REPORT

Cell 2 Design
Salt Valley Road Class Landfill Facility

Submitted to:

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1.0 INTRODUCTION
IW Projects Pty Ltd (IWP) has engaged Golder Associates Pty Ltd (Golder) to provide technical studies to support the design of the Class II landfill site known as Opal Vale Landfill, designed by IWP. This report has been prepared in accordance with our proposal P19123998-001-R-Rev0 dated 29 May 2019.

Based on the provided information, the proposed Cell 2 is to be located to the east, adjacent to the existing Cell 1. The proposed Cell 2 has a base level of RL 275.5 m AHD with filling capacity provided up to RL 306 m AHD.

The scope of this report is summarised as follows:

- Provide comment on the suitability of the specified cushion geotextile based on the maximum expected waste height.
- Provide comment on the leachate capacity in relation to the landfill storage capacity based on previous modelling results.
- Assess stability of the cell on the liner and for the waste mass with consideration of the filling plans and maximum theoretical filling heights.

2.0 REFERENCE DOCUMENTS
Golder previously provided technical studies and carried out construction quality assurance (CQA) for the construction of Cell 1. Information obtained from the documents associated with the Cell 1 design have been used in this report. These documents include:

Table 1: Information from Previous Studies

<table>
<thead>
<tr>
<th>Document Description</th>
<th>Reference Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opal Vale Salt Valley Road, Class II Landfill, Lot 11 Chitty Road, Toodyay, Works Approval Application Supporting Documentation, IW Projects, dated 21 December 2014.</td>
<td>Ref 3</td>
</tr>
<tr>
<td>Report on: Ground Water Assessment, Stass Environmental, dated December 2014.</td>
<td>Ref 4</td>
</tr>
</tbody>
</table>

Table 2: Information Provided by IWP

<table>
<thead>
<tr>
<th>Document Description</th>
<th>Reference Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>IWP drawings, Drg No: OV-C2-01-11, OV-C2-SK1, OV-WA-34-35 and OV-WA-40.</td>
<td>Ref 5</td>
</tr>
<tr>
<td>CAD Models corresponding to selected drawings from the above.</td>
<td>Ref 6</td>
</tr>
<tr>
<td>Personal communication with Ian Watkins from IWP.</td>
<td>Ref 7</td>
</tr>
<tr>
<td>Request for tender, Opalvale Pty Ltd, ref: Tender OV01/19, dated 6 June 2019.</td>
<td>Ref 8</td>
</tr>
</tbody>
</table>

3.0 CUSHION GEOTEXTILE ASSESSMENT
IWP drawing OV-C2-06 indicates the basal liner system will comprise the following (top to bottom):

- Separation geotextile (A24 or similar);
- Drainage aggregate layer 300 mm thick;
- Cushion geotextile (A64 or similar);
High-density polyethylene (HDPE) geomembrane (2.0 mm thick) double textured;

Geosynthetic Clay Liners (GCL).

The basal liner system is illustrated in Figure 1.

**Figure 1: Basal Liner System Configuration (extracted from IWP drawing OV-C2-06)**

Based on the design information provided, the cushion geotextile will be supporting a maximum load of 360 kPa (based on a total waste thickness of 36 m and an assumed density of 10 kN/m³). Smart Solutions Technical Note SM-116, “Simplified Design Charts for Geomembrane Cushions”\(^1\) was used to estimate the mass of geotextile required to provide protection to the HDPE geomembrane against stress and strain under long term loading conditions. Based on the SM-116 method the suggested minimum mass per unit area (Mₐ) is 800 g/m². Detail calculation sheets are presented in Appendix A.

The specified cushion geotextile (A64) is a continuous filament non-woven needle punched polyester geotextile and has a reduced Mₐ of 510 g/m². Geotextile with reduced Mₐ comprising of a non-woven needle punched continuous filament material can achieve similar mechanical properties to the staple fibre material. However, there is little established literature to evaluate continuous filament material. Based on Golder’s experience the specified A64 is expected to have similar tensile properties to a staple fibre material with a heavier mass (i.e. 800 g/m²) and is therefore considered suitable for this project, subject to modified cylinder testing under site specific conditions.

