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Geotechnical Analysis Report

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GEOTECHNICAL ANALYSES REPORT

Pescadito Environmental Resource Center
MSW No. 2374
Webb County, Texas

PESCADITO
ENVIRONMENTAL RESOURCE CENTER

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This document is released for the purpose of permitting only under the authority of Michael W. Oden, P.E. #67165. It has been Revised in August 2016 to add Appendix III-D.5-7 and Updated in August 2017 to match current landfill configuration. It is not to be used for bidding or construction. Texas Registered Engineering Firm F-5650.

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Updates August 2017
Part III, Attachment III-D, Appendix III-D.5, Geotechnical Analyses Report
- Updated text to match new landfill geometry
- Updated Tables to match calculations corresponding to new geometry

Appendix III-D.5-1, Summary of Geotechnical Design Parameters
- Updated assumptions to match new landfill geometry
- Updated calculations to match new landfill geometry

Appendix III-D.5-2, Slope Stability Analyses
- Updated calculations to match new landfill geometry

Appendix III-D.5-3, Foundation Bearing Capacity Analyses
- Updated calculations to match new landfill geometry

Appendix III-D.5-4, Landfill Foundation Settlement, Waste Settlement, and Liner Strain Analyses
- Updated calculations to match new landfill geometry

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GEOTECHNICAL ANALYSES REPORT

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GEOTECHNICAL ANALYSES REPORT

Introduction

This Report presents the results of the geotechnical analyses that were performed to evaluate the Pescadito Environmental Resource Center Landfill. Specifically, the analyses evaluated the stability and structural integrity of the landfill during the construction / development stage, operations stage, and closure / post-closure care stage. The results of the analyses demonstrate that the landfill will be stable at all times, and the structural integrity of the leachate collection, liner, and final cover systems will be maintained throughout the life of the facility (i.e., development, operations, and closure / post-closure care stages).

The geotechnical analyses and discussions presented herein have been prepared by **CB&I Environmental & Infrastructure, Inc.** under the direct supervision of a Texas-licensed Professional Engineer (Jesse P. Varsho, PE - License No. 114074) on behalf of Rancho Viejo Waste Management, LLC. The geotechnical analyses and discussions have been updated by **APTIM Environmental & Infrastructure, Inc.** (formerly known as CB&I Environmental & Infrastructure, Inc.) under the direct supervision of a Texas-licensed Professional Engineer (Michael W. Oden, PE - License No. 67165 to reflect the current landfill configuration.) This Report was prepared in compliance with the regulatory requirements specified in *Title 40 Code of Federal Regulations (CFR) §258.15* and *Title 30 Texas Administrative Code (TAC) §330.559* for unstable areas, and *Title 30 TAC §330.337(e)*.for special liner design constraints.

- Title 40 CFR §258.15:
  (a) Owners or operators of new MSWLF units, existing MSWLF units, and lateral expansions located in an unstable area must demonstrate that engineering measures have been incorporated into the MSWLF unit's design to ensure that the integrity of the structural components of the MSWLF unit will not be disrupted. The owner or operator must place the demonstration in the operating record and notify the State Director that it has been placed in the operating record. The owner or operator must consider the following factors, at a minimum, when determining whether an area is unstable:
  - *(1) On-site or local soil conditions that may result in significant differential settling;*
  - *(2) On-site or local geologic or geomorphologic features; and*
  - *(3) On-site or local human-made features or events (both surface and subsurface).*

  (b) For purposes of this section:

  (1) Unstable area means a location that is susceptible to natural or human-induced events or forces capable of impairing the integrity of some or all of the landfill structural components responsible for preventing releases from a landfill. Unstable areas can include poor foundation conditions, areas susceptible to mass movements, and Karst terranes.

  (Note the language contained in *Title 30 TAC §330.559* is identical to that of Part (a) of *Title 40 CFR §258.15.*)

- Title 30 TAC §330.337(e):
  (e) Prior to excavating any unit below the seasonal high water table, the owner or operator shall perform a preliminary foundation evaluation satisfactory to the executive director. The foundation evaluation shall consider stability, settlement, and constructability.

