PROJECT NUMBER: S142019

PROJECT NAME: USEN – Trench 13 Design

DATE: June 2015

CALCULATION NUMBER: C.11 Revision:

**CALCULATION TITLE: Trench 13 Foundation Settlement Estimate**

**DESCRIPTION OF CALCULATION:**

Estimate of the settlement of the Trench 13 foundation (cell bottom)

**REFERENCES USED:** Number of Reference Pages Attached:

1. Trench 13 Excavation and Final Slope Stability calculation (Calculation C.02). Soil and waste properties used in this calculation and determined by lab testing and previous trench calculations).

2. Landfill Report for Trench 12, 1996 foundation settlement calculation

**REVIEW COMMENTS:**

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|---|---|---|---|
| CALCULATION MADE BY: | SLW (SRES) | DATE: | June 2015 |
| CALCULATION CHECKED BY: | PAZ | DATE: | June 25, 2015 |
| CALCULATION REVISED BY: | | DATE: | |
| CALCULATION REVIEWED BY: | SLW (SRES) | DATE: | June 25, 2015 |

# TRENCH 13 FOUNDATION SETTLEMENT ESTIMATE

## APPROACH

Calculation intended to estimate settlement of native soil material at the base of Trench 13 disposal cell(s) under the influence of the full thickness of disposed waste and final cover.

Calculation is made by the same method used for the similar calculation made for USEN Trench 12. That calculation approach, as included in the 1996 Design Report (design drawings and supporting calculations) and originally approved by NV DEP for Trench 12, is assumed still to be acceptable. Later modifications to the 1996 design, as approved by NDEP and as constructed, certified, and approved for waste disposal, were based on many of the earlier calculations that were made in support of the design, including the settlement calculation.

The assumption is made that settlement under the influence of full waste thickness will result from the difference between the settlement caused by the weight of native soil removed for construction of Trench 13 and the combined weight of waste and final cover. Further, the location of maximum settlement will be along the line representing the horizontal superposition of maximum waste thickness and maximum soil removal (per additional assumptions provided below).

For this calculation, the following additional assumptions are made:

- The density of all native soil materials is assumed to be 120 pcf (pounds per cubic feet). The assumption considers the difference between the density of non-cohesive surface soil (110 pcf) and all deeper removed soil (120 pcf) to be negligible.

- The difference between the (density of the lower portion of deposed waste (i.e., 115 pcf, from 50 feet deep to the bottom of disposed waste) and that of select waste (i.e., no density assumed, first 30 inches of material placed on the liner) is negligible.

- The difference between the density of final cover soil (110 pcf) and the density of the upper 50 feet of disposed waste (100 pcf) are similar and the weight of both can be approximated by the waste density.

- The geometric difference between the location of maximum native soil removal (i.e., south end of Trench 13) and the location of maximum waste thickness (near north end of Trench 13) is ignored and the two extremes are assumed to be applied along the same geographic line (east-west line) across all phases of Trench 13.

- The weight of liner materials is not considered.

The source of vertical thicknesses and densities is the Trench 13 Excavation and Final Slope Stability calculation (**Calculation C.02**) and references to sources of values provided in that calculation.

**NATIVE SOIL MATERIAL REMOVAL**

Maximum vertical thickness removed = 75 feet
Native soil density (average, across all removed strata) = 120 pcf (lb/ft$^3$)

Load applied vertically at base of cell excavation = 75 ft x 120 pcf = 9,000 psf (lb/ft$^2$)

<u>Waste material and final cover</u>

Total maximum vertical thickness, including 3 feet of final cover =155 feet
Waste density – upper 53 feet (3 feet of final cover and 50 feet of waste) = 100 pcf
Waste density – from 53 feet deep to 150 feet deep = 115 pcf

Load applied vertically at base of cell excavation
= [53 ft x 100 pcf] + [(155-53) ft x 115 pcf]
= 17,030 psf

Difference between loadings
(also described as "net stress increase at the foundation level")
= 17,030 psf – 9,000 psf = 8,030 psf
= 4 tsf (tons/ft$^2$)