It is recommended that modified cylinder testing be undertaken in accordance with ASTM D5514 Standard Test Method for Large Scale Hydrostatic Puncture Testing of Geosynthetics for the supplied cushion geotextile, drainage aggregate, and HDPE with a maximum allowable global strain of 4% for the double textured HDPE material (refer Environmental Protection Authority (EPA) Victoria “Siting, design, operation and rehabilitation of landfills, dated August 2015 (BPEM)).

### 4.0 LEACHATE GENERATION

Golder has been informed that the base level of Cell 2 was modified from the original design to align with the Cell 1 floor level, which resulted in approximately 9,100 m³ of additional landfill airspace.

According to Table 16.6.1 in the Works Approval Application Supporting Documentation (Ref 3) the anticipated airspace of the previous design of Cell 2 was 270,000 m³. With the proposed design change the total airspace of Cell 2 will now be 279 100 m³.

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The increase in airspace volume, used in the previous leachate generation estimates, is 3.4% more than the original airspace volume. This marginal increase will not impact on the leachate generation quantities estimated in the Cell 1 design (Ref 3).

As per the original recommendations, the leachate generation rate should be monitored and used to calibrate the model. If required, the development of additional leachate ponds should be brought forward.

5.0  STABILITY ASSESSMENT

A global stability analysis of Cell 2 was undertaken taking into account the basal liner system and waste slopes.

In terms of global stability, the most likely failure plane is expected within the interface of the basal liner system, possibly between the cushion geotextile and HDPE or HDPE and GCL due to the characteristic low frictional properties of these interfaces.

5.1  Assumptions

The following assumptions have been made for the global stability analysis:

- The effect of landfill gas on the landfill stability is negligible (i.e. gas collection system is fully functional).
- No reinforcement strength is provided by geosynthetic materials in tension.
- All soft materials in the foundation layers (subgrade) will be removed and replaced with competent compacted material in accordance with the specification (Ref 8). Shear strength of the foundation is as per previous Golder study (Ref 1 and Ref 2).
- The groundwater level is assumed to be at least 2 m below the base of the landfill, not affecting the stability of the waste or the liner system. Thus, it was not incorporated into the models.

5.2  Approach

The global stability for Cell 2 was carried out using the 2D limit equilibrium slope stability analysis software SLIDE version 2018 (Rocscience). The analyses were performed using the Morgenstern-Price method, which adopts the method of slices approach, but satisfies both equilibrium of forces and moments acting on individual slices. Several scenarios were evaluated (see Section 5.3.2.3).
5.3 Global Stability Inputs

5.3.1 Modelled Sections

Based on the design geometry provided by IWP (Ref 5 and Ref 6), the stability analyses were undertaken on two cross-sections: Section A and Section B. These sections were considered to represent the highest risk of instability for the landfill slopes, according to the following criteria:

- Geometry of the landfill
- Geometry of the subsurface conditions – Earthworks and existing surface
- Sequence of deposition – Interaction between Cell 1 and Cell 2.

The location of these sections is shown in Figure 3.

Modelling was undertaken for the design height of an approximate relative level (RL) of 306 m and an assumed operational height of 303 m RL based on operational filling considerations. The geometry provided reaches an approximate relative level (RL) of 306 m, with a shape similar to a pyramid, as it can be seen in Figure 3. This geometry is not practically achievable on site with the landfill construction equipment and practices. The stability analysis was performed by modifying the provided geometry to an RL of 303 m, in which a crest width of approximately 30 m was generated for construction purposes. However, for verification purposes, Section 5.4.1 presents the critical sections at the final modelled design height of 306 m RL.