Organization of Report

This Report presents a summary narrative of the analytical results with Appendices III-D.5-1 through III-D.5-6 containing the analytical calculations. The Report is organized as follows:

- Summary Narrative of Analytical Results
  - Slope Stability Analyses
  - Foundation Bearing Capacity Analyses
  - Landfill Foundation Settlement, Waste Settlement, and Soil Liner Strain Analyses
  - Final Cover Stability Analysis

- Sideslope Liner Runout Analyses (with and without an Anchor Trench)

- Appendices Containing Analytical Calculations
  - III-D.5-1 - Summary of Geotechnical Design Parameters
  - III-D.5-2 - Slope Stability Analyses
  - III-D.5-3 - Foundation Bearing Capacity Analyses
  - III-D.5-4 - Landfill Foundation Settlement, Waste Settlement, and Soil Liner Strain Analyses
  - III-D.5-5 - Final Cover Stability Analysis
  - III-D.5-6 - Sideslope Liner Runout Analyses (with and without an Anchor Trench)
  - III-D.5-7 - Slope Stability Analysis with Flexible Membrane Cover

Slope Stability Analyses

The stability of the landfill was analyzed under static conditions at three different stages in the life of the landfill: landfill cell excavation / development, landfill operations at interim waste fill heights, and at complete landfill build-out / final landform. The three landfill stages were analyzed using two separate modes of failure — translational (non-circular / block) failure and rotational (circular) failure. The translational failure mode was used to analyze the stability of the liner system along critical (weak) interfaces; and the rotational failure mode was used to analyze the stability of the waste mass and the foundation.

Short-Term and Long-Term Shear Strength Under Static Conditions

The stability analyses were performed for both short-term and long-term shear strength conditions. Under short-term shear strength conditions, it is assumed that pore water pressure is positive because the pore water pressure has not had enough time to dissipate. Therefore undrained shear strength conditions are assumed for the evaluation of the short-term stability. The long-term shear strength conditions represent potential "softening" or residual shear strength conditions. The short-term and long-term shear strength conditions were applied to the modeled scenarios representing the complete landfill build-out / final landform. The scenarios representing the cell excavation / development stage, and the operational / interim waste fill height stages were only evaluated for short-term shear strength conditions, since long-term shear strength conditions will most likely occur following the complete build-out of the landfill.

Analyses were performed only for static conditions. Pseudo-static (seismic) analyses were not performed since it was determined the site is not located within a seismic impact zone. In accordance with *Title 40 CFR §258.15* and *Title 30 TAC §330.557* a seismic impact zone is defined as *an area with a 10% or greater probability that the maximum horizontal acceleration in lithified earth material, expressed as a percentage of the earth's gravitational pull, will exceed 0.10g in 250 years. Maximum horizontal acceleration in lithified earth material is defined as the maximum expected horizontal acceleration depicted on a seismic hazard map, with a 90% or greater probability that the acceleration will not be exceeded in 250 years.* From the United State Geologic Survey (USGS) Earthquake Hazards Program - National Seismic Hazard Mapping website, the seismic coefficient for the landfill site area was determined to be between 0.02g and 0.04g, expressed as a percentage of the earth's gravitational pull. Therefore the site is not in a seismic impact zone and seismic analyses are not required in accordance with Title 30 TAC §330.557.

Critical Cross Section

Cross Section A-A' was determined to be the most critical cross section for the global mass stability of the proposed landfill design. Cross Section A-A' is orientated from south to north through the landfill and is characterized by the following features:

- Peak final landform elevation of approximately 704- feet MSL;
- Final cover sideslopes are 4H:1V with a 6% slope across the plateau;
- Cell excavation slope of 3H:1V; and
- Maximum waste column thickness of 241-feet.

The location of Cross Section A-A' is presented on **Figure 1** contained in **Appendix III-D.5-2**.

Modeled Stability Scenarios

The stability analyses were performed for the following modeled scenarios:

