PART III, ATTACHMENT 3

APPENDIX III-3B

SETTLEMENT ANALYSIS

HAWTHORN PARK RECYCLING AND DISPOSAL FACILITY
APPENDIX III-3B, SETTLEMENT ANALYSIS

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Objective: Estimate the following:

1) Subgrade settlement
2) Strain on the clay liner from differential settlement

Assumptions:

Layer I will be partially excavated within the landfill footprint. Layer I and III clays are compressible while the Layer II sand is incompressible.

The maximum settlement will occur where the compressible materials beneath the liner are thickest and the change in overburden stress is the greatest. The location that provides the thickest section of compressible material and the greatest change in overburden stresses occurs at approximately the center of the waste fill area.

The groundwater elevation is above the base of the landfill.

Calculations:

1) Subgrade Settlement

Settlement is estimated from the equation:

$$S = \left[\frac{H}{(1+eo)}\right][C_r log(\sigma'_c/\sigma'_o)+C_c \log(\sigma'_f/\sigma'_c)]$$

where:

S =	settlement	(ft)
C_c =	compression index	
C_r =	recompression index	
H =	layer thickness	(ft)
σ'_o =	initial overburden pressure	(tsf)
σ'_c =	preconsolidation pressure	(tsf)
σ'_f =	final overburden pressure	(tsf)
e_o =	initial void ratio	

C_c, C_r, σ'_0, and e_0 were determined based on consolidation test results.

Overburden pressure is the sum of the overburden thickness of each material multiplied by it's effective unit weight. The initial and final overburden pressures are calculated at the analysis point of each layer being analyzed.

For Sheets 1 through 4

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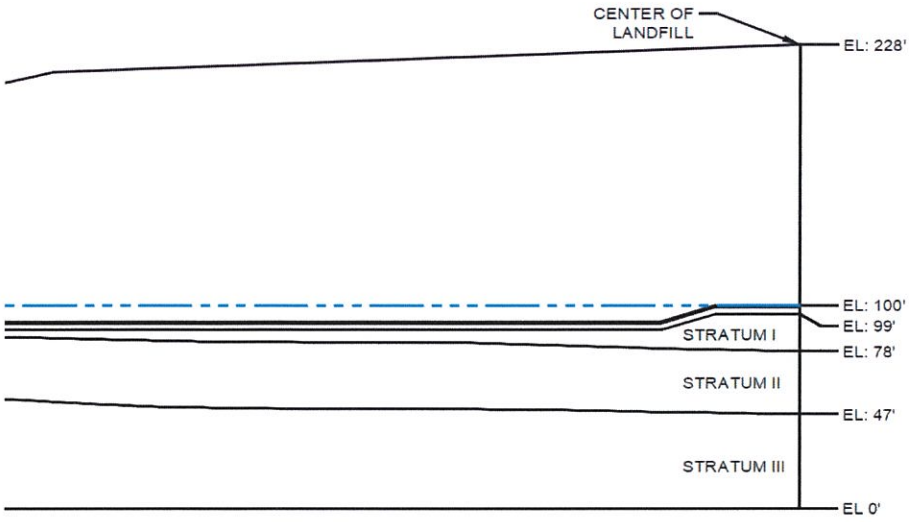

Figure 1: Cross-Section - Center of Landfill

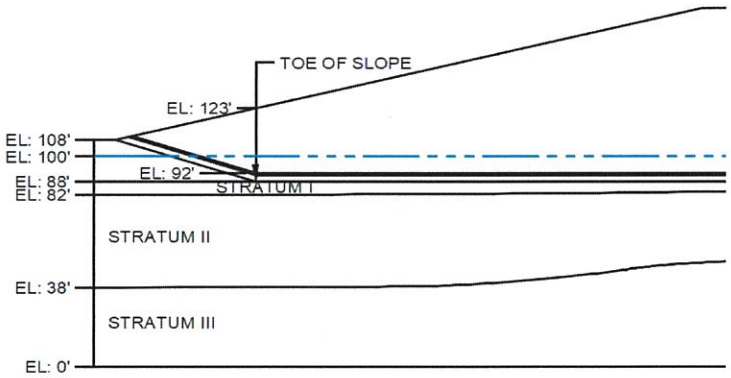

Figure 2: Cross-Section - Toe of Slope

2A) <u>Center of Landfill</u>

Determine the initial and final overburden pressures.