Figure 3: Location of Modelled Sections (final landform contours shown as provided by IWP)

5.3.2 Boundary and Loading Conditions

Several stability analyses were undertaken with different configurations. The model scenarios were defined based on boundary and loading conditions, considering pore pressure in the waste and liner, and seismicity of the zone, as explained in the following sections.
5.3.2.1 Pore Pressure
For the global stability analysis, three phreatic surface conditions (leachate level in waste, assumed as water) were considered:

- No phreatic surface - No pore pressure in the waste or liner.
- Elevated phreatic surface – Representing ‘Steady state’ condition. The phreatic surface was applied simulating a head of approximately 0.3 m above the liner.
- High phreatic surface – representing a malfunction of the leachate pumps. The phreatic surface was applied simulating a head of approximately 1.0 m above the liner.

5.3.2.2 Seismicity
Pseudo-static limit equilibrium analysis was undertaken to address the effect of a seismic event. For pseudo-static limit equilibrium analysis, the seismic forces are modelled as inertial forces of the mass. These forces are modelled with horizontal and vertical accelerations coefficients ($k_h$ and $k_v$, respectively) where the vertical component is usually ignored, and the horizontal component is estimated based on the Peak Ground Acceleration (PGA) of the site. This is a simplified approach commonly used for slope stability analysis of landfill and embankments, with more complex analysis generally justified only in cases where the simplified analysis indicates stability concerns.

Seismic forces for the stability analysis were based on information attained from the Atlas of Seismic Hazard Maps of Australia, as per Golder’s previous study (Ref 1).

The seismic return period intervals adopted in the pseudo-static stability analysis are as follows:

- Operation Basis Earthquake (OBE): 500 year return period. PGA of 0.07 g. $k_h$ equals to 0.07.
- Maximum Design Earthquake (MDE): 1,000 year return period. PGA of 0.13 g. $k_h$ equals to 0.13.
- Maximum Credible Earthquake (MCE): Deterministic (no associated return period). For stability purposes, PGA was estimated considering a 2,500 year return period. PGA of 0.22 g. $k_h$ equals to 0.22.

5.3.2.3 Modelled Scenarios
The scenarios that were considered are summarised in Table 3.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>No Phreatic Surface</th>
<th>Elevated Phreatic Surface ('Steady-State')</th>
<th>High Phreatic Surface (Malfunction of the Leachate Pumps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static</td>
<td>Normal operational</td>
<td>Normal operational conditions</td>
<td>Malfunction of leachate pumps: Operational landforms</td>
</tr>
<tr>
<td>Static OBE</td>
<td>Normal operational</td>
<td>Normal operational conditions</td>
<td>Malfunction of leachate pumps: Operational landforms</td>
</tr>
<tr>
<td>Static MDE</td>
<td>Normal operational</td>
<td>Normal operational conditions</td>
<td>Malfunction of leachate pumps: Operational landforms</td>
</tr>
<tr>
<td>Pseudo-static MCE</td>
<td>Operational landforms</td>
<td>Operational landforms</td>
<td>Post closure landform. Only evaluated for the external slope of Cell 2.</td>
</tr>
</tbody>
</table>
5.3.3 Material Parameters

The stability of the landfill relies, to a large extent, on the liner interface shear strength. Shear testing had been undertaken to assess the interface shear strength between the cushion geotextile and the underlying double textured geomembrane liner during construction of Cell 1, Leachate Pond 1 and Leachate Pond 2 (Ref 2).

It was assumed that all soft materials on the foundation will be removed and replaced with competent compacted material as per the specification. Shear strength of the foundation and waste material will be maintained as per the previous Golder study (Ref 1).

The material parameters used in the stability assessment are summarised in Table 4.

<table>
<thead>
<tr>
<th>Material</th>
<th>Unit Weight (kN/m^2)</th>
<th>Friction angle, ( \phi ) (°)</th>
<th>Cohesion (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundation</td>
<td>20</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>Waste (Cell 1 and Cell 2)</td>
<td>10</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>Liner System*</td>
<td>10</td>
<td>21</td>
<td>0</td>
</tr>
</tbody>
</table>

Notes: *Double textured HDPE geomembrane according to drawings (Ref 5), Cell 1 CQA tests (Ref 2)

5.3.4 Minimum Factor of Safety

Currently there are no specific requirements or guidelines from the Western Australian regulatory authorities for landfills. All applications are assessed based on risk.