- Global Stability of Complete Build-Out / Final Landform
  - *Stability of Liner System* - evaluated the stability of the liner system under short-term and long-term shear strength / static conditions. *(Note that because the liner shear strength parameters are the same for both short- and long-term conditions, the resulting critical failure surface and safety factor are identical for both short- and long-term analyses.)*
  - *Stability of Waste and Foundation* - evaluated the stability of the waste mass and foundation under short-term and long-term shear strength / static conditions.
- Stability at Interim Waste Fill Height
  - *Stability of Liner System* -- evaluated the stability of the liner system under short-term shear strength / static conditions. Landfill filling is intended to progress from North to South (cell NE-1 through NE-3). Therefore the stability of the interim waste was modeled from the maximum waste thickness with 100-foot benches every 60 vertical feet with 3H:1V sideslopes. with complete buildout in cell NE-1 and partial buildout in cells NE-2 and NE-3 . *(Note that because the liner shear strength parameters are the same for both short- and long-term conditions, the resulting critical failure surface and safety factor for the long-term conditions would be identical to that of the short-term conditions analysis.)*
  - *Stability of Waste and Foundation* -- evaluated the stability of the waste mass and foundation for short-term shear strength / static conditions.
- Stability of Cell Excavation / Development
  - *Stability of Liner System* -- evaluated the stability of the liner system under short-term shear strength / static conditions. Landfill cell development is intended to progress from North to South (cell NE-1 through NE-3). Therefore the stability of the initial cell excavation/development was modeled in cell NE-1 along section A-A' from North to South. *(Note that because the liner shear strength parameters are the same for both short- and long-term conditions, the resulting critical failure surface and safety factor for the long-term conditions would be identical to that of the short-term conditions analysis.)*
  - *Stability of Foundation* -- evaluated the stability of the foundation under short-term shear strength / static conditions.

Slope Stability Results

The results of the slope stability analyses as presented on **Table 1** on the following page, demonstrate that the proposed landfill development meets and/or exceeds the recommended safety factor of 1.5, and complies with the regulatory requirements of *Title 40 CFR §258.15* and *Title 30 TAC §330.337*. The recommended safety factor of 1.5 was taken from USEPA's *Solid Waste Disposal Facility Criteria - Technical Manual* dated 1993. Further, the results of the stability analyses demonstrate that the landfill has been designed to be protective of public health, welfare and safety. Supporting calculations are provided in **Appendix III-D.5-2**.

Table 1 **Slope Stability Summary** **Stability Section A-A'**		
Scenario	**Safety Factor**	
	Short-Term Conditions	**Long-Term Conditions**
Complete Build- Out / Final Landform:		
Global Stability of Liner System - **Block**	**2.005** *(Bishop)*	**2.005** *(Bishop)*
Global Stability of Waste & Foundation - **Circular**	**2.453** *(GLE/M-P)*	**2.091** (GLE/M-P)
Excavated / Partially Lined Cell w/ 100-ft Length of Sideslope Liner Installed, Complete Base Liner Installed, and 35-ft High Lift of Waste Fill Placed at 3H:1V Slope:		
Stability of Liner System - **Block**	**1.711** *(Bishop)*	*same*
Stability of Waste & Foundation - **Circular**	**1.518** *(Janbu)*	*n/a*
Excavated / Developed Cell w/ Complete Liner System Installed, & 100-ft High Waste Fill Lift Placed (at 3H:1V Slope with 100-ft Wide Benching):		
Stability of Liner System - **Block**	**1.551** *(Bishop)*	*same*
Stability of Waste & Foundation - **Circular**	**1.733** *(Janbu)*	*n/a*
Interim Waste Fill Height with 3H:1V Waste Slope and 100-ft Wide Benching (Maximum Elevation - 704 ft MSL):		
Stability of Liner System - **Block**	**1.512** *(Bishop)*	*same*
Stability of Waste & Foundation - **Circular**	**1.688** *(Janbu)*	*n/a*

Foundation Bearing Capacity Analyses

Bearing capacity analyses were performed to demonstrate that the foundation materials beneath the landfill exhibit sufficient strength to support anticipated loads. The most critical location across the landfill base was analyzed (maximum waste height of approximately 241 feet). Terzaghi's bearing capacity equation was used to calculate the ultimate bearing capacity. The calculated safety factor is the ratio of the ultimate bearing capacity to the overburden pressures expected to act on the foundation. Using conservative assumptions, safety factors greater than 2.0 under static conditions were achieved as shown below in **Table 2**. The recommended safety factor of 2.0 for bearing capacity is based on traditional geotechnical practice. Supporting calculations are provided in **Appendix III-D.5-3**.

Table 2
Factors of Safety Against Bearing Capacity Failure

Loading Conditions	Calculated Safety Factor	Minimum Recommended Safety Factor
Short-Term / Static Conditions: Vehicle Loading	6.4	2.0
Long-Term / Static Conditions: Final Landform Loading	6.1	2.0

Landfill Foundation Settlement, Waste Settlement, and Soil Liner Strain Analyses

Analyses of the foundation settlement and soil liner strain due to the foundation settlement were performed. The analysis of the foundation settlement was performed to demonstrate that the integrity of the leachate collection system and soil liner system will not be compromised due to differential settlement throughout the entire life of the landfill. Specifically, the leachate collection system will maintain a positive slope for collection and drainage of leachate; and the soil liner system will continue to serve as a low permeable barrier to leachate and be protective of underlying groundwater systems. Additionally, analysis of waste settlement was performed to demonstrate the final cover system will not be damaged due to differential settlement.

