**APPENDIX N**

**NEPTUNE EROSION ANALYSIS**

**(NEPTUNE, 2021)**

NAC-0166_R0

# Clive DU PA Model—Response to DWMRC 1-28-2021 Comments

5 April 2021

Prepared by

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| CSM | conceptual site model |
| DEQ | (Utah) Department of Environmental Quality |
| DU | depleted uranium |
| DWMRC | Division of Waste Management and Radiation Control |
| ET | evapotranspiration |
| GWPL | groundwater protection limits |
| LLRW | low-level radioactive waste |
| MOP | member of the public |
| NRC | (United States) Nuclear Regulatory Commission |
| PA | performance assessment |
| SCS | Soil Conservation Service |
| SER | Safety Evaluation Report |
| TEDE | total effective dose equivalent |
| UDEQ | Utah Department of Environmental Quality |

# Executive Summary

The Clive depleted uranium (DU) performance assessment (PA) evaluates the range of likely impacts of disposal of DU in a new Federal Cell to be located in the southwest corner of the licensed area. The DU PA is created as a systems-level model using the GoldSim probabilistic modeling platform and is currently at version 1.4. The DU PA v1.4 model and supporting documentation have been evaluated by the Utah Department of Environmental Quality (UDEQ) and their contractor, SC&A Inc., for a number of years since its initial publication in 2015 (Neptune 2015b).

The current round of questions (Utah DEQ 2021) ask that the "hybrid" cover design introduced in the 2020 response to interrogatories (Neptune 2020b) be subject to additional verification. The hybrid cover features an evapotranspiration (ET) cover system of native soils and vegetation on the large top slope area; and rip rap armoring of the steeper side slope area. The ET cover has been selected for its superior performance in minimizing infiltration of atmospheric precipitation into the waste; while the rock armor cover has been selected for its improved assurance in minimizing the potential for erosion of the steeper side slopes.

The concerns expressed in Utah DEQ (2021) could be distilled to a simple question: If one engineers a pile of rocks and soil in Utah's west desert, will that structure remain in place for 10,000 years or more? Natural forces such as erosion might be expected to have some effect on the embankment. This response quantifies the likely behavior of these forces; and discusses how that behavior has been accounted for within the DU PA v1.4 model.

To address these comments, additional erosion modeling of the full hybrid cover system has been performed using the SIBERIA landscape evolution model, which provides three-dimensional projections of the effects of sheet and gully erosion. As detailed below, this modeling projects that the hybrid cover design will provide excellent resistance to erosion. The DU PA v1.4 actually models greater levels of sheet and gully erosion than projected in the current work. Accordingly, the disposal system remains within the bounds of previous analyses that demonstrate acceptable embankment performance.

The *Final Report for the Clive DU PA Model, Clive DU PA Model v1.4* (Neptune 2015b) provides the following summary of DU PA v1.4 results for the quantitative compliance period of 10,000 years. Additional work preparing interrogatory and comment responses after creation of version 1.4 has not changed the principal analysis and reported conclusions.

> Compliance with the performance objectives for the inadvertent intruder dose of 500 mrem in a year and for the MOP of 25 mrem in a year is clearly established for all three types of potential future receptors. This indicates that for the disposal configuration where DU wastes are placed below grade, doses are expected to remain well below applicable dose thresholds…
>
> Results are also available for the offsite (MOP) receptors. None of the 95$^{th}$ percentile dose estimates for these receptors exceeds 1 mrem in a year, and all of the peak mean dose estimates are at or below 0.1 mrem in a year.

**Table ES-1. Peak TEDE: statistical summary**

| | peak TEDE (mrem in a yr) within 10,000 yr | | |
|---|---|---|---|
| **receptor** | **mean** | **median (50th %ile)** | **95th %ile** |
| ranch worker | 6.2E-2 | 5.1E-2 | 1.5E-1 |
| hunter | 4.5E-3 | 3.8E-3 | 9.9E-3 |
| OHV enthusiast | 8.4E-3 | 7.5E-3 | 1.8E-2 |

Results are based on 10,000 realizations of the Model.
TEDE: Total effective dose equivalent

For those radionuclides for which GWPLs exist, as specified in the facility's permit (UWQB 2009), results are shown in Table ES-2. For all such radionuclides compliance with the GWPLs is clearly demonstrated.

**Table ES-2. Peak groundwater activity concentrations within 500 yr, compared to GWPLs**

| | | peak activity concentration within 500 yr (pCi/L) | | |
|---|---|---|---|---|
| **radionuclide** | **GWPL[1] (pCi/L)** | **mean** | **median (50th %ile)** | **95th %ile** |
| $^{90}Sr$ | 42 | 0 | 0 | 0 |
| $^{99}Tc$ | 3790 | 26 | 4.3E-2 | 150 |
| $^{129}I$ | 21 | 1.7E-2 | 4.3E-11 | 1.1E-1 |
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| $^{233}U$ | 26 | 5.6E-24 | 0 | 3.9E-28 |
| $^{234}U$ | 26 | 2.1E-23 | 0 | 2.2E-28 |
| $^{235}U$ | 27 | 1.6E-24 | 0 | 2.0E-29 |
| $^{236}U$ | 27 | 2.7E-24 | 0 | 3.3E-29 |
| $^{238}U$ | 26 | 1.5E-22 | 0 | 1.8E-27 |

[1]GWPLs are from UWQB (2009) Table 1A.
Results are based on 10,000 realizations of the Model.

Figure ES-1 displays Table ES-1 dose results graphically in context with the dose limit of 25 mrem/year for members of the public under R313-25-20. Typical background radiation dose is also provided on this figure as a point of reference. DU PA v1.4 results are 2 to 3 orders of magnitude below the dose limit.

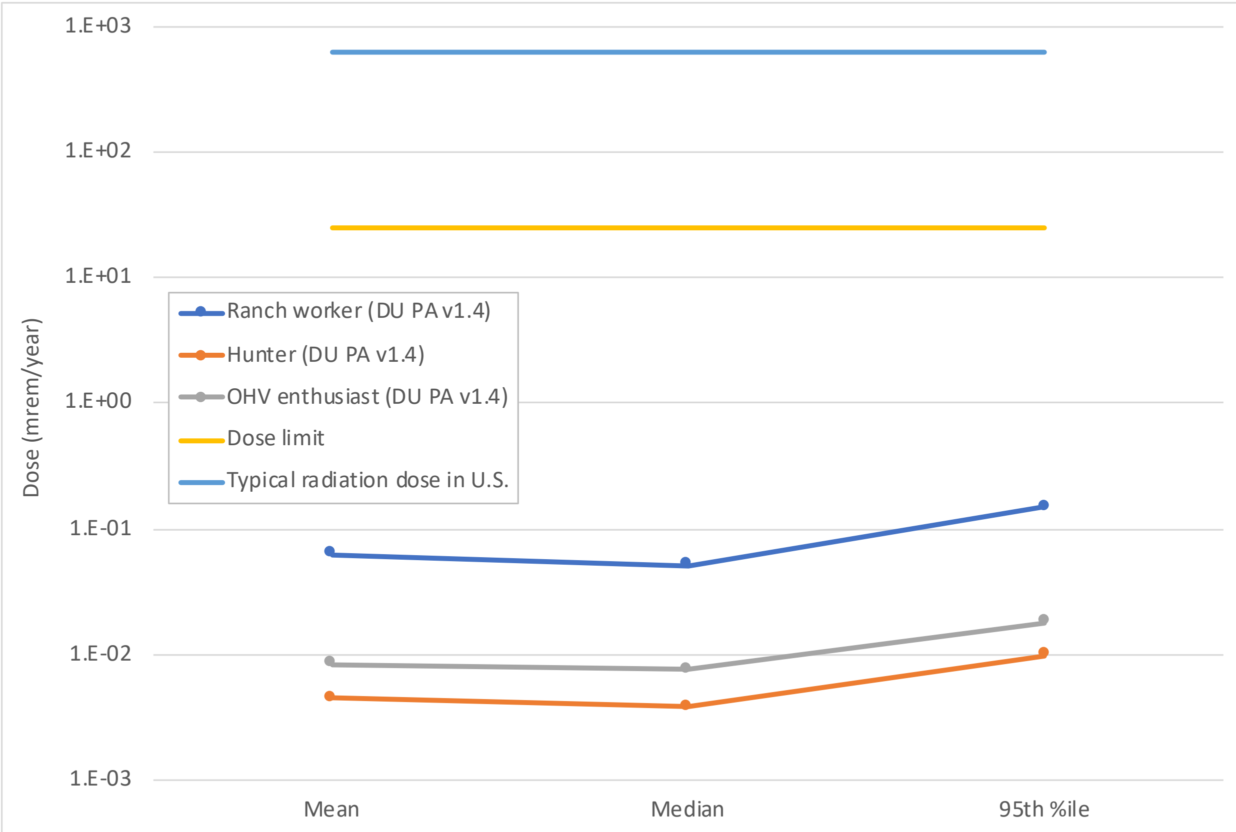


**Figure ES-1. DU PA v1.4 dose results, R313-25-20 dose limit, and typical background dose.**

As detailed in Section 4.4.1.3 below, DU PA v1.4 overestimates the volume, depth, and impact of gully erosion. Based on SIBERIA modeling of the clay borrow pit at Clive, DU PA v1.4 calculates how deep the gullies excavate and a volume of gully material is eroded from the "waste" layers[1] when the full cover thickness is penetrated. For the deterministic run, the deepest gullies reach the top 3 out of 27 waste layers (as a fraction of the overall surface area); and the averaged activity concentration from the waste layers in gullies is used in the dose calculations. Results of the deterministic model with gullies turned on/off show no difference in the doses to onsite receptors, but they do show small differences in uranium hazard. The uranium hazard quotients are very small (~1e$^{-15}$); compared with a target threshold of 1.

In comparison, SIBERIA modeling of the hybrid cover design (Neptune 2021a) projects that the deepest gullies do not penetrate the full cover profile into the waste layers. Accordingly, DU PA v1.4 overstates likely impacts of erosion on embankment performance.

[1] It is acknowledged that the embankment layers between DU and the cover will not be permitted to contain Class A LLRW until a specific performance assessment authorizing such is approved. Modeled as clean soil fill initially in DU PA v1.4, this material is discussed in supporting documentation as "waste" since it is expected to accumulate some activity from the DU waste placed at the cell floor via radon emanation/decay and diffusion.

DU PA v1.4 demonstrates compliance with the dose and groundwater protection requirements of Utah regulations relating to DU disposal. The interrogatory and response process has added to the record supporting these conclusions but has not caused the quantitative model itself to require revision. Accordingly, DU PA v1.4 remains the basis for demonstrating compliance of the disposal facility.

Compliance with UAC R313-25-9(5)(a) is affirmed by DU PA v1.4, together with the supporting documentation as supplemented by the interrogatory/response cycle.

# 1.0 Introduction

Beginning in 2009, Energy*Solutions* contracted Neptune to create a probabilistic performance assessment (PA) for the disposal of large quantities of depleted uranium (DU) at their Clive, Utah low-level radioactive waste (LLRW) disposal facility.

The initial model was submitted as version 1.0 on June 1, 2011 (Neptune 2011) and was revised to version 1.2 on June 5, 2014 (Neptune 2014). A Safety Evaluation Report (SER) based on review of version 1.2 was issued by UDEQ in April 2015 (SC&A 2015).

On November 25, 2015, Energy*Solutions* submitted *Radioactive Material License UT2300249: Safety Evaluation Report for Condition 35.B Performance Assessment; Response to Issues Raised in the April 2015 Draft Safety Evaluation Report* (Energy*Solutions* 2015). This document included version 1.4 of the DU PA (Neptune 2015b), prepared in response to open primary and new interrogatories raised after development and Division of Waste Management and Radiation Control (DWMRC) review of version 1.0; included in Appendix C and Appendix B, respectively, of the SER.