The minimum acceptable factor of safety (minimum FoS) recommended are based on typical values used internationally for municipal solid waste (MSW) landfills and experience with similar projects in Australia. Table 5 shows the minimum recommended FoS.

Table 5: Minimum Recommended FoS

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Minimum Recommended FoS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under static loading – Acceptable lifetime stability. For long term conditions that may be present for 20 years or more</td>
<td>1.5</td>
</tr>
<tr>
<td>Under static loading – Acceptable interim stability. For short term conditions that may be present for less than 20 years</td>
<td>1.3</td>
</tr>
<tr>
<td>Under static loading – Acceptable stability where the landfill is subject to high pore pressure build-up from a phreatic surface about 1.0 m above the liner, representative of the malfunction of the leachate pump system. Assumed to be a short-term scenario of no more than two weeks.</td>
<td>1.1</td>
</tr>
<tr>
<td>Under earthquake loading – Acceptable stability where landfill is subjected to an OBE event</td>
<td>1.1</td>
</tr>
<tr>
<td>Under earthquake loading – Acceptable stability where landfill is subjected to MDE or MCE events</td>
<td>1.0</td>
</tr>
</tbody>
</table>

5.4 Results of Global Stability Analysis

The stability analyses were undertaken for the two selected critical sections. Section A evaluates the stability of Cell 2 constructed on top of Cell 1, with a 1V (vertical) :2.5H (horizontal) slope, increasing the height of the landfill.
Section B shows a cross section in Cell 2. As explained in Section 5.3.1, a crest of approximately 30 m was generated at RL 303 m, for construction purposes. This section shows an internal slope of 1V:2.5H and an external 1V:5H slope, assumed to represent the final landform and therefore a permanent long-term slope. Under this scenario, both the steeper internal slope and the flatter external slope were evaluated. For verification of the maximum design height (RL 306 m), Section 5.4.1 presents the results of both critical sections evaluated for the critical scenarios.

5.4.1  Section A and Section B Results, RL 306 m

Table 6, Table 7 and Table 8 show the results of the stability analysis for Section A and Section B, for the critical scenarios.

The critical scenarios were selected in order to satisfy the minimum recommended FoS mentioned in 5.3.4. Only scenarios with pore pressure above the liner system were evaluated, representing a more critical scenario than the ones without the phreatic surfaces. For the pseudo-static approach, the same criteria were assumed; evaluating the pseudo-static scenarios at their most critical phreatic surface for each scenario showed in Table 3.

Table 6: Section A (Waste Slope 1V:2.5 H) – Critical scenarios Interim Internal Slope RL 306 m

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Factor of Safety*</th>
<th>Minimum Recommended FoS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liner**</td>
<td>Waste***</td>
</tr>
<tr>
<td>Static</td>
<td>Elevated Phreatic Surface</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>High Phreatic Surface</td>
<td>1.4</td>
</tr>
<tr>
<td>Pseudo-static OBE</td>
<td>Elevated Phreatic Surface</td>
<td>1.2</td>
</tr>
<tr>
<td>Pseudo-static MDE</td>
<td>Elevated Phreatic Surface</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Notes:  * FoS values were rounded up to 1 decimal place; ** Block failure through the liner system and the waste; *** Circular failure through the waste

Table 7: Section B (Waste Slope 1V:2.5H) – Critical scenarios Interim Internal Slope RL 306 m

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Factor of Safety*</th>
<th>Minimum Recommended FoS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liner**</td>
<td>Waste***</td>
</tr>
<tr>
<td>Static</td>
<td>Elevated Phreatic Surface</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>High Phreatic Surface</td>
<td>1.4</td>
</tr>
<tr>
<td>Pseudo-static OBE</td>
<td>Elevated Phreatic Surface</td>
<td>1.2</td>
</tr>
<tr>
<td>Pseudo-static MDE</td>
<td>Elevated Phreatic Surface</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Notes:  * FoS values were rounded up to 1 decimal place; ** Block failure through the liner system and the waste; *** Circular failure through the waste

