

> *The Envirocare investigation indicates that the total thickness of Unit 1 is at least 75 m (250 ft) (Envirocare, 2004). The deepest borehole at the time of this investigation was drilled to 250 ft below ground surface (bgs) without encountering bedrock. Unit 1 is saturated beneath the facility and contains a locally confined aquifer.*

Since the PA states that it is uncertain how deep Unit 1 extends, the text should reference a section of the PA describing how the layer thickness is accounted for in the numerical GoldSim model. We note that, in 1996, Envirocare contractor Broken Arrow Inc. drilled a water supply well adjoining Section 29. From review of its boring log, it is clear that bedrock is deeper than 620 feet bgs (DWR 2014, water right number 16-816 and associated well log 11293). From gravity geophysical surveys of nearby Ripple Valley[6] (Baer and Benson 1987, Cook et al. 1964), its unconsolidated deposits in the Clive area appear to be approximately 3,000 feet thick (depth to bedrock).

In addition, it is unclear whether the confining unit mentioned is separate from or includes Unit 2, described as "*clay with occasional lenses or interbeds of silty sand*." Information is missing about how permeable or impermeable this layer is to vertical components of flow, and, if a confining unit does exist (1) the kind of head differences that exist on either side of it, (2) the calculated vertical components of flow resulting from the differences in head and the hydraulic conductivity associated with this confining unit, and (3) how these vertical components of flow compare with horizontal components of flow. Neither is there information about local downward components of hydraulic gradient at the site that result in groundwater mounding. If the text does not discuss these topics specifically, it should provide references to documented analyses that do, either elsewhere in the PA or in other relevant reports.

[6] Ripple Valley is located about 4 miles north of Section 32 and is found north of I-80 and east of the Greyback Hills.

**REFERENCES:**

Baer, J.L, and A.K. Benson, Results of Gravity Survey, Skull Valley-Ripple Valley, Tooele County, Utah, in Dames and Moore, the Ralph M. Parsons Company, and Roger Foott Associates, Inc., *Site Proposal for the Superconducting Super Collider: Geotechnical Report*, Vol. 2, pp. E1–E8, 1987.

Cook, K.L., M.D. Halverson, J.C. Steep, and J.W. Berg, Jr., *Regional gravity survey of the northern Great Salt Lake Desert and adjacent areas in Utah, Nevada, and Idaho*, Geological Society of America Bulletin, Vol. 75, No. 8, pp. 715–740, 1964.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility,* May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Utah Division of Water Rights, water rights and well log database at http://waterrights.utah.gov/wrinfo/query.asp. Accessed February 7, 2014.

**INTERROGATORY CR R313-25-7-102/1: SEISMIC ACTIVITY**

**PRELIMINARY FINDING:**

Refer to R313-25-7: *(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

*(2) 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.*

**INTERROGATORY STATEMENT:**

Address the fact that active faults tens of miles away from the site can potentially cause local ground accelerations, even if the site itself does not have any known active faults in its vicinity, or explain and justify why the issue is not important to the long-term stability of Clive embankments.

**BASIS FOR INTERROGATORY:**

Section 3.3.2, page 9, of the Conceptual Site Model report states that "*The Clive site does not have any known active faults in its vicinity.*" Geophysicists who have worked in this region have noted that active faults tens of miles away from the site can potentially cause local ground accelerations. For example, the Stansbury Fault and other faults nearby are estimated to be able to cause peak ground accelerations in the range of 0.24 to 0.28g (Black et al., 1999; AMEC, 2005; AMEC, 2011a; AMEC, 2011b; AMEC, 2011c). On the Modified Mercalli scale, such accelerations correspond to an intensity value of VIII, which the U.S. Geological Survey (2014) states is historically associated elsewhere with very strong perceived shaking and moderate to heavy potential damage. The PA should account for this information or explain and justify why the issue is not important to the long-term stability of Clive embankments.

This same comment applies to Section 6.0, page 9, of the FEP Analysis report, which states the following:

> *Note that seismic activity is unlikely to impact the Clive facility. Faults are not present within the vicinity of Clive, although effects of isostatic rebound are still possible in the Lake Bonneville area.*

**REFERENCES:**

AMEC Earth & Environmental, Inc., *Geotechnical Report, Combined Embankment Study, Envirocare, Clive, Utah*, AMEC Job No. 4-817-004769, December 13, 2005.

AMEC Earth & Environmental, Inc., *Geotechnical Update Report, Class A West Embankment Study, Energy Solutions Clive Facility, Clive, Tooele County, Utah*, AMEC Job No. 10-817-05290, February 15, 2011a.

AMEC Earth & Environmental, Inc., *Response to Interrogatory CAW R313-25-8(4)-16/1: Seismic Hazard Analysis*, Job Number 10-817-05290, October 25, 2011b.

AMEC Earth & Environmental, Inc., *Response to Interrogatory CAW R313-25-8(4)-16/2: Seismic Hazard Analysis*, EnergySolutions Clive Facility, Class A West Embankment, Clive, Tooele County, Utah, Job Number 10-817-05290, December 23, 2011c.

Black, B.D., B.J. Solomon, and K.M. Harty, *Geology and Geologic Hazards of Tooele Valley and the West Desert Hazardous Industry Area*, *Tooele County*, *Utah*, Utah Geological Survey Special Study 96, 1999, available at www.ugs.state.ut.us/geology/online/ss/ss-96.pdf, retrieved January 17, 2014.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

Neptune and Company, Inc., *FEP Analysis for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 1 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

U.S. Geological Survey, *ShakeMap Scientific Background*, available at (http://earthquake.usgs.gov/earthquakes/shakemap/background.php), accessed January 17, 2014.

## INTERROGATORY CR R313-25-7-103/1: HISTORICAL FLOODING

### PRELIMINARY FINDING:

Refer to R313-25-7: *(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

*(2) 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.*

### INTERROGATORY STATEMENT:

Discuss historical non-chronic flooding that has occurred on site and how this can potentially impact infiltration, especially once the cover system is compromised by erosion, burrowing, and other events. Discuss flooding that has occurred on the site prior to the human historical record but within the historical geologic record (based on evidence from the field).

### BASIS FOR INTERROGATORY:

Section 3.4.1, page 10, of the Conceptual Site Model report states that "*NRC (1993) indicates that no historical (chronic) flooding has occurred in the vicinity of the site.*" The conceptual site model should discuss any historical non-chronic flooding that has locally occurred on site, such as in spring 2011 and previous years, and how this can potentially impact infiltration, especially once the cover system is compromised by erosion, burrowing, and other events. The text should also discuss flooding that has occurred on the site prior to the human historical record but within the historical geologic record (based on evidence from the field). The report should also provide all related technical references that support the discussion.

### REFERENCES:

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(2)-104/1: INFILTRATION IN THE PRESENCE OF RIP RAP OR NATURAL ROCK

### PRELIMINARY FINDING:

Refer to R313-25-7(2): *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.*

### INTERROGATORY STATEMENT:

1. Realistically quantify the impacts on infiltration or water penetration when the presence of rip rap or natural rock on the embankment cover decreases both evaporation and transpiration. Include technical evidence to support the conclusions made regarding evapotranspiration effects on water infiltration.
2. Specify the total length of the soil zone path used in unsaturated flow modeling and describe the characteristics of the soil involved.
3. Explain and justify how much time will be needed to complete the cover system siltation and establishment of a permanent and viable plant community after closure of the DU cell, including how much of the cover system vertical profile will be in-filled with silts and other Aeolian deposits.
4. Explain and justify why the proposal to use human intervention to help mitigate the effects of future events that could jeopardize the stability of the engineered facility at Clive is congruent with the rule requirement to eliminate active maintenance of the disposal site.

### BASIS FOR INTERROGATORY:

1. Section 3.4.2.1, page 10, of the Conceptual Site Model report states that "*An upward gradient is not only due to evaporation of water at the ground surface, it is also driven by the transpiration of plants, which pull water from the ground and release it to the dry atmosphere. The coupled effect of these two processes, or evapotranspiration, serves to keep near-surface soils dry enough that precipitation often does not penetrate to lower soils.*" In light of this statement, the text should discuss possible impacts on infiltration or water penetration within the embankment cover system, and the underlying vadose zone, when the presence of rip rap or natural rock on the embankment cover reduces evaporation to relatively low or even negligible levels (see CR R313-25-7(1)-100/1) and also inhibits plant growth, and thus decreases both evaporation and transpiration to very low values. Realistic quantification of these impacts should be attempted within the model and discussed in the PA and referenced in this section. Energy*Solutions* should include technical evidence to support the conclusions made regarding evapotranspiration effects on water infiltration. Alternatively, it should explain and justify why the statements should be accepted by the DRC Director as they stand.

2. Section 7.1.1.1, page 27, of the Conceptual Site Model report describes the soil zone used in the unsaturated flow modeling. The text should identify the total length of this path and the characteristics of the soils involved.

3. Section 7.1.4.1, page 32, of the Conceptual Site Model report states, "*It is expected that plants will be the first colonizers of the Clive cap, though that is not expected to occur until the uppermost riprap layer has silted in sufficiently to allow for germination and root establishment*." Energy*Solutions* should explain and justify how much time will be needed to complete the cover system siltation and establishment of a permanent and viable plant community (after closure of the DU cell). It should also explain and justify how much of the cover system vertical profile will be in-filled with silts and other aeolian deposits. This explanation should emphasize the function of the sacrificial soil layer in the cover and the underlying Filter B layer. Energy*Solutions* should explain and justify how this soil development and plant community will be uniformly distributed across the entire DU cell cover system area.

4. Section 7.2.1.6, page 41, of the Conceptual Site Model report states the following:

   > *…human intervention could help to mitigate the effects of future events that could jeopardize the stability of the engineered facility at Clive. For example, the disposal cell could be protected by adding more rip-rap material, a seawall, or berm (or other engineered barriers) to prevent the deleterious effects of wave action in the event of future lake formation.*

Energy*Solutions* should explain and justify why this approach is congruent with the requirement in R313-25-7(2) that active maintenance of the disposal site be eliminated. If this concept is to be applied, Energy*Solutions* should explain how that will be accomplished via use of its low-level radioactive waste surety bond of the State's Perpetual Care Fund for Clive.

**REFERENCES:**

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

**INTERROGATORY CR R313-25-8(4)(A)-105/1: HUMAN USE OF GROUNDWATER**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

**INTERROGATORY STATEMENT:**

Identify the human uses for which the groundwater at the Clive site is suitable, and consider the potential human uses of the groundwater after treatment.

**BASIS FOR INTERROGATORY:**

Section 3.4.2.2, page 10, of the Conceptual Site Model report states that the groundwater at the Clive site "*is not suitable for most human uses*." Since the text uses the qualifier "*most*," the document should identify the human uses for which the groundwater is suitable. The report should also consider the potential human uses of the groundwater once it is treated by reverse osmosis or other desalination technologies. Recent advances in this area now make it possible to desalinate seawater and other waters with high TDS where the need is sufficiently great to justify the relatively high cost of desalination. The problem is not a technical one of saline water not being usable by humans; instead, it is an issue of whether there might be a sufficiently strong economic reason under some circumstances to employ the technology to make the water potable for beneficial uses. Systems suitable for single family use are also commercially available at relatively low cost. Water with a TDS value of 40,500 mg/L (Brodeur, 2006; Energy*Solutions*, 2013) is a little more saline than Mediterranean seawater currently being treated via desalination to provide fresh water for 40–80% of Israel's needs (Sales, 2013), but it is less saline than Persian (aka Arabian) Gulf water currently being desalinated to provide potable water for many people in the Gulf States. Cotruvo (2005) gives the value for average TDS for eastern Mediterranean seawater as 38,600 mg/L and for the Arabian Gulf at Kuwait as 45,000 mg/L. All of these waters are comparable in TDS to Clive's shallow groundwater; deep groundwater at Clive consists of even lower TDS. The Conceptual Site Model report should be revised to reflect this information or explain and justify why these technologies are not appropriate and will not be called on in the future in deserts near Clive.

**REFERENCES:**

Brodeur, J.R., *Mixed Low-Level Radioactive and Hazardous Waste Disposal Facilities*, Energy Sciences and Engineering, Kennewick, Washington, 2006.

Cotruvo, J.A., *Water Desalination Processes and Associated Health and Environmental Issues*, Water Conditioning & Purification, Vol. 47, No. 1, pages 13–17, January 2005, available from www.wcponline.com/pdf/0105%20Desalination.pdf, accessed January 17, 2014.

Energy*Solutions*, *2012 Annual 113.(2), LARW, Class A West, and Mixed Waste Groundwater Monitoring Report*, March 1, 2013.

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility,* May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

Sales, B., *Water surplus in Israel? With desalination, once unthinkable is possible*, JTA, May 28, 2013 3:46pm, available from www.jta.org/2013/05/28/news-opinion/israel-middle-east/water-surplus-in-israel-with-desalination-once-unthinkable-is-possible#ixzz2fRo3XR7J, accessed September 2013.

## INTERROGATORY CR R313-25-8(4)(A)-106/1: DESALINATION POTENTIAL

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

### INTERROGATORY STATEMENT:

Modify the text to reflect the fact that TDS concentrations at Clive are not a barrier to desalination to potable water levels.

### BASIS FOR INTERROGATORY:

Section 3.4.2.2, page 11, of the Conceptual Site Model report states that Brodeur (2006) reports that groundwater beneath the Clive site has a TDS content of 40,500 mg/L. This is fairly consistent with mean TDS values in groundwater reported to DRC for monitoring wells at the site, which average 42,237 mg/L (Energy*Solutions*, 2012).

The text also states that "*sea water typically has a TDS content of 35,000 mg/L (35 %o), thus the salinity content at the site is much higher than average sea water*." DRC review of 57 shallow groundwater samples collected at Clive in the 2012 facility annual groundwater sampling event[7] found an average TDS of about 42,000 mg/L, with a range of 10,400–69,000 mg/L. Consequently, average Clive groundwater TDS is 20% higher than typical seawater. However, Energy*Solutions*' statement does not convey the higher values found in various water bodies where desalination along coasts is commonly occurring. Mediterranean seawater has a mean TDS value of about 37,000–39,000 mg/L, and the Persian (aka Arabian) Gulf TDS values are in the range of about 41,000 to 70,000 mg/L in the Persian or Arabian Gulf (e.g., see Khan 2000, Wilf and Klink 2001, Falah et al. 2012, Ladewig and Asquith 2012, Cotruvo 2005). This is an important factor to consider in the PA, since Israel and Persian (aka Arabian) Gulf states often use seawater at these concentrations as the raw water from which potable water is provided for their citizens and industry, showing that the high TDS content of groundwater at Clive does not appear to be a barrier to groundwater use. Although reverse osmosis treatment is expensive, it is feasible.

[7] DRC Excel Spreadsheet *TDS-Clive GW Monitoring Wells* prepared by David Edwards, February 18, 2014

**REFERENCES:**

Brodeur, J.R., *Mixed Low-Level Radioactive and Hazardous Waste Disposal Facilities*, Energy Sciences and Engineering, Kennewick, Washington, 2006.

Energy*Solutions*, *2012 Annual 113.(2), LARW, Class A West, and Mixed Waste Groundwater Monitoring Report*, March 1, 2013.

Cotruvo, J.A., *Water Desalination Processes and Associated Health and Environmental Issues*, Water Conditioning & Purification, Vol. 47, No. 1, pages 13–17, January 2005, available from www.wcponline.com/pdf/0105%20Desalination.pdf, accessed January 17, 2014.

Falah, A., R.E. Khatib, and N. Yahfoufi, *Water quality survey of Arabian Peninsula in regions of Dubai in the United Arab Emirates*, Canadian Journal on Chemical Engineering & Technology, Vol. 3, pp. 1–5, 2012.

Khan, W.Z., *Purification of Arabian Gulf high-salinity water by aromatic polyamide hollow fiber membranes*, in Goosen, M.F.A., and W.H. Shayya, Water Management, Purification, and Conservation in Arid Climates – Water Purification, Volume 2, Technomic Publishing Company, Inc., Lancaster, PA, 2000.

Ladewig, B., and B. Asquith, *Desalination Concentrate Management*, Springer, New York, 2012.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility,* May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Wilf, M. and K. Klink, *Optimization of seawater RO systems design*, Hydranautics, Oceanside, CA, accessed January 2014 from www.membranes.com/docs/papers/06_optimization.pdf.

**INTERROGATORY CR R313-25-7(1)-107/1: PREDOMINANT VEGETATION AT THE CLIVE SITE**

**PRELIMINARY FINDING:**

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

**INTERROGATORY STATEMENT:**

Reconcile apparent discrepancies with respect to which type of vegetation predominates at the Clive site and revise the Conceptual Site Model report to be consistent with the research conducted previously by Energy*Solutions* contractors at Clive.

**BASIS FOR INTERROGATORY:**

Section 3.5.1, page 11, of the Conceptual Site Model report claims that "*Envirocare (2000) and SWCA (2011) confirmed that the predominant vegetation over most of the site is shadscale*."

However, SWCA (2011) indicates that, for the three plots located on or fairly near the Clive site that were studied for the report (two others were located in or near the mountains), the predominant vegetation depends on the plot, and it is not shadscale in the majority of the plots.

In Plot 3, black greasewood dominates among the forbs and shrubs, constituting 4.5% of ground cover, with Mojave seablite, gray molly, and shadscale saltbush constituting 0.3%, 0.2%, and 0.1%, respectively, of soil cover. The total for these four shrubs is thus 5.1% ground cover. Halogeton, a forb, makes up 0.7% of the ground cover. Biological soil crust is said to constitute 84.8% of ground cover. Plant litter covers 6.1% of the soil. Bare ground makes up 2.3% of the surface. Shadscale makes up only 1/10$^{th}$ of 1% of ground cover, so it can hardly be called predominant here.

In Plot 4, halogeton dominates among the forbs and shrubs, constituting 3.3% of the ground cover. Shadscale saltbush makes up only 2.3% of the cover.

In Plot 5, located to the west of most current operations, shadscale saltbush does dominate among shrubs and forbs, at 12.5%, but the coverage is relatively small compared to biological soil crust coverage at 70.7%.

SWCA Environmental Consultants, which from June 13–23, 2012, conducted field studies on eight plots in the Clive area that it selected as being ecological analogs to the future embankment cover system at the Clive site, reports the following for all of the studied plots in general (SWCA, 2012):

> *Vegetation: Average plant species cover consisted of 14.3% black greasewood (*Sarcobatus vermiculatus*), 5.9% Sandberg bluegrass (*Poa secunda*), and approximately 3% cover each of shadscale saltbush (*Atriplex confertifolia*) and Mojave seablite (*Suaeda torreyana*). Fourwing saltbush (*Atriplex canescens*) and gray molly (*Bassia americana*) occurred in low densities with 1.6% and 1.3%*

> *cover, respectively. Ground cover was dominated by 79.2% average biological soil crust cover.*

Thus, in the area in or fairly near the Clive site, instead of dominating the site as a whole, shadscale saltbush appears to cover from less than 0.3% to 12.5% of the ground, and shadscale saltbush only predominates in one of three plots studied in 2011. Among forbs and shrubs in the 2012 studies, shadscale saltbush came in tied only for third place in terms of ground coverage.

**REFERENCES:**

Envirocare, *Assessment of Vegetative Impacts on LLRW*, Salt Lake City, Utah, November 2000.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility,* May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

SWCA Environmental Consultants, *Field Sampling of Biotic Turbation of Soils at the Clive Site, Tooele County, Utah*, prepared for Energy*Solutions*, January 2011.

SWCA Environmental Consultants, *Vegetated Cover System for the Energy*Solutions *Clive Site: Literature Review, Evaluation of Existing Data, and Field Studies, Summary Report*, prepared for Energy*Solutions*, August 2012.

**INTERROGATORY CR R313-25-8(4)(A)-108/1: BIOINTRUSION**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

**INTERROGATORY STATEMENT:**

Include additional information about biointrusion from SWCA (2012).

**BASIS FOR INTERROGATORY:**

Section 3.5.2, page 11, of the Conceptual Site Model report discusses local wildlife, which is important with regard to biointrusion. Additional important information relative to biointrusion is found in SWCA (2012). Among the conclusions that can be drawn from SWCA (2012) are that (1) coyote burrows, while not seen in the plots, were observed near or close to the plots, indicating the potential for coyotes to burrow in an embankment on the site, (2) badger burrows were observed in two of the plots, and badgers themselves were seen moving about during the sampling event and were photographed, and (3) burrowing owls were also observed on site and photographed. Coyotes and badgers are documented to dig relatively deeply, more deeply than the planned Federal Cell cover system depth of 5.5 feet (Lindzey, 1976; McKenzie et al., 1982; Hampton, 2006). SWCA (2012) reports that "*the presence of the badgers…in the study area indicates the potential for large volume soil bioturbation within the existing vegetation communities and soil types*." The Conceptual Site Model report should be revised to be consistent with available technical literature and other information generated by Energy*Solutions* consultants.

**REFERENCES:**

Hampton, N.L, *Biological Data to Support Operable Unit 7-13/14: Modeling of Plant and Animal Intrusion at Buried Waste Sites*, INEEL/EXT-01-00273, Revision 1, Project No. 23378, Idaho Cleanup Project, January 2006.

Lindzey, F.G., *Characteristics of the natal den of the badger*, Northwest Science, Vol. 50, pp. 178–180, 1976.

McKenzie, D.H., L.L. Cadwell, L.E. Eberhardt, W.E. Kennedy, Jr., R.A. Peloquin, and M.A. Simmons, *Relevance of Biotic Pathways to the Long-Term Regulation of Nuclear Waste Disposal*, NUREG/CR-2675, Pacific Northwest Laboratory, Richland, Washington, 1982.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

SWCA Environmental Consultants, *Vegetated Cover System for the Energy*Solutions *Clive Site: Literature Review, Evaluation of Existing Data, and Field Studies, Summary Report*, prepared for Energy*Solutions*, August 2012.

## INTERROGATORY CR R313-25-7(2)-109/1: GEOCHEMICAL DEGRADATION OF RIP RAP

### PRELIMINARY FINDING:

Refer to R313-25-7(2): *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.*

Refer also to R313-25-24(4): *Covers shall be designed to minimize, to the extent practicable, water infiltration, to direct percolating or surface water away from the disposed waste, and to resist degradation by surface geologic processes and biotic activity.*

### INTERROGATORY STATEMENT:

Address the issue of the geochemical degradation of the rip rap over time and indicate why potential rip rap degradation will not require perpetual care.

### BASIS FOR INTERROGATORY:

Section 3.6.2, page 12, of the Conceptual Site Model report does not address the issue of rip rap degrading geochemically over time. DRC and Energy*Solutions* have paid attention to a small but significant portion of the rock at the nearby Vitro site that has degraded geochemically at a substantial rate within the past several decades. Rock degradation could potentially affect stability and competence of a cover system. The Conceptual Site Model report should be revised to adequately resolve this phenomenon, or a revised engineering design and specification should be provided that prevents or mitigates rip rap degradation.

### REFERENCES:

Bishop, C., Utah Department of Environmental Quality, Memorandum to Phil Goble, Compliance Section, *Energy*Solutions *Petrographic Studies of Rock Fragments*, January 29, 2014.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(A)-110/1: RADON TRANSFER FROM WATER

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

### INTERROGATORY STATEMENT:

Provide a basis for stating that radon has a preference for remaining in water.

### BASIS FOR INTERROGATORY:

Section 7.1.3.1, page 29, and Section 9.4.1, page 53, of the Conceptual Site Model report state that radon has a "*strong preference*" (page 29) or "*preference*" (page 53) for remaining in water. The document should provide a basis for these statements, as they appear to contradict statements by others from the technical literature. For example, Connell (2013) states that "*Due to radon's very high Henry's Law Constant, radon will quickly evolve from water when it is aspirated or exposed to the air*." EPA (1999) made the same argument, stating on page 2-2 that "*Because of its large Henry's Law constant, radon easily transfers into air above water.… Radon's relatively high Henry's Law constant indicates that it can transfer from water into air faster than both ammonia and carbon dioxide, which are readily strippable gases*." Drago (1998) also addresses this issue. The Conceptual Site Model report should be revised to incorporate new conclusions based on available technical literature, or Energy*Solutions* should explain and justify why the DRC Director should accept the existing statements as they now stand.

### REFERENCES:

Connell, C.P., *Radon – A Brief Discussion*, Forensic Applications Consulting Technologies, Inc., available at www.forensic-applications.com/radon/radon.html, retrieved September 2013.

Drago, J.A., *Critical Assessment of Radon Removal Systems for Drinking Water Supplies*, American Water Works Association, 1998.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility,* May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

U.S. Environmental Protection Agency, *Technologies and Costs for the Removal of Radon from Drinking Water*, Office of Water, EPA 815-D-99-004, May 1999.

## INTERROGATORY CR R313-25-7-111/1: LIKELIHOOD OF LAVA DAM FORMATION

### PRELIMINARY FINDING:

Refer to R313-25-7: *The application shall include certain technical information. The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25:*

*(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

### INTERROGATORY STATEMENT:

Describe why the future likelihood of lava dam formation is considered small, given that lava dams formed during the Pleistocene and affected Lake Bonneville.

### BASIS FOR INTERROGATORY:

Section 7.2.1.4, page 39, of the Conceptual Site Model report describes the formation of lava dams during the Pleistocene and their affect on Lake Bonneville. It states that "*Future changes in the regional hydrology in response to any future lava flows or regional volcanic activity could result in similar implications for future pluvial lake events (i.e., increase or decrease in discharge to the basin).*"

However, Section 2.0, page 3, of the Deep Time Assessment states the following:

> *Other less likely geologic events could also occur in the next 2.1 My. Events such as meteor strikes, and volcanic activity such as Yellowstone could also be considered. However, events other than the cyclic return of large lakes are not considered further in this model because their likelihood is small, and their consequences are likely to be much greater and far reaching for human civilization.*

The text should describe why, if lava dams formed during the Pleistocene affected Lake Bonneville, their future likelihood is considered small.

### REFERENCES:

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility,* May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA,* May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(A)-112/1: HYDRAULIC CONDUCTIVITY

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

### INTERROGATORY STATEMENT:

Revise the hydraulic conductivity values to be consistent with the values in NUREG/CR-7028. Increase the model's radon barrier permeability by at least two orders of magnitude and re-run the simulations, or provide evidence, explanation, and justification as to why the DRC Director should accept the current assumptions as presented.