On May 11, 2017, UDEQ provided *Amended and New Interrogatories Related to Clive DU PA Modeling Report Version 1.4 Dated November 2015* (Utah DEQ 2017). This document contains clarifications to the original interrogatories from DU PA version 1.0 that remained open, clarifications to the interrogatories newly raised with version 1.2 and new interrogatories introduced with version 1.4 of the DU PA.

On April 2, 2018, Energy*Solutions* submitted *Radioactive Material License UT2300249: Responses to Amended and New Interrogatories Related to Clive DU PA Modeling Report Version 1.4 Dated November 2015* (Energy*Solutions* 2018). As suggested by UDEQ, this document included seven topical reports organized consistently with the themes expressed in the interrogatory package (Utah DEQ 2017).

On July 25, 2019, UDEQ provided *Depleted Uranium Performance Assessment (DU PA); Clive Facility; Model Version 1.4 Amended Interrogatories; Radioactive Materials License #2300249* (Utah DEQ 2019). This document contains amended interrogatories of open issues regarding version 1.4 of the DU PA model, closes several interrogatories, and introduces two more new interrogatories. Neptune responded to these interrogatories on April 24, 2020 (Neptune 2020b).

In the 2020 response to interrogatories, a new “hybrid” cover design was introduced. This cover design incorporates an evapotranspiration cover on the top slope; and a rock armor cover on the side slope.

On December 3, 2020, UDEQ provided “Comments on Energy*Solutions* Cover Design System Described in the DU PA, Draft Federal Cell License Application” (Utah DEQ 2020). This letter poses 12 technical questions relating to the hybrid cover design. Neptune is preparing a response to those issues as a separate report (Neptune 2021c).

Additional UDEQ comments were provided under separate cover “RE: Technical Report” dated January 28, 2021 (Utah DEQ 2021). This second comment document includes concerns relating to erosion and embankment stability, and is the subject of this response document.

Full text of each comment is quoted using blue text in Arial font, size 10.5 pt, and is indented to visually distinguish the comment from the response. An example is shown below:

> Sample format for quoting comment text.

Utah DEQ (2021) includes comments under three general headings: (1) surface drainage and erosion protection; (2) geotechnical stability; and (3) infiltration. This response will address items 1.1, 1.2, and 1.3; and Section 3. Item 1.4 indicated “No applicant response is expected from this list at this time” and is assumed to be addressed by Energy*Solutions* under separate cover.

Comments under Section 2 will be addressed by Energy*Solutions* under separate cover. Based on prior assessments of stability for other, larger embankments at the Clive site (Neptune 2015e), this report assumes that geotechnical stability of the Federal Cell will be affirmed by that work.

# 2.0 Revised Federal Cell Design

In the 2020 response to interrogatories, the Federal Cell cover design was revised to adopt a rock armor cover for the side slopes (Neptune 2020b). The ET cover previously analyzed for the top slopes is retained. The ET cover has been selected for its superior performance in minimizing infiltration of atmospheric precipitation into the waste; while the rock armor cover has been selected for its improved assurance in minimizing the potential for erosion of the steeper side slopes.

The 2020 design has been further revised as discussed below. These revisions have been carried through new and updated modeling as applicable. Updated drawings 14004-C01 through 14004-C05 are included as Attachment 1.

## 2.1 Embankment Footprint

Energy*Solutions* has revised the embankment footprint in order to provide greater separation between the Federal Cell and the 11e.(2) Cell to the east. The revised footprint is slightly narrower east to west and slightly longer north to south than it was in prior drawings. The grade of the top and side slope areas is unchanged; and the thickness of the cover layers are unchanged from the drawings submitted previously.

The revised embankment footprint has slightly shorter top slope lengths; and a longer embankment crest. Figure 1 shows the revised embankment footprint; Figure 2 shows the version previously analyzed. Side slope lengths are unchanged. These changes result in a peak embankment elevation at the crest that is one foot lower than that of the previous footprint[2].

The current embankment footprint has been considered in SIBERIA-2D modeling performed to address UDEQ comments.

The current embankment footprint has also been incorporated in HYDRUS-2D modeling of erosion, with results presented under separate cover (Neptune 2021c).

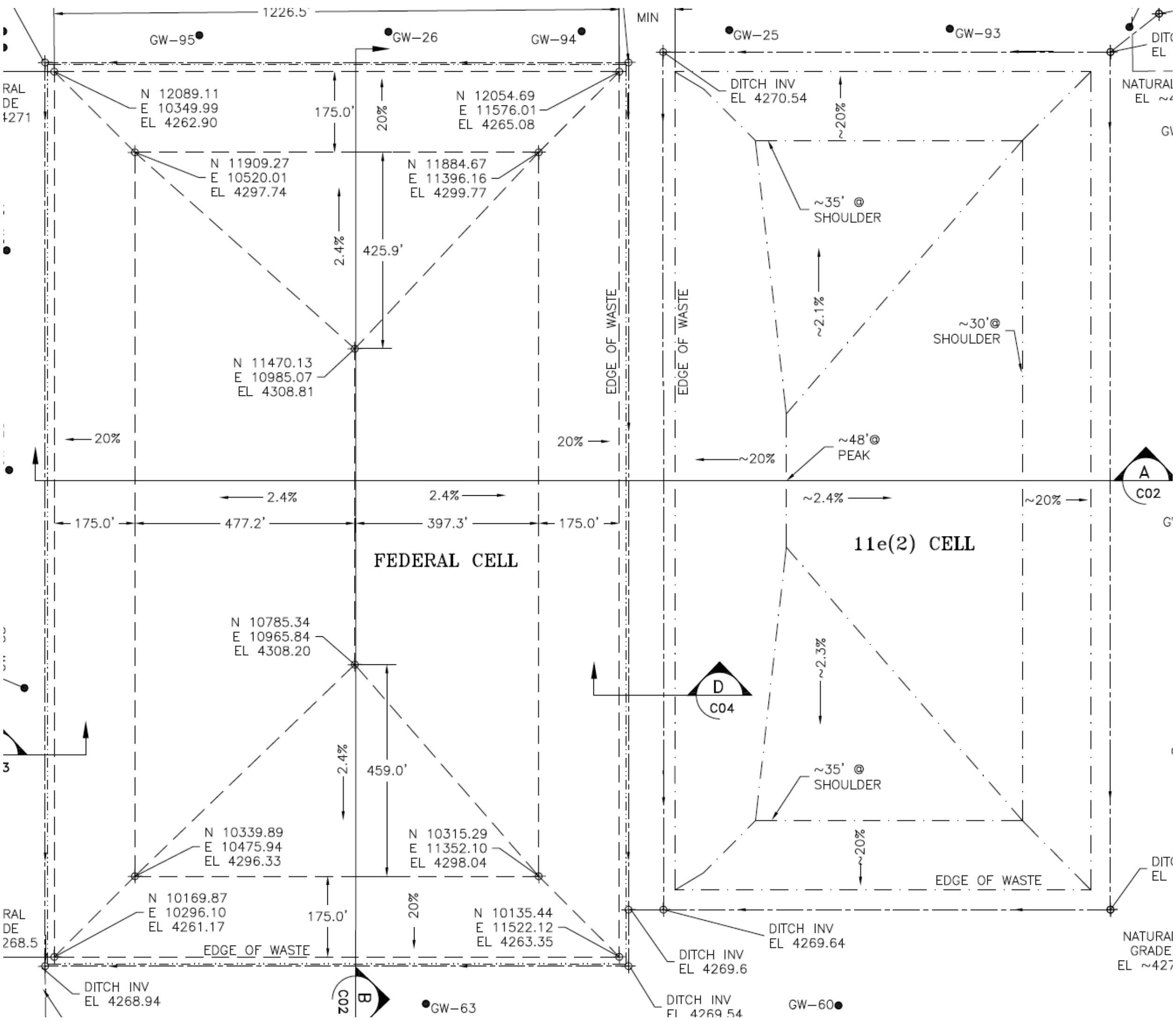


**Figure 1. Revised (2021) Federal Cell footprint (from drawing 14004-C01, rev 2).**

[2] Embankment thickness is considered in DU PA v1.4 in the context of radon emanation. This is modeled as an average thickness of material between the DU waste and the surface, calculated to be 39.7 feet. The revised embankment footprint changes this dimension to be 39.6 feet.

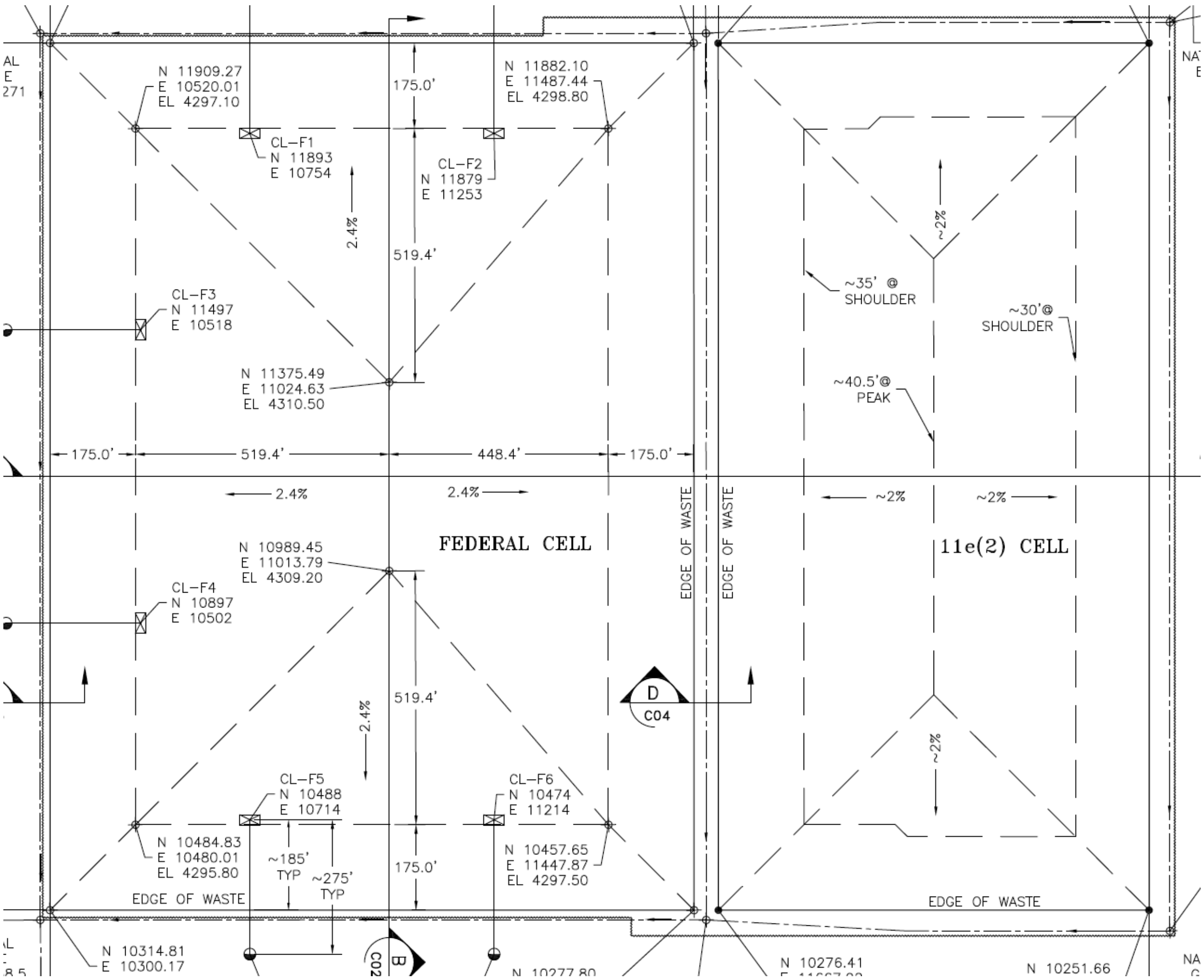


**Figure 2. Former (2020) Federal Cell footprint (from drawing 14004-C-01, rev. 0).**

## 2.2 Top Slope Surface Layer Thickness

In the 2020 design change to utilize rip rap armoring on the side slopes, the top slope surface layer thickness was increased from 6 inches to 12 inches. This change slightly increases the storage capacity of the ET cover design. SIBERIA-2D evaluation of the full hybrid cover includes this revision. Figure 3 provides the top slope layering.