**SETTLEMENT ESTIMATE**

The 1996 calculation, made using Schmertmann's Method, determined net settlement to be as follows:

After 10 years, net settlement (inches) = 0.42 $\Delta p$ where $\Delta p$ = net stress increase in tsf
= 0.42 * 4 tsf = 1.68 inches

After 100 years, net settlement (inches) = 0.48 $\Delta p$
= 0.48 * 4 tsf = 1.92 inches

**CONCLUSION**

The estimated net foundation settlement determined by this calculation is less than two inches, occurring along the east-west line beneath the crest of the final cover. Settlement that can be expected at locations moving away (in either direction – north or south) from the line of maximum settlement will be proportionately less. As the design slope of the cell foundation (i.e., cell floor) is approximately a 20 feet difference from north (higher elevation) to south (lower elevation), the cell floor elevation changes (i.e., lower elevations) resulting from settlement (i.e., much less than 2 inches) will be negligible with regard to functioning of the leachate collection and leak detection

functions of the cell floor liner. Further, the settlements resulting from waste placement will be uniform and will not result in differential settlement of a magnitude that would degrade the functioning of the liner system.

**Reference 1**

**See Calculation C.02**

**Trench 13 Excavation and Final Cover Slope Stability**

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5.5 Settlement of Foundation Soils.

Settlement at the foundation level is calculated using Schmertmann's equation (Ref 2):

$$\delta = c_1 \cdot c_2 \cdot \Delta p \cdot \frac{I_z}{E} \cdot \Delta z$$

$c_1 \doteq 1$ for areal load

$c_2 = 1 + 0.2 \log_{10}\left(\frac{t}{0.1}\right)$, $t$ in years.

for $t = 10$ years, $c_2 = 1.4$

for $t = 100$ years, $c_2 = 1.6$

$I_z = 0.6$ (max)

$E = 2 q_c = 2 \times (6 \times N)$

Let $N = 100$ blows per foot (for a very dense sand) $\Rightarrow E = 1200$ tsf.

This elastic modulus is not high considering the foundation soils are being reloaded.

$\Delta z$ = depth of influence below the foundation level, assumed to be 50 feet.



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upon completion of waste placement, $t \doteq 10$ years,

$$\delta = 1 \times 1.4 \times \Delta p \times \frac{0.6}{1200} \times 50' \times 12''$$

$$= 0.42\ \Delta p, \text{ inches.}$$

(where $\Delta p$ is expressed in tsf. $\Delta p$ is the net stress increase at the foundation level, see page 27/33 for detailed calcs.)

at $t = 100$ years

$$\delta = 1 \times 1.6 \times \Delta p \times \frac{0.6}{1200} \times 50' \times 12''$$

$$= 0.48\ \Delta p$$

The potential increase of settlement over the first 90 years is about 14%, which is quite negligible considering the low differential settlements (see page 27/33 for details).



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REFERENCE 2

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Total settlement at $t = 10$ years is calculated as follows:

| Point | Waste Fill Thickness (ft) | Original Foundation stress (tsf) (1) | $\Delta P$ Net Foundation Stress (tsf) (2) | $\delta$ Settlement (in) (3) |
|---|---|---|---|---|
| D' | 150 | 4.69 | 2.81 | 1.18 |
| E' | 130 | 4.69 | 1.81 | 0.76 |
| F' | 100 | 3.13 | 1.87 | 0.79 |
| G' | 0 | 0. | 2.38 | 1 |

(1) Original Foundation stress is calculated as:

$$75' \times 125 \text{ pcf} / 2000 = 4.69 \text{ tsf}$$

(2) Net Foundation stress is calculated as:

$$\Delta P = \frac{D \times 100 \text{ pcf}}{2000} - \text{original foundation stress}$$

where D = depth of waste fill.

(3) $\delta$ (inches) $= 0.42 \cdot \Delta P$

$\Rightarrow$ Maximum differential settlement of foundation soil due to weight of fill is on the order of 0.4 inches which is quite negligible



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REFERENCE 2

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comparing to other sources of settlements. Also, the settlements of foundation soil will essentially be completed at the end of waste placement. As a result, settlement of foundation soil is not considered as part of post-closure settlement.



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