### BASIS FOR INTERROGATORY:

The modeled saturated hydraulic conductivity values for clay radon barriers at the site of DU disposal, as noted in Table 1 of the Unsaturated Zone Modeling report, are generally much too low for post-construction values (see NUREG/CR-7028). Long-term post-construction hydraulic conductivity values for cover system soils historically tend to be at least one, and generally two or more, order(s) of magnitude **higher** than as-built hydraulic conductivity values. Furthermore, the value used in the model for the less-permeable radon barrier soil is not within the range specified as being realistic for planning in NUREG/CR-7028. The values used in the GoldSim model and described in the text are maintained unrealistically at their as-built values for any modeling past the initial several years. Moreover, the extremely low hydraulic conductivity value claimed for the lower radon barrier actually results from chemical treatment of the soil (with phosphate ion). The resulting decrease in hydraulic conductivity has not been confirmed as continuing for extended periods of time (e.g., hundreds, thousands, tens of thousands, or millions of years). Energy*Solutions* should increase the model's radon barrier permeability by at least two orders of magnitude and re-run the simulations, or provide evidence, explanation, and justification as to why the DRC Director should accept the current assumptions as presented.

### REFERENCES:

Benson, C.H., Albright, W.H., Fratta, D.O., Tinjum, J.M., Kucukkirca, E., Lee, S.H., Scalia, J., Schlicht, P.D., and Wang, X., *Engineered Covers for Waste Containment: Changes in Engineering Properties and Implications for Long-Term Performance Assessment*, NUREG/CR-7028, Volume 1, U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, December 2011.

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(5)(A)-113/1: PLACEMENT OF BULK LOW-LEVEL WASTE AMONG DU CANISTERS**

**PRELIMINARY FINDING:**

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

**INTERROGATORY STATEMENT:**

Describe modeling and consequent assessment related to the placement of bulk low-level waste between, above, or below the DU canisters.

**BASIS FOR INTERROGATORY:**

UAC R313-25-8(5)(a) requires that the PA include "*total quantities of concentrated depleted uranium and other wastes*." If Energy*Solutions* would like to place bulk low-level waste between, above, or below DU canisters at some time in the future, then the model's waste source term concentrations should be increased accordingly. This will also entail modeling and quantitative assessment of radioactivity concentrations in environmental media and doses to a member of the public during the 10,000-year compliance period for inclusion in the PA report. Also, additional justification will be needed for why this added waste source term does not alter current Energy*Solutions* findings regarding inadvertent intruders. In addition, new modeling and qualitative assessment of the revised radioactivity concentrations and doses during the remaining, post-10,000-year performance period must be performed under the revised assumption that fill around the DU canisters will comprise low-level waste at Class A limits. This will, of course, potentially increase calculated environmental media concentrations and doses. Section 6.4, page 26, of the Model Parameters report states, in terms of the Inventory\ClassA_LLW_Inventory container, that "*This is a placeholder container. No other LLW inventory is assumed in the model.*" Descriptions of this needed modeling and consequent assessment should be included within the PA. Energy*Solutions* should revise the Model Parameters report and the GoldSim model inputs and re-run the simulations, or provide evidence, explanation, and justification of why this issue is of little consequence and the report can stand as is. Based on the specific plans for waste emplacement, we expect that revisions to the quality assurance/quality control specifications will be required to address how fill around the bulk waste will be treated during disposal.

**REFERENCES:**

Neptune and Company, Inc., *Model Parameters for the Clive DU PA Model*, May 28, 2011. (Appendix 16 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-19-114/1: ELEVATED CONCENTRATIONS OF Tc-99

### PRELIMINARY FINDING:

Refer to R313-25-19: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.*

### INTERROGATORY STATEMENT:

Discuss the transport of technetium in groundwater at the site, including Tc-99 soil/water partitioning coefficients used in the GoldSim model and results of model predictions for transport of technetium in groundwater at the site for periods of at least 10,000 years. Describe steps that can be taken to limit the presence of technetium in groundwater to concentrations less than or equal to the Utah groundwater protection level of 3,790 pCi/L.

### BASIS FOR INTERROGATORY:

Section 4.1.11, page 15, of the Geochemical Modeling report indicates that some of the proposed DU waste contains Tc-99 at elevated concentrations. This includes DU from SRS (see, for example, Table 5 of the Waste Inventory report). Impacted wastes and/or containers also appear to include Tc-99 at elevated concentrations in about 5% of the GDP DU waste canisters. Tc-99 exists under oxic conditions in the subsurface primarily as the $TcO^{-4}$ anion. This species has relatively high solubility and generally very low to even negative partition coefficient values. As a result, Tc-99 will tend to be highly mobile in groundwater. The text should provide a reference to a section(s) of the PA that extensively covers (1) Tc-99 soil/water partitioning coefficients used in the GoldSim model by Energy*Solutions* and (2) results of model predictions for transport of technetium in groundwater at the site for periods of at least 10,000 years. It should also discuss steps that can be taken to limit the presence of technetium in groundwater to concentrations less than or equal to the Utah groundwater protection level of 3,790 pCi/L, specified in Table 1A of Part I.C.1 of the Ground Water Quality Discharge Permit No. UGW450005. The PA should consider waste acceptance criteria that will exclude sources of DU that have elevated concentrations of Tc-99 and thereby limit potential contamination of groundwater at and near the site by this radionuclide. Alternatively, Energy*Solutions* should explain and justify why the DRC Director should accept the PA as it currently stands.

### REFERENCES:

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

State of Utah, Division of Water Quality, Utah Water Quality Board, Ground Water Quality Discharge Permit No. UGW450005, issued to Energy*Solutions*, LLC, 2013. Available from www.radiationcontrol.utah.gov/EnSolutions/docs/2013/10Oct/SignedfinalPermit.pdf.

**INTERROGATORY CR R315-101-5.3(6)-115/1: URANIUM TOXICITY REFERENCE DOSES**

**PRELIMINARY FINDING:**

Refer to R315-101-5.3(6): *Identification of toxicity information gathered for all identified hazardous constituents for carcinogenic, slope factors and weight-of-evidence classification, noncarcinogenic effects, chronic reference doses (RfDs) and critical effects associated with RfDs from, in order of preference, the Integrated Risk Information System (IRIS), Health Effects Assessment Summary Tables (HEAST), Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles, Environmental Criteria and Assessment Office (ECAO), or other scientifically accepted listings. The source and date of the toxicological information must be identified and be acceptable to the Director.*

**INTERROGATORY STATEMENT:**

Expand the discussion of uranium toxicity to include the Superfund and drinking water RfDs, indicate whether they are for soluble or insoluble uranium salts or both, describe why there is a five-fold difference between the two RfDs, and indicate the basis for assigning a 50/50 probability to each RfD.

**BASIS FOR INTERROGATORY:**

Section 3.4.5, pages 25–26, of the Dose Assessment report references EPA documents with regard to uranium toxicity. However, the PA should briefly describe the Superfund and drinking water uranium RfDs. For example, it should indicate whether the RfDs are for soluble or insoluble uranium salts, or both. Section 3.4.5, page 26, states that there is a five-fold difference between the two RfDs; a brief description of why there is this difference would be helpful. The text should also indicate the basis for assigning a 50/50 probability to each RfD (see Table 1 of the Biological Assessment report) rather than assigning 100% probability to the Superfund RfD, since it is the more recent, or 100% probability to the drinking water RfD, since it is the more limiting?

**REFERENCES:**

Neptune and Company, Inc., *Biologically-Induced Transport Modeling for the Clive DU PA*, May 28, 2011. (Appendix 9 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Dose Assessment for the Clive DU PA*, May 28, 2011. (Appendix 11 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(4)(A)-116/1: Cs-137 DECAY**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

**INTERROGATORY STATEMENT:**

Change Figure 1 and the Excel file to show the correct amount of Cs-137 decaying to Ba-137.

**BASIS FOR INTERROGATORY:**

Figure 1, page 7, of the Model Parameters report (and the Excel file) shows 100% of Cs-137 decaying to Ba-137m. While 100% of Cs-137 activity is by beta decay, only 94.7% goes to Ba-137m, with essentially all of the remaining Cs-137 (i.e., 5.3%) decaying directly to Ba-137 (Browne and Tuli, 2007).

**REFERENCES:**

E. Browne and J.K. Tuli, *Nuclear Data Sheets for A = 137*, Nuclear Data Sheets, Vol. 108, Issue 10, pages 2173–2318, October 2007, available through the National Nuclear Data Center, Brookhaven National Laboratory, www.nndc.bnl.gov/nds/, accessed January 17, 2014.

Neptune and Company, Inc., *Model Parameters for the Clive DU PA Model*, May 28, 2011. (Appendix 16 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(5)(A)-117/1: GROUNDWATER PROTECTION LIMIT FOR Tc-99

### PRELIMINARY FINDING:

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

### INTERROGATORY STATEMENT:

Provide documentation (e.g., a Result Mode GoldSim file) that supports the contention that the Tc-99 GWPL will be met for 10,000 years. In addition, explain why Energy*Solutions* is proposing to include a Tc-99 waste source term concentration limit of 1,720 pCi/g under the side slope, given statements in various places in the PA report that no DU is to be included under the side slopes.

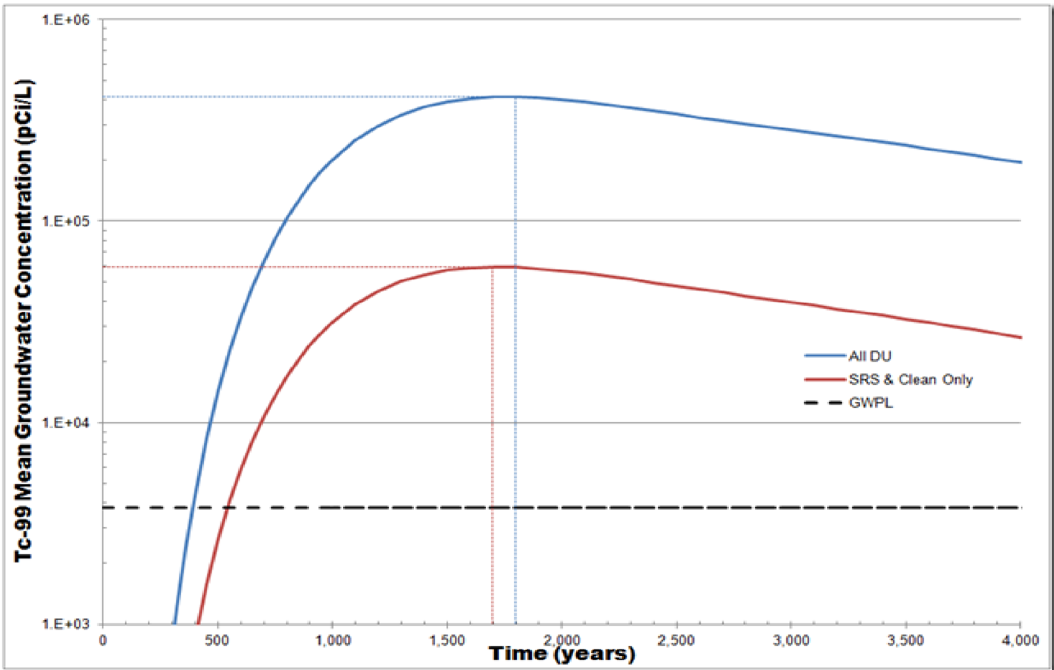
### BASIS FOR INTERROGATORY:

Section 3.1.3, page 3-3, of the 2013 Compliance Report, Revision 1, states the following:

> *The infiltration model for the Federal Cell and Division-approved Class A West Embankment covers use GoldSim to demonstrate that the infiltration and radionuclide transport models show that any depleted uranium waste disposed will satisfy all of the groundwater protection criteria, provided that the concentrations of $Tc_{99}$ are limited to the concentrations used in the transport modeling. Since the $Tc_{99}$ disposal concentrations are already limited to 1,720 pCi/g under the Class A West side slope, Energy*Solutions *proposes the same Federal Cell disposal limitations of 1,720 pCi/g under the side slope and 23,800 pCi/g under the top slope.*

It is not clear that all of the groundwater protection criteria will be satisfied if the stated Tc-99 limits are imposed on the waste. According to Table 5 of the Waste Inventory report, the PA assumes that the mean Tc-99 content is 23,800 pCi/g. This model input waste source term concentration appears to need additional justification and possible revision, as noted in other interrogatories. Section 2.5, page 2-12, of the 2013 Compliance Report, Revision 1, indicates that the DU waste is to be buried at 10 meters. In this case, FRV1 Table 2 shows a peak mean for Tc-99 of 14,400 pCi/L, which is significantly above the GWPL of 3,790 pCi/L.

The figure below shows SC&A's GoldSim simulations comparing Tc-99 concentrations against the GWPL. One case indicates that the Tc-99 GWPL is exceeded after 390 years. We also ran a case where the only source of Tc-99 was the $DUO_3$ from SRS and determined that the Tc-99 GWPL would be exceeded after 539 years. In another simulation, we decreased the infiltration rate to 0.09 cm/yr (Whetstone 2012, Section 2.4.1) and determined that the Tc-99 GWPL was exceeded in 494 years. Note that none of SC&A's simulations demonstrated that shallow Clive groundwater quality would be protected, below the Tc-99 GWPL, for at least 10,000 years. Based on FRV1 Table 2 and our simulations, it appears that Tc-99 will not meet the established GWPL if the DU is buried at 10 meters.




In addition, Section 2.5, page 2-11 of the 2013 Compliance Report, Revision 1, states that "*no depleted uranium will be placed beneath the Federal Cell's side slopes*." This and similar statements are made in many places in FRV1 and its appendices. However, as noted above, Section 3.1.3, page 3-3, states that "*Energy*Solutions *proposes the same Federal Cell disposal limitations of 1,720 pCi/g under the side slope….*" The reason for including a Tc-99 waste source term concentration limit of 1,720 pCi/g instead of a limit of 0 should be explained.

**REFERENCES:**

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

State of Utah, Division of Water Quality, Utah Water Quality Board, Ground Water Quality Discharge Permit No. UGW450005, issued to Energy*Solutions*, LLC, 2013.

Whetstone Associates, Inc., *Energy*Solutions *Class A West Disposal Cell Infiltration and Transport Modeling*, February 23, 2012.

## INTERROGATORY CR R313-25-7(10)-118/1: GOLDSIM RESULTS

### PRELIMINARY FINDING:

Refer to R313-25-7(10): *Descriptions of quality assurance programs, tailored to low-level waste disposal, including audit and managerial controls, for the determination of natural disposal site characteristics and for quality control during the design, construction, operation, and closure of the land disposal facility and the receipt, handling, and emplacement of waste.*

Refer also to R313-35-8(4): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

*(b) Analyses of the protection of inadvertent intruders shall demonstrate a reasonable assurance that the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided.*

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

*(d) 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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

### INTERROGATORY STATEMENT:

Provide the GoldSim model files (i.e., .gsm files) that support the results (i.e., groundwater concentrations, receptor doses, receptor uranium HQs, ALARA, and deep time results) that are reported in FRV1.

### BASIS FOR INTERROGATORY:

Using the GoldSim model file that was supplied to DRC by Energy*Solutions*, we were not able to match the results reported in FRV1 Section 6.0 (i.e., groundwater concentrations, receptor doses, receptor uranium HQs, ALARA, and deep time results). Some of our results came close to those in FRV1, while others, such as groundwater concentrations, differed significantly.

We requested assistance from Neptune through Energy*Solutions* to determine why we were unable to reproduce the Section 6.0 results. However, Energy*Solutions* and Neptune have not been able to determine why we cannot match the Section 6.0 results with our GoldSim runs, nor have they been able to reproduce the Section 6.0 results with their own GoldSim runs. This indicates that the GoldSim model files (i.e., .gsm files) that Energy*Solutions* and Neptune presently have access to are not the same files that were used to generate the results reported in Section 6.0.

**REFERENCES:**

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(A)-119/1: RESUSPENSION AND AIRBORNE PATHWAYS

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

### INTERROGATORY STATEMENT:

Revise the model inputs and re-run the simulations as noted, or provide documentation and justification that the analysis of exposures due to the air pathways in the PA is conservative, in particular with regard to the resuspension flux entered into GoldSim and the model's calculation of the resuspension rate and airborne radionuclide concentrations, particularly when gullies that extend into the buried DU are present.

### BASIS FOR INTERROGATORY:

Even though radon completely dominates the general population doses, a brief check of the non-radon pathway doses was performed, including the air exposure pathways. The check focused on the case assuming 3-meter burial, with gullies, as the doses associated with that case are known to not be as highly dependent on the radon pathways as the other cases. This check led to the following concerns with the airborne pathways (i.e., inhalation and immersion):

(1) For the soil resuspension flux (ResuspensionFlux), Section 6.4, page 19, of the Air Modeling report states that the resuspension flux is "*represented in the GoldSim PA model using a log-uniform distribution with boundaries of 2.5E-07 and 0.30 kg/m$^2$-yr*." However, Table 26 of the Model Parameters report gives the resuspension flux as a log-uniform distribution with limits of "*small*" (i.e., $1\times10^{-30}$) and 0.3 kg/m$^2$-yr, and a check of the GoldSim file shows this to be the case.

Setting the lower limit to an arbitrary "small" value will tend to artificially reduce the resuspension flux, and thus the airborne concentrations. To be conservative, the lower limit of the resuspension flux should be set to the largest "small" value feasible, and setting it to no more than a million times lower than the upper limit (as suggested in Section 6.4 of the Air Modeling report) would be appropriate.

We do note that, because the results (e.g., doses) are presented as "arithmetic means" over many realizations, the impact of this is not as great as might be expected. A Monte Carlo test performed using Crystal Ball found that using $3\times10^{-7}$ as the lower limit increased the "arithmetic mean" flux by about a factor of 5 over using $1\times10^{-30}$.

(2) The GoldSim model (Processes.AirTransport) calculates the soil resuspension rate (ResuspensionRate) (g/s) from the resuspension flux (kg/m$^2$-y). In doing so, the GoldSim model divides the flux by the total thickness of the cap (i.e., 5.5 feet). However, when the resuspension rate is used to calculate the airborne radionuclide concentration, the GoldSim model applies it only to the activity in the cap's top layer, which has a thickness ranging from 1 to 42.7 centimeters, with a mean of about 22 centimeters. To keep the calculation consistent, the thickness and the activity used in these calculations should both be associated with the same entity, either both with the total cap or both with the cap's top layer. Not doing so results in under-predicting the airborne radionuclide concentration by a factor of about 7.6 (5.5 ft / 22 cm).

(3) The check of Exposure_Dose.Media_Concs.Transport_Media found that when calculating the onsite dust concentration of radionuclides (DustConc_Onsite), the GoldSim model (Disposal.AtmosphericDispersion.AirConc_OnSite) ignores the surface concentration due to gully erosion (SoilConc_Gullies_CAS) and bases the airborne concentration only on the amount of material brought to the surface by biotic activity. This is only important for the 3-meter burial case, but for that case it impacts the airborne concentration by several orders of magnitude. For example, without gullies the U-238 surface soil concentration (SoilConc_Cap_CAS) is about $3\times10^{-4}$ pCi/g, but with gullies the concentration (SoilConc_Embankment_CAS) is about 7,000 pCi/g – an under-prediction of about 20 million times.

**REFERENCES:**

Neptune and Company, Inc., *Atmospheric Transport Modeling for the Clive DU PA*, May 28, 2011. (Appendix 8 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Model Parameters for the Clive DU PA Model*, May 28, 2011. (Appendix 16 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(A)-120/1: GULLIES AND RADON

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

### INTERROGATORY STATEMENT:

Provide justification as to why the presence of gullies in the embankment has no impact on the radon flux at the surface of the embankment, and thus no impact on the general population doses. Alternatively, modify the GoldSim model to have the embankment surface radon flux account for the presence of gullies within the embankment, include the "short-circuiting" of radon migrating upwards though the degraded cap and the release of radon directly to the atmosphere from any gullies that extend downwards into the disposed DU.

### BASIS FOR INTERROGATORY:

For the 3-meter and 10-meter burial cases, SC&A made GoldSim model runs both without and with gullies and compared with the embankment surface peak radon fluxes (PeakRadonFlux) from Section 9.4 of the Unsaturated Zone Modeling report. Since the presence of gullies would provide a "short-circuit" pathway for radon to escape from the embankment, a higher peak radon flux was expected for the cases with gullies than for the cases without gullies. This is especially true since some of the gullies contained within the PA model extend downward through the cap's radon barrier. However, when the GoldSim-calculated peak radon fluxes were compared, the flux with gullies was identical to the flux without gullies.

Also, for some of the 3-meter burial case realizations, the gullies extend downward into the DU itself. However, a review of the GoldSim model did not reveal where it calculates the direct release of radon to the atmosphere due to the decay of uncovered Ra-226. For example, EPA (1986, page 3-15) specifies as a "rule-of-thumb" a Rn-222 release rate from uncovered Ra-226 of 1 pCi (Rn-222)/m$^2$-s per pCi (Ra-226)/g, or the Rn-222 release rate can be calculated from the diffusion equation. The model inputs should be revised accordingly and the simulations re-run. Alternatively, Energy*Solutions* should explain and justify why its approach as currently modeled is representative of future site conditions.

**REFERENCES:**

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Environmental Protection Agency, *Final Rule for Radon – Emissions from Licensed Uranium Mill Tailings, Background Information Document*, Office of Radiation Programs, EPA 520/1-86-009, August 15, 1986.

## INTERROGATORY CR R313-25-19-121/1: GULLIES AND RECEPTOR LOCATION

### PRELIMINARY FINDING:

Refer to R313-25-19: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.*

### INTERROGATORY STATEMENT:

When gullies are assumed to be present in the embankment, provide justification for using the radionuclide soil concentration and radon flux averaged over the entire embankment surface (including areas without and with gullies) when calculating exposures to hunters, ranchers, and off-highway vehicle (OHV) enthusiasts. Alternatively, provide the estimated exposures to these receptors when they are assumed to spend all (or most) of their time in the gullies.

### BASIS FOR INTERROGATORY:

SC&A's review of the GoldSim model (Exposure_Dose.Dose_Calculations.Environ_Concs_2D) reveals that the average embankment air and soil concentrations are used to calculate OHV enthusiast doses. This implies that the time an OHV enthusiast spends inside the gullies is proportional to the areal size of the gullies relative to the areal size of the embankment. For example, if gullies are formed over 5% of the entire embankment area, then the present GoldSim model assumes that the OHV enthusiast spends 5% of his or her time in the gullies.

However, Section 3.2.2, page 4, of the Erosion Modeling report states that the "*engineered cap at the Clive facility may be subject to gully erosion via a disturbance attributed to…off-highway vehicle (OHV) track.*" Since the gullies may be formed by the OHV enthusiasts, it seems logical that the OHV enthusiasts' exposure calculation would assume that they spent all (or most) of their time in the gully tracks. For the example above, an assumption that the OHV enthusiast spends 100% of his or her time in the gullies (instead of 5%) would result in an exposure that is a factor of 20 larger than what is currently predicted.

Because the GoldSim model also assumes that the hunters and ranchers use OHVs, this interrogatory also includes them.

### REFERENCES:

Neptune and Company, Inc., *Erosion Modeling for the Clive PA*, June 1, 2011. (Appendix 10 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(D)-122/1: SIZE OF PLUVIAL LAKES

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

### INTERROGATORY STATEMENT:

Provide complete references to support assumptions with respect to the size of recurring pluvial lakes. Revise the Deep Time Assessment report to rely on more recent paleolake evidence focused on the Bonneville Basin.

### BASIS FOR INTERROGATORY:

Section 3.1, page 5, of the Deep Time Assessment report states the following:

> *However, of the seven most recent 100 ky glacial cycles, it is estimated that only four of them presented very large lakes in the Bonneville Basin. Variation in climatic conditions appears to be sufficient that large differences have occurred in each of the past 100 ky cycles.*

This statement attempts to tie global climate cycles as manifested in high latitude ice cores (Jouzel et al., 2007) to large lakes in the mid-latitude Bonneville basin. While existing journal literature (e.g., Balch et al., 2005; Davis, 1998) documents a number of 100 ky glacial-interglacial lake cycles, the exact number, timing, and recurrence interval over the past 2 million years is not firmly established. Moreover, for cycles of large lakes documented regionally throughout geologic time, the recurrence interval is not uniform, and it is smaller than 100 kya. The Little Valley lake peaked in elevation at about 135 ky BP, the Cutler Dam lake peaked about 65 ky BP, and the Bonneville lake peaked about 18 ky BP (see Machette et al. 1992).

Energy*Solutions* should revise the appendix to also rely on more recent paleolake evidence focused on the Bonneville Basin, such as that in Machette et al. (1992) and Madsen (2000).

### REFERENCES:

Balch D.P., A.S. Cohen, D.W. Schnurrenberger, B.J. Haskell, B.L.V. Garces, J.W. Beck, H. Cheng, and R.L. Edwards, *Ecosystem and paleohydrological response to Quaternary climate change in the Bonneville basin, Utah*, Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 221, pp. 99–121, 2005.

Davis, O.K., *Palynological evidence for vegetation cycles in a 1.5 million year pollen record from the Great Salt Lake, Utah, U.S.A.*, Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 138, pp. 175–185, 1998.

Jouzel, J., V. Masson-Delmotte, O. Cattani, and G. Dreyfus, et al., *Orbital and millennial Antarctic climate variability over the past 800,000 years*, Science, Vol. 317, pp. 793–796, 2007.

Machette, M.N., S.F. Personius, and A.R. Nelson, *Paleoseismology of the Wasatch fault zone: A summary of recent investigations, interpretations, and conclusions*, in Gori, P.L., and W.W. Hays, eds., Assessment of regional earthquake hazards and risk along the Wasatch Front, Utah, U.S. Geological Survey Professional Paper 1500-A-J, pp. A1−A71, 1992.

Madsen, D.B., editor, *Late Quaternary Paleoecology in the Bonneville Basin*, Utah Geological Survey Bulletin 130, 2000.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(D)-123/1: TIMING OF LAKE CYCLES

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

### INTERROGATORY STATEMENT:

Incorporate other existing literature on lake cycles in the Bonneville basin for a complete perspective on lake cycles in the Bonneville basin. Describe why the Burmester core data are applicable to the Clive site, including location and distance from Clive, ground elevation, and geologic setting.

### BASIS FOR INTERROGATORY:

Section 3.2, page 6, of the Deep Time Assessment report states the following:

> *To establish the approximate timing of previous lake cycles, Oviatt et al. (1999) examined sediments from the Burmester sediment core and suggested that a total of four deep-lake cycles occurred during the past 780 ky (Table 2). They found that the four lake cycles correlated with marine $\delta^{18}O$ stages 2 (Bonneville lake cycle: ~24–12 ky), 6 (Little Valley lake cycle: ~186–128 ky), 12 (Pokes Point lake cycle: ~478–423 ky), and 16 (Lava Creek lake cycle: ~659–620 ky).*

The report should also describe why the Burmester core data are applicable to the Clive site, including, but not limited to, location and distance from Clive, ground elevation, and geologic setting and similarities (or differences). This discussion should consider that a greater understanding and more data are available concerning the four different stages of Lake Bonneville most likely because it was the most recent paleolake to exist in the Bonneville Basin. In other words, older pluvial lakes may have also had multiple shorelines at varying elevations, but because of the inherent mechanics of erosion and sediment redistribution forces of the more modern Lake Bonneville sequence, modern evidence of these former lake features has likely been lost.