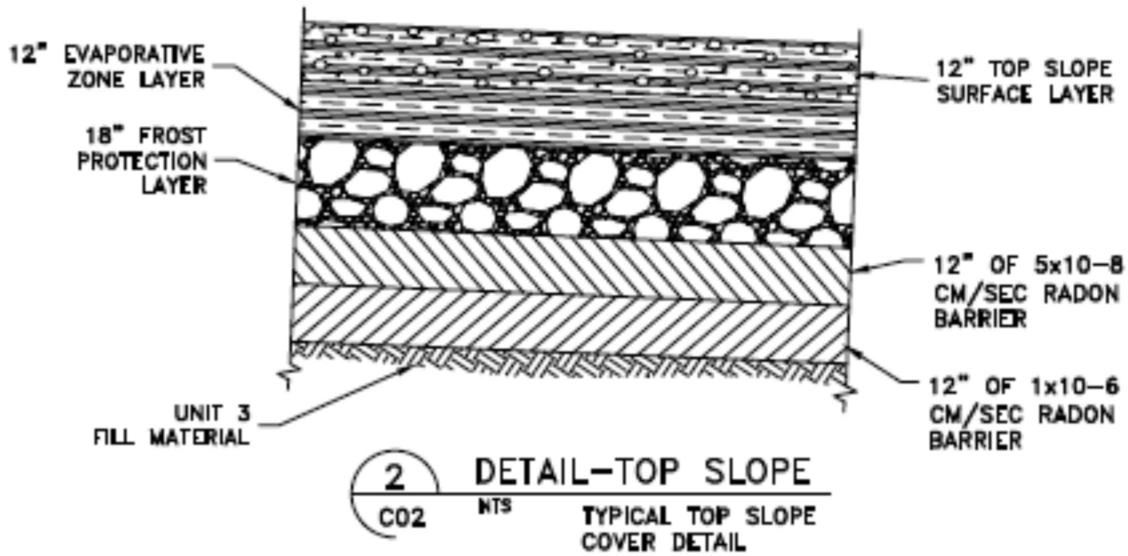


**Figure 3. Top Slope Detail (from drawing 14004-C05, rev. 1).**

## 2.3 Transition Zone and Side Slope Frost Protection Layer

The transition zone revision from the ET cover top slope to the rip rap cover side slope has been revised from that presented in the 2020 design. The revision moves the transition zone to the shoulder of the embankment and reduces its width. These changes were made to reduce the impact of increased infiltration through the rip rap portion of the cover. Figure 4 provides the transition zone detail as currently modeled; Figure 5 displays the prior design.

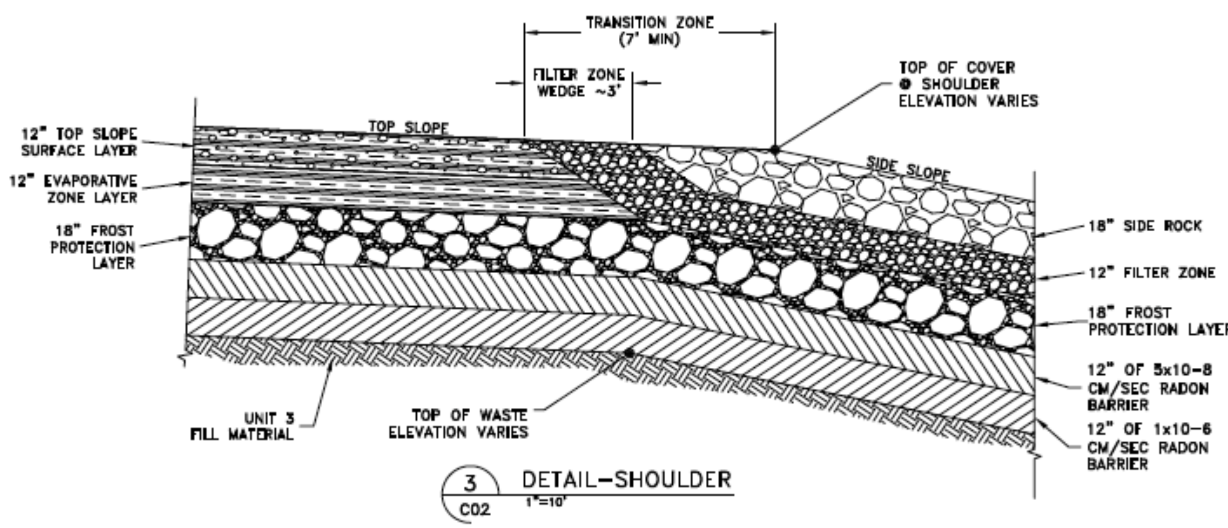


**Figure 4. Transition Zone (2021) Detail (from drawing 14004-C05, rev. 1).**

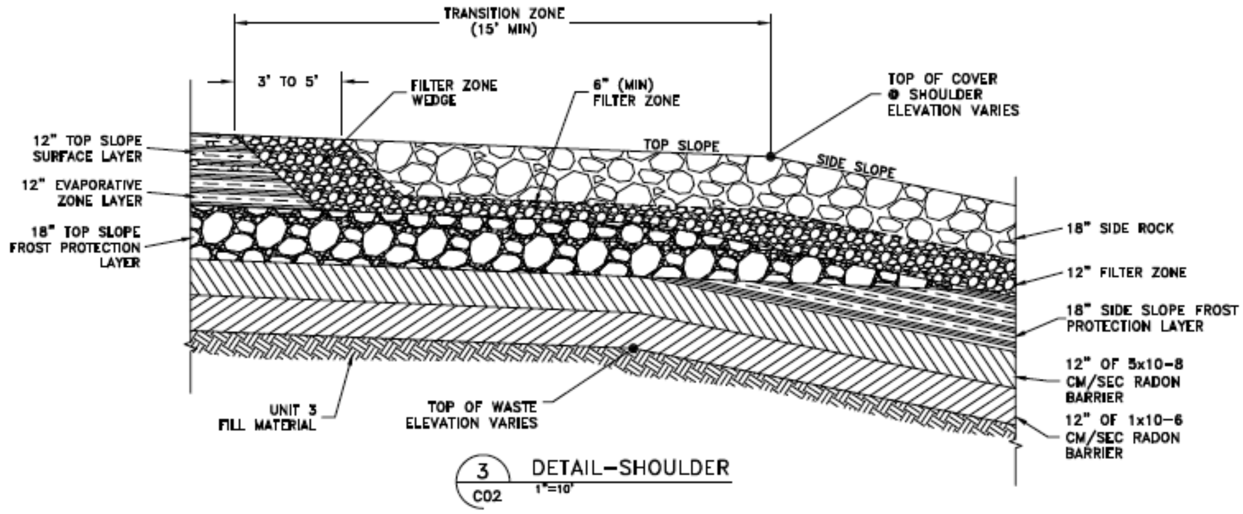


**Figure 5. Former Transition Zone (2020) Detail (from drawing 14004-C05, rev. 0).**

Concurrent with this change, the material used as the frost protection layer for the side slope has been changed. The current design specifies this material to be the same bank run as used for the frost protection layer on the top slope, where the 2020 design used native clay soils for the side slope. This material was changed in order to ensure consistent drainage properties from the top slope onto the side slope at this layer in the cover system. The change also improves constructability of the transition zone.

SIBERIA-2D evaluation of the full hybrid cover includes these revisions.

# 3.0 Results from the DU PA v1.4 Model

Since initial submittal of DU PA v1.4 (Neptune 2015b), many technical issues have been resolved relating to the probabilistic performance assessment (PA) model, through the interrogatory/response process summarized in Section 1.0. Based on prior evaluations of the potential for erosion, the DU PA v1.4 model assumes ongoing embankment stability throughout the 10,000-year compliance period (Neptune 2015e). In this report, Neptune presents analyses of the hybrid cover design performance in relation to this assumption. If the hybrid cover is demonstrated to retain stability for the 10,000-year period of performance, then the results of DU PA v1.4 can be considered to hold as well.

The *Final Report for the Clive DU PA Model, Clive DU PA Model v1.4* (Neptune 2015b) provides the following summary of DU PA v1.4 results for the quantitative compliance period of 10,000 years. Additional work preparing interrogatory and comment responses after creation of version 1.4 (Neptune 2015b) has not changed the principal analysis and reported conclusions.

> Compliance with the performance objectives for the inadvertent intruder dose of 500 mrem in a year and for the MOP of 25 mrem in a year is clearly established for all three types of potential future receptors. This indicates that for the disposal configuration where DU wastes are placed below grade, doses are expected to remain well below applicable dose thresholds…

Results are also available for the offsite (MOP) receptors. None of the 95th percentile dose estimates for these receptors exceeds 1 mrem in a year, and all of the peak mean dose estimates are at or below 0.1 mrem in a year.

**Table ES-1. Peak TEDE: statistical summary**

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Results are based on 10,000 realizations of the Model.
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For those radionuclides for which GWPLs exist, as specified in the facility's permit (UWQB 2009), results are shown in Table ES-2. For all such radionuclides compliance with the GWPLs is clearly demonstrated.

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Results are based on 10,000 realizations of the Model.

Figure 6 displays Table ES-1 dose results graphically in context with the dose limit of 25 mrem/year for members of the public under R313-25-20. Typical background radiation dose is also provided on this figure as a point of reference. DU PA v1.4 results are 2 to 3 orders of magnitude below the dose limit.