Overburden	H_o (ft)	H_f (ft)	Unit Wt (pcf)	σ'_o (psf)	σ'_f (psf)
Final Cover	0	2	120	0	240
Waste	0	126	70	0	8820
PCOV	0	1	120	0	120
CLAY	0	3	120	0	360
I	10.5	10.5	120	605	605
Effective stress at middle of Layer I =				**605**	**10,145**
Final Cover	0	2	120	0	240
Waste	0	126	70	0	8820
PCOV	0	1	120	0	120
CLAY	0	3	120	0	360
I	21	21	120	1210	1210
II	31	31	120	1786	1786
III	23.5	23.5	120	1354	1354
Effective stress at middle of Layer III =				**4349**	**13,889**

Determine the settlement in the subgrade.

Layer	H (ft)	σ'_o (psf)	σ'_c (psf)	σ'_f (psf)	C_r	C_c	e_o
I	21	1210	1980	10145	0.003	0.063615	0.490
III	47	4349	4349	13889	0	0.099658	0.812

$S_{III,\ CENTER\ OF\ LANDFILL}$ =	**1.95 ft**

2B) Toe of Slope

Determine the initial and final overburden pressures.

Overburden	H_o (ft)	H_f (ft)	Unit Wt (pcf)	σ'_o (psf)	σ'_f (psf)
Final Cover	0	2	120	0	240
Waste	0	29	70	0	2030
PCOV	1	1	120	0	120
CLAY	3	3	120	0	360
I	3	3	120	173	173
Effective stress at middle of Layer I =				**173**	**2923**
Overburden	**H_o (ft)**	**H_f (ft)**	**Unit Wt (pcf)**	**σ'_o (psf)**	**σ'_f (psf)**
Final Cover	0	2	120	0	240
Waste	0	29	70	0	2030
PCOV	0	1	120	0	58
CLAY	0	3	120	0	360
I	6	6	120	346	346
II	44	44	120	2534	2534
III	19	19	120	1094	1094
Effective stress at middle of Layer III =				**3974**	**6662**

Determine the settlement in the subgrade.

Layer	H (ft)	σ'_o (psf)	σ'_c (psf)	σ'_f (psf)	Cr	Cc	e_o
I	6	173	1980	2923	0.003	0.063615	0.49
III	38	3974	3974	6662	0	0.099658	0.81

$S_{III,\ TOE\ OF\ SLOPE}$ =	**0.53 ft**

settlement at center =	**1.95 ft**
settlement at toe =	**0.53 ft**
differential settlement =	**1.42 ft**

3) Compacted Soil Liner Strain

The allowable tensile strain in the compacted soil liner is 0.1% (Ref. 3). From 2) above, the maximum predicted differential settlement between the toe and center of the landfill is

1.42 feet

The length of the compacted clay liner along which the differential settlement occurs is approximately

600 feet

Initial surface length =	600 ft
ΔS =	1.42 ft
$\tan\theta$ =	ΔS/Horizontal Surface
$\tan\theta$ =	2.4E-03
θ =	0.14 degrees
Final Surface length =	600.002 ft

Strain

Strain =	ΔL/L
=	(final surface - initial surface) /Initial
=	0.000003 ft/ft
=	0.0003 %

Therefore, differential settlement will not be detrimental to the clay liner since the predicted strain is significantly less than the allowable strain (0.1%).

Reference:

1) Essentials of Soil Mechanics and Foundations, 2nd Edition, McCarthy, Reston Publishing.
2) TM 5-818-1 Soils and Geology Procedures for Foundation Design of Buildings and Other Structures, US Army COE, October 1983.
3) Daniel, David E. Geotechnical Practice for Waste Disposal, Chapman and Hall, Boundary Row, London, 1993.