In addition to Oviatt et al. (1999), Balch et al. (2005) and Davis (1998) provide a picture of lake cycles in the Bonneville basin that is considerably more complex than this statement would indicate. Additional information on the Bonneville Basin paleolakes can be found in sources such as Machette et al. (1992) and Madsen (2000).

### REFERENCES:

Balch D.P., A.S. Cohen, D.W. Schnurrenberger, B.J. Haskell, B.L.V. Garces, J.W. Beck, H. Cheng, and R.L. Edwards, *Ecosystem and paleohydrological response to Quaternary climate* *change in the Bonneville basin, Utah*, Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 221, pp. 99–121, 2005.

Davis, O.K., *Palynological evidence for vegetation cycles in a 1.5 million year pollen record from the Great Salt Lake, Utah, U.S.A.*, Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 138, pp. 175–185, 1998.

Machette, M.N., S.F. Personius, and A.R. Nelson, *Paleoseismology of the Wasatch fault zone: A summary of recent investigations, interpretations, and conclusions*, in Gori, P.L., and W.W. Hays, eds., Assessment of regional earthquake hazards and risk along the Wasatch Front, Utah, U.S. Geological Survey Professional Paper 1500-A-J, pp. A1–A71, 1992.

Madsen, D.B., editor, *Late Quaternary Paleoecology in the Bonneville Basin*, Utah Geological Survey Bulletin 130, 2000.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Oviatt, C.G., R.S. Thompson, D.S. Kauffman, J. Bright, and R.M. Forester, *Reinterpretation of the Burmester core, Bonneville Basin, Utah*, Quaternary Research, Vol. 52, pp. 180–184, 1999.

## INTERROGATORY CR R313-25-8(4)(D)-124/1: MECHANISMS FOR PLUVIAL LAKE FORMATION

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

### INTERROGATORY STATEMENT:

The discussion of mechanisms for pluvial lake formation is incomplete. Describe other possible forcing mechanisms that have been proposed for the formation of Great Basin pluvial lakes and present the basis for the selected approach.

### BASIS FOR INTERROGATORY:

Section 3.2, page 7, of the Deep Time Assessment report states the following:

> *These extensive glaciations are suggested to have been controlled by the mean position of storm tracks throughout the Pleistocene, which were in turn controlled by the size and shape of the ice sheets (Oviatt, 1997; Asmerom et al., 2010).*

However, other mechanisms have been proposed for the formation of the Great Basin pluvial lakes. For example, Lyle et al. (2012) propose that changes in Pacific Ocean circulation were the forcing mechanism for Great Basin pluvial lakes, rather than steering of storm tracks by the continental ice sheets. Ruddiman (2006) is another source of information on the subject. The DU PA should provide an assessment of alternate forcing mechanisms.

### REFERENCES:

Lyle, M., L. Heusser, C. Rovelo, M. Yamamoto, J. Barron, N.S. Diffenbaugh, T. Herbert, D. Andreasen, *Out of the Tropics: The Pacific, Great Basin Lakes, and Late Pleistocene Water Cycle in the Western United States*, Science, Vol. 337, p. 1629–1633, 2012.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Ruddiman, W.F., *Orbital Changes and Climate*, Quaternary Science Reviews, Vol. 25, pp. 3092–3112, 2006.

**INTERROGATORY CR R313-25-8(4)(D)-125/1: DEEP LAKE CYCLES**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

**INTERROGATORY STATEMENT:**

Correct the age ranges for the Lake Bonneville flood events to reflect more recent information.

**BASIS FOR INTERROGATORY:**

Section 3.2, page 8, of the Deep Time Assessment report states that *"The high-stand (i.e., the highest level reached) of the lake at the Zenda threshold (1,552 m), located north of Red Rock Pass, occurred approximately 18.3–17.4 ky BP."*

However, Miller et al. (2013) give a more up-to-date review of the correct chronology of Lake Bonneville and the Bonneville flood event.

**REFERENCES**:

Miller, D.M., C.G. Oviatt, and J.P. Mcgeehin, *Stratigraphy and chronology of Provo shoreline deposits and lake-level implications, Late Pleistocene Lake Bonneville, eastern Great Basin, U.S.A.*, Boreas, Vol. 42, pp. 342–361, 2013.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(4)(D)-126/1: SHALLOW LAKE CYCLES**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

**INTERROGATORY STATEMENT:**

Examine the presumed shallow lake cycles within the context of other references regarding lake cycles from other areas of the Great Basin.

**BASIS FOR INTERROGATORY:**

Section 3.3, page 9, of the Deep Time Assessment report states the following:

> *From the Clive pit wall interpretation, it is presumed that at least three shallow lake cycles occurred prior to the Bonneville cycle, although there is some uncertainty associated with that estimate. These shallow cycles could in fact be part of the transgressive phase (i.e., rising lake level) of the Bonneville cycle (C.G. Oviatt, personal communication). By analyzing the Knolls core interpretation, which is more representative of Clive than the Burmester core due to its relative proximity and differences in their regional topography, the Little Valley cycle is present at approximately 16.8 m from the top of the core. Given the pit wall at Clive was 6.1 m deep and does not capture the Little Valley cycle, it can be speculated that other smaller lake cycles occurred in the Clive region in addition to the three shallow lake events noted in Table 3 (labeled as Pre-Bonneville Lacustrine Cycles).*

We note that the sedimentation rates described are speculative without any age dating. While the examination of the Clive exposure in the field and the Knoll core was accomplished by an acknowledged expert in Great Basin geochronology and geomorphology (Oviatt), these conclusions should be examined within the context of other references regarding lake cycles from other areas of the Great Basin (e.g., Balch et al., 2005; Davis, 1998).

**REFERENCES:**

Balch D.P., A.S. Cohen, D.W. Schnurrenberger, B.J. Haskell, B.L.V. Garces, J.W. Beck, H. Cheng, and R.L. Edwards, *Ecosystem and paleohydrological response to Quaternary climate change in the Bonneville basin, Utah,* Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 221, pp. 99–121, 2005.

Davis, O.K., *Palynological evidence for vegetation cycles in a 1.5 million year pollen record from the Great Salt Lake, Utah, U.S.A.*, Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 138, pp. 175–185, 1998.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(4)(D)-127/1: CARBONATE SEDIMENTATION**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

**INTERROGATORY STATEMENT:**

Provide additional rationale for the assumption that carbonate sedimentation will not occur in intermediate lakes, based on the limnology literature.

**BASIS FOR INTERROGATORY:**

Section 3.3, page 10, of the Deep Time Assessment report states that *"Intermediate lakes are assumed to be smaller lakes that reach and exceed the altitude of Clive, but are not large enough that carbonate sedimentation can occur."*

However, lake size has little relationship to the nature of lacustrine sedimentation, carbonate or otherwise. Standard limnology texts and journal literature illustrate the complexity of sedimentation in lakes of all sizes. For example, the relatively shallow modern Great Salt Lake has well documented carbonate sedimentation (Gwynn, 2002, and references therein; Hutchinson, 1957; Kalff, 2002). Sediments at Clive may be dominantly carbonates. Studies for the licensee conducted at the University of Utah Research Institute (1993) show that clay and silt particles of a sample of Unit 4 silty clay at the Clive site consist predominantly of calcium carbonate (65% of total fines). Of that, most is aragonite (82% of all calcium carbonate). The cited assumption should be revised based on the information in these references.

**REFERENCES:**

Gwynn, J.W., ed. *Great Salt Lake: An overview of change*, Utah Geological Survey Special Publication of the Division of Natural Resources, 2002.

Hutchinson, G.E., *A treatise on limnology: Volume 1,* Geography, physics and chemistry, Part 2 – Chemistry of lakes, Wiley and Sons, New York, 1957.

Kalff, J., *Limnology*, Prentice Hall, 592 pp., 2002.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

University of Utah Research Institute, *Summary of X-Ray Diffraction Analysis, University of Utah Research Institute, Earth Science Laboratory*, included as an attachment to a letter report on Evaluation of Long Term Permeability of Treated Clay Notice of Deficiency: Radioactive Materials License UT2300249, Envirocare Disposal Facility, Toole County, Utah, Project No.

11293, from Robert E. Edgar of Applied Geotechnical Engineering Consultants, Inc., to Steve Petersen of Envirocare of Utah, Inc., dated February 17, 1993.

## INTERROGATORY CR R313-25-8(4)(D)-128/1: LAKE SEDIMENTATION

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

### INTERROGATORY STATEMENT:

Use the information in existing journal literature on sedimentation rates to update statements in the Deep Time Assessment report. Emphasize how the core data and sedimentation rates for those locations are relevant to the Clive site given the paleodepositional facies involved.

### BASIS FOR INTERROGATORY:

Section 3.4, page 11, of the Deep Time Assessment report states that "*Given the Little Valley event occurred 150 ky BP, a sedimentation rate can be approximated for the depth between this event and the transgressive phase of the Bonneville cycle of 110 mm/kr.*" This section also includes other similar statements. However, a variety of core types exist in the Bonneville basin, exhibiting a wide variety of sedimentation rates, as indicated in the literature (Balch, et al., 2005; Davis, 1998). The statements in the report should be reviewed in light of this literature. Discussion of this and other available technical literature should emphasize how the core data and sedimentation rates for those locations are relevant to the Clive site given the paleodepositional facies that were involved.

### REFERENCES:

Balch D.P., A.S. Cohen, D.W. Schnurrenberger, B.J. Haskell, B.L.V. Garces, J.W. Beck, H. Cheng, and R.L. Edwards, *Ecosystem and paleohydrological response to Quaternary climate change in the Bonneville basin, Utah,* Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 221, pp. 99–121, 2005.

Davis, O.K., *Palynological evidence for vegetation cycles in a 1.5 million year pollen record from the Great Salt Lake, Utah, U.S.A.*, Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 138, pp. 175–185, 1998.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA,* May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

**INTERROGATORY CR R313-25-8(4)(D)-129/1: LAKE EROSION**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

**INTERROGATORY STATEMENT:**

Provide a reference to support the assumption that a lake is large enough to obliterate a relatively soft pile. Explain why such obliteration will not be cause for ongoing active maintenance.

**BASIS FOR INTERROGATORY:**

Section 4.0, page 13, of the Deep Time Assessment report states that *"In effect, it is assumed that a lake is large enough that obliteration of a relatively soft pile will occur."* However, no references are given to support this assumption. A wide range of engineering and scientific literature exists to substantiate this statement and should be referenced (e.g., Komar, 1998, and references therein) and the appendix revised accordingly. On the other hand, whether or not obliteration occurs depends on meteorological conditions and the extent of the growth of boundaries of a lake and its depth relative to the position of the facility.

Energy*Solutions* should also explain and justify how erosion of the waste embankment during deep time (10,000 years or more) will not be cause for ongoing active maintenance by the future owner or responsible party.

**REFERENCES:**

Komar, P.D., *Beach Processes and Sedimentation*, 2nd Ed., Prentice Hall, New Jersey, 1998.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(4)(D)-130/1: LAKE GEOCHEMISTRY**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

**INTERROGATORY STATEMENT:**

Provide references to support statements concerning the geochemisty of uranium in the carbonate system and adsorption behavior on clays, iron oxides, and ferrihydrites and revise the statements as needed to reflect the literature.

**BASIS FOR INTERROGATORY:**

Section 4.0, page 13, of the Deep Time Assessment report states the following:

> *While the lake is present, some waste in the water column will bind with carbonate ions and precipitate out into oolitic sediments, while the remaining waste will fall out with the sediment as the lake eventually recedes.*

However, although the details of the geochemical behavior of uranium exist elsewhere in the PA, this statement is cursory and undocumented. Quartz and carbonates are not the only minerals present in pelagic sediments of Lake Bonneville. For example, Oviatt et al. (1994) show that carbonates plus "sand" account for only 30–90% of the total weight of deep water Lake Bonneville sediments. Research by Turk et al. (1973, Table 2) on surface clay deposits in the vicinity of Wendover, Utah, and across the Bonneville Salt Flats (likely deposited by the Gilbert Stage of Lake Bonneville) shows that these clay-sized unconsolidated sediments are composed of the following minerals (determined by x-ray diffraction in weight%):

- ~74.7–87.0% aragonite and calcite (predominantly aragonite)
- ~2.6–21.4% quartz
- ~6.1% gypsum
- ~4.7–8.6% montmorillonite and illite (actual clay minerals)

In the case of silt-sized earth materials, Turk et al. (1973) found the following mineral content (weight%):

- 50.6–91.9% aragonite and calcite
- ~3.8–49.4% quartz
- ~2.2–16.6% gypsum
- ~1.8–31.2% montmorillonite and illite

Clearly, carbonate minerals compose 50% or more of the silt and clay earth materials in sediments most likely deposited by the Gilbert Stage of Lake Bonneville. Clay minerals are almost certainly in the minority. It is expected that varying amounts of iron hydroxides are almost certainly present, although not reported in the literature. Gilbert (1890, Table III) reports alumina weights of 3.2–12.0% (most likely present as clays) and ferric iron of 1.2–4.0% for Bonneville marls. Uranium has long been recognized to exhibit important adsorption and desorption behavior on a variety of the minerals that would in all likelihood be present in future lakes of the Great Basin. Sources such as Davis and Kent (1990), Fenton and Waite (1996), His and Langmniur (1985), Payne et al. (1996), and Stumm and Morgan (1996) should also be reviewed, and discussion added to justify the geochemistry of the Lake Bonneville-related sediments.

**REFERENCES:**

Davis, J.A., and D.B. Kent, *Surface complexation modeling in aqueous geochemistry*, in Hochella, M.F. and A.F. White, eds., Mineral-Water Interface Geochemistry. In Reviews in Mineralogy and Geochemistry, Mineralogical Society of America, Washington, DC, Vol. 23, pp. 177–260, 1990.

Fenton, B.R., and T.D. Waite, *A kinetic study of cation release from a mixed mineral assemblage: implications for determination of uranium uptake*, Radiochimica Acta, Vol. 74, pp. 251–256, 1996.

Gilbert, G.K., *Lake Bonneville*, U.S. Geological Survey Monograph 1, 438 pp., 1890.

Hsi, C-K.D., and D. Langmuir, *Adsorption of uranyl onto ferric oxyhydroxides: application of the surface complexation site-binding model*, Geochemica Cosmochimica Acta, Vol. 49, pp. 1931–1941, 1985.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA,* May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Oviatt, C.G., G.D. Habiger, and J.E. Hay, *Variation in the composition of Lake Bonneville marl: a potential key to lake-level fluctuations and paleoclimate*, Journal of Paleolimnology, Vol. 11, pp. 19–30, 1994.

Payne, T.E., J.A. Davis, and T.D. Waite, *Uranium adsorption on ferrihydrite: effects of phosphate and humic acid*, Radiochimica Acta, Vol. 74, pp. 239–243, 1996.

Stumm, W., and J.J. Morgan, *Aquatic chemistry: chemical equilibria and rates in natural waters*, Wiley-Interscience, 1996.

Turk, L.J., S.N. Davis, and C.P. Bingham, *Hydrogeology of Lacustrine Sediments, Bonneville Salt Flats, Utah*, Economic Geology, Vol. 68, pp. 65–78, 1973.

**INTERROGATORY CR R313-25-8(4)(D)-131/1: POTENTIAL WAVE ENERGY**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

**INTERROGATORY STATEMENT:**

Provide support and references for the assumption that shallow lakes have low wave energy.

**BASIS FOR INTERROGATORY:**

Section 4.0, bottom of page 13, of the Deep Time Assessment report (FRV1, Appendix 13) states the following:

> *It should be noted that a Gilbert-sized lake would just barely reach Clive and the wave energy would very likely not erode the waste embankment (C.G. Oviatt, personal communication). The size of lake in the PA model that is needed to obliterate the waste embankment can be as small as 1 m, which might not have sufficient wave power to obliterate the site.*

This statement seems at odds with other statements in the Deep Time Assessment report , e.g., the last introductory paragraph of Section 4.0, top of page 12 and the first paragraph of page 12.

Waves that develop in small lakes, such as the relatively shallow modern Great Salt Lake, have been shown to be extremely destructive to features such as the railroad causeway that separates the north and south arms of the lake.

Fundamental wave dynamics and theory demonstrate that wave energy is concentrated in the upper few meters of the water column that wave energy is a function of storm duration, wind speed, and fetch of the water body. This means even shallow lakes are capable of producing significant wave power. References such as the Shore Protection Manual, Griggs and Fulton-Bennett (1988), and Komar (1998) should be reviewed and the report revised accordingly.

**REFERENCES:**

U.S. Army Corps of Engineers, *Shore Protection Manual*, Waterways Experiment Station, Coastal Engineering Research Center, Volumes I and II, 1984.

Griggs, G.B., and K.W. Fulton-Bennett, *Rip rap revetments and seawalls and their effectiveness along the central California coast*, Shore and Beach, Vol. 56, pp. 3–11, 1988.

Komar, P.D., *Beach Processes and Sedimentation*, Prentice Hall, New Jersey, 1998.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(D)-132/1: SEDIMENTATION MODEL

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

### INTERROGATORY STATEMENT:

Provide more detail on the sedimentation model as it relates to the text.

### BASIS FOR INTERROGATORY:

Section 6.3, page 26, of the Deep Time Assessment report states the following:

> *The year-to-year variation can be modeled as a second-order autoregressive process AR(2) (Brockwell and Davis, 1991), a model that accounts for year to year temporal correlations in the variation.*

Figure 10 provides an example of a simulation of an AR(2) process.

However, the text should provide the basis for using a time series technique (Brockwell and Davis, 1999).

### REFERENCES:

Brockwell, P.J. and R.A. Davis, *Time Series: Theory and Methods*, *2nd Ed.*, Springer Verlag, New York, NY, 579 pp., 1991.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA*, May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(D)-133/1: CALCULATIONS OF RADIOACTIVITY IN WATER AND SEDIMENT

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

### INTERROGATORY STATEMENT:

Provide context for the equations and variables presented for calculating radioactivity in water and sediment.

### BASIS FOR INTERROGATORY:

Sections 6.5.1 and 6.5.2, pages 31-32, of the Deep Time Assessment report present a number of equations without providing an interpretation of what the results for R (radioactivity), C (concentration), and $C_{sediment}$ (concentration in the sediment) actually mean, since the text provides no background on specific input variables, such as time, area of sediment that contains the waste, diffusion coefficients, and possible lake depths.

### REFERENCES:

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA,* May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-8(4)(D)-134/1: FUTURE LAKE LEVEL ELEVATIONS

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

### INTERROGATORY STATEMENT:

Provide further discussion on the potential rise of the lake level with respect to the proposed facility and more specific definitions of the depth of "intermediate" and "deep" lakes.

### BASIS FOR INTERROGATORY:

Section 3.3, page 10, of the Deep Time Assessment report states that *"Under current climate conditions, it is assumed that intermediate lakes will not occur."*

The behavior of the two largest lake systems in the Great Basin (Lake Bonneville/Great Salt Lake and Lake Lahontan/Pyramid Lake/Walker Lake) during the Holocene (past 10,000 years) is incompletely documented. The technical literature does suggest that lakes deeper than about 30 meters (98 feet) above the elevation of modern playas or lakes such as Pyramid Lake or the Great Salt Lake have not been a part of the landscape. The most significant radiocarbon work in the western portion of the Great Basin (Adams, 2003; Briggs et al., 2005) suggests that Holocene lakes rose 25–30 meters (82–164 feet) as recently as 2,000 years ago. Somewhat lesser (15–20 meter) rises of the Great Salt Lake during the Holocene in the eastern Great Basin have been proposed (Currey et al., 1984), although radiocarbon dating of shorelines associated with these events is lacking. The relatively small difference in elevation between the Energy*Solutions* facility (about 1,301 meters (4,270 feet above mean sea level)) and the current Great Salt Lake (about 1,280 meters (4,200 feet above mean sea level)) suggests that potential lake level rises should be investigated further.

Furthermore, although current understanding of Great Basin climate during the present warm climate cycle and the behavior of lakes therein appears in line with the assumption that intermediate lakes will not occur under current climate conditions, a more precise definition of the depth of "intermediate" and "deep" lakes should be given.

### REFERENCES:

Adams, K.D., *Age and paleoclimatic significance of late Holocene lakes in the Carson Sink, NV, USA*, Quaternary Research, Vol. 60, pp. 294–306, 2003.

Briggs, R.W., S.G. Wesnousky, and K.D. Adams, *Late Pleistocene and late Holocene lake highstands in the Pyramid Lake subbasin of Lake Lahontan, Nevada, USA*, Quaternary Research, Vol. 64, pp. 257–263, 2005.

Currey, D.R., G. Atwood, and D.R. Mabey, *Major levels of Great Salt Lake and Lake Bonneville*, Utah Geological Survey Map 73, May 1984.

Neptune and Company, Inc., *Deep Time Assessment for the Clive DU PA,* May 30, 2011. (Appendix 13 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-19-135/1: EXPOSURE TO GROUNDWATER**

**PRELIMINARY FINDING:**

Refer to R313-25-19: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.*

**INTERROGATORY STATEMENT:**

Provide a calculation of the doses to an individual who pumps, processes, and uses the groundwater from a well located near the Clive facility to ensure that exposures are below the levels specified in R313-25-19. Examine how byproducts of future desalination processes that might rely on radio-contaminated groundwater at Clive will need to be managed to protect public health and the environment, incorporating additional dose to a member of the public if needed.

**BASIS FOR INTERROGATORY:**

DRC is aware that a number of individuals and/or companies in the region near the Clive facility are presently pumping the groundwater to the surface, processing it through a desalination system, and making use of the groundwater. These include the Delle Auto Truck Stop located on Interstate 80 at Exit 70, among other industrial users in the region. Because it is already occurring in the vicinity of the Clive site, it is not unreasonable to expect that at some point in the future an individual or company will use the desalinized groundwater from the Clive site as a water source.

We performed a simple scoping calculation of the doses to an individual who processes and uses the groundwater and found that the doses have the potential to exceed the limits specified in R313-25-19. This calculation recognized that the groundwater would need to be processed before it could be used and took credit for the processing reducing not only the TDS but also any Tc-99 and I-129 that the GoldSim model predicted would be present.

The results of the calculation for Tc-99 are shown in the table below. The calculation also found that I-129 in the groundwater may be of concern, although to a lesser degree. The maximum doses from either Tc-99 or I-129 were calculated to occur at about 1,700–1,800 years, which is slightly longer than the 500-year Neptune model predictions but well within the minimum 10,000-year model prediction interval required by UAC R313-25-8(5)(a).

**Base Case: Tc-99 Pathway Maximum Dose**

| Groundwater Cleanup Level | Tc-99 Pathway Maximum Dose (mrem/yr) | | | | | |
|---|---|---|---|---|---|---|
| | **Drinking Water** | **Animal Products** | **External Plume and Groundshine** | **Inhalation** | **Terrestrial Crops** | **Total** |
| DF = 1 – No Processing | 716.5 | 62.7 | 0.30 | 0.00 | 1343.5 | 2,123. |
| DF = 10 – NUREG-0017 | 71.7 | 6.3 | 0.03 | 0.00 | 134.3 | 212.3 |
| DF = 21.1 – R309-200-5, 2,000 mg/L | 33.9 | 3.0 | 0.01 | 0.00 | 63.6 | 100.5 |
| DF = 42.2 – R309-200-5, 1,000 mg/L | 17.0 | 1.5 | 0.01 | 0.00 | 31.8 | 50.3 |
| DF = 84.5 – 10 CFR 143.3, 500 mg/L | 8.5 | 0.74 | 0.00 | 0.00 | 15.9 | 25.1 |

The table shows the calculated Tc-99 doses if the groundwater was (1) used unprocessed (included as a benchmark only, in recognition that the unprocessed groundwater could not be used), (2) processed once through a reverse osmosis system with the NRC's recommended decontamination factor (DF) of 10, (3) processed to meet the Utah Drinking Water Board's "no better water available" TDS limit of 2,000 mg/L, (4) processed to meet the Utah Drinking Water Board's TDS limit of 1,000 mg/L, or (5) processed to meet EPA's Secondary Drinking Water TDS limit of 500 mg/L (10 CFR 143.3).

These results should not be taken as definitive, but rather as an indication that even after processing to make the groundwater drinkable, the doses from this pathway may exceed the limits specified in R313-25-19, and more detailed analysis is needed. Energy*Solutions* should also examine how byproducts of future desalination processes (e.g., reject brines and precipitates) that might rely on radio-contaminated groundwater at Clive will need to be managed to protect public health and the environment. Depending on the type of management required or assumed for these byproducts, additional dose to a member of the public may also need to be incorporated into these calculations.

**REFERENCES:**

*Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 143, *National Secondary Drinking Water Regulations*.

U.S. Nuclear Regulatory Commission, *Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors*, NUREG-0017, Revision 1, Office of Nuclear Reactor Regulation, April 1985.

Utah Drinking Water Board, *Primary Drinking Water Standards*, UAC R309-200-5, September 4, 2009.

**INTERROGATORY CR R313-25-7(1)-136/1: IRON (HYDRO)OXIDE FORMATION**

**PRELIMINARY FINDING:**

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

Refer also to R313-25-8(4)(a): *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 R313-25-19.*

**INTERROGATORY STATEMENT:**

Clarify whether the formation of iron (hydro)oxides derived from the waste containers was considered in predicting sorption.

**BASIS FOR INTERROGATORY:**

Section 2.0, page 3, of the Geochemical Modeling report states that *"No credit is given for containment by the steel drums or cylinders."* However, it is not clear whether the geochemical model includes any degradation of the steel to form iron (hydr)oxide phases and subsequent sorption of the radionuclides to those phases. Degradation of the engineered barrier materials is known to produce (hydr)oxide phases with high sorption capacities for cationic radionuclides (see, for example, Bargar et al. 2000, McBeth et al. 2011, Powell et al. 2005, and Tochiyama et al. 1995). For steel canister degradation, these phases may include ferrihydrate, magnetite, goethite, and hematite. If no credit is given for sorption to these steel degradation products, this should be explicitly stated. Furthermore, due to the known strong sorption of uranium to these iron phases, specific consideration of these phases when selecting appropriate $K_d$ values must be demonstrated.

**REFERENCES:**

Bargar, J.R., R. Reitmeyer, J.J. Lenhart, and J.A. Davis, *Characterization of U(VI)-carbonato ternary complexes on hematite: EXAFS and electrophoretic mobility measurements*, Geochimica et Cosmochimica Acta, Vol. 64, pp. 2737–2749, 2000.

McBeth, J.M., J.R. Lloyd, G.T.W. Law, F.R. Livens, I.T. Burke, K. Morris, *Redox interactions of technetium with iron-bearing minerals*, Mineralogical Magazine, Vol. 75, pp. 2419–2430, 2011.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Powell, B.A., R.A. Fjeld, D.I. Kaplan, J.T. Coates, and S.M. Serkiz, *$Pu(V)O_2$+ adsorption and reduction by synthetic hematite and goethite*, Environ. Sci. Technol., Vol. 39, pp. 2107–2114, 2005.