Table 8: Section B (Waste Slope 1V:5H) – Critical scenarios Slope RL 306 m Final External Slope RL 306 m

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Factor of Safety*</th>
<th>Minimum Recommended FoS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liner**</td>
<td>Waste***</td>
</tr>
<tr>
<td>Static</td>
<td>Elevated Phreatic Surface</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>High Phreatic Surface</td>
<td>3.1</td>
</tr>
<tr>
<td>Pseudo-static OBE</td>
<td>Elevated Phreatic Surface</td>
<td>2.3</td>
</tr>
<tr>
<td>Pseudo-static MCE</td>
<td>High Phreatic Surface</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Notes:  * FoS values were rounded up to 1 decimal place; ** Block failure through the liner system and the waste; *** Circular failure through the waste
5.4.2 Section A Results

The stability analysis results for Section A are summarised in Table 9. Only the internal interim slope was evaluated. The other side of Section A, with an external slope was not evaluated as the geometry was flatter and less critical than the internal slope (i.e. if the internal slope is estimated to be stable, the external slope is unlikely to fail. This slope is around 1V: 5.5H, and does not represent the steepest slope because it is not perpendicular to the contours, thus, the steepest slope will be evaluated in Section B.

### Table 9: Section A (Waste Slope 1V:2.5 H) – Interim Internal Slope

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Factor of Safety*</th>
<th>Minimum Recommended FoS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liner**</td>
<td>Waste***</td>
</tr>
<tr>
<td>Static</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Phreatic Surface</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Elevated Phreatic Surface</td>
<td>1.4</td>
<td>1.5</td>
</tr>
<tr>
<td>High Phreatic Surface</td>
<td>1.4</td>
<td>1.5</td>
</tr>
<tr>
<td>Pseudo-static OBE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Phreatic Surface</td>
<td>1.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Elevated Phreatic Surface</td>
<td>1.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Pseudo-static MDE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Phreatic Surface</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Elevated Phreatic Surface</td>
<td>1.0</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Notes: * FoS values were rounded up to 1 decimal place; ** Block failure through the liner system and the waste; *** Circular failure through the waste

5.4.3 Section B Results

Table 10 shows the results of the stability analysis for Section B, for the internal slope, while Table 10 presents the results of the stability for the external slope of Section B.

### Table 10: Section B (Waste Slope 1V:2.5H) – Interim Internal Slope

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Factor of Safety*</th>
<th>Minimum Recommended FoS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liner**</td>
<td>Waste***</td>
</tr>
<tr>
<td>Static</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Phreatic Surface</td>
<td>1.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Elevated Phreatic Surface</td>
<td>1.5</td>
<td>1.6</td>
</tr>
<tr>
<td>High Phreatic Surface</td>
<td>1.4</td>
<td>1.5</td>
</tr>
<tr>
<td>Pseudo-static OBE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Phreatic Surface</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Elevated Phreatic Surface</td>
<td>1.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Pseudo-static MDE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Phreatic Surface</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Elevated Phreatic Surface</td>
<td>1.1</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Notes: * FoS values were rounded up to 1 decimal place; ** Block failure through the liner system and the waste; *** Circular failure through the waste