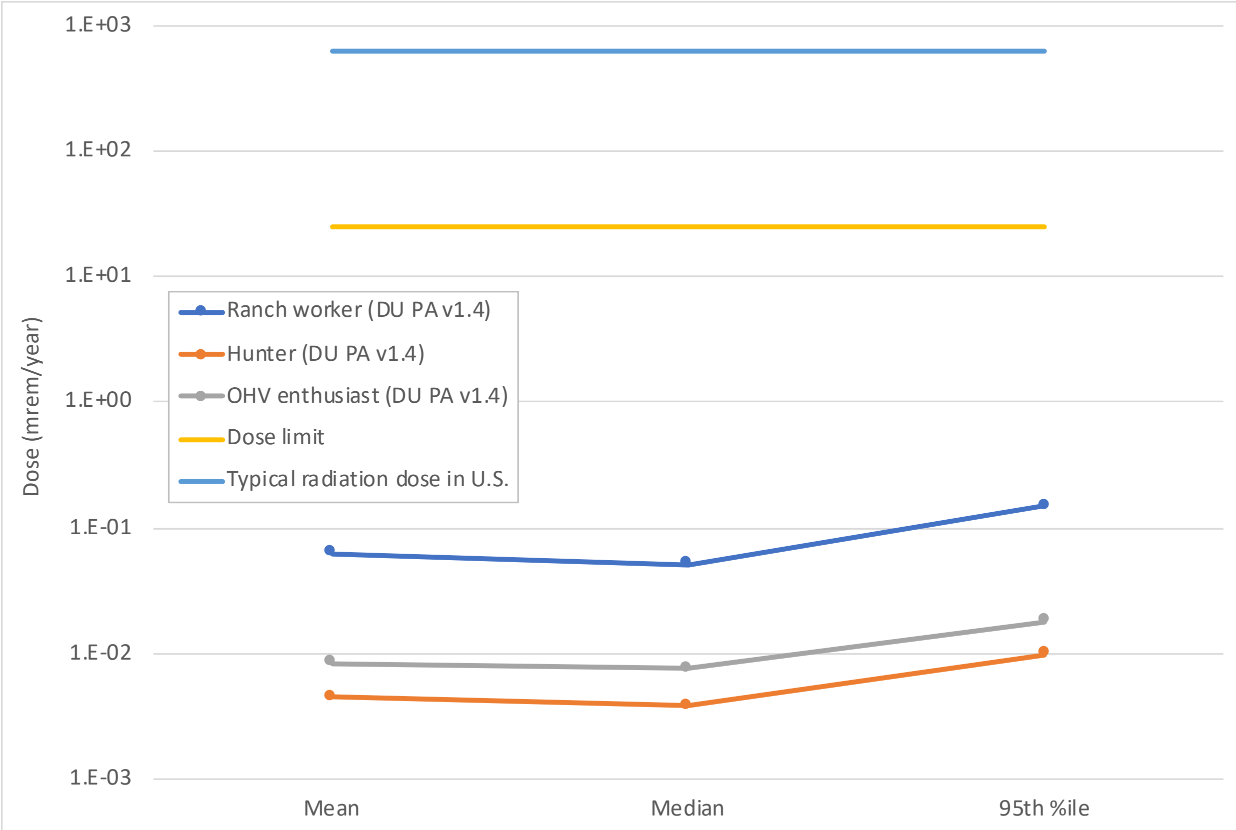


**Figure 6. DU PA v1.4 dose results, R313-25-20 dose limit, and typical background dose.**

DU PA v1.4 demonstrates compliance with the dose and groundwater protection requirements of Utah regulations relating to DU disposal. The interrogatory and response process has added to the record supporting these conclusions but has not caused the quantitative model to require revision. Accordingly, DU PA v1.4 remains the basis for demonstrating compliance of the disposal facility.

Compliance with UAC R313-25-9(5)(a) is affirmed by DU PA v1.4, together with the supporting documentation as supplemented by the interrogatory/response cycle.

Ultimately, the DU PA v1.4 evaluates an above-grade embankment located in a terminal desert basin. Annual potential evapotranspiration in Utah's west desert far exceeds precipitation, which is quite low at an average of roughly 8 inches per year. There are five comparable embankments for radioactive waste disposal in the immediate vicinity of the proposed Federal Cell, with comparable dimensions and similar cover designs. Projections of ongoing stability for an embankment in this context are not only reasonable, they are to be expected.

# 4.0 UDEQ Comments and Responses

Each comment is quoted in full followed by Neptune's response.

## 4.1 UDEQ Comment 1.1: Erosion Protection Using NUREG-1623 & NUREG/CR-4620—Design of Erosion Protection for Long-term Stabilization

Questions on the potential for erosion were raised in Section 4.4.2 of the April 2015 DU PA SET (SC&A 2015). The Division expressed concern that gullies will form and enhance radon diffusion, deep infiltration, and contaminant transport. For this subject matter, interrogatories **INT CR R313-25-8(4)(a)-71/1; INT CR R313-25-25(4)-201/1 and INT CR R313-25-25(4)-205/1** have been identified to track inquiries and responses regarding various aspects of erosion analysis. In the latest status of interrogatory 71 (SC&A 2019), SC&A concluded *"With the maximum permissible velocities recommended by NRC and SCS, and the NAC-0108_R0 calculated flow velocities, gullies can be expected to form. Because the permissible velocity assumptions are less conservative than NRC recommendations, this interrogatory remains open."*

Within DU PA Final Report (NAC-0147_R), pg 23, 4/24/20) Neptune responded to interrogatory 201 that the erosion analysis using NUREG-1623 had been revised but Neptune appears to continue to contend that the higher maximum permissible velocity should be satisfactory. This may not be an appropriate response, particularly for the side slopes, for which an ET cover system design has been replaced by a rock-armor cover system design. In an unpublished document SC&A confirmed, "Energy*Solutions* agreed that the rainfall intensity had been calculated incorrectly and provided revised calculations [in App. F]. The revised flow velocities for the top and side slopes were 2.37 and 2.07 feet per second (ft/sec), respectively. Based on a maximum permissible velocity of 2.5 ft/sec, Energy*Solutions* concluded that gullies would not form in an ET cover. Since the ET cover design has been replaced, it appears to the Division that parameters for the new hybrid cover design have not been accounted for and analyzed properly." SC&A has indicated to the Division that no similar calculations were provided for a riprap cover or the new hybrid cover. In addition, SC&A points out that, work by other investigators (i.e., Smith and Benson, 2016) has shown that deep gullies can form in riprap covers. Energy*Solutions*/Neptune need to provide a quantitative as well as a mechanistic explanation for the conflicting results and justify, in similar manner, why the hybrid cover design would be effective for all or part of the compliance period.

The Division needs to restate that the DU PA modeling should rely on engineered barriers during the initial 500 years or out to the specified service life as determined by barrier design with adequate technical justification. As explained earlier, it is the Division's understanding that the DU PA needs to account for degradation resulting from erosion and discontinued functioning of the engineered barriers after they have been in service for 500 years or more.

### 4.1.1 Comment 1.1 Response

This comment is addressed in two parts: (1) permissible velocity calculation for the side slopes; and (2) SIBERIA modeling of the revised Federal Cell design.

#### 4.1.1.1 Permissible Velocity Calculation

A permissible velocity calculation for the revised embankment geometry and hybrid cover design is provided below. NUREG-1623 (NRC 2002) describes the permissible velocity method of evaluating erosion potential of covers.

Note that the comment incorrectly assigns revised flow velocities for the Federal Cell in Neptune (2018). The cited values of 2.37 and 2.07 ft/sec are associated in that document with the Class A

West Cell. Calculated flow velocities for the Federal Cell, with shorter top and side slope dimensions, were 1.60 ft/sec for the top slope and 2.03 ft/sec for the side slope. Regardless, the calculation is repeated for the current embankment geometry (Figure 1). Because the slopes remain the same and the dimensions are only slightly different, the results are very similar to those in Neptune (2018).

Slope Description

The Federal Cell is designed as a covered embankment with relatively steeper sloping sides nearer the edges. The upper part of the embankment referred to as the top slope has a slope of 2.4 percent, while the side slope is steeper with a slope of 20 percent. The length of the side slope is 175 ft. Top slopes of the embankment have different lengths. The longest top slope length is 477.2 ft.

Flow Concentration

The peak flow unit discharge, Q (cubic feet per second per foot [cfs/ft]), is calculated using the Rational Formula (NRC 2002):

$$Q = F \times c \times i \times A$$

where

- $F$ is flow concentration factor,
- $c$ is dimensionless runoff coefficient,
- $i$ is rainfall intensity (inches/hour [in/hr]), and
- $A$ is catchment area (acres).

A default value of 3 is recommended in NRC (2002) for the flow concentration factor, F.

A value for the runoff coefficient of 0.5 is recommended for a graveled surface in Table 4.6 of NUREG 4620 (NRC 1986). NUREG 4620 does not include a runoff coefficient for riprap; Energy*Solutions* (2012) rock cover calculations use a runoff coefficient of 0.8 based on an example calculation in Appendix D of NUREG-1623 (NRC 2002). Accordingly, the value of 0.5 is used for the gravel-amended ET cover top slope and 0.8 is used for the riprap side slope.

The rainfall intensity used for the projection is 18.3 inches for the top slope and 19.8 inches for the side slope of the Federal Cell. See the response to UDEQ Interrogatory 201 (Neptune 2018) for a description of the method used to calculate these values.

The catchment area is the area of a 1-ft wide strip along the length of the slope. Using these values, the peak flow unit discharge, Q, for the top slope and side slope are found to be 0.301 and 0.191 cfs/ft respectively.

<u>Flow Depth</u>

The flow depth, y, is then calculated using the Manning equation for normal depth on a one-foot-wide strip of the slope. This equation is given by NRC (2002) as

$$y^{5/3} = Qn \big/ \left(1.486\, S^{1/2}\right)$$

where

| | |
|---|---|
| $y$ | is flow depth (ft), |
| $n$ | is Manning $n$, and |
| $S$ | is slope (ft/ft). |

A value of 0.05 is used for the Manning's *n* based on the calculation method of Bray for natural channels described in Coon (1998).

Using the previously calculated values for Q and the Manning's $n$, flow depths are calculated to be 0.195 ft for the top slope and 0.078 ft for the side slope.

<u>Maximum Permissible Velocity</u>

A value of 5.0 ft/s is chosen as the maximum permissible velocity (MPV) based on the characteristics of the channel. This is the value listed for gravel in Table CH13-T103 of Colorado Water Conservation Board (CWCB 2006) and in Table 4.7 of Nelson et al. (1986). Additional justification for this value is provided in Neptune (2020b).

The NRC (2002) method requires that the MPV be adjusted to account for the flow depth. Correction factors developed by Chow are provided in Appendix A of NRC (2002). The correction factor for flows less than 0.25 ft in depth is 0.5. The adjusted MPV values for both the top slope and the side slope are adjusted to 2.5 ft/s.

<u>Actual Flow Velocity</u>

The actual flow velocity is determined by dividing the discharge by the flow depth:

$$V_a = Q/y$$

Using this equation, the top slope and side slope velocities are 1.54 ft/s and 2.45 ft/s.

These velocities for the top slope and side slope do not exceed the adjusted MPV, so the design is acceptable. These empirical calculations are confirmed by RHEM and SIBERIA modeling of the hybrid cover design, as discussed in Section 4.1.1.2 and 4.1.1.3, respectively.

#### 4.1.1.2 SIBERIA Model of Revised Federal Cell Design

Neptune (2021b) summarizes a SIBERIA model of the full hybrid cover system, prepared to evaluate landform evolution of the Federal Cell for 10,000 years. This modeling projects that the hybrid cover design will provide excellent resistance to erosion. The DU PA v1.4 actually models greater levels of sheet and gully erosion than projected in the current work, as discussed in more detail in Section 4.4.1.

## 4.2 UDEQ Comment 1.2: Use of SIBERIA and USLE to Model Federal Cell Erosion

Questions on the application of SIBERIA and USLE as intended for modeling erosion of the embankment cover have been outstanding for some time. For this subject matter the following seven interrogatories: **INT CR R313-25-7(2)-191/1; INT CR R313-25-25(4)-197/1; INT CR R313-25-25(4)-198/1; INT CR R313-25-25(4)-199/1; INT CR R313-25-25(4)-200/1; INT CR R313-25-25(4)-202/1; and INT CR R313-25-25(4)-205/1** have been identified to track inquiries and responses regarding various aspects of applying and utilizing SIBERIA and USLE to model land form evolution.

In the latest status of interrogatories (SC&A 2019), among many issues, SC&A pointed out that use of USLE to model cover erosion does not consider effects of gully erosion and may be inadequate to analyze a dual-slope erosion line. Regarding SIBERIA, SC&A comments that the *"Use of the borrow pit at Clive to model land form evolution with SIBERIA is flawed because no attempt is made to rationalize the borrow pit parameters with those of the Federal Cell. Additionally, the description of the borrow pit modeling in Appendix 10 to DU PA v1.4 is confusing and lacking in detail."* Within the discussion for interrogatory 199 it was surmised that the SIBERIA modeling may add *"little to the ability to characterize the erosion behavior of the Federal Cell.* Six of the seven interrogatories remained opened as of July 2019 (SC&A 2019).