Tochiyama, O., S. Endo, and Y. Inoue, *Sorption of Neptunium(V) on Various Iron-Oxides and Hydrous Iron-Oxides*, Radiochim. Acta, Vol. 68, pp. 105–111, 1995.

## INTERROGATORY CR R313-25-7(1)-137/1: TOTAL DISSOLVED CARBONATE CONCENTRATIONS AND OTHER GEOCHEMICAL DATA

### PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

Refer also to R313-25-8(4)(a): *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 R313-25-19.*

### INTERROGATORY STATEMENT:

1. Reassess the total dissolved carbonate concentrations to determine whether they were underestimated, leading to the underestimation of uranium sorption in subsurface earth materials.
2. Explain and justify why the geochemical data from the seven wells listed in Tables 5 and 6 of the Geochemical Modeling report are representative of the shallow aquifer at Clive, especially in light of the presence of 78 compliance monitoring wells now found in Section 32.
3. Describe what hydrostratigraphic units the water table occupies below the Class A South cell, including in terms of groundwater mounding that exists near GW-19A.
4. Explain and justify the range of TDS quoted for the shallow aquifer at Clive.

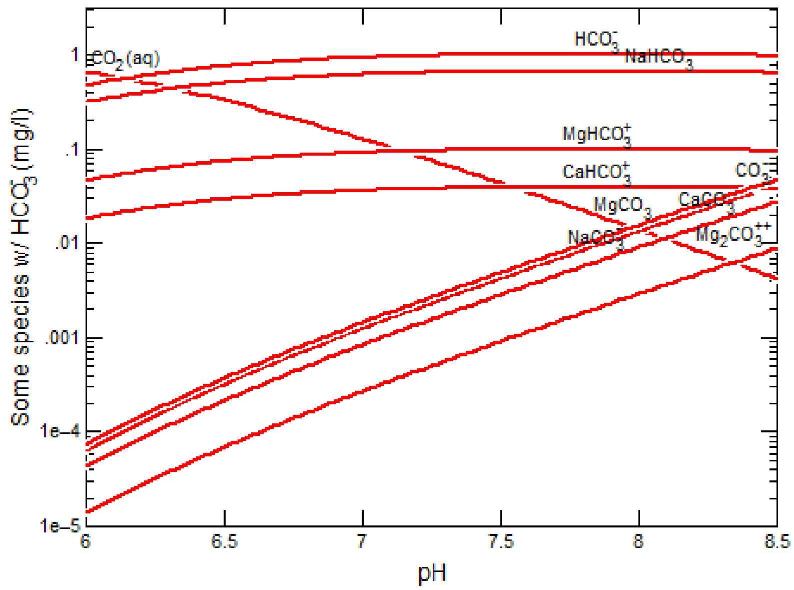
### BASIS FOR INTERROGATORY:

1. Section 2.1, page 5, of the Geochemical Modeling report states that *"Dissolved oxygen and carbon dioxide are expected to be largely in equilibrium with atmospheric conditions, at least in the upper profile including the DU waste zone."*

As noted in other interrogatories, the silt and clay earth materials laid down by the Gilbert Stage of Lake Bonneville are dominated by carbonate minerals. Therefore, specific dissolution of carbonate minerals in the vadose zone and aquifers may yield concentrations of aqueous carbonate higher than those expected assuming equilibration with atmospheric carbonate. The presence of carbonate can hinder uranium sorption through the formation of uranyl-carbonate species as noted in Section 2.0 of the Geochemical Modeling report and by Um et al. (2007), Wan et al. (2005), and Don et al. (2005). It is notable that decreased sorption can be due to binary U(VI)-carbonate species or ternary alkali earth-U(VI)-carbonate species. Therefore, it is important to know both the carbonate and alkali earth element concentrations.

For example, assuming a pH range of 6–8.5 and the average ion concentrations listed in Table 6, the total carbonate concentration in equilibrium with atmospheric carbon dioxide should be around 1 mg/L (see the Geochemist Workbench model output in the figure below). However, the bicarbonate concentrations listed in Table 5 of the report range from 102–350 mg/L. Thus, by assuming only equilibration with atmospheric carbonate, the total dissolved carbonate concentration will be underestimated. This assumption appears to conflict with a statement in Section 2.2, page 5, of the Geochemical Modeling report that previous consultants to Energy*Solutions* have determined the shallow aquifer is super-saturated in calcite and dolomite.

(Modeling was performed with Geochemist Workbench Standard 8.0, using database thermo.com.v8.r6+.dat.)




2. Energy*Solutions* should explain and justify why geochemical data from the seven wells listed in Tables 5 and 6 of the Geochemical Modeling report are representative of the shallow aquifer at Clive; especially in light of the presence of 78 compliance monitoring wells now found in Section 32. Alternatively, if DU disposal is to be done only in the Class A South cell, the text should explain and justify why the seven wells in Tables 5 and 6 adequately represent the 19 shallow monitoring wells that surround the Class A South cell.

3. With respect to hydrostratigraphic units already identified at Clive, Section 2.2, page 5, of the Geochemical Modeling report should describe what units the water table occupies below the Class A South cell, including in terms of groundwater mounding known to exist at the southwestern margin of the Class A South cell (e.g., near GW-19A).

4. Energy*Solutions* should explain and justify the range of TDS quoted for the shallow aquifer at Clive. Energy*Solutions* sampling in 2012 (Energy*Solutions* 2013) found the low end of

the range at 10.4 parts per thousand (10,400 mg/L in GW-60, located on the southeast margin of the Class A South cell).

**REFERENCES:**

Dong, W., W.P. Ball, C. Liu, Z. Wang, A.T. Stone, J. Bai, and J.M. Zachara, *Influence of calcite and dissolved calcium on uranium(VI) sorption to a Hanford subsurface sediment*, Environ. Sci. Technol., Vol. 39, pp. 7949–7955, 2005.

Elzinga, E.J., C.D. Tait, R.J. Reeder, K.D. Rector, R.J. Donohoe, and D.E. Morris, *Spectroscopic investigation of U(VI) sorption at the calcite-water interface*, Geochimica et Cosmochimica Acta, Vol. 68, pp. 2437–2448, 2004.

EnergySolutions, *2012 Annual 11e.(2), LARW, Class A West, and Mixed Waste Groundwater Monitoring Report*, March 1, 2013.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Um, W., R.J. Serne, C.F. Brown, and G.V. Last, *U(VI) adsorption on aquifer sediments at the Hanford Site*, J. Contam. Hydrol., Vol. 93, pp. 255–269, 2007.

Wan, J., T.K. Tokunaga, E. Brodie, Z. Wang, Z. Zheng, D. Herman, T.C. Hazen, M.K. Firestone, and S.R. Sutton, *Reoxidation of bioreduced uranium under reducing conditions*, Environ. Sci. Technol., Vol. 39, pp. 6162–6169, 2005.

**INTERROGATORY CR R313-25-26(1)-138/1: MONITORING WELL COMPLETION ZONES**

**PRELIMINARY FINDING:**

Refer to R313-25-26(1): *At the time a license application is submitted, the applicant shall have conducted a preoperational monitoring program to provide basic environmental data on the disposal site characteristics. The applicant shall obtain information about the ecology, meteorology, climate, hydrology, geology, geochemistry, and seismology of the disposal site. For those characteristics that are subject to seasonal variation, data shall cover at least a 12-month period.*

Refer also to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

**INTERROGATORY STATEMENT:**

Clarify from which completion zones the wells are sampled.

**BASIS FOR INTERROGATORY:**

Section 2.2, page 6, of the Geochemical Modeling report states that *"The Clive Facility has a large number of monitoring wells with completion zones in this aquifer and monitoring data are currently collected from these wells on at least an annual basis."* Although this section relates to the shallow aquifer, both the deep confined aquifer and the shallow aquifer are discussed in the preceding paragraph, so clarification is needed as to which is meant by "*this aquifer*."

**REFERENCES:**

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-7(1)-139/1: ION CHARGE BALANCE**

**PRELIMINARY FINDING:**

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

**INTERROGATORY STATEMENT:**

Clarify the ion charge balance.

**BASIS FOR INTERROGATORY:**

Section 2.2, page 7, of the Geochemical Modeling report states that *"Excellent charge balance is obtained using these data, indicating all major ions are being accounted for."* This statement may be misleading, since sodium and chloride are the dominant ions by far and thus a clear picture of the other major ion concentrations is obscured by the balance of sodium and chloride. The charge balance values should be clarified in the report. The text should note what fraction of the charge is due to sodium and chloride and what fraction is due to all other ions. Doing so will demonstrate how the dominance of sodium and chloride is influencing the reported values.

**REFERENCES:**

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(1)-140/1: DETERMINATION OF $K_d$ VALUES

### PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

### INTERROGATORY STATEMENT:

1. Provide a more detailed description of the determination of $K_d$ values used in the recent PA modeling.
2. For those elements/nuclides that are redox sensitive, describe the redox condition assumed in selecting appropriate $K_d$ values and compare this assumption with all aquifer redox data collected from the shallow Clive aquifer to date.
3. Add a summary table to Section 4.1 of the Geochemical Modeling report that provides more detail on inputs to the model.
4. Compare the site-specific $K_d$ values determined by Adrian Brown Consultants (1997) with the PA model's $K_d$ descriptive statistics and explain and justify any similarities or differences in light of the local geologic conditions and geochemistry and the depositional environment that created the pluvial lake deposits occupied by the Clive vadose zone and shallow aquifer.

### BASIS FOR INTERROGATORY:

1. Section 4.1.3, pages 11–12, of the Geochemical Modeling report describes the determination of the $K_d$ range for cesium. However, the description of how the $K_d$ values were selected is too vague to determine if representative values were actually selected. Clarification is needed for statements such as, "*For this PA model, cesium* $K_d$ *values were selected largely from the look up tables in EPA (1999c), but were adjusted lower due to the high TDS in the saturated zone*" (page 12). A description of how the values were adjusted and the range of TDS values considered from EPA (1999c) (402-R-99-004B) should be included so readers can determine how far down the values were extrapolated.

In addition, the text should explain why and how the $K_d$ values for protactinium were reduced based on high TDS values. Section 4.1.8, page 14, of the report does not provide evidence that protactinium sorbs via ion exchange, making the rationale in reducing the $K_d$ based on TDS unclear.

Strong cesium sorption to many soils is predominantly due to ion exchange reactions that are profoundly influenced by ionic strength. Since the empirical $K_d$ model selected for this PA cannot account for changes in ionic strength, it is vital that the proper range of $K_d$ values is selected.

2. For those elements/nuclides that are redox sensitive, Energy*Solutions* should also describe the redox condition assumed by Neptune in its selection of appropriate $K_d$ values, then

compare this assumption with all aquifer redox data collected from the shallow Clive aquifer to date.

3. A summary table should be added to Section 4.1 of the Geochemical Modeling report to provide the following information:
   - Nuclide simulated in the GoldSim model
   - $K_d$ distribution used in the model, whether normal or log-normal
   - Mean $K_d$ value (or geomean)
   - Standard deviation (or geometric standard deviation)
   - Coefficient of variance for each nuclide $K_d$
   - Full range of $K_d$ inputs used for each nuclide, whether minimum and maximum values or the upper and lower confidence intervals
   - The corresponding laboratory-determined $K_d$, using Clive soils and Clive groundwater, reported by Adrian Brown Consultants (1997)
4. Energy*Solutions* should compare the site-specific $K_d$ values determined by Adrian Brown Consultants (1997) with the Neptune model's $K_d$ descriptive statistics, as listed in the new table. Any $K_d$ similarities or differences in the values used by Neptune should be explained and justified. Where the Neptune used $K_d$ values show a significant difference in mean (or geomean) values, or a higher degree of variance, compared to the site-specific data reported by Adrian Brown Consultants (1997), this practice should be explained and justified in light of the local geologic conditions and geochemistry and the depositional environment that created the pluvial lake deposits occupied by the Clive vadose zone and shallow aquifer.

**REFERENCES:**

Adrian Brown Consultants, *Response to UDEQ $K_d$ Interrogatories*, Report 3101B.970422, April 22, 1997.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Environmental Protection Agency, *Understanding the Variation in Partition Coefficient, $K_d$, Values*, 402-R-99-004B, Volume II, 1999.

## INTERROGATORY CR R313-25-7(1)-141/1: pH AND $K_d$ VALUES AND SERNE (2007)

### PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

### INTERROGATORY STATEMENT:

Consider pH values when estimating $K_d$ values and provide more detail on the "*non-groundwater scenario*" used in Serne (2007).

### BASIS FOR INTERROGATORY:

Section 4.0, page 10, of the Geochemical Modeling report refers to the work of Serne (2007) and states that "*Of note is that the Hanford soils are slightly acidic, with organic content of 0.5 to 1.5% organic carbon somewhat different from the Clive location.*" However, Section 2.0, page 3, of the report indicates that the pore water pH values at the Clive location are neutral to slightly alkaline. The pH of a system may be the most important variable influencing sorption. If the pH values are different, there will be a very high level of uncertainty when using data from Serne (2007), even if the results are important only "*from a semi-quantitative perspective*."

The text should cite the range of pH values for the Hanford system examined by Serne (2007).

Additionally, the text should cite the range of total organic carbon content in the groundwater, based on analysis of local groundwater samples.

In addition, Section 4.0 refers in several places (e.g., Section 4.1.2, page 11) to the "*non-groundwater scenario*" included in Serne (2007). The text should describe this scenario.

### REFERENCES:

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Serne, R.J., *Kd Values for Agricultural and Surface Soils for Use in Hanford Site Farm, Residential, and River Shoreline Scenarios*, Technical Report for Ground-Water Protection Project – Characterization of Systems Task, PNNL-16531, August 2007.

## INTERROGATORY CR R313-25-7(1)-142/1: REFERENCES FOR $K_d$ DISCUSSION

### PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

### INTERROGATORY STATEMENT:

Provide additional references to support the discussion of $K_d$ values. Alternatively, either (1) select conservatively low $K_d$ values or (2) collect Clive soil and groundwater samples and perform independent laboratory testing to determine a site-specific empirical value(s).

### BASIS FOR INTERROGATORY:

Section 4.0, pages 11–16, of the Geochemical Modeling report describes the derivation of the partition coefficient for each element used in the transport model. Each subsection begins by stating the expected chemical species of each ion. The model used to determine these species should be provided, including a referenced list of thermodynamic constants or a referenced database.

Furthermore, since this PA used an empirical $K_d$ model, it seems the discussion of the chemical speciation is somewhat irrelevant. However, since it is included, it should be properly documented. A recommended approach would be to show that speciation and the speciation from the sites from which the $K_d$ values are selected. Matching the aqueous species between the two sites would enable much more confidence in the $K_d$ approach.

The solid phase composition between sites should also be compared, if possible. However, this may not be possible when using the EPA look-up tables since exact solid phase compositions are not considered when using the tables. Since direct comparisons cannot be made in all cases, and use of data from the EPA look-up tables is necessary for this modeling framework, the emphasis should be on demonstrating that the most appropriate data were selected from the tables. Alternatively, Energy*Solutions* can either (1) select conservatively low $K_d$ values (i.e., values that equal or are nearly equal to the lowest data in the peer-reviewed literature) or (2) collect Clive soil and groundwater samples and perform independent laboratory testing to determine a site-specific empirical value(s).

### REFERENCES:

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(1)-143/1: NEPTUNIUM SPECIATION

### PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

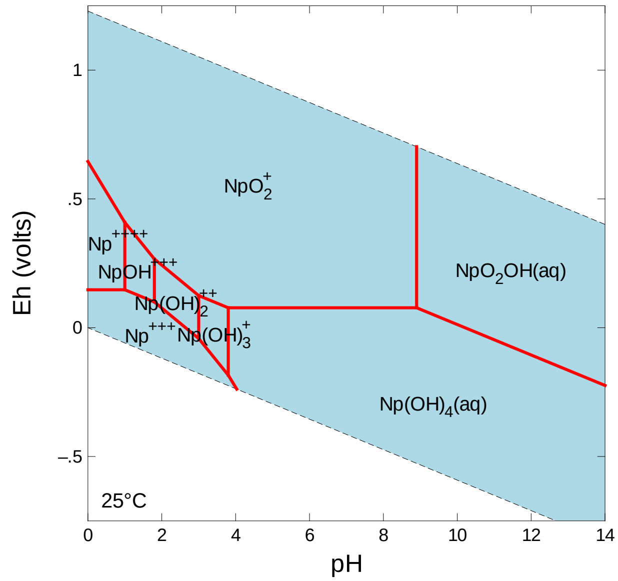
### INTERROGATORY STATEMENT:

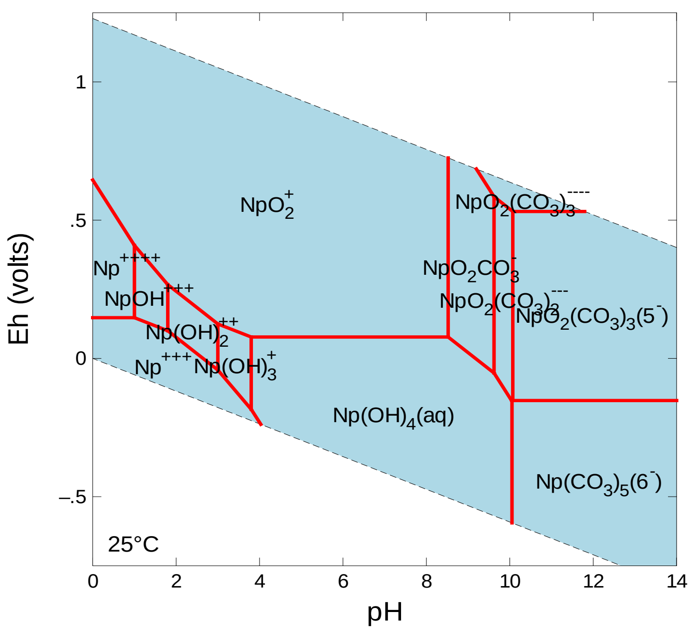
Correct a reference to Np(VI) and provide citations. Alternatively, either (1) select conservatively low $K_d$ values or (2) collect Clive soil and groundwater samples and perform independent laboratory testing to determine a site-specific empirical value(s).

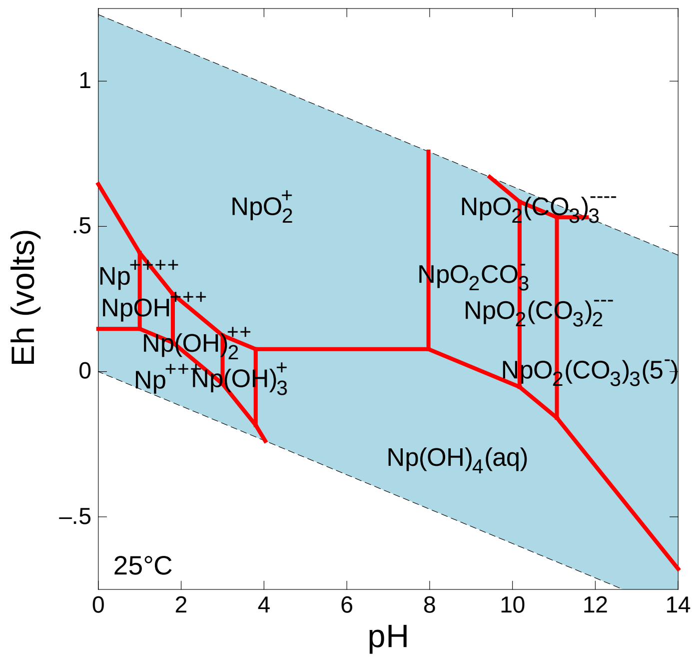
### BASIS FOR INTERROGATORY:

Section 4.1.6, page 13, of the Geochemical Modeling report states that "*The transient, mildly reducing conditions that can exist at Clive and the presence of carbonates may lead to the formation of Np(VI) carbonate complexes above pH 7*." However, based on the $E_H$-pH diagrams below, Np(VI) phases will not form under the reported conditions of the Clive site. Modeling was performed without atmospheric $CO_2$(g) (top figure),with atmospheric $CO_2$(g) (middle figure), and with 350 mg/L of total carbonate (bottom figure) with Geochemist Workbench Standard 8.0 using database thermo.com.v8.r6+.dat. The maximum carbonate concentration listed in Table 5 of the Geochemical Modeling report is 350 mg/K. Only a small region of stability for Np(VI) exists in the presence of carbonate around pH 10 and electrode potentials of 0.6 volts. Increasing the carbonate concentration only increases the stability of the Np(V) complexes, not the NP(VI) complexes. If the mention of Np(VI) in the text was a typographical error and the text intended to refer to Np(IV) forming carbonate species, it should include a reference for the thermochemical constants used to determine that speciation.

If for any reason Energy*Solutions* is unable to reconcile these or any other discrepancies with neptunium $K_d$ values used in the GoldSim model with local Clive geologic and geochemical conditions (vadose or shallow aquifer), Energy*Solutions* will need to (1) use conservatively low K*d* values found in available peer-reviewed technical literature or (2) collect Clive soil and groundwater samples and perform independent laboratory testing to determine a site-specific empirical value(s).


NpO2+
Np++++
NpOH+++
Np(OH)2++
Np+++
Np(OH)3+
NpO2OH(aq)
Np(OH)4(aq)
25°C
Eh (volts)
pH


NpO2+
NpO2(CO3)3----
NpO2CO3-
NpO2(CO3)2---
NpO2(CO3)3(5-)
Np++++
NpOH+++
Np(OH)2++
Np+++
Np(OH)3+
Np(OH)4(aq)
Np(CO3)5(6-)
25°C
Eh (volts)
pH




**REFERENCES:**

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(1)-144/1: PLUTONIUM SPECIATION

### PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

### INTERROGATORY STATEMENT:

Provide additional information to support the assumptions with respect to plutonium speciation.

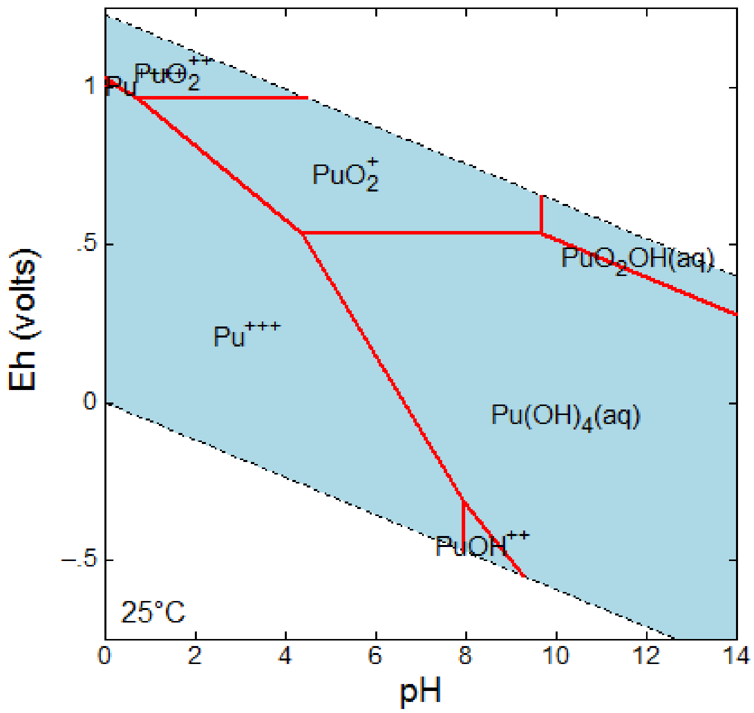
### BASIS FOR INTERROGATORY:

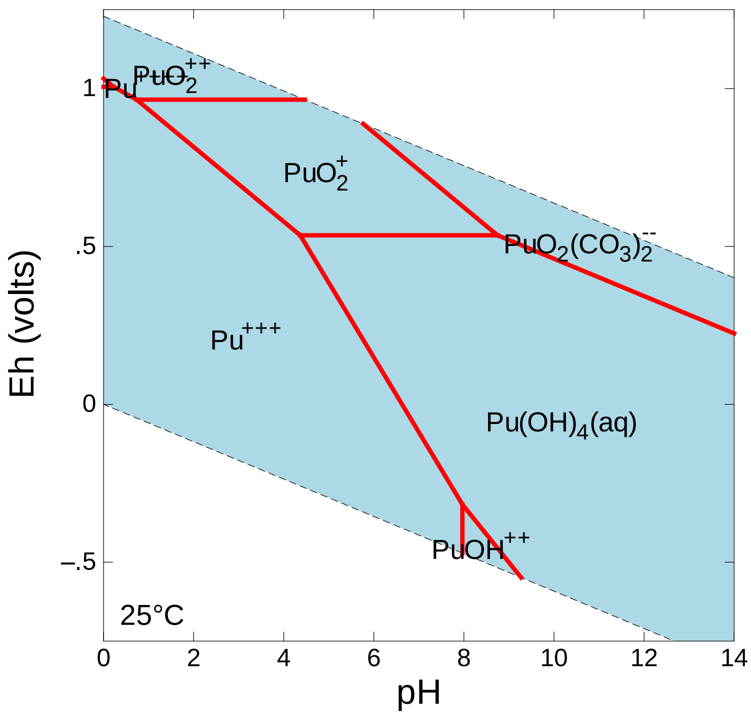
Section 4.1.7, page 13, of the Geochemical Modeling report states that "*Plutonium can be found in a number of valence states under the conditions at Clive. The most likely states are as Pu(V) and Pu(VI) both as cations and complexed with hydroxide and carbonate.*"

The specific data or model used to verify the statement should be provided. The simple Eh-pH figure below, generated from our own modeling, and many similar ones that can be found in the literature indicate that Pu(V) and Pu(VI) species will likely not be the dominant species given the pH and Eh ranges reported in Table 5. The top figure is the model output in the absence of atmospheric carbonate and the bottom figure is the model output with the carbonate concentration set to 350 mg/L total carbonate (which is the maximum carbonate concentration listed in Table 5 of the Geochemical Modeling report). There is no significant change in the redox speciation between the two models. Since the existing thermochemical databases for plutonium may have some conflicting data, it is important to document the model used for the statements quoted from the Geochemical Modeling report. However, even if Pu(V) and Pu(VI) are thermochemically predicted to be stable under the porewater conditions at the Clive site, many studies have demonstrated surface mediated reduction of Pu(V) on metal oxide, soil, and sediments (see Kenney-Kennicutt and Norse, 1985; Powell et al., 2004 and 2005; Romachuk et al., 2011; and Sanchez et al., 1985).

(Modeling was performed with Geochemist Workbench Standard 8.0 using database thermo.com.v8.r6+.dat.)

If for any reason Energy*Solutions* is unable to reconcile these or any other discrepancies with neptunium $K_d$ values used in the GoldSim model with local Clive geologic and geochemical conditions (vadose or shallow aquifer), Energy*Solutions* will need to (1) use conservatively low $K_d$ values found in available peer-reviewed technical literature or (2) collect Clive soil and groundwater samples and perform independent laboratory testing to determine a site-specific empirical value(s).