### Table 11: Section B (Waste Slope 1V:5H) – Final External Slope

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Factor of Safety*</th>
<th>Minimum Recommended FoS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liner**</td>
<td>Waste***</td>
</tr>
<tr>
<td>Static</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Phreatic Surface</td>
<td>3.5</td>
<td>3.3</td>
</tr>
<tr>
<td>Elevated Phreatic Surface</td>
<td>3.4</td>
<td>3.3</td>
</tr>
<tr>
<td>High Phreatic Surface</td>
<td>3.2</td>
<td>3.2</td>
</tr>
<tr>
<td>Pseudo-static OBE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Phreatic Surface</td>
<td>2.5</td>
<td>2.4</td>
</tr>
<tr>
<td>Elevated Phreatic Surface</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Pseudo-static MDE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Phreatic Surface</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Elevated Phreatic Surface</td>
<td>2.0</td>
<td>1.9</td>
</tr>
<tr>
<td>Pseudo-static MCE****</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Phreatic Surface</td>
<td>1.5</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Notes: * FoS values were rounded up to 1 decimal place; ** Block failure through the liner system and the waste; *** Circular failure through the waste; **** FoS evaluated in the external slope of selected Section B.
5.5 Stability Assessment Conclusions

The stability analyses undertaken for the basal liner system interface has shown that the minimum acceptable FoS are achieved for the analysed scenarios.

For both cross sections analysed, the critical failure mode for the stability is the non-circular surface, representing sliding along the liner system interface. It is important to note that the stability of Cell 2 is dependent on the shear strength of the liner system, which is achieved using a double textured HDPE geomembrane and assuming similar materials to what was used in the previous cell construction. Prior to construction, interface shear testing should be carried out on each interface to support the assumptions made in this assessment. The testing should identify the interface friction and cohesion and be interpreted by a qualified and experienced engineer. The stability assessment should be revised with the test results, if required.

The stability analyses undertaken for the waste (circular failure) has shown that the minimum acceptable FoS are achieved for the analysed scenarios under the assumptions utilized in the analyses. Waste slopes should not be steeper than 1V:2.5H for the operational landform and not steeper than 1V:5H for the final landform. The external waste slope of Cell 2 is going to be placed over an excavated zone. Due to the 1V:5H slope and the geometry of the excavated surface, failure in this area is unlikely (Section B).

The stability for Cell 2 has been analysed up to a height of RL 303 m which is deemed an achievable height for constructability. However, the stability analysis undertaken for Cell 2 up to the 3D model height of 306 m (Section 5.4.1) indicates that the minimum acceptable FoS are achieved for the same scenarios as RL 303 m, under the assumptions utilised in the analyses. Note that this geometry is highly unlikely to be achieved based on operational filling considerations and the RL 303 m is considered a more realistic approach.

6.0 SUMMARY AND RECOMMENDATIONS

The results of the assessments carried out and associated recommendations can be summarised as follows:

- **Cushion geotextile:** The results of the assessment show the minimum mass per unit area required for the cushion geotextile is 800 g/m² based on the use of a non-woven needle punched staple fibre material. Geotextile comprising of a non-woven needle punched continuous filament material can achieve similar mechanical properties to the staple fibre material with a reduced Mₐ. Based on Golder’s experience, and the assessment undertaken, the specified A64 (that has a reduced Mₐ of 510 g/m² and is a non-woven needle punched continuous filament material) is considered suitable subject to modified cylinder testing under site specific conditions. It is recommended that modified cylinder testing be undertaken in accordance with ASTM D5514 Standard Test Method for Large Scale Hydrostatic Puncture Testing of Geosynthetics for the supplied cushion geotextile, drainage aggregate, and HDPE with a maximum allowable global strain of 4% for the double textured HDPE material (refer BEPM).

- **Leachate generation:** The amendment to the Cell 2 design results in approximately 3.4% additional airspace. This additional airspace will not result in a significant increase in leachate generation quantities estimated as part of the Cell 1 design. However, the leachate generation rate should be monitored and used to calibrate the model.
Stability: The results of the stability analyses on the basal liner system indicated that the critical failure mode is the non-circular surface, sliding along the liner system interface, therefore, stability is dependent on the shear strength of the liner system. The required factors of safety for stability is achieved by using a double textured HDPE geomembrane, assuming similar material will be used for the construction of Cell 2 to what was used in Cell 1 construction. An Interface shear test should be carried out on each interface to support the assumptions in this assessment. Stability analyses on the waste model indicated that a waste slope not exceeding 1V:2.5H for operational conditions and 1V:5H for the final landform would achieve the required FoS. The assessment was carried out based on a maximum height of RL 306 m and an assumed operational-construction height at RL 303 m.
Signature Page