Foundation Settlement and Soil Liner Strain

To analyze potential impacts due to differential settlement of the landfill foundation on the liner / leachate collection system, locations of where the largest differential settlement would occur were evaluated. From this evaluation, the largest differential settlement of the landfill foundation / liner system is expected to occur in the Cell NE-2, between foundation settlement points F1 and F2 as shown on **Figure 1** in **Appendix III-D.5-4**. Specifically, the settlement point locations were selected for the following reasons:

- Foundation settlement point F1is located over the maximum waste column over the leachate collection pipe and point F2 is located where the minimum waste column thickness occurs over the leachate collection pipe; and
- Foundation settlement point F1 is located just south of the maximum elevation for the final landform and point F2 is located where the lowest elevation for the leachate collection system grades occurs.

The estimated maximum differential settlement of the landfill foundation was calculated to be approximately **0.0007399 ft/ft**. This settlement value is deemed negligible and will not cause failure of the liner or leachate collection system (LCS). The initial slope of the LCS is **0.5%** and the slope of the LCS at the end of the post-closure care period will be approximately **0.39%** which will allow for proper leachate drainage and collection. The strain on the compacted low permeable soil liner due to the foundation settlement was estimated to be **0.0003178%** which is deemed within acceptable limits for a compacted clay soil, and therefore the soil liner integrity will not be compromised due to cracking. A summary of the foundation settlement, the initial and final LCS slopes, and soil liner strain is presented below in **Table 3**. Supporting calculations are provided in **Appendix III-D.5-4.**

Table 3
Summary of Foundation Differential Settlement, Initial and Final LCS Slopes, and Soil Liner Strain

Location	Foundation Differential Settlement	Initial LCS Slope	Final LCS Slope	Compacted Low Permeable Soil Liner Strain
Between Settlement Points F1 and F2	0.07399%	0.5%	0.39346%	0.0003178%

Waste Settlement

To analyze potential impacts due to differential settlement of the final cover system, locations of where the largest differential settlement of the waste would occur were evaluated. From this evaluation, the largest differential settlement of waste is expected to occur between waste settlement points W1 (maximum waste thickness of 241 feet) and W2 (minimum waste thickness of 0 feet at the edge of the landfill). The locations of the waste settlement points are presented on **Figure 2** in **Appendix III-D.5-4**. The estimated maximum differential settlement of the landfill final slopes due to waste settlement was calculated to be approximately **0.0498 ft/ft**. This value is considered to be negligible and will not cause or contribute to the failure of the final cover system. Supporting calculations are provided in **Appendix III-D.5-4.**

Final Cover Stability Analysis

Stability of the final cover system was evaluated using the infinite slope method of analysis under static conditions. The results of the analysis yielded a **safety factor of 8.02**, greater than the recommended safety factor of 1.5. The recommended safety factor of 1.5 was taken from USEPA's *Solid Waste Disposal Facility Criteria - Technical Manual* dated 1993. Supporting calculations are provided in **Appendix III-D.5-5**.

Sideslope Liner Runout Analyses (*with and without an Anchor Trench*)

Analyses were performed to determine the minimum required length of liner runout from the top of the landfill liner sideslope. Two scenarios were assumed: 1) liner terminates in an anchor trench and 2) liner terminates without use of an anchor trench. Assuming 3-feet of final cover soil over the liner runout and a 1.5-foot deep anchor trench, the minimum required length of runout between the top of liner slope and the **edge of the anchor trench** was calculated to be approximately **0.47-feet** in the horizontal direction. If **no anchor trench** is constructed, the minimum required length of liner runout beyond the top of the liner slope is approximately **2.57-feet** in the horizontal direction. A summary of the minimum required lengths of liner runout for the two scenarios is presented below in **Table 4**. Supporting calculations are provided in **Appendix III-D.5-6**.

Table 4
Minimum Required Length of Sideslope Liner Runout

With Anchor Trench [1,2]	NO Anchor Trench [1]
0.47 feet	2.57 feet

Notes:
1. Depth of cover soil over liner runout assumed to be 3-feet.
2. Depth of anchor trench assumed to be 1.5-feet.