Pu
$PuO_2^{++}$
$PuO_2^+$
$PuO_2OH(aq)$
$Pu^{+++}$
$Pu(OH)_4(aq)$
$PuOH^{++}$
25°C
Eh (volts)
pH
1
.5
0
–.5
0
2
4
6
8
10
12
14


Pu
$PuO_2^{++}$
$PuO_2^+$
$PuO_2(CO_3)_2^{--}$
$Pu^{+++}$
$Pu(OH)_4(aq)$
$PuOH^{++}$
25°C
Eh (volts)
pH
1
.5
0
–.5
0
2
4
6
8
10
12
14

**REFERENCES:**

Kenney-Kennicutt, W.L., J.W. Morse, *The redox chemistry of Pu(V)$O_2$+ interaction with common mineral surfaces in dilute solutions and seawater*, Geochimica et Cosmochimica Acta, Vol. 49, pp. 2577‒2588, 1985.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Powell, B.A., R.A. Fjeld, D.I. Kaplan, J.T. Coates, and S.M. Serkiz, *Pu(V)$O_2$+ adsorption and reduction by synthetic hematite and goethite*, Environ. Sci. Technol., Vol. 39, pp. 2107‒2114, 2005.

Powell, B.A., R.A. Fjeld, D.I. Kaplan, J.T. Coates, and S.M. Serkiz, *Pu(V)$O_2$+ adsorption and reduction by synthetic magnetite ($Fe_3O_4$)*, Environ. Sci. Technol., Vol. 38, pp. 6016‒6024, 2004.

Romanchuk, A.Y., S.N. Kalmykov, and R.A. Aliev, *Plutonium sorption onto hematite colloids at femto- and nanomolar concentrations*, Radiochim. Acta, Vol. 99, pp. 137‒144, 2011.

Sanchez, A.L., J.W. Murray, and T.H. Sibley, *The adsorption of plutonium-IV and plutonium-V on goethite*, Geochimica et Cosmochimica Acta, Vol. 49, p. 2297, 1985.

**INTERROGATORY CR R313-25-7(1)-145/1: SORPTION REVERSIBILITY AND GLOVER ET AL. (1976) DATASET**

**PRELIMINARY FINDING:**

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

**INTERROGATORY STATEMENT:**

Provide further explanation for the potential impact of reversibility of sorption on the PA and the relevance of the Glover et al. (1976) dataset.

**BASIS FOR INTERROGATORY:**

Section 4.1.7, page 13, of the Geochemical Modeling report states that "*Some studies indicate the sorption is non-reversible.*" Since a $K_d$ model was selected for this work and a fundamental assumption in it is that of reversibility, this has significant implications for the model of plutonium transport. The significance of the statement about non-reversibility should be explained, particularly in light of the deep time aspects now required in PA modeling and possible changes in local geochemical conditions.

In addition, the text states that "*Data by Glover et al. (1976) found in the EPA (EPA 1999c) series may be of particular relevance to the Clive location.*" The text should clarify what exactly in the dataset from Glover et al. (1976) makes it particularly relevant for the Clive site and explain how and why Energy*Solutions* increased the limit on the $K_d$ values.

**REFERENCES:**

Glover, P.A., F.J. Miner, and W.O. Polzer. *Plutonium and americium behavior in the soil/water environment, I: Sorption of plutonium and americium by soils*, in Proceedings of Actinide-Sediment Reactions Working Meeting, Seattle, Washington, pp. 225–254, BNWL-2117, Battelle Pacific Northwest Laboratories, Richland, Washington, 1976.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA,* May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

U.S. Environmental Protection Agency, *Understanding the Variation in Partition Coefficient, Kd, Values*, 402-R-99-004B, Volume II, 1999.

## INTERROGATORY CR R313-25-7(1)-146/1: DETERMINATION OF $K_d$ VALUES

### PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

### INTERROGATORY STATEMENT:

Provide further explanation on how the $K_d$ values for each radionuclide were selected. Elaborate on how the soil textures listed in Table 1 of the Geochemical Modeling report, or any other factors, were used to determine the Clive $K_d$ ranges for the respective nuclides. Provide a summary table of actual $K_d$ values used for each element/nuclide.

### BASIS FOR INTERROGATORY:

Table 1 of the Geochemical Modeling report provides the distribution parameters for $K_d$ for materials, as explained in Section 4.0. The text should explain exactly how the $K_d$ values in Table 1 were selected, including the quantitative means used to take the $K_d$ values reported in the literature and determine the ranges given in Table 1. For example, Section 4.1.9, page 14, states that "*A range based on all of the above data was chosen for each material class,*" but does not explain how. Energy*Solutions* should elaborate how the soil textures listed in Table 1, or any other factors, were used to determine the Clive $K_d$ ranges for the respective nuclides. A summary table should be provided to disclose the actual $K_d$ values used for each element/nuclide.

### REFERENCES:

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(1)-147/1: DETERMINATION OF $K_d$ VALUE FOR URANIUM

### PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

### INTERROGATORY STATEMENT:

Provide support for assumptions regarding the derivation of the partition coefficient for uranium with regard to the results of an increase in ionic strength and the potential bias of high Kd values for ferrihydrite and kaolinite.

### BASIS FOR INTERROGATORY:

Section 4.1.13, page 15, of the Geochemical Modeling report states that "*As the ionic strength increases, other cations will displace the uranyl* $(UO_2)^{2+}$ *ion.*" This statement should be supported with a reference; also note that uranyl should be written as ($UO_2^{2+}$).

In addition, Section 4.1.13, page 16, of the report states the following:

> *The minimum value was based on values calculated for quartz with the maximum value based on data calculated for ferrihydrite and kaolinite. These very high* $K_d$ *values are considered potentially biased by one order of magnitude.*

The rationale for this assumption should be presented and justified. If for any reason Energy*Solutions* is unable to adequately justify the uranium $K_d$ values used in the model, in terms of local Clive geologic and geochemical conditions (vadose or shallow aquifer), Energy*Solutions* will need to (1) use conservatively low $K_d$ values found in available peer-reviewed technical literature or (2) collect additional Clive soil and groundwater samples and perform new, independent laboratory testing to determine a site-specific range of empirical values.

### REFERENCES:

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(1)-148/1: INFLUENCE OF CARBONATE ON URANIUM SPECIATION

### PRELIMINARY FINDING:

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

### INTERROGATORY STATEMENT:

Resolve contradictory statements regarding uranium sorption and focus the discussion on the influence of carbonate on uranium speciation.

### BASIS FOR INTERROGATORY:

Section 4.1.13, page 15, of the Geochemical Modeling report states the following:

> *Uranium sorption on iron oxide minerals and smectite clays is extensive except in the presence of carbonate where this is reduced (EPA 1999c).*

However, Section 4.1.13, page 16, states the following:

> *The U(VI) species in the aqueous environment will not have particularly strong sorption tendencies.*

These and other similar statements appear to contradict one another. The text should clarify this discrepancy and focus more on the influence of carbonate on uranium speciation. This is particularly important given that groundwater in the shallow aquifer appears to be super-saturated with carbonate minerals, and its matrix is heavily dominated by carbonate minerals (as noted in another interrogatory).

The wide range of uranium $K_d$ values identified in this section is primarily dependent on the system pH and the concentration of carbonate in the aqueous phase. As the text notes, the presence of carbonate causes a marked decrease in uranium sorption. Therefore, to ensure that proper $K_d$ values were captured within that range, appropriate documentation is needed regarding the carbonate values used in experiments where the selected $K_d$ values were determined. Those carbonate values need to compare favorably to those listed in Table 5 of the report. Some overall discussion should be added regarding how the carbonate concentrations were qualitatively or quantitatively considered when selecting the uranium $K_d$ values. The proposed uranium $K_d$ values should also be compared and justified against the value determined by Adrian Brown Consultants (1997) on Clive soils and groundwater.

If for any reason Energy*Solutions* is unable to adequately justify the uranium $K_d$ values used in the model, in terms of local Clive geologic and geochemical conditions (vadose or shallow aquifer) or the Clive-specific values previously determined by Adrian Brown Consultants (1997), Energy*Solutions* will need to (1) use conservatively low $K_d$ values found in available peer-reviewed technical literature or (2) collect additional Clive soil and groundwater samples and perform new, independent laboratory testing to determine a site-specific range of empirical values.

**REFERENCES:**

Adrian Brown Consultants, *Response to UDEQ $K_d$ Interrogatories*, Report 3101B.970422, April 22, 1997.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA,* May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-7(1)-149/1: AMERICIUM SORPTION**

**PRELIMINARY FINDING:**

Refer to R313-25-7(1): *A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

**INTERROGATORY STATEMENT:**

Provide additional justification for the assumptions made regarding americium sorption and for the preferred range of values in light of the elevated TDS content of shallow Clive groundwater and the competing ion effect.

**BASIS FOR INTERROGATORY:**

Section 5.1.2, page 19, of the Geochemical Modeling report states the following:

> *At Yucca Mountain the americium solubility used in the TSPA model ranged from $10^{-10}$ M to $10^{-6}$ M (LANL 1997). A similar range is used in this PA model.*

This wide range of solubility values for Am(III), without redox reactions causing a broad range, should be explained. In LANL (1997) (LA-13262-MS), most of the Am(III) values were within the range of $10^{-9}$–$10^{-8}$. A value of $10^{-6}$ was reported as potentially suspect. Therefore, the range considered in the PA model as noted in Section 5.1.2 may be unnecessarily broad. Energy*Solutions* should also justify the preferred range of values in light of the elevated TDS content of shallow Clive groundwater and the competing ion effect.

**REFERENCES:**

Los Alamos National Laboratory, *Summary and Synthesis Report on Radionuclide Retardation for the Yucca Mountain Site Characterization Project*, LA-13262-MS, 1997.

Neptune and Company, Inc., *Radionuclide Geochemical Modeling for the Clive DU PA*, May 28, 2011. (Appendix 6 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(2)-150/1: PLANT GROWTH AND COVER PERFORMANCE

### PRELIMINARY FINDING:

Refer to R313-25-7(2): *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.*

### INTERROGATORY STATEMENT:

Clarify the nature and degree to which plant growth might impact future system performance. Justify the use of the selected root penetration value and discuss the potential for deep plant rooting.

### BASIS FOR INTERROGATORY:

FRV1 Section 4.1.2.1, page 27, and various of its appendices describe the cover profile and indicate that the uppermost layer is rip rap, which would seem to inhibit growth of grasses and forbs, at least initially. On the other hand, Section 3.1, page 11, of the Dose Assessment report suggests that aeolian deposits of fine material may allow vegetation to become established. The text further states that increased vegetation would lead to higher evapotranspiration rates (thereby enhancing performance by lowering recharge). Although this may be the case, the macropores left by root systems of former plants (particularly phreatophytes) could lead to focused recharge and significantly greater infiltration rates and depths. Macropores could also lead to increased radon emissions to the surface from the disposal embankment. The text should more fully discuss the potential impacts on embankment and site performance due to the type and distribution of plant growth on the cap.

After discussing the smaller, shallow-rooted greasewood plants noted on site, Neptune and Company, Inc. (2011a) indicates that more deeply rooting black greasewood plants are also observed on site, especially where precipitation runoff is concentrated, and these plants may extend taproots to exploit deeper water. A maximum root depth of 5.7 meters (Robertson 1983, p. 311) is used in this model. It is noted that the depth of only 5.7 meters used in the Neptune and Company, Inc. (2011a) model is far less than the 10–18 meters reported by a number of scientists for maximum depth of rooting by black greasewood at other sites. Thus, the depth described in the PA model does not appear to be reasonably conservative. Energy*Solutions* should justify the use of the root penetration value.

Other plants reported to live on site include shadscale saltbush (*Atriplex confertifolia*) and four-wing saltbush (*Atriplex canescens*). The latter is known from studies at other sites to root very deeply (e.g., USDA 2013). Shadscale saltbush may naturally hybridize with four-wing saltbush when both are present in the same area, since the two species are similar (Simonin 2001). Numerous sources report that saltbush species serve as forage for cattle and sheep (e.g., USDA

2013). Therefore, the PA, which currently denies the potential for deep plant rooting and for forage and plant uptake on site, needs to discuss forage plants on site, including black greasewood, shadscale saltbush, and four-wing saltbush.

In addition, saltbush can potentially bring radionuclides to the surface. Dreesen and Marple (1979) report that, in a greenhouse experiment, uranium nuclides and radium-226 were taken up from soil-covered uranium-mill alkaline tailings by four-wing saltbush and were found in the plant's above-ground biomass at elevated concentrations. Uranium was found at mean concentrations about 41 times that found in four-wing saltbush grown in uncontaminated soil, and radium-226 was found at mean concentrations about 15.5 times that found in four-wing saltbush grown in uncontaminated soil. It is likely that similar activities can occur in shadscale saltbush.

Howard (2003) states that "*Where soils allow, taproots* [of four-wing saltbush] *often extend more than 20 feet (6 m)*." Since four-wing saltbush is present on site, the potential for its taproots to penetrate the cover system and move down into waste and perhaps beyond must be considered in the PA and its associated model.

**REFERENCES:**

Dreeson, D.R., and M.L. Marple, *Uptake of trace elements and radionuclides from uranium mill tailings by four-wing saltbush (*Atriplex canescens*) and alkali sacaton (*Sporobolus airoides*)*, in Proceedings of the Second Symposium on Uranium Mill Tailings Management, Fort Collins, CO, November 19–20, 1979, Geotechnical Engineering, Civil Engineering Program, Colorado State University, 1979.

Howard, J.L., *Atriplex canescens*, in U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, 2003, retrieved October 2013 from www.fs.fed.us/database/feis/plants/shrub/atrcan/all.html.

Neptune and Company, Inc., *Dose Assessment for the Clive DU PA*, May 28, 2011. (Appendix 11 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Biologically-Induced Transport Modeling for the Clive DU PA*, prepared for Energy*Solutions*, May 28, 2011a.

Robertson, J.H., *Greasewood (*Sarcobatus vermiculatus (Hook.) Torr.*)*, Phytologia, Vol. 54, pp. 309–324, 1983.

Simonin, Kevin A, *Atriplex confertifolia*, in Fire Effects Information System, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, 2001, retrieved October 2013 from www.fs.fed.us/database/feis/plants/shrub/atrcon/all.html/.

U.S. Department of Agriculture (2013) Fourwing saltbush, Atriplex canescens (Pursh) Nutt., Plant Guide, U.S. Department of Agriculture, Natural Resources Conservation Service. Retrieved February 2013 from http://plants.usda.gov/plantguide/pdf/pg_atca2.pdf.

## INTERROGATORY CR R313-25-8(4)(A)-151/1: RADON BARRIER ATTENUATION

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

### INTERROGATORY STATEMENT:

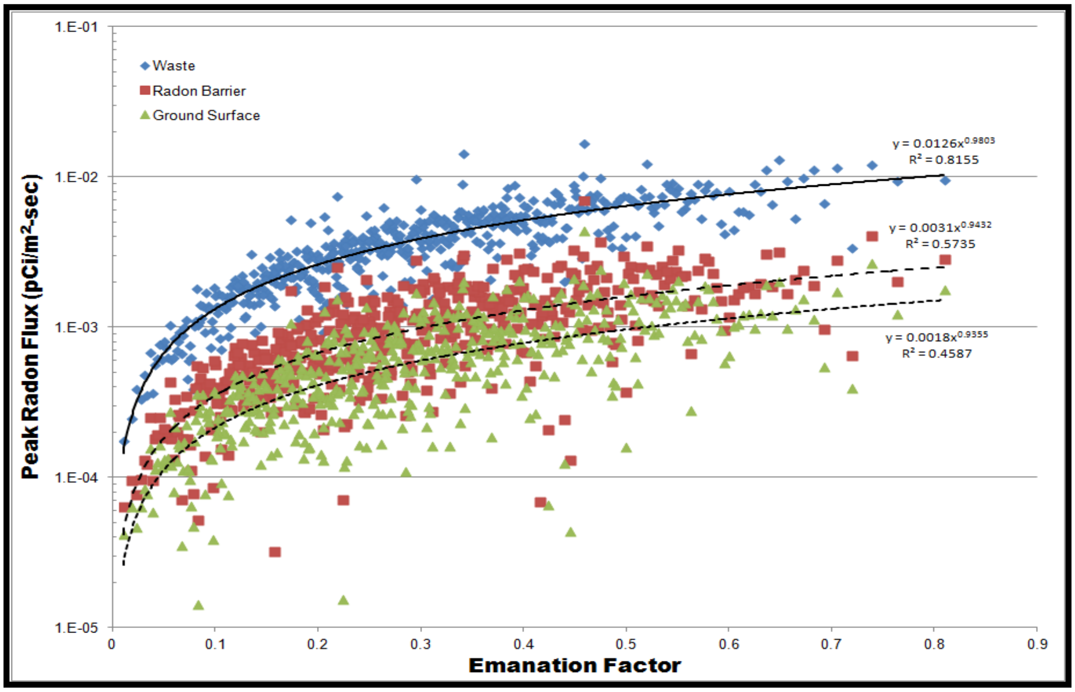
Describe the role performed by the design of the radon barrier in demonstrating that the exposures to humans from the release of radon will not exceed the limits in R313-25-19. Include the value of any diffusion coefficients used (and justification for their selection) and the basis for any radon attenuation calculated. If either of the diffusion coefficients or attenuation is different for the DU PA model from what were used for other facilities at the Clive site (e.g., the LLRW and 11e.(2) disposal facilities), provide justification for those differences.

### BASIS FOR INTERROGATORY:

As a part of this review, GoldSim analyses were performed using the DU PA model that was supplied to DRC by Energy*Solutions*. The figure below shows some of the results from running that model for the case of 10-meter burial, without gullies. It depicts the peak radon flux on top of the 27-layer waste pile, on top of the two-layer radon barrier, and on the ground surface, as a function of the radon emanation factor. These fluxes were extracted from the Results Mode of the GoldSim file.

Best fit equations have been formed for each of the three sets of radon fluxes, and the resulting trendlines are also shown on the figure. The $R^2$ value associated with each set shows that the emanation factor accounts for about 82% of the flux variability on top of the waste, about 57% on top of the radon barrier, and only about 46% on the ground surface. This behavior is expected and shows that as the flux gets further away from the source, there are more parameters with uncertainty to influence the flux.

**Peak Radon Flux on Top of the Waste, on Top of the Radon Barrier, and on the Ground Surface**




The mean emanation factor used in the DU PA model is 0.29 (Table 25 of the Model Parameters report). If this mean emanation factor is plugged into the best fit equations for on top of the waste and on top of the radon barrier, the resulting radon fluxes are 0.0037 and 0.00096 pCi/m$^{2-}$s, respectively. By dividing the top of the waste flux into the top of the barrier flux, the attenuation of the radon barrier is calculated to be about 0.26 (0.00096 / 0.0037).

IAEA (2013) states that the radon attenuation of a material of thickness "t" centimeters can be estimated by: exp(-t / DL), where DL is the diffusion length, defined as:

$$\sqrt{D_C/\lambda},$$

Where:

$\lambda$ = the Rn-222 decay constant (s$^{-}$1)
$D_{c\,=}$ the radon diffusion coefficient (cm$^2$/s)

These relationships can be rearranged to calculate the radon diffusion coefficient associated with a 2-foot (61-centimeter) thick radon barrier that provides about 0.26 attenuation. Plugging these values into the rearranged equations results in a diffusion coefficient estimate of about 0.0053 cm$^2$/s.

Rogers (2002) provides an analysis and argument for using a radon diffusion coefficient for the clay material of the LLRW and 11e.(2) disposal facility's radon barrier of 0.00064 cm$^2$/s (Rogers 2002, Scenarios 1, 3, and 5) to replace a coefficient of 0.008 cm$^2$/s (Rogers 2002, Scenarios 2 and 4).

It is not clear why the radon barrier over the DU disposal area would have a different diffusion coefficient from the barrier over the LLRW and 11e.(2) disposal facilities. Since in the DU PA model the doses to the general population (both individual and population) are dominated by radon flux, it is important that the basis for calculating the attenuation of the radon barrier be thoroughly understood. The radon diffusion coefficients used in the PA model should be fully explained and justified.

**REFERENCES:**

International Atomic Energy Agency, *Measurement and Calculation of Radon Releases from NORM Residues*, Technical Report Series No. 474, 85 pp., 2013.

Neptune and Company, Inc., *Model Parameters for the Clive DU PA Model*, May 28, 2011. (Appendix 16 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Rogers, T., *A Change in Envirocare's Disposal Cell Design*, Envirocare of Utah, Waste Management '02 Conference, February 24–28, Tucson, AZ, 2002.

## INTERROGATORY CR R313-25-8(5)(A)-152/1: GOLDSIM INPUT PARAMETERS

### PRELIMINARY FINDING:

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

### INTERROGATORY STATEMENT:

Provide documentation and justification for the radon correction factors (RnDiffusivityCorrection) used in the GoldSim DU PA Model.

### BASIS FOR INTERROGATORY:

FRV1 and its appendices describe in detail the DU PA Model developed by Energy*Solutions* and Neptune. This model was converted into one or more GoldSim model files (i.e., .gsm files). The GoldSim model file “Clive DU PA Model v1.0.gsm” was reviewed to determine whether the data from FRV1 and its appendices were correctly implemented.

We primarily reviewed three data types: (1) scalar data, GoldSim icon: , (2) stochastic data or probability distributions, icon: , and (3) lookup tables, icon: . We used the GoldSim icons to identify the data to be reviewed and then searched FRV1, primarily the Model Parameters report, to confirm that the GoldSim value was the same as the documented value. Using this method, we reviewed in total almost 1,200 data points.

In subcontainers to the TopSlope container, the term RnDiffusivityCorrection is used several times. In the LocalAir subcontainer, RnDiffusivityCorrection has the value of 0.96, while in the RnBarrierLayers/LocalAir and Liner/LocalAir subcontainers, it has the value of 0.85, and in the WasteLayers\LocalAir subcontainer it has the value of 0.343. FRV1 and its appendices did not provide documentation for these numerical values. Although Section 9.4.3, pages 55–56, of the Unsaturated Zone Modeling report describes why the radon correction factors are needed and how they should be calculated, it does not document what radon correction factors should be used.

Because no documentation is provided for these values, it is unknown whether the three radon corrections factors are conservative, realistic, or liberal. Since the radon pathway is a major contributor to the dose for most of the cases studied (including burial at 10 meters), additional documentation and justification of these radon correction factors is needed.

**REFERENCES:**

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Model Parameters for the Clive DU PA Model*, May 28, 2011. (Appendix 16 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-8(4)(D)-153/1: IMPACT OF PEDOGENIC PROCESS ON THE RADON BARRIER**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

**INTERROGATORY STATEMENT:**

Demonstrate that the impact of pedogenic processes has been included in embankment cover performance, particularly with respect to effects on hydraulic conductivity.

**BASIS FOR INTERROGATORY:**

Traditional rock covers require perpetual maintenance of the surface to ensure the radon barrier remains visible. Vegetation gets established in the silt that accumulates in the pores in the rock layer and extends roots into the radon barrier, causing it to desiccate and crack. However, the assessments of the water balance and rock armor cover designs do not acknowledge that pedogenic processes may alter the hydraulic properties of the radon barrier substantially, resulting in an increase in saturated hydraulic conductivity and potentially an increase in percolation rate into the underlying waste (Benson et al. 2011). The radon barrier will be moist compared to other layers in the profile, particularly if compacted near optimum water content to achieve the desired saturated hydraulic conductivity of $5x10^{-8}$ cm/s. Over time, opportunistic vegetation will extend roots into this layer to remove the moisture for transpiration, resulting in a decrease in pore water pressure, shrinkage of the barrier material, and cracking.

This phenomenon was observed in 2007 when exhuming caisson lysimeters used to evaluate a water balance cover for the Monticello Disposal Facility in Monticello, Utah. Roots had penetrated the radon barrier, resulting in cracks and higher than anticipated hydraulic conductivity. One large-scale undisturbed block sample from the radon barrier had a saturated hydraulic conductivity of $3.2x10^{-4}$ cm/s (Benson et al. 2008), or nearly four orders of magnitude more permeable than radon barrier proposed in the water balance and rock armor covers for the Federal Cell.

In addition, Section 3.1.5, page 3-4, of the 2013 Compliance Report, Revision 1, states that "*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.*" Energy*Solutions* should provide additional information on how the model input parameters account for the deleterious effects of vegetation on the cover system and the subsequent impacts on the modeling results.

**REFERENCES:**

Benson, C., W. Albright, D. Fratta, J. Tinjum, E. Kucukkirca, S. Lee, J. Scalia, P. Schlicht, X. Wang, *Engineered Covers for Waste Containment: Changes in Engineering Properties &*

*Implications for Long-Term Performance Assessment*, NUREG/CR-7028, U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, 2011.

Benson, C., S. Lee, X. Wang, W. Albright, and W. Waugh, *Hydraulic Properties and Geomorphology of the Earthen Component of the Final Cover at the Monticello Uranium Mill Tailings Repository*, Geological Engineering Report No. 08-04, University of Wisconsin, Madison, Wisconsin, 2008.

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

## INTERROGATORY CR R313-25-8(4)(D)-154/1: USE OF FIELD DATA TO VALIDATE DISPOSAL CELL COVER PERFORMANCE

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

### INTERROGATORY STATEMENT:

Document the extent to which field data were used to validate the performance of the proposed Federal Cell cover design; include consideration of information from DOE disposal sites.

### BASIS FOR INTERROGATORY:

Hydrologic assessment of cover performance has become increasingly reliant on confirmation of performance using field data from site-specific studies or from analog studies with similar properties. This type of comparison is used to confirm or build confidence in predictions made with variably saturated flow models in performance assessments.

There are two field studies of particular relevance to the Federal Cell: (1) the long-term monitoring study being conducted by the DOE Office of Legacy Management on the water balance cover at the Monticello Disposal Facility and (2) the Enhanced Cover Assessment Project study being conducted by the same DOE office on rock armor covers at the Cheney Disposal Facility near Grand Junction, Colorado (DOE 2012, DOE 2013). Monticello is wetter than the location of the Federal Cell (average annual precipitation = 353 mm/yr), whereas the Cheney site has comparable precipitation (average annual precipitation = 196 mm/yr).

Figure 1 (Benson et al. 2008) and Figure 2 (Bareither and Benson 2013) show the cover profiles at these sites. Both sites employ large-scale volumetric lysimeters based on the design developed in the Alternative Cover Assessment Program, as described in Benson et al. (2001) and Albright et al. (2010). The Cheney site has two replicate lysimeters, labeled C and R. Percolation rates measured at these sites are summarized in Table 1 (Monticello) and Table 2 (Cheney) (DOE 2012, DOE 2013). The lysimeters at Monticello and Cheney are at 2% grade, similar to the top deck of the Federal Cell.