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APPENDIX A

Cushion Geotextile Design Worksheet
Design Parameters | Unit | Note |
---|---|---|
$P'_{allow}$ | 2023.20 | kPa |
$H$ | 17.50 | mm |
MF<sub>S</sub> | 1.00 | 1 - Angular, 2 - Subrounded, 3 - Rounded |
MF<sub>PC</sub> | 1.00 | 1 - Isolated Protrusions, 0.5 - Uniformly Packed Surface |
MF<sub>A</sub> | 0.25 | 1 - No Arching Effect, 0.5 - Moderate Arching Effect, 0.25 - Maximum Arching Effect |
$F_{S_CEO}$ | 2.00 | 1 for $3 < \text{pH} < 10$, 1.5 - 2.0 for PET, 1.0 - 1.5 for PP (Bidim A64 - PET) |
$P_{actual}$ | 360.00 | kPa |
$\gamma$ | 10.00 | kN/m<sup>2</sup> |
h | 36.00 | m |
$F_{S_{geom}}$ | 5.62 | Isolated Protrusions |

$$P'_{allow} = \left( 450 \cdot \frac{M_a}{H^2} \right) \left( \frac{1}{M_{F_S}} \cdot \frac{1}{M_{F_{PC}}} \cdot \frac{1}{F_{S_{CEO}}} \right)$$

Where:

$P'_{allow}$ = Allowable pressure on geomembrane (kPa)

$450$ = Empirical constant (kPa-mm<sup>2</sup>/g/m<sup>3</sup>)

$M_a$ = Required mass per unit area of nonwoven, needle-punched geotextile (g/m<sup>2</sup>)

$H$ = Effective height of protrusion (mm)

$M_{F_S}$ = Modification factor for protrusion shape (dimensionless)

$M_{F_{PC}}$ = Modification factor for protrusion configuration (dimensionless)

$F_{S_{CEO}}$ = Factor of safety for geotextile chemical/biological degradation (dimensionless)

$P_{actual} = \gamma \cdot h$

Where:

$\gamma$ = Unit weight of overburden material or liquid (kN/m<sup>2</sup>)

$h$ = Design height of overburden material or liquid depth (m)

$P_{actual}$ = Estimated maximum pressure on geomembrane (kPa)

$P'_{allow} \geq F_{S_{geom}} \cdot P_{actual}$

Where:

$F_{S_{geom}}$ = Global Factor of Safety (dimensionless)
APPENDIX B

Stability Assessment Outcome
Section B Internal - No phreatic surface - Liner interface - Static

Section B Internal - No phreatic surface - Liner interface - OBE

Section B Internal - No phreatic surface - Liner interface - MDE
Section B Internal - No phreatic surface - Waste mass - Static

Section B Internal - No phreatic surface - Waste mass - OBE

Section B Internal - No phreatic surface - Waste mass - MDE
Section B Internal - Elevated phreatic surface - Liner interface

Section B Internal - High phreatic surface - Liner interface - Static

Section B Internal - High phreatic surface - Waste mass - Static
Critical Slip Surface (FoS = 3.4 static)
(FoS = 2.4 OBE)
(FoS = 2.0 MDE)

RL 303 m

Phreatic Surface: Elevated phreatic surface

Foundation

Liner

Cell 2 Waste

Section B External - Elevated phreatic surface - Liner interface

Critical Slip Surface (FoS = 3.2)

RL 303 m

Phreatic Surface: High phreatic surface

Foundation

Liner

Cell 2 Waste

Section B External - High phreatic surface - Liner interface - Static

Critical Slip Surface (FoS = 1.5 MCE)

RL 303 m

Phreatic Surface: High phreatic surface

Foundation

Liner

Cell 2 Waste

Section B External - High phreatic surface - Liner interface - MCE

Figure B8
APPENDIX C

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