The SIBERIA model used to model erosion in the DU PA not only fails to account for any rock armor on the side slopes but it is calibrated to the results of an older version of another model, RHEM, applied to a soil cover. RHEM is described in Nearing et al. (2011) and Al-Hamdan et al. (2015) as not having been intended for modeling erosion of disturbed soil when that erosion occurs due to flow concentration. Based on experience at the Facility, the Division believes that erosion of disturbed soil due to flow concentration is likely to be the case at the proposed Federal Cell and to continue to be that way for extremely long periods of time. Erosion of the embankment could be great in magnitude, and it could be an essentially perpetual problem. This concern needs to be resolved and justification provided for ensuring the Federal Cell is stable over long periods of time.

As explained within several interrogatories of the DU PA Final Report (NAC-0147_R, 4/24/20) Neptune's analysis of erosion and landform evolution appears to have been discontinued. Many of Neptune's responses to these interrogatories indicate that "Energy*Solutions has chosen to apply rock armor to the embankment side slopes; therefore, the discussion of SIBERIA and its applicability no longer applies."*

SC&A has indicated to the Division that in their response, Energy*Solutions*/Neptune note that rip-rap is now proposed for the side slopes of the Federal Cell. Energy*Solutions* has provided no design basis or information on the expected performance of the rip-rapped side slopes. Modeling studies by Smith and Benson (2016) using SIBERIA show that, at 1,000 years, the maximum erosion in a semi-arid climate was about 7 m (23 ft) for a riprap embankment side slope of 41 m (134 ft) (Smith & Benson 2016, Figure D.1). At 1,000 years (the simulation end date), the rate of erosion was increasing at a rate of about 1.8 meters per year (6 ft/yr). This study emphasizes the need for detailed cover modeling to demonstrate the feasibility that rip-rap side slopes will perform adequately for an assumed 10,000 year compliance period. Energy*Solutions*/Neptune need to provide quantitative analysis of the cover's long-term response to erosional forces and explain the analysis mechanistically.

Contrary to what is implied or said in the draft license application [on p. 6-4], it does not appear that the modeling done to date for erosion at the proposed Federal Cell in the DU PA is appropriate or adequate. The borrow pit modeled by Energy*Solutions*/Neptune and proposed as an analog for the Federal Cell does not seem to offer a suitable match useful for modeling the erosion potential of the proposed Federal Cell. The materials, dimensions and slopes involved seem dramatically different. The borrow pit model was for a cover of fine-grained soil. The borrow pit model is not applicable to the top slope because of substantial differences in dimensions and slope gradient. The addition of only 15% gravel to the top slope of the proposed Federal Cell may also not effectively limit erosion to the extent needed. There seems to be no validated modeling evidence presented to date to indicate that erosion would be prevented or minimized by that relatively low percentage of gravel. The fractional coverage assumed and described for plants growing on the cover system, which may affect the modeled rate of erosion, also seems unlikely.

### 4.2.1 Comment 1.2 Response

Neptune (2021b) summarizes a SIBERIA model of the full hybrid cover system, prepared to evaluate landform evolution of the Federal Cell for 10,000 years. This modeling projects that the hybrid cover design will provide excellent resistance to erosion. The DU PA v1.4 actually models greater levels of sheet and gully erosion than projected in the current work, as discussed in more detail in Section 4.4.1.

Appendix B of Neptune (2021b) briefly assesses differences between the SIBERIA implementations in the current work and Smith and Benson (2016).

## 4.3 UDEQ Comment 1.3: Hybrid Cover

Energy*Solutions* has not presented site-specific models of erosion of the proposed hybrid cover system of the Federal Cell, with an evapotranspirative (ET) cover on the top slope, rock-armor cover on the side slope, and transitional material on the shoulders. Contrary to what is implied or said in the draft License Application [on p. 10-21], there is no modeling done to date, which the Division is aware, that indicates that velocities of flow down the rock-armored side slopes of the proposed Federal Cell would be less than the threshold velocity initiating erosion. Erosion modeling for the new hybrid cover must be performed. Consequently, there currently appears to be no peer review and interrogatory history on the hybrid-cover design.

### 4.3.1 Comment 1.3 Response

Neptune (2021b) summarizes a SIBERIA model of the full hybrid cover system, prepared to evaluate landform evolution of the Federal Cell for 10,000 years.

Section 4.1.1 addresses the question of threshold velocity calculations for the riprap side slopes.

## 4.4 UDEQ Comment 3: Resulting Infiltration

The Introduction and Sections 1 and 2 of this report have highlighted the Division's concerns regarding the potential for enhanced infiltration following the expected service life of engineered features of the disposal site. As previously highlighted NUREG-1573 states *"Because site conditions and the physical properties of engineered barriers will not remain the same throughout the period covered by the performance assessment analysis, infiltration into the disposal unit may increase over time. For example, infiltration may be enhanced if the site experiences a change or loss in vegetation (Gee et al., 1992; and Smyth et al., 1990) and cover performance may be reduced by plant and animal intrusion, settling and slumping, or erosion."*

It is the Division's impression that the DU PA modeling treated the end of service life and subsequent degradation of the proposed engineered cover as a non-contributing factor for infiltration. Subsequently, the possibility for enhanced infiltration after the initial service life has apparently not been integrated into the infiltration modeling. However, as NUREG-1573 recommended, the infiltration modeling might approach the progressive stages of cover performance with the use of temporal variations of the input parameters. *"A key feature of the approach is how progressive stages of cover performance degradation over time are captured in the infiltration analysis by using ranges of percolation rates and hydraulic parameters for engineered materials. At each stage of cover degradation, hydraulic parameter values for engineered materials are developed to represent the state of cover degradation for the stage."*

Energy*Solutions*/Neptune need to explain quantitatively and mechanistically how the DU PA has accounted for the potential for enhanced infiltration due to the potential erosion of the cover.

### 4.4.1 Comment 3 Response

The DU PA, v1.4 accounts for the potential for enhanced infiltration due to long-term naturalization of the embankment cover by evaluating the potential for damaging erosion; and by assuming that cover materials themselves naturalize and do not retain as-built hydraulic material properties.

Evidence at the site and in the local area, as demonstrated in the conceptual site model (CSM) (Neptune 2015e) and in SIBERIA landscape evolution modeling discussed in Neptune (2021b), shows that erosion of the cover will not likely occur to a large extent on the embankment. As discussed in Section 5.6.1.3 of Neptune (2021c), the proposed ET cover is not expected to degrade to a point where the hydrology of the cover changes significantly, if at all, from erosion over the 10,000-year period modeled.

#### 4.4.1.1 Cover Erosion

Net sheet erosion of the cover is projected to be negligible. There are several lines of evidence that point to this conclusion, as described in Neptune (2015d), Neptune (2015e), and Neptune (2021b). Recent work to evaluate the hybrid cover design has not changed this fundamental conclusion.

Erosion potential for the hybrid cover design is assessed using the SIBERIA landscape evolution model, which provides three-dimensional projections of the effects of sheet and gully erosion. While gullies do develop over time, the depth of the 95$^{th}$ percentile of erosion in these gullies is only 5 cm after 500 years, and only 34 cm after 10,000 years. The mean values are much lower, 1 cm and 11 cm respectively. Additionally, these results do not include aeolian depositional processes, which were estimated to be around 55 cm after 10,000 years or about five times the rate of erosion over the same time period (Neptune 2020a). Without considering aeolian deposition the cover remains stable over the next 10,000 years; if deposition is considered, then it is likely to dominate erosional processes over this same time period.

#### 4.4.1.2 Cover Naturalization

As discussed in Neptune (2015e), Section 8.3, engineered covers can be subject to degradation processes such as biointrusion, freeze-thaw, and erosion. For the embankment at the Clive Site, however, these processes will be very slow to develop. The structure of the cover is designed with an Evaporative Zone and Frost Protection Layer which inhibit biotic intrusion, freeze-thaw processes and infiltration.

As discussed in Section 5.6.1.3 of Neptune (2021c), a capillary-barrier style ET cover inhibits downward flow of water through the cover system by creating a capillary break between layers of different pore size. This type of cover facilitates evapotranspiration via water storage in upper-layer fine-grained soil and limits downward water movement into lower layers. Radon barrier layers deeper in the cover limit upward radon movement by retaining water, which limits the airspace available for gaseous transport. Partially saturated clays maintain low pressure heads due to the fine pore structure, which inhibits liquid flow upward.

Evidence of slow progress of pedogenesis at the site and surrounding environment is found in the stratigraphic studies at the Clive site (Neptune (2015e), Section 3.3.3). Recent field studies (Neptune 2015f) show weak development of soil profiles in the natural setting, with preserved layers of eolian silt deposits at and beneath the current soil surface. One of the conclusions of this work is that there is not significant enough soil structural development to influence soil hydraulic properties at depth (Neptune (2015e), Section 3.3.3). Surficial soils are expected to have higher hydraulic conductivity (compared to, for example, laboratory testing) due to surface process like plant and animal activity. However, the coarse nature of the frost protection layer is designed to isolate these processes to the top of the cover system.

In addition, the Cover Test Cell deconstruction project (Energy*Solutions* 2020) showed very little change from the as-built specifications for the upper and lower radon barrier layers after 17 years. No degradation was evident. Absent any plausible mechanistic explanation for soil texture evolution, and given the observed stability of both natural and constructed soil layers, it is very difficult to imagine how hydraulic properties of the radon barrier would change appreciably in this environment. Nevertheless, the consequences of hypothetical degradation of the radon barrier are incorporated into the DU PA Model v1.4 via the $K_{sat}$ distribution used in the v1.4 HYDRUS simulations and the GoldSim model; this is discussed further in Section 4.4.1.4.

#### 4.4.1.3 Erosion Implementation in DU PA v1.4

Gully erosion is evaluated in DU PA v1.4 as discussed below. Neptune (2021b) develops a SIBERIA model for the hybrid cover design over the Federal Cell. Results of this updated analysis show that DU PA v1.4 overestimates the volume, depth, and impact of gully erosion.

Erosion is considered in DU PA v1.4 as follows (Neptune 2015b):

> The impact of sheet and gully erosion in the Model is evaluated by the application of results of landscape evolution models of hillslope erosion loss and channel development conducted for a borrow pit at the site…
>
> A subset of the borrow pit model domain was selected to represent the cover. Gully depths estimated by the erosion model were extrapolated to 10,000 years and a statistical model was developed that generated values of the percentage of the cover where gullies ended within a given depth interval. This model provided an estimate of the volume of embankment cover material removed by gullies. The depositional area of the gully fan is assumed to be the same as the area of waste exposed in the gullies, using projections onto the horizontal plane. If these embankment materials include DU waste components, then this leads to some contribution to doses and uranium hazards. No associated effects, such as biotic processes, effects on radon dispersion, or local changes in infiltration are considered within the gullies.

Accordingly, there are gully erosion calculations in the DU PA v1.4, based on SIBERIA modeling of the borrow pit. That modeling derived a maximum gully depth of less than 3.5 meters and areal coverage for all gullies of less than 1 percent of the cover area at 10,000 years. In a deterministic run, DU PA v1.4 calculates the total volume of gullies to be 1,127 $m^3$ at 10,000 years; with a total surface area of 1,508 $m^2$ at that time.

Implementation of the gully erosion calculations in DU PA v1.4 was the subject of Interrogatory CR R313-25-25(4)-205/1; which questioned the relative depth of gullies in probabilistic model runs. In responding to this comment, Neptune (2018) concludes:

> The April 2015 SER (SC&A 2015) also notes that the embankment's performance with respect to radon flux would be adequate even with complete removal of the cover system, as predicted doses are several orders of magnitude below regulatory limits. Thus, the comparison of the Clive DU PA Model v1.4 with other radon flux predictions, which show only modest differences at relevant depths, does not detract from the conclusion that radon fluxes are adequately attenuated by the embankment due to the depth of burial of radon-generating wastes and the prevailing site conditions.