The average percolation rate for the water balance cover at Monticello is 0.5 mm/yr, which is about 25 times higher than the percolation rate predicted for the water balance cover for the Federal Cell. Monticello is in a wetter climate, which can increase the percolation rate, but Monticello also uses a much thicker storage layer (Figure 1) than the cover proposed for the Federal Cell, which will reduce the percolation rate. Thus, the very low percolation rate predicted for the Federal Cell needs additional justification.

Similarly, for the rock armor cover at the Cheney Disposal Facility, the average percolation rate is 1.0 mm/yr (Cheney-C) or 2.8 mm/yr (Cheney-R), or 1.9 mm/yr on average. This percolation rate is more than two times the average percolation rate predicted for the rock armor cover for the Federal Cell as reported in Energy*Solutions* (2012) (pp. 3-7 and 3-8), even though the average precipitation at Cheney has been lower than the average precipitation cited for the Federal Cell. The significance of this difference in percolation rates needs clarification.

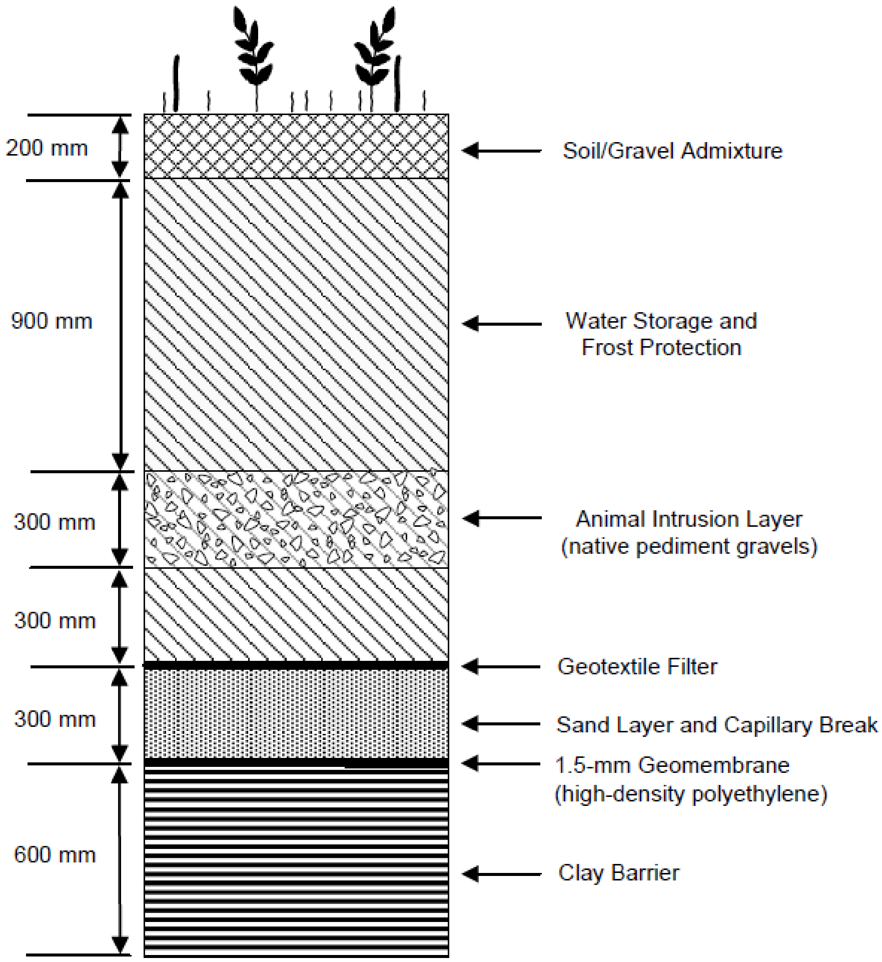



Fig. 1. Profile of cover used at Monticello Disposal Facility. The cover prolife above the geomembrane constitutes the water balance cover

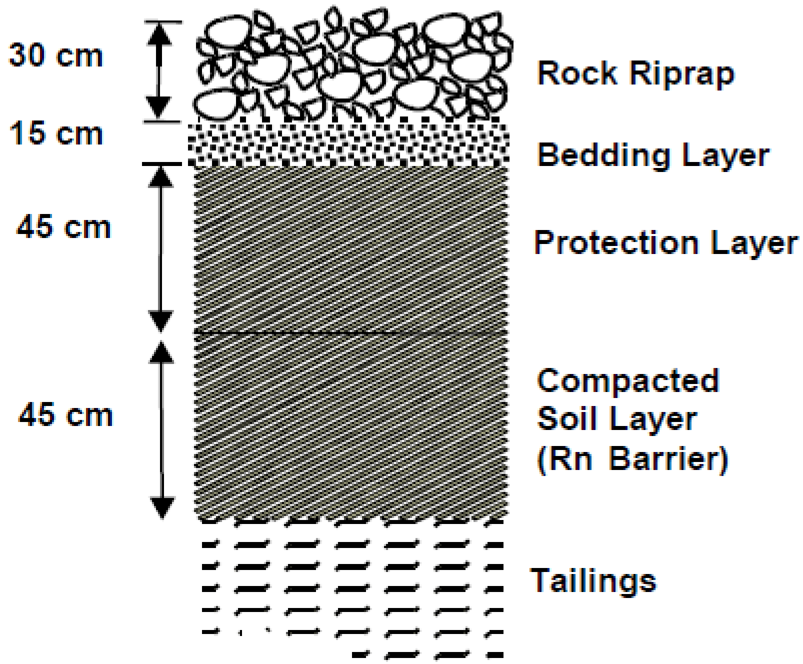



Fig. 2. Profile of rock armor cover used at Cheney Disposal Facility.

Table 1. Summary of water balance data from Monticello Lysimeter.

| Year | Precipitation (mm) | Runoff (mm) | Evapotranspiration (mm) | Percolation (mm) |
|---|---|---|---|---|
| 2001 | 377.7 | 4.2 | 400.4 | 0.0 |
| 02 | 231.9 | 3.3 | 221.2 | 0.0 |
| 03 | 364 | 0 | 360.5 | 0.0 |
| 04 | 442 | 12.3 | 352.4 | 0.2 |
| 05 | 481.6 | 28.1 | 515.7 | 3.8 |
| 06 | 447.3 | 0 | 389.1 | 0.2 |
| 07 | 304.5 | 1.2 | 317.5 | 0.0 |
| 08 | 293.6 | 3.6 | 329.4 | 0.7 |
| 09 | 241.0 | 4 | 246.9 | 0.0 |
| 10 | 512.6 | 15 | 446.3 | 1.9 |
| 11 | 354.9 | 0.1 | 395.3 | 0.1 |
| 12 | 275.0 | 2.3 | 287.3 | 0.0 |
| 13 | 273.6 | 1.4 | 269.1 | 0.0 |
| **Avg** | **353.8** | **5.8** | **348.5** | **0.5** |

Table 2. Summary of water balance data from Cheney Lysimeters.

| Cover | Period | Precipitation (mm) | Runoff (mm) | ET (mm) | Percolation (mm) |
|---|---|---|---|---|---|
| C | 11/15/07-06/30/08 | 122.4 | 0.0 | 110.6 | 1.4 |
| | 07/01/08-06/30/09 | 195.1 | 0.0 | 175.7 | 0.5 |
| | 07/01/09-06/30/10 | 209.0 | 0.0 | 203.2 | 0.6 |
| | 07/01/10-06/30/11 | 234.7 | 0.1 | 241.3 | 1.3 |
| | 07/01/11-06/30/12 | 177.0 | 0.0 | 188.0 | 0.6 |
| | 07/01/12-06/30/13 | 93.8 | 0.0 | 112.4 | 1.0 |
| | 07/01/13-12/26/13 | 267.0 | 0.0 | 265.9 | 1.3 |
| | **Average** | **185.6** | **0.0** | **185.3** | **1.0** |
| R | 11/15/07-06/30/08 | 122.4 | 0.0 | 100.3 | 2.8 |
| | 07/01/08-06/30/09 | 195.1 | 0.0 | 163.0 | 0.1 |
| | 07/01/09-06/30/10 | 209.0 | 0.0 | 224.3 | 6.4 |
| | 07/01/10-06/30/11 | 234.7 | 0.1 | 232.8 | 3.6 |
| | 07/01/11-06/30/12 | 177.0 | 0.0 | 187.5 | 3.9 |
| | 07/01/13-09/29/13 | 93.8 | 0.0 | 108.0 | 0.0 |
| | 07/01/13-12/26/13 | 267 | 0.1 | 263.5 | 3.0 |
| | **Average** | **185.6** | **0.0** | **182.8** | **2.8** |

**REFERENCES:**

Albright, W., C. Benson, and W. Waugh, *Water Balance Covers for Waste Containment: Principles and Practice*, ASCE Press, Reston, VA, 2010.

Benson, C., S. Lee, X. Wang, W. Albright, and W. Waugh, W., *Hydraulic Properties and Geomorphology of the Earthen Component of the Final Cover at the Monticello Uranium Mill Tailings Repository*, Geological Engineering Report No. 08-04, University of Wisconsin, Madison, Wisconsin, 2008. Access at http://chbenson.engr.wisc.edu/images/stories/pdfs/Reports/Monticello Report.pdf

Bareither, C., and C. Benson, C., *Evaluation of Bouwer-Rice Large-Particle Correction Procedure for Soil Water Characteristic Curves,* Geotechnical Testing J., Vol. 36, No. 5, pp. 680–694, 2013. Access at http://chbenson.engr.wisc.edu/images/stories/pdfs/Unsat_Soil/Bareither y Benson 13 large-part corr SWCC .pdf

Benson, C., T. Abichou, W. Albright, G. Gee, and A. Roesler, *Field Evaluation of Alternative Earthen Final Covers*, International J. Phytoremediation, Vol. 3, Issue 1, pp. 1–21, 2001.

Energy*Solutions*, *Utah Low-Level Radioactive Material License (RML UT2300249) Updated Site-Specific Performance Assessment*, October 8, 2012.

U.S. Department of Energy, *Applied Science and Technology Fiscal Year 2012 Year-End Summary Report*, LMS/ESL/S09384, ESL-RPT-2012-04, prepared by S.M. Stoller Corporation for the DOE Office of Legacy Management, Grand Junction, CO, 2012.

U.S. Department of Energy, *Long-Term Surveillance Operations and Maintenance Fiscal Year 2013 Year-End Summary Report*, LMS/ESL/S10692, ESL-RPT-2013-03, prepared by Environmental Sciences Laboratory for the DOE Office of Legacy Management, Washington, DC, September 2013.

**INTERROGATORY CR R313-25-8(4)(D)-155/1: COVER PERFORMANCE FOR 10,000 YEARS**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

**INTERROGATORY STATEMENT:**

Document how expected climate changes and other FEPs that may degrade cell performance over 10,000 years have been factored into the cover cell design. Also discuss historical analogs of similar structures and how they have functioned over long periods of time.

**BASIS FOR INTERROGATORY:**

To provide confidence in the performance of the disposal cell embankment for a minimum of 10,000 years, the PA should examine historical analogs of similar structures that have remained reasonably intact for long time periods. The analog evidence should be buttressed by simulations of FEPs that may degrade over that time period. For example, climate change can result in episodic precipitation events that are greater in both magnitude and frequency than those based on the historical record. Climate change can affect animal and vegetation species. These effects need to be considered in the PA.

Thus, an evaluation of processes that alter the behavior of the cover should be conducted, including long-term changes in climatic conditions, evolution of the vegetation community in response to changes in climate or other externalities, and the impacts of the environment on the engineering properties of the cover materials (e.g., wet-dry cycling, freeze-thaw cycling, root intrusion). The latter includes changes in the properties of the earthen materials that comprise the cover, which are known to change substantially and quickly in some cases (Benson et al. 2011). None of these issues appear to have been taken into account when evaluating the hydrology of the cover for 10,000 years. Section 3.2, page 14, of the Unsaturated Zone Modeling report contends that "*bioturbation and homogenization of radon barriers will probably occur very slowly relative to the 10,000-yr time frame*," an inference that is inconsistent with current thinking regarding the engineering properties of cover materials, particularly radon barriers compacted with high water saturation and low saturated hydraulic conductivity (Benson et al. 2011).

**REFERENCES:**

Benson, C., W. Albright, D. Fratta, J. Tinjum, E. Kucukkirca, S. Lee, J. Scalia, P. Schlicht, X. Wang, *Engineered Covers for Waste Containment: Changes in Engineering Properties & Implications for Long-Term Performance Assessment*, NUREG/CR-7028, U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, 2011.

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-26(2‒3)-156/1: SEPARATION OF WASTES IN FEDERAL CELL

### PRELIMINARY FINDING:

Refer to R313-25-26(2‒3): *(2) During the land disposal facility site construction and operation, the licensee shall maintain an environmental monitoring program. Measurements and observations shall be made and recorded to provide data to evaluate the potential health and environmental impacts during both the construction and the operation of the facility and to enable the evaluation of long-term effects and need for mitigative measures. The monitoring system shall be capable of providing early warning of releases of waste from the disposal site before they leave the site boundary.*

*(3) After the disposal site is closed, the licensee responsible for post-operational surveillance of the disposal site shall maintain a monitoring system based on the operating history and the closure and stabilization of the disposal site. The monitoring system shall be capable of providing early warning of releases of waste from the disposal site before they leave the site boundary.*

### INTERROGATORY STATEMENT:

Since the Federal Cell will have no isolation barrier or groundwater monitoring system, explain how the DU waste and 11e.(2) waste will be isolated from each other and how groundwater passing beneath the DU will be monitored before site closure and for 100 years after site closure so as to meet Utah rules and protect the public from undue radiation exposure during the time before DOE takes stewardship of the Federal Cell.

### BASIS FOR INTERROGATORY:

Page ES-1 of the Executive Summary of the 2013 Compliance Report, Revision 1, states the following:

> *Once approved, it is Energy*Solutions*' intention to begin disposal of significant quantities of depleted uranium in a Federal Cell using the currently-approved Class A West Embankment cover design. The Federal Cell was initially submitted for DRC approval as the "Class A South" cell, with a revised application and completeness review response package dated June 9, 2009. Energy*Solutions*' records show that DRC indicated interrogatories on this design were under preparation but not received at the time the application was withdrawn on May 2, 2011.*

In addition, Section 1, page 1-1, of the 2013 Compliance Report, Revision 1, states the following:

> *As is illustrated in Figure 1-1, Energy*Solutions *has evaluated a new Federal Cell, using the Division-approved and licensed Class A West Embankment cover design, as the ultimate destination for the large volumes of depleted uranium. The Federal Cell was initially submitted for DRC approval as the "Class A South" cell, with a revised application and completeness review response package dated June 9, 2009. Energy*Solutions*' records show that DRC indicated*

> *interrogatories on this design were under preparation but not received at the time the application was withdrawn on May 2, 2011. Reviewers should note that the former Class A South cell included an isolation barrier between Class A and 11e.(2) wastes as well as a proposed system for monitoring groundwater beneath this barrier; in order to differentiate the source of any potential groundwater contamination as being from Class A or 11e.(2) wastes. Depending on the terms of DOE agreement to take stewardship of a Federal Cell, these features may not be required.*

Section 2.2, page 2-6, of the 2013 Compliance Report, Revision 1, states the following:

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

The basis for stating that waste separation is not needed within the Federal Cell requires additional justification, since DOE ownership of the disposed DU may not occur for some period of time after waste disposal has been completed.

**REFERENCES:**

Energy*Solutions, Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

**INTERROGATORY CR R313-25-8(5)(A)-157/1: INCLUSION OF DU AND OTHER WASTES IN PA**

**PRELIMINARY FINDING:**

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

**INTERROGATORY STATEMENT:**

Provide documentation that the PA includes the total quantities of DU and other wastes.

**BASIS FOR INTERROGATORY:**

Section 1, page 1-1, of the 2013 Compliance Report, Revision 1, states that "*Under this License authorization, approximately 18,400 Ci of depleted uranium were safely disposed in the* [sic] *at Clive between 1990 and 2010.*" This is equivalent to about 46,000 MTU assuming that the specific activity of depleted uranium is 4.02E+02 pCi/mg (Battelle 2011).

UAC R313-25-8(5)(a) requires a PA that does the following:

> *…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.* [emphasis added]

Therefore, it follows that Energy*Solutions*' PA must include a demonstration that the performance standards will be met for the total quantities of concentrated DU and other wastes, including wastes already disposed of. However, the PA does not appear to include this demonstration.

**REFERENCES:**

Battelle 2011. *Site Profiles for Atomic Weapons Emloyees that Worked Uranium Metals*. Battelle-TBD-6000, Rev. 1.

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

**INTERROGATORY CR R313-15-1009(2)(B)(I)-158/1: WASTE PACKAGING**

**PRELIMINARY FINDING:**

Refer to R313-15-1009(2)(b)(i): *Waste shall have structural stability. A structurally stable waste form will generally maintain its physical dimensions and its form, under the expected disposal conditions such as weight of overburden and compaction equipment, the presence of moisture, and microbial activity, and internal factors such as radiation effects and chemical changes. Structural stability can be provided by the waste form itself, processing the waste to a stable form, or placing the waste in a disposal container or structure that provides stability after disposal.*

**INTERROGATORY STATEMENT:**

Address in the PA the use of soft-sided containers for the disposal of DU oxides, including how well these containers would survive long-distance transportation to and handling at the Clive low-level waste facility, how full of DU oxides each container would be and how much headspace would remain, the weight of the contents of each container, and the nature of the materials constituting the container.

**BASIS FOR INTERROGATORY:**

According to B&W Conversion Services (2013), use of newer, soft-sided containers is being considered for shipping and disposal of DU:

> *Babcock & Wilcox Conversion Services, LLC (BWCS), the prime Contractor to the United States Department of Energy (DOE) for the Depleted Uranium Hexafluoride (DUF6) Conversion Plants, is submitting a request for information (RFI) from prospective parties that have the capability to provide a system design for packaging containers of depleted uranium oxide ("oxide") into soft-sided oxide containers to meet facility production requirements.*
>
> *The current process at the BWCS $DUF_6$ conversion facilities involves filling modified $DUF_6$ cylinders with oxide after processing the original content. This existing system is proving inadequate for keeping pace with plant production capabilities….*
>
> *STATEMENT OF REQUIREMENTS*
>
> *1. The DUF6 conversion facilities operate 24 hours per day, seven days a week. The Portsmouth DUF6 Conversion Facility currently has a projected life cycle of 18 years, and 25 years at the Paducah DUF6 Conversion Facility.*
>
> *2. Containers and fill/packaging systems must meet the requirements for Department of Transportation (DOT) Industrial Package Type 1 (IP-1) rated soft side packages in accordance with 49CFR 173.410 and 49CFR 173.411.*
>
> *3. The waste product is compacted U3O8 powder with a density of approximately three grams per cubic centimeter (approximately190 pounds per cubic foot). The most common cylinder processed is the 48G, with an internal volume of approximately 140 cubic feet.*

However, the 2013 Compliance Report, Revision 1, does not contain any assessment related to the use of soft-sided oxide containers for DU oxides. It does not describe how well these containers would survive long-distance transportation to and handling at the Clive low-level waste disposal facility. The weight of the contents of each container and the nature of the materials constituting the container are also unknown.

The PA does not indicate whether all DU oxide materials or only a fraction of them will go into the new containers. It is not known how well these newer containers will be packed and how much headspace (on a percentage basis) will be left. The PA should clearly discuss the fraction of headspace in each container and evaluate it with respect to the future stability of the embankment cover.

**REFERENCES:**

B&W Conversion Services, LLC, *Request for Information on Soft-Sided Containers for Depleted Uranium Oxide*, August 2, 2013. Available at www.bwconversionservices.com/index.php?cID=295

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

**INTERROGATORY CR R313-25-8(4)(D)-159/1: EMBANKMENT DAMAGE BY LAKE FORMATION**

**PRELIMINARY FINDING:**

Refer to R313-25-8(4)(d): *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, surface drainage of the disposal site, and the effects of changing lake levels. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.*

**INTERROGATORY STATEMENT:**

Explain how radon releases will be controlled when the embankment is destroyed by wave action and the intruding waters subsequently recede to levels below the current ground surface.

**BASIS FOR INTERROGATORY:**

Section 1, page 1-3, of the 2013 Compliance Report, Revision 1, identifies one of the policy issues as follows:

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

Although we agree that destruction of an above-ground embankment by wave action associated with development of one or more large-scale lakes sometime in the next 2 million years is likely, it is not sufficient for Energy*Solutions* to address this simply by disposing of waste below ground, as shown in Figure 1-2 of the 2013 Compliance Report, Revision 1. Not only must waste remain below ground when lakes develop, but adequate soil barriers to radon emanation above the waste must be available. Otherwise, potential exposure from the waste to humans becomes a problem. Energy*Solutions* should plan for such barriers in the PA or explain why they are not necessary.

**REFERENCES:**

Energy*Solutions, Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

**INTERROGATORY CR R313-25-7(2)-160/1: COMPARISON OF CLASS A WEST AND FEDERAL CELL DESIGNS**

**PRELIMINARY FINDING:**

Refer to R313-25-7(2): *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.*

**INTERROGATORY STATEMENT:**

Address the significant differences between the Class A West embankment and Federal Cell designs in order to justify why the existing Class A West design would suffice for the Federal Cell.

**BASIS FOR INTERROGATORY:**

Energy*Solutions* speaks of a new Federal Cell that uses the Division-approved and -licensed Class A West embankment cover design. However, Energy*Solutions* should make it clear that no design has yet been submitted for the Federal Cell, and that, although the proposed Federal Cell may use a design for a cover similar to that which has been approved for the Class A West embankment cell, no design for Federal Cell embankment has yet been submitted nor approved by DRC. The Federal Cell will have a different location, different dimensions, different geometry, different waste, and different waste containers within it as compared to the Class A West embankment cell. Moreover, the performance of the Federal Cell must be demonstrated for 10,000 years.

Section 2.2, page 2-6, of the 2013 Compliance Report, Revision 1, states the following:

> *Analyses in support of the Class A West Embankment cover design are applicable to the Federal Cell on the following bases:*
>
> 1. *The Class A West Embankment has a larger surface area and thicker overall waste column than the Federal Cell. This indicates that bounding conditions have been evaluated for infiltration, runoff, and static and seismic stability.*
> 2. *Waste characteristics and placement procedures will be identical, as captured in the LLRW and 11e.(2) Construction Quality Assurance/Quality Control (CQA/QC) Manual.*
> 3. *Embankment liner and construction procedures will be identical, as captured in the LLRW and 11e.(2) Construction Quality Assurance/Quality Control (CQA/QC) Manual.*

Section 2.5 of the 2013 Compliance Report, Revision 1, makes a similar argument about the Class A West analysis being bounding for the Federal Cell. However, Energy*Solutions* has not demonstrated that, regardless of the larger surface area and thicker overall waste column of the

Class A West cell compared to the Federal Cell, and other similar characteristics, the design would not need to take into account the following facts:

- The geometry, slopes, and boundary shapes and sizes would differ between the two different cells.
- The distance to a monitoring well from the central portion of the cell would differ between the two cells.
- The current PA proposes that the DU waste disposal cell be conjoined with the 11e.(2) cell, with no isolation barrier between them.
- DU waste components in the Federal Cell would ingrow, thereby becoming more hazardous instead of less hazardous with time, contrary to what would be the case for the bulk of waste in the Class A West cell.
- Over a sufficiently long time, Ra-226, which would be present at relatively high concentrations in the Federal Cell, would increase in activity until it exceeds Class C limits, unlike the bulk of the waste disposed of in the Class A West cell.
- Some of the containers from the Paducah and Portsmouth GDPs that would be disposed of in the Federal Cell would contain heels having relatively high concentrations of highly mobile Tc-99, unlike the bulk of the waste disposed of in the Class A West cell.
- The heels in these cylinders would also contain transuranics, unlike the bulk of the waste deposited in the Class A West cell.
- The Federal Cell must meet design requirements for a minimum of 10,000 years.

Moreover, the Construction Quality Assurance/Quality Control Manual would need to reflect any and all changes in design that could in any way affect the transport of radionuclides vertically, horizontally, or both. Energy*Solutions* should make these revisions or justify why they are not required.

**REFERENCES:**

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

**INTERROGATORY CR R313-25-7(2–3)-161/1: INCONSISTENT INFORMATION ON WASTE EMPLACEMENT**

**PRELIMINARY FINDING:**

Refer to R313-25-7(2–3): *(2) 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.*

*(3) Descriptions of the principal design criteria and their relationship to the performance objectives.*

**INTERROGATORY STATEMENT:**

Resolve the conflicting statements about available thickness in the embankment for waste emplacement and emplacement depths. Explain and justify the plans given in the text of the PA given the information in Figure 1.2 and revise as necessary.

**BASIS FOR INTERROGATORY:**

Section 2.5, page 2-12, of the 2013 Compliance Report, Revision 1, claims that, in the 10-meter (completely below grade) model, GDP contaminated waste, SRS waste, and GDP uncontaminated waste may all be contained within a zone that is 11.58 feet thick, at depths between 33.07 and 44.65 feet below the base of the top slope engineered cover, which presumably would all be below grade. However, Figure 1.2 of the 2013 Compliance Report, Revision 1, shows the embankment extending only 10.0 to 10.5 feet below grade, with 3 feet of that being clay liner or liner protective cover, leaving only 7.0 to 7.5 feet for below-grade disposal of DU waste. This limitation appears to conflict with the description in Section 2.5, which as noted assumes that DU waste is disposed of in a zone 11.58 feet thick. This is 4.08 to 4.58 feet greater than the space that appears to be available, based on Figure 1.2.

Section 2.5 allocates a layer with a thickness of only 1.65 feet (= 34.72–33.07 feet) for contaminated waste from the GDPs. However, most DU waste that would be transported to Clive would be in 12-foot-long, 4-foot-diameter sturdy steel cylinders, which would not fit in the 1.65-foot-thick layer. The PA should explain how the waste would be emplaced in the allocated layer (e.g., would it be removed from the cylinders, and then what would be done with the cylinders).

Similarly, Section 2.5 allocates a layer with a thickness of only 1.66 feet (= 36.38–34.72 feet) for SRS waste. However, this waste is contained in 55-gallon drums that have diameters of approximately 2 feet. Such drums, if intact and uncrushed, would not fit in the 1.66-foot-thick layer. The PA should explain how the SRS waste would be emplaced in the allocated layer (e.g., would it be removed from the drums, and then what would be done with the drums).

**REFERENCES:**

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

**INTERROGATORY CR R313-25-22-162/1: DISPOSAL CELL STABILITY**

**PRELIMINARY FINDING:**

Refer to R313-25-22: *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.*

**INTERROGATORY STATEMENT:**

Address factors affecting stability, including wave-cutting erosion, gully erosion, catastrophic storms, differential settling driven by canister disintegration and cover rock degradation in greater detail to demonstrate long-term disposal system stability.