Based on prior SIBERIA modeling of the borrow pit, DU PA v1.4 calculates how deep the gullies excavate and a volume of gully material is eroded from the "waste" layers[3] when the full cover thickness is penetrated. For the deterministic run, gullies reach the top 3 out of 27 waste layers (as a fraction of the overall surface area). Out of 10,000 realizations of DU PA v1.4 (seed 2), 69% of the realizations have gullies that reach the top three or four waste layers, while 8% of realizations do not get as deep as waste layer 1, and no realizations reach waste layer 5.

Based on the gully volume excavated in each waste layer, weighted average activity concentrations from the waste layers in gullies are used in the dose calculations to first calculate plant concentrations in the gullies and then used as part of the concentration of contaminants in

[3] It is acknowledged that the embankment layers between DU and the cover will not be permitted to contain Class A LLRW until a specific performance assessment authorizing such is approved. Modeled as clean soil fill initially in DU PA v1.4, this material is discussed in supporting documentation as "waste" since it is expected to accumulate some activity from the DU waste placed at the cell floor via radon emanation/decay and diffusion.

beef and game meat. Those concentrations are incorporated into the dose calculations for the Rancher and Hunter; and into the uranium hazard calculations for rancher and hunter.

Results of the deterministic model with gullies turned on/off show no difference in the doses to onsite receptors (rancher, hunter), but they do show small differences in uranium hazard quotients. The uranium hazard quotients are very small (~$1e^{-15}$); compared with a target threshold of 1.

These results reflect that the gullies are shallow enough that the concentrations of contaminants in the gullies do not contribute to doses for the deterministic run, although they do contribute to the uranium hazard quotients. If long-lived radionuclides were disposed closer to the cover, these results would be expected to increase though they could remain within applicable dose criteria.

Local changes to infiltration associated with gully development are not considered in DU PA v1.4. In development of DU PA v1.4, the small area and volume of gullies modeled to be present at 10,000 years was considered reasonable assurance that gully erosion would have a negligible impact on infiltration at model year 500, the point of compliance for GWPLs. After this time, the non-potable groundwater is not considered a dose pathway for the exposure scenarios affecting onsite and offsite receptors.

SIBERIA modeling of the hybrid cover explicitly evaluates erosion impacts at model year 500 in order to better quantify the approach taken in DU PA v1.4. The mean erosion observed in this time period is 1 cm, with the 95$^{th}$ percentile of erosion at 5 cm, indicating that no local changes to infiltration are expected on the cover during this 500-year period. Additional results are discussed in Neptune (2021b).

#### 4.4.1.4 Cover Naturalization Implementation in DU PA v1.4

The potential for increased infiltration associated with cover naturalization is addressed by the incorporation of increased radon barrier $K_{sat}$ distributions used in the v1.4 HYDRUS simulations that inform infiltration in the DU PA v1.4 model; and by having the radon barrier clay saturated hydraulic conductivity ($K_{sat}$) values change from the as-built conditions to naturalized conditions for both the lower and upper radon barriers within the DU PA v1.4 model. As-built $K_{sat}$ values are $4e^{-}3$ cm/day and $8.6e^{-2}$ cm/day for the upper and lower radon barriers, respectively (Neptune 2015c). Average Cover Test Cell deconstruction project found that these values were $5e^{-3}$ and $1e^{-2}$ cm/day, respectively (Energy*Solutions* 2020); indicating essentially no change from the as-built condition over 18 years.

Nonetheless, in DU PA v1.4, $K_{sat}$ values for both radon barriers are modeled to reflect naturalized values chosen from the log-normal distribution: LN(3.37, 3.23), with a right shift of 0.00432, in cm/day units. These values are two to three orders of magnitude higher than as-built conditions. The naturalized $K_{sat}$ values are the same for the upper and lower radon barriers.

These changes are implemented at time zero for the model so that naturalization occurs at the beginning of the model run. This timing is much earlier than what would be expected to occur at the site, per Section 4.4.1.2 and validated by the Cover Test Cell deconstruction.

As described in Neptune (2015a), average annual infiltration was incorporated into the GoldSim DU PA model with a regression equation developed from HYDRUS-1D simulation results. Average percolation through the cover was not found to be sensitive to saturated conductivity ($K_{sat}$) of the radon barrier, as percolation is determined by the performance of the capillary barrier in the overlying cover layers. Average water contents in the radon barrier layers, however, were found to be sensitive to $K_{sat}$; higher $K_{sat}$ was associated with lower average water content. Section 5.4.1 of Neptune (2021c) discusses this issue in more detail.

As such, increasing the $K_{sat}$ of the radon barrier at the outset of a model realization to account for a hypothetical naturalized condition results in lower moisture content in the radon barrier. A lower moisture content in the radon barriers means that the radon barriers are not functioning as effectively at keeping radon from migrating to the surface, resulting in higher radon flux.

A test case of DU PA v1.4 was run with naturalization occurring at 500 years to evaluate this effect. Radon flux results and related dose results decrease about 1–3% under this scenario, compared with the assumption of immediate naturalization that is embedded in DU PA v1.4.

# 5.0 Conclusion

DU PA v1.4 demonstrates compliance with the dose and groundwater protection requirements of Utah regulations relating to DU disposal. The interrogatory and response process has added to the record supporting these conclusions; but has not caused the quantitative model to require revision. Accordingly, DU PA v1.4 remains the basis for demonstrating compliance of the disposal facility.

Compliance with UAC R313-25-9(5)(a) is affirmed by DU PA v1.4 and Deep Time model v1.5, together with their supporting documentation as supplemented by the interrogatory/response cycle.

# 6.0 Attachments

1. Federal Cell engineering drawings, series 14004

# 7.0 References

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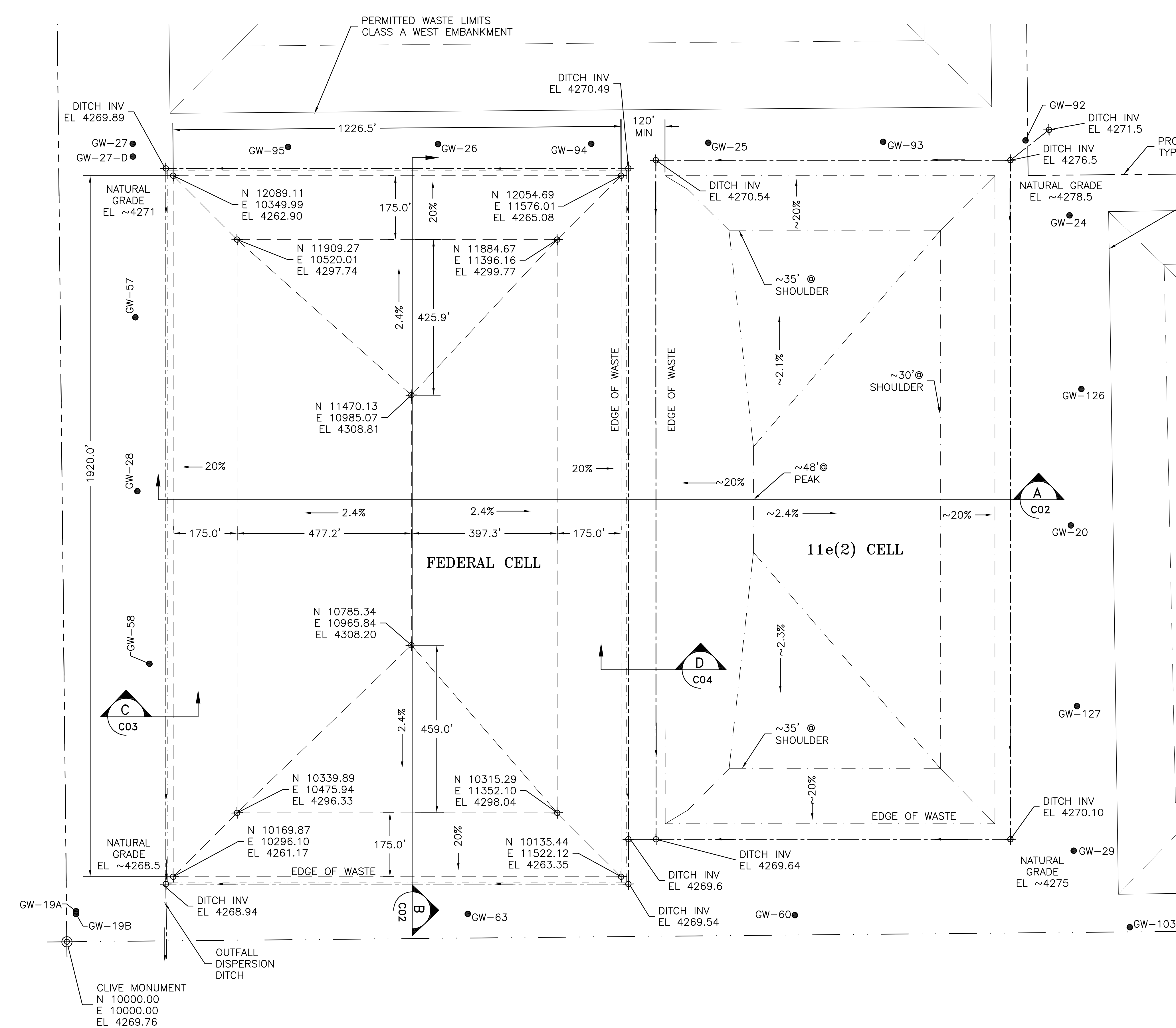
# Attachment 1:

# Federal Cell Drawings 14004-C01 through 14004-C05




## LEGEND

- SECTION LINE
- PROPERTY LINE
- FEDERAL CELL WASTE BREAKLINES
- FEDERAL CELL CLAY LINER LIMITS
- 11e.(2) CELL WASTE BREAKLINES
- LINER LIMITS (MINIMUM)
- DRAINAGE DITCH CENTERLINE

150 0 150 300

## NOTES

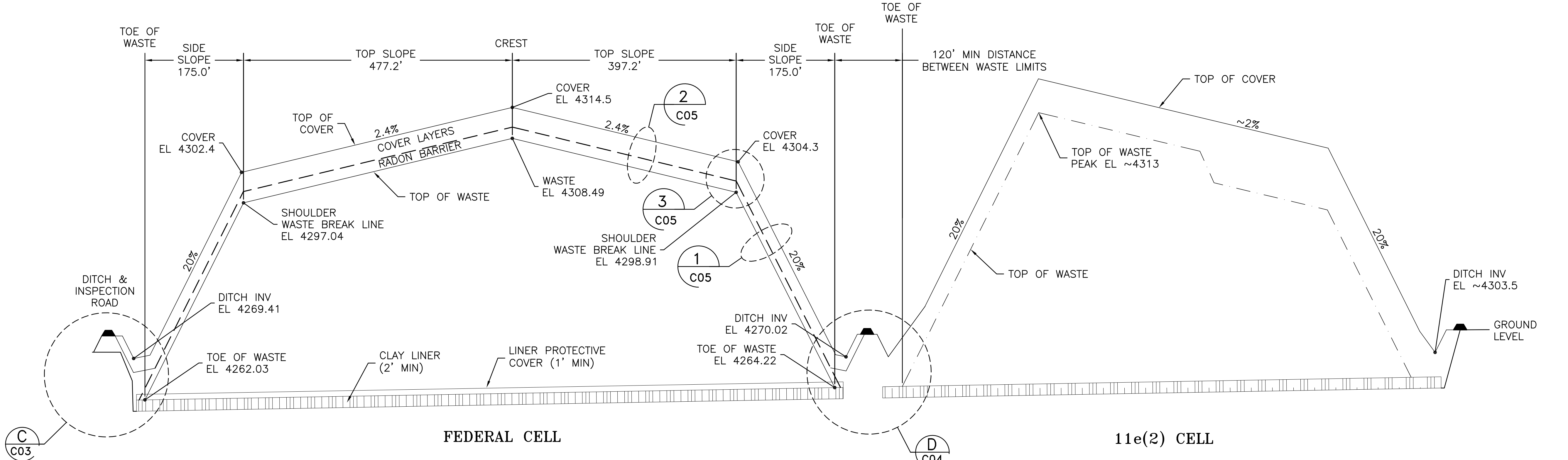
1. ALL ELEVATIONS SHOWN ARE FOR TOP OF WASTE UNLESS OTHERWISE NOTED.
2. COORDINATES ARE BASED ON THE CLIVE MONUMENT.
3. THE CALCULATED VOLUME OF THE FEDERAL CELL IS XX YD³.
4. REFER TO THE LLRW AND 11e.(2) CONSTRUCTION QUALITY ASSURANCE/QUALITY CONTROL (CQA/QC) MANUAL FOR MATERIAL AND CONSTRUCTION SPECIFICATIONS.
5. THE 11e.(2) EMBANKMENT IS SHOWN FOR REFERENCE ONLY. REFER TO 11e.(2) LICENSE DRAWINGS FOR ADDITIONAL DESIGN DETAIL.

| | DATE | BY | DESCRIPTION OF CHANGE |
|---|---|---|---|
| 2 | 2/12/21 | DFB | FOR LICENSE APPLICATION--REVISED WASTE LIMITS |
| 1 | 1/16/20 | DFB | FOR LICENSE APPLICATION |

ENERGYSOLUTIONS

CLIVE FACILITY
FEDERAL WASTE CELL
EMBANKMENT FEATURES AND CONTROLS
CLIVE, UTAH

DRAFTED BY D. BOOTH
REVIEWED BY T. ORTON
APPROVED BY D. BOOTH
SCALE AS NOTED | DATE 01/08/20 | REV. 2
DRAWING NO. 14004 C01




WEST–EAST CROSS SECTION
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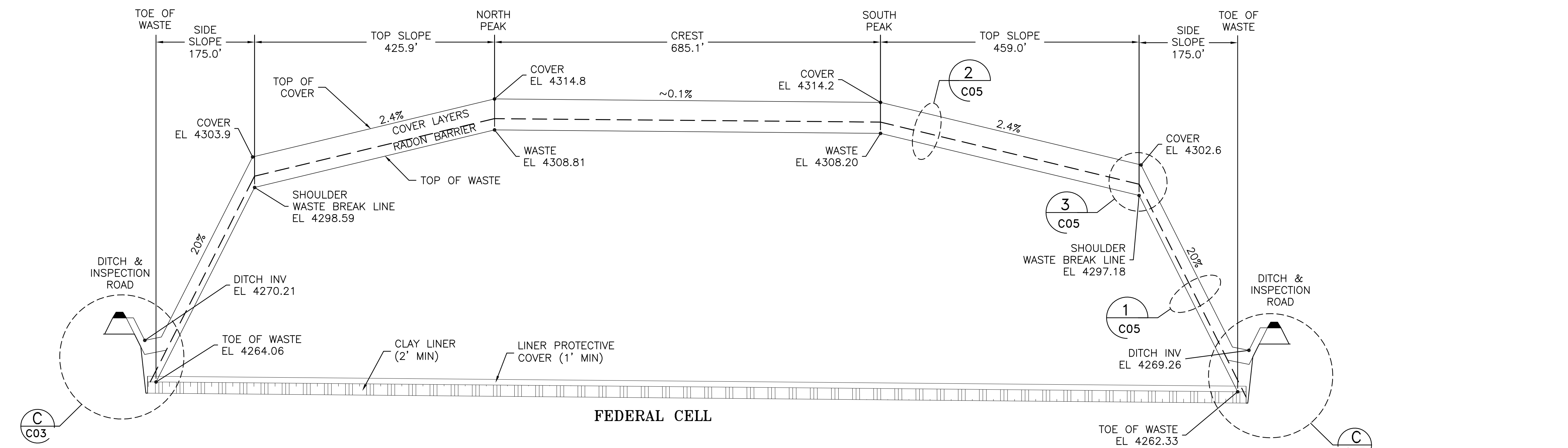
VERTICAL SCALE: 1" = 20'



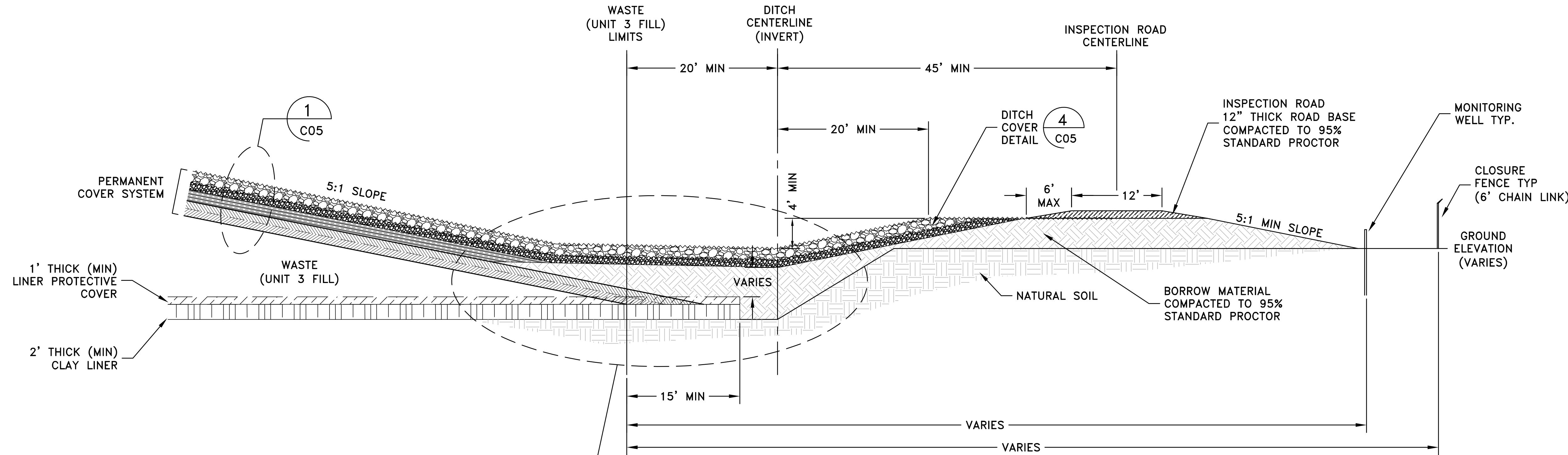

SOUTH–NORTH
HORIZONATAL SCALE: 1" =200'
VERTICAL SCALE: 1" = 20'

| | DATE | BY | DESCRIPTION OF CHANGE |
|---|---|---|---|
| 2 | 2/12/21 | DFB | FOR LICENSE APPLICATION – REVISED WASTE LIMITS |
| 1 | 1/16/20 | DFB | FOR LICENSE APPLICATION |

ENERGYSOLUTIONS

CLIVE FACILITY
FEDERAL WASTE CELL
EMBANKMENT CROSS SECTIONS
CLIVE, UTAH

DRAFTED BY: D. BOOTH
REVIEWED BY: T. ORTON
APPROVED BY: D. BOOTH
SCALE: AS NOTED
DATE: 01/08/20
REV.: 2
DRAWING NO.: 14004 C02




C DITCH & ROAD DETAIL TYP.
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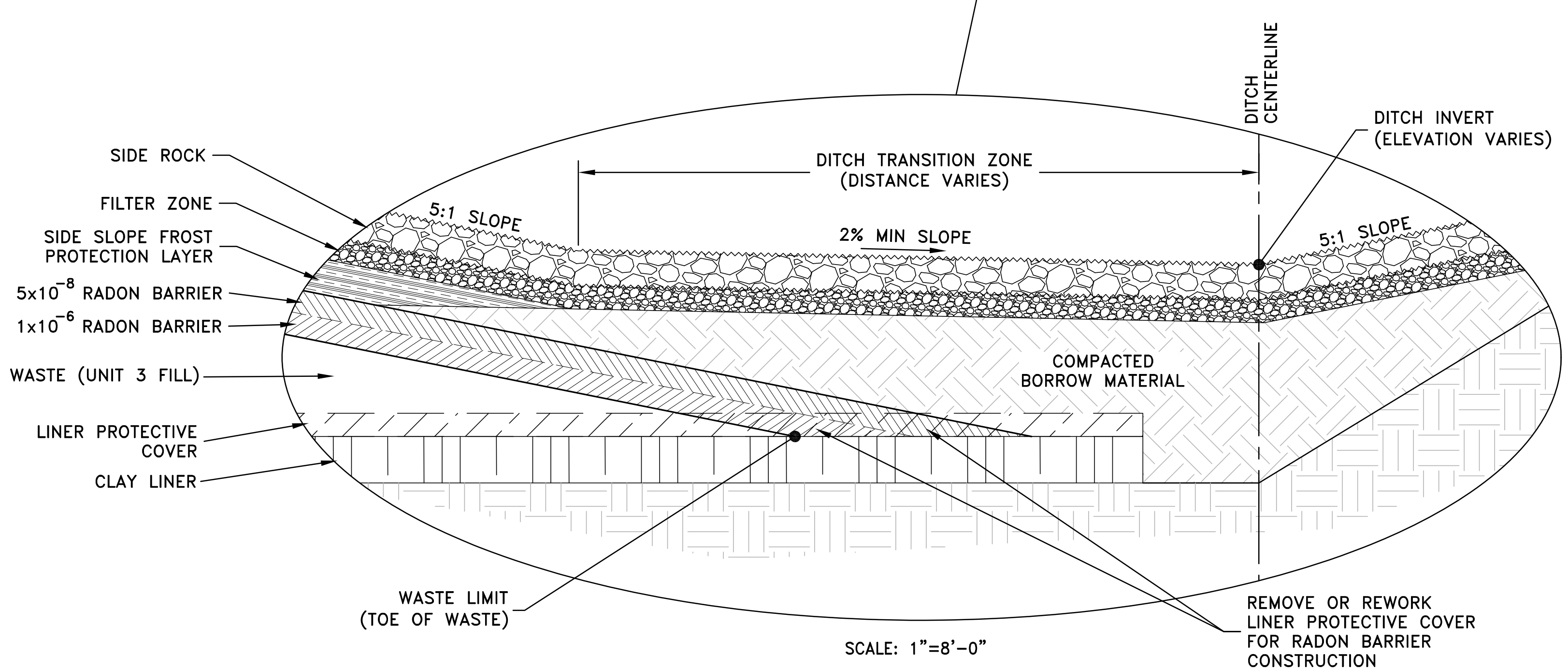