**BASIS FOR INTERROGATORY:**

The PA needs to provide a complete analysis of ways in which the embankment can be constructed to minimize or eliminate damage from the following:

(1) erosion by wave-cutting of embankment materials by lacustrine waves, including how this will affect exposures and doses prior to complete washing away of the embankment

(2) gully erosion on a large scale after long periods of time, including how this would affect mammalian and plant biointrusion into bulk waste, and possibly into DU waste, as well as how it would affects doses to inadvertent intruders

(3) destruction of embankments by catastrophic storms such as tornadoes

(4) damage via differential settlement of the cover system as a result of collapse of DU canisters as they deteriorate, such as may occur if the canisters are not filled completely

(5) cover-system rock degradation

Most of these are also not addressed in previous discussions of stability of the Class A West embankment (AMEC 2011), which is supposed to be an analog for the Federal Cell. Energy*Solutions* should fully address all aspects of embankment stability, including the five items listed above. The discussion below expands on these deficiencies.

<u>Erosion by wave-cutting of embankment materials</u>. As waves from future Lake-Bonneville-type lakes start to cut into the embankment, bulk waste in the embankment will be exposed. The process of wave cutting may take place over decades or hundreds of years. During this time, potential radioactive exposures may be high. After complete inundation by lake water, there may still be high levels of radioactive exposure to people or animals above the site. Unless radon barrier clays are placed where they will not be eroded by wave action, there will be little or no protection against radioactive exposures from disposed of DU and its daughter products, including radium and radon. The dose from the initial wave cutting may be peak at this time, and it needs to be determined in the PA, as UAC R313-25-8(5)(a) mandates simulations out to peak dose.

<u>Gully erosion</u>. Gully erosion is expected on the embankment and may provide inadvertent intruders with exposure to radioactive bulk waste. Previous simulations in the PA have

experimented with various degrees of gully erosion, but quantification as a function of time has not been provided. As noted in Section 4.0, pages 4–5, of the Erosion Modeling report, "*The purpose of the initial gully model in the Clive PA model is to determine whether gullies and fans are significant contributors to dose and whether a more sophisticated erosion model is needed*. [To that end,] *a simple screening-type gully model was developed….*" Since gullies can have a significant impact on long-term performance, such as by increasing radon release and increasing infiltration, it appears that a more sophisticated erosion model is needed.

Destruction of embankments by catastrophic storms. Previous versions of the PA have not properly accounted for damage to the embankment by tornados in Utah. However, the Tornado History Project (2014) indicates that Utah has experienced about 100 recorded tornados over the last century. Destruction or damaging of the embankment by tornados or other storms needs to be modeled.

Damage to the cover system from differential settlement. The amount of headspace in cylinders partially filled with deconverted triuranium octaoxide ($U_3O_8$) is not known, nor is the ability to fill the void space in these cylinders with controlled low-strength material (CLSM). Section 3.4, page 3-14, of the 2013 Compliance Report, Revision 1, states the following:

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

However, the information provided is not sufficient to address differential settling issues. The PA model specifically needs to account for differential settlement and cover-system damage due to degradation of the cylinders, perhaps over several hundred years, with subsequent collapse.

Cover-system rock degradation. Some of the rocks at Vitro have been noted in field inspections to have undergone moderate to severe degradation over a period of 10 to 20 years (Bishop 2014). The PA needs to account for any rip rap used at the Federal Cell undergoing similar degradation over similar and extended periods of time.

In order for the disposal facility to be 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, the PA needs to consider each of the above factors.

**REFERENCES:**

AMEC Earth & Environmental, Inc., *Geotechnical Update Report, Energy Solutions Clive Facility, Class A West Embankment Study, Clive, Tooele County, Utah,* AMEC Job No. 10-817-05290, February 15, 2011.

Bishop, Charles, Memorandum to Files: *Energy*Solutions *Petrographic Studies of Rock Fragments*, Utah Division of Radiation Control, January 29, 2014.

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Neptune and Company, Inc., *Erosion Modeling for the Clive PA*, June 1, 2011. (Appendix 10 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

TornadoHistoryProject.com, *Tornadoes in Utah*, accessed January 3, 2014. (www.tornadohistoryproject.com/tornado/Utah/table; data within this database has been pulled from the Storm Prediction Center's (SPC) historical tornado data file at www.spc.noaa.gov/wcm/#data)

## INTERROGATORY CR R313-25-8(5)(A)-163/1: GROUNDWATER COMPLIANCE FOR 10,000 YEARS

### PRELIMINARY FINDING:

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

### INTERROGATORY STATEMENT:

Include results describing groundwater concentrations for a minimum of 10,000 years and indicate whether a dose standard of 4 mrem/yr TEDE is met for the compliance period.

### BASIS FOR INTERROGATORY:

FRV1 Section 1.3, page 16, states that "*Part 1.D.1 of the Permit specifies that the performance standard for radionuclides is 500 years.*" However, Part 1.D.1 of the permit actually states, "*However, under no circumstances shall the facility cause ground water at the compliance monitoring wells (Part I.F.I) to exceed the ground water protection levels in Part I.C for the following minimum periods of time.*" After this statement, the table gives 500 years for mobile and non-mobile radionuclides. Thus, the 500-year time frame is a minimum, not a maximum, time period. The time frame can be longer, based on an assessment of need by the DRC Director.

Furthermore, based on UAC R313-25-8(5)(a), a compliance period of 500 years would only apply to facilities that have not proposed to dispose of significant quantities of concentrated DU. For those facilities in Utah that have proposed to dispose of significant quantities of concentrated DU, UAC R313-25-8(5)(a) gives 10,000 years as the minimum period of compliance during which performance standards must be met for DU and other wastes. The groundwater performance standard of 4 mrem/yr must be met throughout the compliance period of 10,000 years or more. Thus, the PA should include results that model groundwater concentrations over a period of at least 10,000 years.

### REFERENCES:

Neptune and Company, Inc., *Final Report for the Clive DU PA Model version 1.0*, June 1, 2011. (Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

State of Utah, Division of Water Quality, Utah Water Quality Board, Ground Water Quality Discharge Permit No. UGW450005, issued to Energy*Solutions*, LLC, 2013. Available from www.radiationcontrol.utah.gov/EnSolutions/docs/2013/10Oct/SignedfinalPermit.pdf.

**INTERROGATORY CR R313-15-1009-164/1: INCORRECT RULE CITATION**

**PRELIMINARY FINDING:**

Refer to R313-15-1009: *Classification and Characteristics of Low-Level Radioactive Waste.*

**INTERROGATORY STATEMENT:**

Correct the indicated rule citation.

**BASIS FOR INTERROGATORY:**

Section 4.2.2, page 18, of the Conceptual Site Model report refers to Utah rule R313-15-1008 as being called "*Classification and Characteristics of Low-Level Radioactive Waste*." The title of Figure 5 also refers to R313-15-1008. However, the correct rule number associated with that title is UAC R313-15-1009.

**REFERENCES:**

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-15-1009(1)(C)(I)-165/1: INCORRECT CITATION OF Ra-226 LIMIT

### PRELIMINARY FINDING:

Refer to R313-15-1009(1)(c)(i): *(c) Classification determined by long-lived radionuclides. If the radioactive waste contains only radionuclides listed in Table I, classification shall be determined as follows:*

*(i) If the concentration does not exceed 0.1 times the value in Table I, the waste is Class A.*

### INTERROGATORY STATEMENT:

Ensure that the DU PA model and associated text use the correct limit for Ra-226 and that all other model input parameters correctly interpret the concentrations in Table 1 of R313-15-1009.

### BASIS FOR INTERROGATORY:

Section 4.2.2, page 18, of the Conceptual Site Model report states the following:

> *Rule R313-15 contains section R313-15-1008* Classification and Characteristics of Low-Level Radioactive Waste*. 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 (see Figure 5),* ***with a concentration limit of 100 nCi/g*** *(Utah, 2010).* [emphasis added]

However, the listing of 100 nCi/g for Ra-226 in Table I of UAC R313-15-1009(1)(c) is not a concentration limit for Class A waste. UAC R313-15-1009(1)(c)(i) states that "*If the concentration does not exceed 0.1 times the value in Table I, the waste is Class A.*" 100 nCi/g is 10 times the Class A waste concentration limit for Ra-226, which, based on the rule, is only 10 nCi/g. Energy*Solutions* should ensure that 10 nCi/g is the limit used in the model, that all other model input parameters interpret the Table 1 concentrations correctly, and that this issue is clarified in the text of the PA.

### REFERENCES:

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility,* May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-22-166/1: STABILITY OF WASTE**

**PRELIMINARY FINDING:**

Refer to R313-25-22: *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.*

**INTERROGATORY STATEMENT:**

Analyze stability conditions as compaction of disintegrating drums and cylinders occurs. Consider the presence of any headspace in the waste containers and include a statement that the waste is **not** uncontainerized but rather is emplaced in drums and cylinders.

**BASIS FOR INTERROGATORY:**

Section 8.3, page 46, of the Conceptual Site Model report states the following:

> *Subsidence is not expected to be an important process at the Clive facility, since the waste is aggressively compacted in order to prevent this occurrence (Energy*Solutions*, 2009c).*

However, this subsidence does not include compaction of DU in its drums or canisters, which may behave very differently in the embankment from, for example, bulk waste that may be compacted. Drums or canisters of DU-related low-level waste from SRS or the GDPs, respectively, may have headspace within the associated containers that may not respond to compaction efforts at Clive. This headspace may become important as the containers deteriorate over long periods of time and as the headspace is filled in by overlying waste, resulting in differential subsidence.

Section 9.2, page 51, of the Conceptual Site Model report states that "*The disposed DU waste is assumed to be uncontainerized, since standard operations at the site include significant compaction of disposed waste.*" However, this appears to be an incorrect assumption. Planned disposal practices at the site include disposal of SRS drums and GDP canisters as well as the DU waste that each type of container holds. This discrepancy needs to be resolved in the model and the text. Any headspace in the containers or air gaps under the containers will eventually allow for partial collapse of the waste and cover above it, affecting the physical stability of the design.

**REFERENCES:**

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

**INTERROGATORY CR R313-15-1009(2)(A)(VII)-167/1: PYROPHORICITY OF $DUO_2$**

**PRELIMINARY FINDING:**

Refer to R313-15-1009(2)(a)(vii): *Waste shall not be pyrophoric. Pyrophoric materials contained in wastes shall be treated, prepared, and packaged to be nonflammable.*

**INTERROGATORY STATEMENT:**

Address the pyrophoric tendencies of DUO2. Either provide for the exclusion of uranium dioxide ($UO_2$) from the waste or justify the disposal of waste container $UO_2$ at the site. Consider development of finely divided particles and possible pyrophorism during physical transport by rail or road, placement in an embankment, or geochemical modification subsequent to burial.

**BASIS FOR INTERROGATORY:**

The PA assumes that the deconverted radioactive waste from the GDPs will primarily be $U_3O_8$. However, the exact nature of the oxides produced at the GDPs is not stated.

A number of sources suggest that at least some of the deconverted DU material may also contain $UO_2$. An NRC web site (NRC 2012) states the following:

> *What will happen to the waste products from the deconversion process? Deconversion permits the recovery of fluoride compounds…. As the fluorine is extracted, the uranium is converted to an oxide (either $U_3O_8$ or $UO_2$).*

Section 2.3, page 6, of the Radioactive Waste Inventory report states the following:

> *The UDS dry conversion is a continuous process in which $DUF_6$ is vaporized and converted to a mixture of uranium oxides (primarily $DU_3O_8$ but with some $UO_2$) by reaction with steam and hydrogen in a fluidized-bed conversion unit*.

International Isotopes Fluorine Products won a combined construction/operating license in November 2012 for the deconversion of 8,000,000 pounds (300 canisters) of $DUF_6$ per year, and it *"plans to convert DUF6 first into DUF4 and AHF. Then a proprietary fluorine extraction process would convert DUF4 into two million pounds/year as BF3 and/or SiF4 and 6.2 million pounds/year of UO2*" (Dials and Hogg 2013). International Isotopes' website states that *"The following chemical equation summarizes this robust process: $UF_4$ (solid) + $SiO_2$ (solid) + Heat = $UO_2$ (solid) + $SiF_4$ (gas)*" (International Isotopes 2014). It is noted that the final product of this process is described as $UO_2$. If commercial facilities generate $DUO_2$ as waste and seek to dispose of it at Clive, then the potential pyrophoricity of $UO_2$ becomes an issue. This needs to be discussed in the PA. Plans for prevention of pyrophoric events need to be developed and presented in the PA, or justification for not doing so should be provided.

$UO_2$ formed by some processes is known to be pyrophoric when finely divided. Finely divided uranium oxide materials may be created during processing, or fine particles of uranium oxide may form as a result of movement and abrasion of uranium oxide during shipping and waste handling. Examples of UO2 pyrophoricity are summarized below.

A document published by Oak Ridge National Laboratory (Thein and Bereolos 2000) states, "*$UO_2$ may even be pyrophoric when the particle size is very fine*." A U.S. Air Force translation of Budnikov et al. (1963) states, *"Finely dispersed $UO_2$ has pyrophoric properties, it burns to*

*$U_3O_8$*." Clayton and Aronson (1958) indicate that whether or not $UO_2$ is pyrophoric depends on the process used in chemically preparing it. Eidson and Beals (2010) state, "*Finely divided $UO_2$ is pyrophoric, oxidizing in air to a variety of oxide phases including $U_3O_8$ as the most stable phase*." Hightower and Trabalka (2000) state that $UO_2$ powder is "*potentially pyrophoric unless treated*," that "*The pyrophoric behavior of…fine $UO_2$ powders makes long-term storage of these forms undesirable*," and that "*Forms of DU that were judged less desirable for extended storage because of reactivity, solubility, or pyrophoric behavior are also considered less desirable for direct disposal. These include $UO_3$ and finely divided $UO_2$….*" Gupta and Singh (2003) warn, "*When dealing with uranium powder or some other powder in a finely divided form, it should borne in mind that one is handling pyrophoric materials and that it is absolutely necessary to exercise the corresponding control and implement precautions in every stage of production and processing*…."

Pyrophoric wastes may present significant hazards. Disposal of pyrophoric wastes, unless they are first treated, prepared, and packaged to be nonflammable, is forbidden by rule in Utah (R313-15-1009(2)(a)(vii)). The PA must establish that no waste to be disposed of at Clive will be pyrophoric, and that no materials contained in the waste will be pyrophoric, unless first treated, prepared, and packaged to be nonflammable. In establishing this, Energy*Solutions* should provide suitable experimental evidence or other appropriate justification.

In addition, the presence of finely divided uranium-associated particles is linked to pyrophoricity. For this reason, the Nevada Test Site (NTS) sets standards on uranium particle size. Gates-Anderson et al. (2004) discuss the standards as follows:

> *The NTS Waste Acceptance Criteria (WAC) document specifies requirements that must be met, before a waste is considered suitable for disposal at their permitted land disposal site. NTS requires that fine particles in waste packages be limited to no more than 1 wt% for particles less than $10^{-6}$ m diameter and 15 wt% for particles less than 200 $m^{-6}$ diameter.*

Note that sub-micron-size particles cannot be present at more than 1 wt%. Particles 200 microns or smaller cannot be present at greater than 15 wt%. It is assumed that these standards are reasonable as one means by which potential pyrophoricity can be minimized or prevented. Energy*Solutions* should describe experimental data showing that these particle-size standards will be met at Clive, even after railcar transport, and justify whether or not similar standards or waste acceptance criteria should or should not be included in license conditions for the site at Clive.

**REFERENCES:**

Budnikov, P.P., and A.S. Berezhnov, et al., Translation of: *Objects from uranium dioxide*, Foreign Technology Division, Air Force Systems Command, Wright-Patterson Air Force Base CQ, Ohio, 1963.

Clayton, J.C., and S. Aronson, S., *Some preparation methods and physical characteristics of UO2 powders*, Contract AT-11-l-GEN-14, WAPD-178, UC-25: Metallurgy and Ceramics, TID-4500 (14th Ed.), 1958.

Dials, G.E., and R.C. Hogg, *Memoirs of a start-up*, Nuclear Engineering International, January 1, 2013. Available at www.neimagazine.com/features/featurememoirs-of-a-start-up/.

Eidson, A.F., and D.M. Beals, *Radioactive materials*, in Morrison, R.D., and B.L. Murphy, eds., Environmental Forensics: Contaminant Specific Guide, Academic Press, Elsevier Science, pp. 111–141, 2010.

Gates-Anderson, D.D., C.A. Laue, and T.E. Fitch, *Dissolution Treatment of Depleted Uranium Waste*, UCRL-TR-202275, University of California, Lawrence Livermore Laboratory, February 12, 2004.

Gupta, C., and H. Singh, *Uranium Resource Processing: Secondary Resources*, Springer, 2003.

Hightower, J.R., and J.R. Trabalka, Compilers, *Depleted uranium storage and disposal trade study: summary report*, ORNL/TM-2000/10, Chemical Technology Division, Oak Ridge National Laboratory, 2000.

International Isotopes Inc., *Fluorine EXTRACTION Process: Frequently Asked Questions*, accessed at www.intisoid.com/index.php/fep/more-information/1300-2/ on February 19, 2014.

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Thein, S.M., and P. J. Bereolos, *Thermal Stabilization of* $^{233}U0_2$, $^{233}U0_3$ *and* $^{233}U_30_8$, ORNL/TM-2000/82, Oak Ridge National Laboratory, July 2000.

U.S. Nuclear Regulatory Commission, *Frequently Asked Questions about Depleted Uranium Conversion Facilities*, November 30, 2012. Accessed at www.nrc.gov/materials/fuel-cycle-fac/ur-deconversion/faq-depleted-ur-decon.html#5.

**INTERROGATORY CR R313-25-7(2)-168/1: RIP RAP SIZING**

**PRELIMINARY FINDING:**

Refer to R313-25-7(2): *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.*

**INTERROGATORY STATEMENT:**

Resolve the discrepancy in descriptions of the side slope in the Erosion Modeling report and the 2013 Compliance Report, Revision 1.

**BASIS FOR INTERROGATORY:**

Section 3.0, page 2, of the Erosion Modeling report states the following:

> *At the Clive facility, the top slope of the cap is composed of 18 inches of armor material (rip rap) above a 6-inch gravel layer, a 12-inch sacrificial soil layer, and a 6-inch lower gravel layer (Energy*Solutions*, 2009). The side slope has the same composition as the top slope, except with an 18-inch lower gravel layer.*

However, depending on the meaning of the word "*composition*," the claim made in this statement does not appear to be the case.

Other parts of the PA documentation indicate that the side slope has a very different nominal rip rap size than the top slope.

With regard to the top slope, Section 2.3, page 2-7, of the 2013 Compliance Report, Revision 1, states the following:

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

With regard to the side slopes, Section 2.3, page 2-8, of the 2013 Compliance Report, Revision 1, states the following:

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

**REFERENCES:**

Energy*Solutions, Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report,* Revision 1, November 8, 2013.

Neptune and Company, Inc., *Erosion Modeling for the Clive PA*, June 1, 2011. (Appendix 10 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

**INTERROGATORY CR R313-25-7(9)-169/1: CLARIFICATION OF STATISTICAL TREATMENT OF CHEMICAL AND ISOTOPIC ASSAYS**

**PRELIMINARY FINDING:**

Refer to R313-25-7(9): *Descriptions of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal facility.*

**INTERROGATORY STATEMENT:**

Clarify issues related to the statistical treatment of uranium chemical and isotopic assays as presented in the Waste Inventory report.

**BASIS FOR INTERROGATORY:**

Our review discovered several issues with the Waste Inventory report:

(1) Table 8, page 14, is missing SRS Sample #8, which is included in Table 16 of Beals et al. (2002). Table 12, page 29, provides the data from which Table 8 was derived (also excluding Sample #8) and includes data on replicates. Although Table 12 references Table 16 of Beals et al. (2002) as its source, Table 16 of Beals et al. (2002) does not include the replicate data. Energy*Solutions* should identify the source of the replicate data and the reason for omitting Sample #8.

(2) Section 3.2.2, page 14, of the Waste Inventory report states the following:

> *To partition activity% and activity concentrations for $^{235+236}U$ and $^{233+234}U$, uranium abundances expressed as atomic% are multiplied by their respective specific activities, and renormalized to calculate activity%.*

However, it is not clear how Table 8 can list values for U-233 ranging from 1.22 to 1.29 activity% when the U-233 atom% is listed as zero in Table 16 of Beals et al. (2002). Energy*Solutions* should provide spreadsheets documenting the calculations supporting Tables 5, 8, and 9 in the Waste Inventory report or provide sample calculations.

(3) Section 2.2 of the Waste Inventory report refers to Fussell and McWorter (2002) on page 4 and Energy*Solutions* (2009b) on page 5, and they are included in the reference list on page 27:

> *Fussell, G.M, and D. L. McWhorter, 2002.* Project Plan for the Disposition of the SRS Depleted, Natural, and Low-Enriched Uranium Materials. *WSRC-RP-2002-00459, Washington Savannah River Site, November 21, 2002.*
>
> *Energy*Solutions*. 2009b.* Radioactive Waste Profile Record, EC 0230, Rev. 7, plus attachments *(Form 9021 33), EnergySolutions Inc. Clive UT.*

However, these documents could not be located on the DRC website for the DU PA: www.radiationcontrol.utah.gov/EnSolutions/depleteduranium/performassess/dupareferences.htm
.

(4) The Waste Inventory report generally refers to the SRS data set as SRS-2002 or SRS 2002. However, it also includes an SRS 2002 in the reference list:

> *SRS (Savannah River Site). 2002. SRS Interoffice Memorandum 071802 Sampling Plan for DU. Westinghouse Savannah River Company, SRS, NMM-ETS-2002-00108, Revision 0. Dated July 18, 2002. To Robertson, Breidenback, Howell, from Loftin, McWhorter.*

The text should make clear in each case whether the citation is referring to the data set or to the specific reference (i.e., the memorandum).

(5) Section 2.2, page 4, of the Waste Inventory report states that "*After additional purification, the uranium stream was transferred to the FA-Line Facility where it was processed into uranium trioxide ($UO_3$) for storage in about 36,000 drums*." A citation for this information should be provided.

(6) Many of the tables in the Waste Inventory report (e.g., Tables 5, 6, and 9) refer to concentrations in units of pCi/g. The document should make clear the basis for the grams; that is, whether it is U or $UO_3$ or something else.

**REFERENCES:**

Beals, D.M., S.P. LaMont, J.R. Cadieux, C.R. Shick, Jr., and G. Hall, *Determination of Trace Radionuclides in SRS Depleted Uranium (DU)*, WSRC-TR-2002-00536, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC, 2002.

Neptune and Company, Inc., *Radioactive Waste Inventory for the Clive DU PA*, May 28, 2011. (Appendix 4 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-7-170/1: DU WASTE FORM RELEASE MECHANISMS AND RATES**

**PRELIMINARY FINDING:**

Refer to R313-25-7: *The application shall include certain technical information. The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25:*

*(1) A description of the natural and demographic disposal site characteristics shall be based on and determined by disposal site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.*

*(2) 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.*

Refer also to R313-25-23: *(1) The primary emphasis in disposal site suitability is given to isolation of wastes and to disposal site features that ensure that the long-term performance objectives are met.*

*(2) The disposal site shall be capable of being characterized, modeled, analyzed and monitored.*

**INTERROGATORY STATEMENT:**

Provide a detailed description of the conceptual mechanisms, equations, and assumptions used in the model to determine the rate of release of contaminants from the DU waste material (solid phase) to infiltrating waters (liquid phase).

**BASIS FOR INTERROGATORY:**

DRC review of both the Embankment Modeling report and the Unsaturated Zone Modeling report shows that Energy*Solutions* did not describe how a contaminant release rate or leach rate for embankment contaminants was determined for the model. Consequently, it is unknown what conceptual mechanisms, equations, bounding conditions, and assumptions were used to estimate the rate of contaminant release from the solid matrix of the DU waste form to infiltrating waters. Without this information, DRC is unable to confirm the fraction of the total contaminant source term (or inventory) that will remain in the embankment in solid form for any given year of the model, nor the fraction (and rates) that will exit the disposal cell via leachates. Likewise, the current report does not allow DRC to confirm the model-predicted time intervals when a given nuclide, as a solute, may reach a point of compliance, nor when said nuclide may exceed its respective state GWPL in the future (i.e., in deep time).

Energy*Solutions* should modify the report to fully describe whether the nuclide-specific DU contaminant release rates were fixed and unchanging in the GoldSim model, or whether they were allowed to vary under Monte Carlo analysis. If they were allowed to vary, Energy*Solutions* should provide the descriptive statistics the model used to generate the waste form values used in its calculations, including, but not limited to, mean rate and standard deviation, total release rate variance, and type of statistical distribution used (normal or log normal).

Energy*Solutions* should also explain and justify why the conceptual mechanisms, equations, bounding conditions, and assumptions used to arrive at the model's waste release rates (or leach rates) are representative of the physio-chemical environment that will exist in the embankment waste after disposal. As an alternative, Energy*Solutions* may use conservatively high release rates.

If a contaminant solubility approach was used to determine release rates, Energy*Solutions* should explain how element speciation was accounted for in determining an appropriate release rate. For example, two statements in FRV1 require clarification. The FRV1 Executive Summary, page 5, explains how the SRS DU, as $UO_3$, will be "*washed out of the embankment in roughly 50,000* [years]." FRV1 Section 4.1.2.13, page 41, states that "*The deep-time model assumes that the form of DU available for deep-time transport is $U_3O_8$, which is far less soluble than $UO_3$.*" After Energy*Solutions* discloses how the contaminant release rates were simulated in the PA model, it should explain and justify why the deep time simulations would rely only on the less soluble $U_3O_8$ species. Alternatively, it should explain how the PA model already accounted for these solubility differences, in an adequate or conservative manner; or modify the PA model accordingly.

**REFERENCES:**

Neptune and Company, Inc., *Embankment Modeling for the Clive DU PA Model*, May 28, 2011. (Appendix 3 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Neptune and Company, Inc., *Unsaturated Zone Modeling for the Clive PA*, May 28, 2011. (Appendix 5 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

**INTERROGATORY CR R313-25-7-171/1: ADEQUACY OF DU CELL BUFFER ZONE**

**PRELIMINARY FINDING:**

Refer to R313-25-7: *The application shall include certain technical information. The following information is needed to determine whether or not the applicant can meet the performance objectives and the applicable technical requirements of R313-25: …*

*(2) 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. …*

*(12) A description of the environmental monitoring program to provide data and to evaluate potential health and environmental impacts and the plan for taking corrective measures if migration is indicated.*

**INTERROGATORY STATEMENT:**

Describe the location, dimensions, and attributes of the buffer zone at the proposed DU disposal cell, and explain and justify how it will be adequate for environmental monitoring and future mitigative actions, if needed.

**BASIS FOR INTERROGATORY:**

After Energy*Solutions* determines the specific engineering design for the DU disposal cell and submits engineering plans and specifications, it must provide a description and analysis of the buffer zone surrounding the cell. This analysis and justification will assist the DRC Director in determining that the proposed buffer zone location, dimensions, and attributes are adequate to allow representative environmental monitoring to be performed and future corrective action or mitigation to be taken, if needed. Some of the issues that need to be included in this analysis, but not all, are described in the DRC letter and completeness review (Morton 2008).

**REFERENCES:**

Morton, L.B., Utah Division of Radiation Control, letter to Tye Rogers, *January 4, 2008 Request to Convert 11 e.(2) Disposal Cell to Class A South Cell for Low-Level Radioactive Waste (LLRW) Disposal: Completeness Review*, November 26, 2008; includes *Completeness Review; Energy*Solutions, *LLC 'Amendment Request; Class A South/11e.(2) Embankment' dated January 4, 2008*, November 25, 2008.

**INTERROGATORY CR R313-25-20-172/1: INADVERTENT INTRUDER PROTECTION**

**PRELIMINARY FINDING:**

Refer to R313-25-20: *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.*

**INTERROGATORY STATEMENT:**

Provide a comprehensive analysis of possible inadvertent human intrusion scenarios.

**BASIS FOR INTERROGATORY:**

At a minimum, the following inadvertent intruder scenarios should be considered:

1. Sand, gravel, clay mining near Section 32. Tooele County has already zoned both the sections to the north (Section 29) and to the south (Section 5) of the Clive site for sand and gravel operations. Energy*Solutions* needs to explain whether or not leaving these excavations could undermine a disposal embankment or lead to long-term erosion on the adjoining sections.
2. Failure to demolish and reclaim existing Energy*Solutions* buildings in Section 29 (currently not accounted for in the Energy*Solutions* low-level radioactive waste or 11e.(2) sureties). These structures could attract people in the future to occupy this adjoining land and encourage human activities of many kinds on the margin of the buffer zone, thus increasing the chance of intrusion into buffer zone or embankment at a later date.

## INTERROGATORY CR R313-25-7(2)-173/1: STABILITY OF EMBANKMENT

### PRELIMINARY FINDING:

Refer to UAC R313-25-7(2): *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.*

### INTERROGATORY STATEMENT:

Demonstrate that the loading created by the high-density DU waste form will not result in subsidence in the disposal embankment that will compromise the performance of the cover/radon barrier system.

### BASIS FOR INTERROGATORY:

Unlike other disposal embankments at the Clive facility, the DU waste proposed for disposal will have a significantly higher density than typical low-level radioactive waste. The DU PA models $U_3O_8$ as having the same properties as Unit 3 silty sand, with a particle density of 2.65 g/cc and a bulk density somewhat lower as determined by the porosity (see Table 9 of the Model Parameters report).

However, the particle density of $U_3O_8$ is 8.3 $g/cm^3$ (Wikipedia 2014), and the tapped bulk density can be about 4 $g/cm^3$ (Mosley 1982). The increased loading on the unsaturated zone could result in increased subsidence within the embankment.

### REFERENCES:

Mosley, W.C., *Use of Cation Exchange Resins for Production of $U_3O$ Suitable for the Al-$U_3O^8$ Powder Metallurgy Process*, Savannah River Laboratory, March 12, 1982. Available at http://sti.srs.gov/fulltext/dpst82388/dpst82388.pdf.

Neptune and Company, Inc., *GoldSim Parameters*, June 1, 2011. (Appendix 16 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

Wikipedia, *Triuranium octoxide*, last modified January 14, 2014, accessed at http://en.wikipedia.org/wiki/Triuranium_octoxide.

**INTERROGATORY CR R313-25-7(6)-174/1: WASTE EMPLACEMENT IN CLASS A SOUTH DISPOSAL CELL**

**PRELIMINARY FINDING:**

Refer to R313-25-7(6): *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 R313-25.*

**INTERROGATORY STATEMENT:**

Provide a more detailed description of the manner in which waste is emplaced in the Class A South disposal cell:

1. Define the terms “clean uranium” in waste layers 13–26 (and layer WasteOut) and “contaminated uranium” in waste layers 7–12.
2. Elaborate on what type of native soil will be used in the “no waste” section (layers 1–6) of the embankment profile or cross-reference where this information can be found. If non-DU waste is to be placed at these intervals, explain and justify why the waste will not contain any nuclides known to be in the SRS or GDP DU waste streams. As an alternative, explain how the model adequately accounted for SRS and GDP radionuclides in these layers as a part of the waste source term or inventory in the PA model.
3. Describe how incoming DU shipments will be controlled and managed to ensure that construction honors the analyzed condition.

**BASIS FOR INTERROGATORY:**

Figure 9, page 13, of the Conceptual Site Model report depicts various layers or lifts in the topslope model for the Class A South cell. Several points need further clarification and explanation:

1. The text or a footnote should define the terms “clean uranium” in waste layers 13–26 (and layer WasteOut) and “contaminated uranium” in waste layers 7–12.
2. Figure 9 also displays “no waste” in waste layers 1–6. The text should elaborate on what type of native soil will be used in this section of the embankment profile or cross-reference where this information can be found. If non-DU waste is to be placed at these intervals, Energy*Solutions* should explain and justify why the waste will not contain any nuclides known to be in the SRS or GDP DU waste streams.

For purposes of radon emanation predictions in the model, and because layers 1–6 are high in the waste profile, initial concentrations of parent nuclides will be important (e.g., U-238, U-234, Ra-226, Th-230, Th-232). With respect to mobile nuclides, at a minimum this evaluation should consider Tc-99, I-129, Np-237, and other isotopes. As an alternative, Energy*Solutions* should explain how the model adequately accounted for SRS and GDP radionuclides in these layers as a part of the waste source term or inventory in the PA model. This concern applies to all three DU waste profile depth scenarios considered in the model by Energy*Solutions*.

3. Because the "contaminated uranium" is to be placed at higher waste lift elevations, Energy*Solutions* should describe how it will control and manage incoming DU shipments to ensure that construction honors the analyzed condition.

**REFERENCES:**

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Neptune and Company, Inc., *Conceptual Site Model for Disposal of Depleted Uranium at the Clive Facility*, May 28, 2011. (Appendix 2 of Appendix A of Energy*Solutions*, *Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report*, June 1, 2011)

## INTERROGATORY CR R313-25-7(2)-175/1: INFILTRATION RATES FOR THE FEDERAL CELL VERSUS THE CLASS A WEST CELL

### PRELIMINARY FINDING:

Refer to R313-25-7(2): *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.*

### INTERROGATORY STATEMENT:

Justify that the Federal Cell infiltration rates are comparable to those predicted for the Class A West cell.

### BASIS FOR INTERROGATORY:

Section 3.6, page 3-15, of the 2013 Compliance Report, Revision 1, states the following:

> *The Class A West Embankment analysis (applicable to the Federal Cell) for the rock armored cover design projects that 0.09 cm/yr and 0.168 cm/yr of water will infiltrate through the traditional rock armored cover's top and side slope, respectively (Whetstone, 2011), with the differences in infiltration rates due to the top and side slope design differences.*

However, it is not clear to DRC that the Federal Cell analysis would also apply to the Class A West embankment for a rock-armored cover design. For example—

- Maximum, or peak, heights, of the embankments would differ.
- Lateral dimensions of the embankments would differ.
- The Federal Cell would be conjoined at the east side by the 11.e.(2) cell, which would result in differences in construction, waste placement, drainage, and infiltration on and near that side compared to the Class A West cell.
- DU waste in the Federal Cell would largely be emplaced in the form of large, 12-foot-long, 4-foot-diameter canisters that may respond differently over time than other waste and containers and would affect differential compaction differently than that induced by temporal changes of waste containers in the Class A West cell.

Energy*Solutions* should justify the approach to apply the analysis of the Class A West cell to the Federal Cell.

### REFERENCES:

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Whetstone Associates, *Energy*Solutions *Class A West Disposal Cell Infiltration and Transport Modeling*, November 28, 2011.

**INTERROGATORY CR R313-25-8(5)(A)-176/1: REPRESENTATIVE HYDRAULIC CONDUCTIVITY RATES**

**PRELIMINARY FINDING:**

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

**INTERROGATORY STATEMENT:**

Model the migration of DU and other associated wastes, including bulk Class A waste components, assuming corrected hydraulic conductivity values provided in NRC guidance (NUREG/CR-7028).

**BASIS FOR INTERROGATORY:**

Utah rule UAC R313-25-8(5)(a) expressly requires that "*Any such performance assessment shall be revised as needed to reflect ongoing guidance and rulemaking from NRC.*" Therefore, Energy*Solutions* needs to revise its PA as needed to reflect NRC guidance, specifically NUREG/CR-7028.

**REFERENCES:**

Benson, C.H., Albright, W.H., Fratta, D.O., Tinjum, J.M., Kucukkirca, E., Lee, S.H., Scalia, J., Schlicht, P.D., and Wang, X., *Engineered Covers for Waste Containment: Changes in Engineering Properties and Implications for Long-Term Performance Assessment*, Volume 1, NUREG/CR-7028, NRC Office of Nuclear Regulatory Research, December 2011.

## INTERROGATORY CR R313-25-8(5)(A)-177/1: DOSE FROM PLANT UPTAKE

### PRELIMINARY FINDING:

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

### INTERROGATORY STATEMENT:

Include a quantitative analysis of dose resulting from plant uptake through "other wastes" in addition to DU.

### BASIS FOR INTERROGATORY:

Section 3.1.5, page 3-4, of the 2013 Compliance Report, Revision 1, states the following:

> *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 are few deep-rooted native plants in the site vicinity. Even those deep-rooted native plants present in the site vicinity do not have root depths sufficient to penetrate the Division-approved cover systems, overlying wastes, and into the depth at which depleted uranium is modeled for disposal (i.e., greater than 5 meters below the base of the cover).*

However, this statement fails to acknowledge the need for a quantitative analysis of dose resulting from plant uptake through "other wastes" in addition to DU itself for a minimum of 10,000 years, as is required by UAC R313-25-8(5)(a).

In addition, black greasewood can be used as forage by cattle and sheep. According to the U.S. Department of Agriculture (2009), "*Black greasewood is poisonous year round, but plants can be consumed safely in light to very moderate amounts in the spring while the leaves are growing, as long as there is a substantial amount of other preferable forage available.*" It is said in that reference that cattle can generally eat up to two or three pounds of the plant per animal at a time and not be poisoned. Sheep can generally eat up to about two pounds per animal at a time. If cattle or sheep were to eat leaves of black greasewood, shadscale saltbush, or four-wing saltbush containing radionuclides from root uptake, then people eating the cattle or sheep could potentially receive doses of radionuclides. The plant pathway needs to receive full consideration within the PA model and text.

**REFERENCES:**

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

U.S. Department of Agriculture (2009) Black Greasewood: *Sarcobatus vermiculatus* (Hook.) Torr., Plant Guide, U.S. Department of Agriculture, Natural Resources Conservation Service, Retrieved December 2012 from http://plants.usda.gov/plantguide/pdf/pg_save4.pdf

## INTERROGATORY CR R313-25-8(5)(A)-178/1: SURFACE WATER PATHWAY

### PRELIMINARY FINDING:

Refer to R313-25-8(4)(a): *The licensee or applicant shall also include in the specific technical information the following analyses needed to demonstrate that the performance objectives of R313-25 will be met:*

*(a) 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 R313-25-19.*

### INTERROGATORY STATEMENT:

Analyze potential doses to humans through the surface water exposure pathway.

### BASIS FOR INTERROGATORY:

Section 3.1.4, page 3-4, of the 2013 Compliance Report, Revision 1, states the following:

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

At the Class A West Embankment, surface drainage systems currently route water from precipitation to ponds after large storm events. The high levels of precipitation in May 2011 (4.28 inches at Clive; see EnergySolutions, 2012) are reported by both ES and DRC personnel to have caused the southeast pond to overflow. Furthermore, the cover system may be compromised due to mammalian burrowing, gully erosion, bank slumping, and other causes, which would potentially allow storm water to mix with waste below the cover system and then overflow or otherwise enter through drainage systems to ponds. Energy*Solutions* should analyze potential doses to humans due to this exposure pathway.

### REFERENCES:

Energy*Solutions*, January 2011 through December 2011 and January 1993 through December 2011 Summary Report of Meteorological Data Collected at Energy*Solutions*' Clive, Utah Facility, Meteorological Solutions, Inc., Project No. 011110111, February 2012.

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

## INTERROGATORY CR R313-25-7(2)-179/1: RIP RAP

### PRELIMINARY FINDING:

Refer to R313-25-7(2): *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.*

### INTERROGATORY STATEMENT:

Clarify the thickness, source, and availability of the rip rap.

### BASIS FOR INTERROGATORY:

Section 2.3, pages 2-7 and 2-8, of the 2013 Compliance Report, Revision 1, proposes 24 inches of rip rap for top slopes and side slopes. The side slopes will use rip rap with a much larger nominal diameter. Energy*Solutions* should provide data showing that this much rip rap material for both top and side slopes would be available from local sources.

In addition, this statement of a thickness of 24 inches is in conflict with numerous other statements throughout the PA proposing use of only 18 inches of rip rap for top and side slopes (e.g., Table 2 in the Embankment Modeling report). It appears that the existing PA model is based on use of only 18 inches. Energy*Solutions* should clarify the actual design thickness.

### REFERENCES:

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Neptune and Company, Inc., *Embankment Modeling*, June 1, 2011. (Appendix 3 of Appendix A of Energy*Solutions, Utah Low-Level Radioactive Waste Disposal License – Condition 53 (RML UT2300249) Compliance Report,* June 1, 2011)

## INTERROGATORY CR UGW450005 PART I.D.1-180/1: COMPLIANCE PERIOD

### PRELIMINARY FINDING:

Refer to Ground Water Quality Discharge Permit UGW450005, Part I.D.1: *Best available technology for the facility will incorporate discharge technology based on the use of earthen materials both in the bottom liner and final cover. However, under no circumstances shall the facility cause ground water at the compliance monitoring wells (Part I.F.1) to exceed the ground protection levels in Part I.C for the following minimum periods of time:*[mobile and non-mobile radionuclides – 500 years].

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

### INTERROGATORY STATEMENT:

Indicate how pertinent performance standards will be met for groundwater for a compliance period of at least 10,000 years, or justify why those standards do not need to be met. Correct the discussion of the type of analysis needed to comply with UAC R313-25-8(5)(a).

### BASIS FOR INTERROGATORY:

Section 1.1, page 1-5, of the 2013 Compliance Report, Revision 1, referring to facility-wide Ground Water Quality Discharge Permit UGW450005, states that "*This permit specifies that groundwater quality protection levels for radioactive constituents must be met for no fewer than 500 years following facility closure*." Although the permit does specify this **minimal** requirement, the criteria for a facility that proposes to dispose of concentrated DU are higher. As stated in UAC R313-25-8(5)(c), these higher criteria are for "*any facility that proposes to land dispose of significant quantities of concentrated depleted uranium*." For such a facility, the rule says that, relative to performance standards for total quantities of concentrated DU and other wastes, a PA must be conducted, and "*the compliance period shall be a minimum of 10,000 years*." Energy*Solutions* needs to indicate how it will ensure that pertinent performance standards will be met for groundwater for a compliance period of at least 10,000 years, or justify why those standards do not need to be met.

In addition, Section 1.5, page 1-20, of the 2013 Compliance Report, Revision 1, states the following:

> *This Report documents the depleted uranium Performance Assessment, conducted in compliance with UAC R313-25-8(5)(a). Analysis includes evaluation of*

> *potential groundwater migration of contaminants to a Point of Compliance well for a period of 500 years following embankment closure, projected peak groundwater well concentrations and general public doses for a period up to 10,000 years following Federal Cell closure, doses to hypothetical individuals who have inadvertently intruded into the waste within 10,000 years following Federal Cell closure, and additional simulations out to deep geologic time frames to qualitatively inform the Performance Assessment.*

Contrary to what is implied in the first two sentences, compliance with UAC R313-25-8(5)(a) does not call for an evaluation of potential groundwater migration of contaminants to a Point of Compliance well for a period of 500 years following embankment closure. Instead, UAC R313-25-8(5)(a) simply calls for modeling of compliance with dose limits for all exposure pathways involving environmental media, including groundwater, as well as biota. Energy*Solutions* should revise this statement accordingly.

**REFERENCES:**

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

State of Utah, Division of Water Quality, Utah Water Quality Board, Ground Water Quality Discharge Permit No. UGW450005, issued to Energy*Solutions*, LLC, 2013.

**INTERROGATORY CR R313-25-19-181/1: GROUNDWATER MORTALITY**

**PRELIMINARY FINDING:**

Refer to R313-25-19: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.*

**INTERROGATORY STATEMENT:**

Provide more detailed justification, including more specific references, for the risk factors and the calculated mortalities presented in Table 3-2 of the 2013 Compliance Report, Revision 1.

**BASIS FOR INTERROGATORY:**

During our review of the 2013 Compliance Report, Revision 1, DRC was unable to verify many of the data presented in Table 3-2. For example, the EPA Integrated Risk Information System (IRIS) (2014) is given as the source for the non-radionuclide drinking water unit risk (DWUR) factors, but when IRIS was checked many of the DWUR factors could not be confirmed, such as those listed below:

- Antimony: "*This substance/agent has not undergone a complete evaluation and determination under US EPA's IRIS program for evidence of human carcinogenic potential*."
- Arsenic: IRIS says of this metalloid substance and its compounds, "*Drinking Water Unit Risk — 5E-5 per (ug/L)*."
- Barium: *II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure. Not applicable. The results of the oral carcinogenicity study suggest that barium is not likely to be carcinogenic to humans*.
- Beryllium: No data for oral exposure carcinogenic risk; one study with rats showed no evidence of excess cancer when exposed to 5 ppm beryllium sulfate over a lifetime.
- Cadmium: Under II.B, IRIS says, "*Not available. There are no positive studies of orally ingested cadmium suitable for quantitation*."
- Chromium: Under II.B, IRIS says, "*No data were located in the available literature that suggested that Cr(VI) is carcinogenic by the oral route of exposure*."
- Mercury: Under II.B, IRIS says, "*None*."
- Molybdenum: "*This substance/agent has not undergone a complete evaluation and determination under US EPA's IRIS program for evidence of human carcinogenic potential.*"
- Selenium: Under II.B, IRIS says "*No data*" for Quantitative Estimate of Carcinogenic Risk from Oral Exposure.

- Silver: Under II.B, IRIS says "*Not available*" for Quantitative Estimate of Carcinogenic Risk from Oral Exposure.
- Zinc: IRIS says "*Not applicable*" for Quantitative Estimate of Carcinogenic Risk from Oral Exposure.

Table 3-2 gives Patterson (2005) as the source for the DWUR factors for TDS and sulfate. However, review of Patterson (2005) did not identify the TDS or sulfate DWUR factors listed in Table 3-2 anywhere in the document, and we question the applicability to humans of risk factors that were developed in a study of steer.

Table 3-2 lists cyanide and TDS, although they are not. While it is conceivable that a listed concentration for cyanide in some instances might be regarded as a surrogate for total or summed concentrations of all dissolved cyanide compounds containing metals, cyanide itself is a non-metallic anion. TDS is a parameter that includes non-metals (e.g., anions) and metalloids as well as metals, so it should not be listed as a metal. Table 3-2 omits thallium, which is a metal and is tested and analyzed for on a regular basis at the Clive facility.

Concentrations for volatiles and semi-volatiles are listed with units of mg/L, which do not appear to be correct. Table 3-2 references Energy*Solutions* (2012c) as the source of the concentrations. However, the units found in this reference differ by three orders of magnitude and are listed as µg/L, not mg/L. Therefore, while Table 3.2 gives numerical values or numbers that match the numerical values listed in Energy*Solutions* (2012c), the units are off by three orders of magnitude. Table 3.2 should list the units for volatiles and semi-volatiles as µg/L, and the PA calculations should be checked to ensure that they are based on these units.

Some of the values assumed for data used in Table 3-2 are not statistically valid, such as those under the heading of the second column, labeled "*Clive's Average Natural Groundwater Concentration*[a]." The note below the table for the superscript "a" states, "*Long-term average concentrations from up-gradient well GW-19A, (Energy*Solutions*, 2012c). Reported concentration for non-naturals is an average of the detection limit.*" Semi-volatile and volatile concentration data for groundwater sampled from upgradient well GW-19A in Table 3-2 are fictitious, and their selection is based on a method that has been shown to be invalid; it is discredited in the literature, as described below. Footnote "a" for these data indicate that the assumed values are equal to "*the average of the detection limit*." Appendix A of Energy*Solutions* (2012c) shows that actually no detections of semi-volatiles (µg/L) were made (29 samples, 29 non-detects), and very few detections of volatiles (µg/L) were made (4% of carbon disulfide, 2% of methylene chloride, and 0% of six other volatiles). However, Table 3-2 lists positive average values for all of the semi-volatiles and volatiles. The use of detection limits, or some fraction of the detection limits, as a substitute for non-detections is not a valid, approved approach. Researchers (Helsel 2005, 2006; Singh et al. 2006) have demonstrated that substitution of the detection limit or half of a detection limit as a value for a non-detect when analyzing statistics for a set of sampled chemical concentration data is a faulty practice; it results in biased mean values. Singh et al. (2006) show that substituting half the detection limit does not work well even when the fraction of non-detects is as low as 10%. Analogous problems would exist when substituting the full detection limit. Therefore, the values assigned to non-detects as found in Energy*Solutions* (2012c) and in the PA are not statistically valid.

In addition, Energy*Solutions* should clarify the meaning of the note in Table 3-2 that the "*Reported concentration for non-naturals is an average of the detection limit*." "*Non-naturals*" appears to be an incorrect choice of term.

Additionally, the Table 3-2 groundwater concentrations were from Energy*Solutions* (2012c). DRC is concerned that the method used to remove "outliers" did not follow EPA recommendations (EPA 2009). Since it directly affects the results in Table 3-2, Energy*Solutions* needs to confirm that EPA (2009) recommendations were correctly followed when the Energy*Solutions* (2012c) groundwater concentrations were developed.

Table 3-2 is titled "*Mortality Rates From The Consumption Of Native Groundwater*" and it lists the Federal Guidance Report 13 mortality risk factor (Eckerman et al. 1999) for the radionuclides given. However, EPA defines the DWUR factors associated with chemicals in the IRIS tables as a cancer morbidity risk and not as a mortality risk. It appears that what is being calculated is a combination of cancer morbidity and mortality risks, which should not be combined.

Finally, to calculate the total probability of cancer, it appears that Energy*Solutions* simply added the individual contaminant's cancer probabilities. While this approach often produces acceptable results when the probabilities are sufficiently small, it is incorrect to use it for Table 3-2, where the total probability approaches 100%. The correct approach is to first calculate the probability that no cancer would occur using the following formula:

$$Q = \prod_{j=1}^{N} (1 - p_j)$$

Where: $Q$ = Total probability that no cancer will occur
$p_j$ = Probability of cancer from contaminant $j$
$N$ = Number of contaminants

In this case, the probability that at least one cancer occurs is simply $(1 - Q)$.

**REFERENCES:**

Eckerman, K.F., R.W. Leggett, C.B. Nelson, J.S. Pushkin, and A.C.B. Richardson. *Federal Guidance Report No. 13: Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, EPA 402-R-99-001, EPA Office of Radiation and Indoor Air, September 1999.

Energy*Solutions*, *Comprehensive Groundwater Quality Evaluation Report – Waste Disposal Facility, Clive Utah*, Report to the Utah Division of Radiation Control, December 10, 2012.

Helsel, D.R., *Nondetects and data analysis: statistics for censored environmental data*, Wiley-Interscience, Hoboken, NJ, 2005.

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Patterson, H.H., P.S. Johnson, W.B. Epperson, and R. Haigh, *Effect of Total Dissolved Solids and Sulfates in Drinking Water for Growing Steers*, Departments of Animal and Range Sciences and Veterinary Science, South Dakota State University, 2005.

Singh, A., R. Maichle, and S.E. Lee, *On the Computation of a 95% Upper Confidence Limit of the Unknown Population Mean Based Upon Data Sets with Below Detection Limit Observations*, EPA/600/R-06/022, March 2006.

U.S. Environmental Protection Agency, *Integrated Risk Information System*, Office of Research and Development and National Center for Environmental Assessment, Electronic Database, available online at www.epa.gov/iris/, accessed February 2014.

U.S. Environmental Protection Agency, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance*, EPA 530-R-09-007, Office of Resource Conservation and Recovery, March 2009.

**INTERROGATORY CR R313-25-19-182/1: GROUNDWATER EXPOSURE PATHWAYS**

**PRELIMINARY FINDING:**

Refer to UAC R313-25-19: *Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem)committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater. Reasonable efforts should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable*.

**INTERROGATORY STATEMENT:**

Expand the discussion in Section 1.3.1, page 1-9, of the 2013 Compliance Report, Revision 1, to include other pathways in addition to ingestion and explain whether or not these additional pathways can significantly contribute to doses.

**BASIS FOR INTERROGATORY:**

The groundwater radioactive dose standard for compliance within the 10,000-year compliance period is given by UAC R313-25-19. However, contrary to implied claims in Section 1.3.1, page 1-9, of the 2013 Compliance Report, Revision 1, exposure through groundwater is not solely "*based on the associated health effects from ingestion*." Instead, the Utah rule refers to "*concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals*" and states that they "*shall not result in an annual dose exceeding an equivalent of 0.25 mSv (0.025 rem) to the whole body, 0.75 mSv (0.075 rem) to the thyroid, and 0.25 mSv (0.025 rem) to any other organ of any member of the public. No greater than 0.04 mSv (0.004 rem) committed effective dose equivalent or total effective dose equivalent to any member of the public shall come from groundwater.*" Groundwater can contribute to total dose from exposure pathways other than ingestion.

For example, groundwater can contribute to exposure to radiation when groundwater containing radionuclides is used for purposes such as construction or industrial activities. Specific activities that may potentially be associated with exposure via groundwater include dust control, washing, cleaning, thermal cooling, climate control activities, and mixing with clays or other materials. Groundwater may also affect radioactive uptake through plants when plant roots invade the groundwater table or the capillary fringe directly above it. Groundwater that rises over long periods of time to the ground surface as soil moisture may evaporate, leaving behind non-volatile radioactive salts and other compounds. Groundwater can also distribute volatile radioactive compounds such as radon and tritium to indoor air spaces (and thus contribute to exposure via inhalation) through, for example, showering. Personnel at the Clean Harbors Aragonite plant (Edwards 2014) indicated that that company uses groundwater for staff showering. Energy*Solutions* needs to acknowledge the potential for impacted groundwater to lead to potential exposure routes other than direct ingestion.

**REFERENCES:**

Energy*Solutions*, *Utah Radioactive Material License – Condition 35 (RML UT2300249) Compliance Report*, Revision 1, November 8, 2013.

Edwards, D. 2014. Personal communication with Mr. Lonnie Brown, Clean Harbors Aragonite Plant, (435) 884-8170, January 2014.