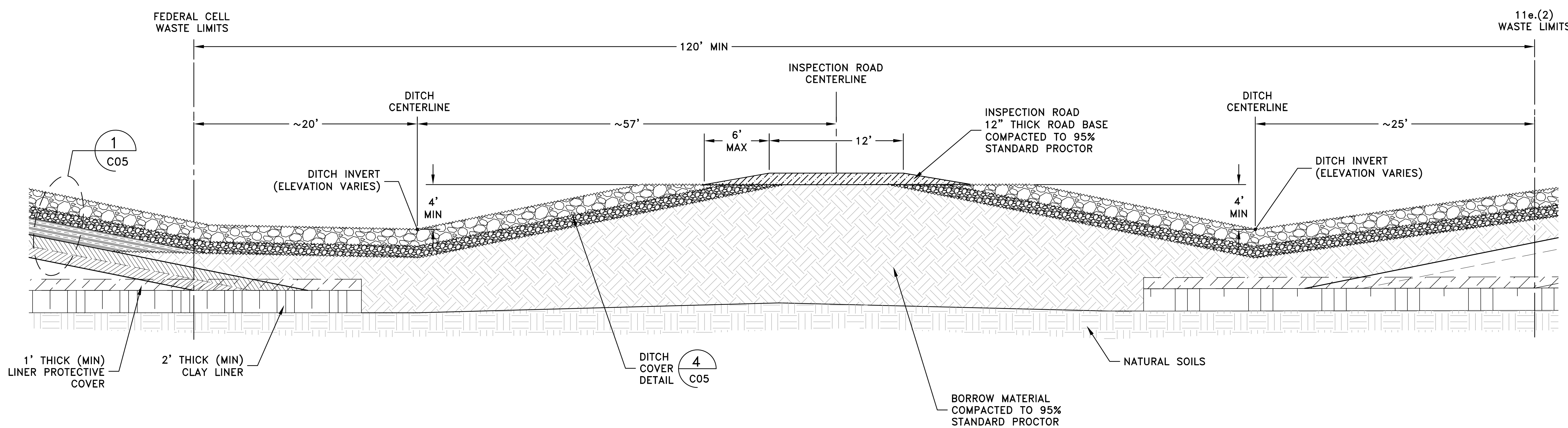

SCALE: 1"=8'-0"

| | | | |
|---|---|---|---|
| 1/16/20 | DFB | FOR LICENSE APPLICATION | |
| DATE | BY | DESCRIPTION OF CHANGE | |

ENERGYSOLUTIONS

ENERGYSOLUTIONS "CLIVE" FACILITY
FEDERAL WASTE CELL
SECTIONS AND DETAILS, 1 OF 3
CLIVE, UTAH

DRAFTED BY D. BOOTH
REVIEWED BY T. ORTON
APPROVED BY D. BOOTH
SCALE AS NOTED | DATE 01/13/20 | REV. 1
DRAWING NO. 14004 C03




D
C01,C02

## DITCH DETAIL BETWEEN CELLS

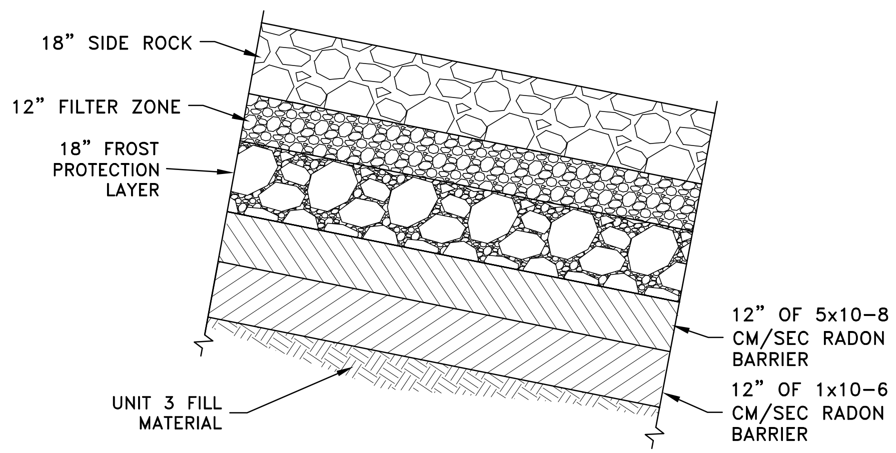
SCALE: 1"=8'-0"

| DATE | BY | DESCRIPTION OF CHANGE |
|---|---|---|
| 2/12/21 | DFB | FOR LICENSE APPLICATION – REVISED WASTE LIMITS |
| 1/16/20 | DFB | FOR LICENSE APPLICATION |

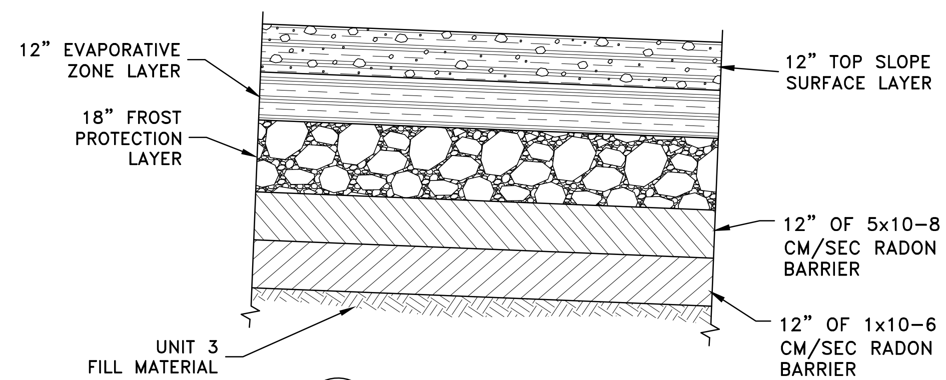
ENERGYSOLUTIONS

ENERGYSOLUTIONS "CLIVE" FACILITY
FEDERAL WASTE CELL
SECTIONS AND DETAILS, 2 OF 3
CLIVE, UTAH

DRAFTED BY: D. BOOTH
REVIEWED BY: T. ORTON
APPROVED BY: D. BOOTH
SCALE: AS NOTED
DATE: 01/14/20
DRAWING NO.: 14004 C04




1 DETAIL-SIDE SLOPE
C02 NTS
TYPICAL SIDE SLOPE COVER DETAIL




2 DETAIL-TOP SLOPE
C02 NTS
TYPICAL TOP SLOPE COVER DETAIL

## COVER MATERIAL SPECIFICATIONS

SURFACE LAYER, TOP SLOPE LAYER:
85% UNIT 4 MATERIAL AMENDED WITH 15% (±3%), BY VOLUME, GRAVEL. GRAVEL IS SPECIFIED AS FOLLOWS.
$D_{100}$ <= 3 INCH
$D_{30}$ <= .85 INCH (40 mm)

EVAPORATIVE ZONE LAYER:
UNIT 4 CLAY MATERIAL. NO COMPACTION SPECIFICATION.

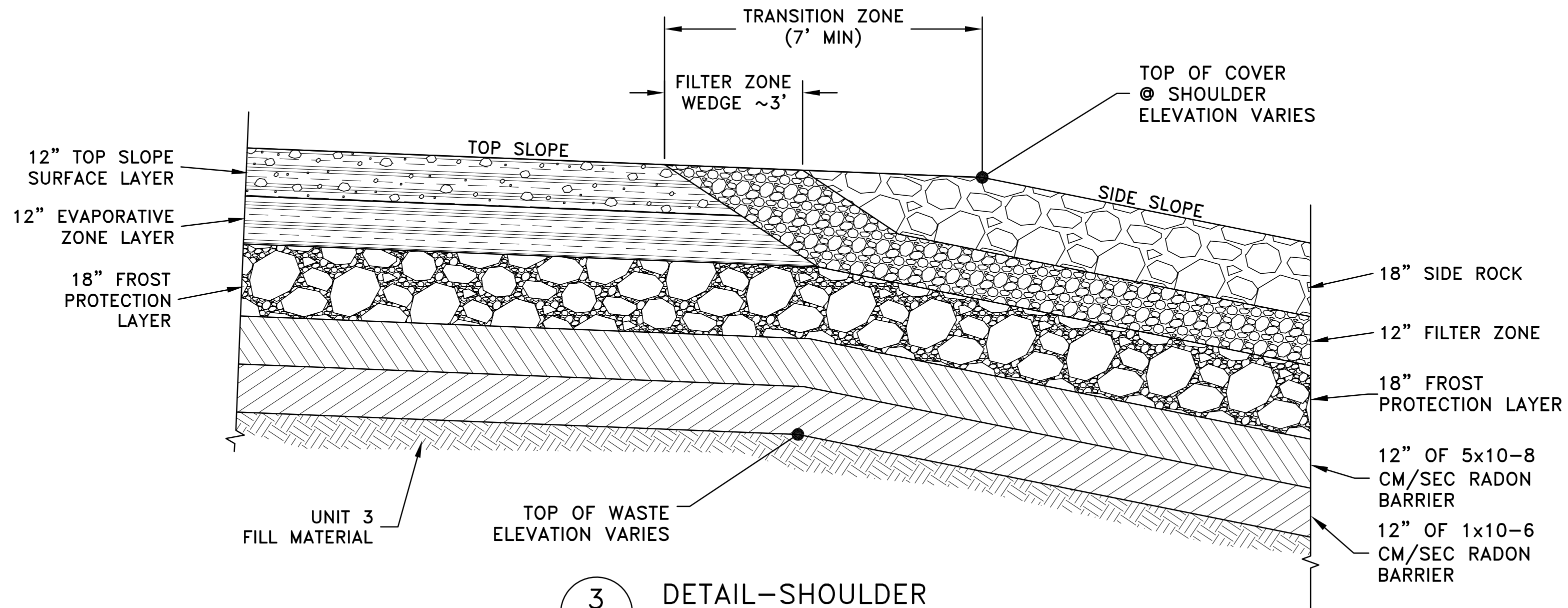
FROST PROTECTION LAYER:
BANK RUN COBBLE/GRAVEL/SOIL MATERIAL. WELL GRADED
$D_{100}$ <= 16 INCH

SIDE ROCK:
$D_{100}$ = 12 TO 16 INCH
$D_{95}$ = 8 TO 12 INCH
$D_{50}$ = 4.5 TO 8 INCH
$D_{15}$ = 2 TO 4 INCH
$D_{5}$ >= NO. 200 SIEVE

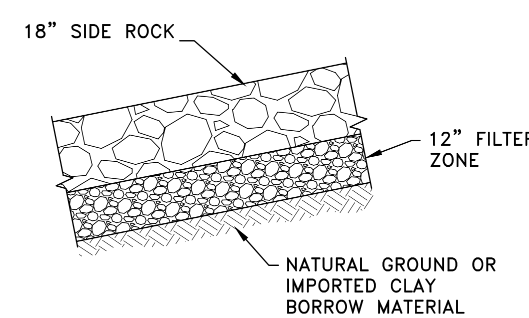
FILTER ZONE
$D_{100}$ = 1.5 TO 3 INCH
$D_{85}$ = 1 TO 2.5 INCH
$D_{50}$ = 0.75 TO 2 INCH
$D_{15}$ = 0.3125 TO 0.625 INCH
$D_{10}$ >= NO. 10 SIEVE (2mm)
$D_{5}$ >= NO. 200 SIEVE

## NOTES:

1. REFER TO THE CURRENT APPROVED LLRW & 11e.(2) CQA/QC MANUAL FOR ADDITIONAL MATERIAL SPECIFICATIONS, GRADATIONS, CONSTRUCTION AND TESTING REQUIREMENTS.
2. SEED THE TOP SLOPE SURFACE LAYER WITH AN APPROVED SEED MIXTURE AND METHOD.




3 DETAIL-SHOULDER
C02 1"=10'




4 DETAIL-DITCH OUTER SLOPE
C03 NTS
TYPICAL PERIMETER DITCH COVER DETAIL

| DATE | BY | DESCRIPTION OF CHANGE |
|---|---|---|
| 2/12/21 | DFB | FOR LICENSE APPLICATION - REVISED COVER |
| 1/16/20 | DFB | FOR LICENSE APPLICATION |

ENERGYSOLUTIONS

ENERGYSOLUTIONS "CLIVE" FACILITY
FEDERAL WASTE CELL
SECTIONS AND DETAILS, 3 OF 3
CLIVE, UTAH

DRAFTED BY D. BOOTH
REVIEWED BY T. ORTON
APPROVED BY D. BOOTH
SCALE AS NOTED
DATE 01/09/20
REV.
DRAWING NO. 14004 C05