



October 2017

DESIGN REPORT

Great Southern Landfill Cell 1, Cell 2 and Ancillary Works

Submitted to:

Alkina Holdings Pty Ltd
PO Box 419
MORLEY BC WA 6943

REPORT



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1 Electronic Copy – Alkina Holdings Pty Ltd
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1.0 INTRODUCTION

Alkina Holdings Pty Ltd (AH) has appointed Golder Associates Pty Ltd (Golder) to provide the supporting technical advice and detailed civil design documentation for a new landfill site known as the Great Southern Landfill (GSL). The GSL is located south of the Great Southern Highway, approximately 20 km west of the town of York, on Lot 4869 of Plan 224502 in Western Australia.

The GSL will be developed in stages, dividing the 36 ha of landfill footprint area into cells, with an average operational airspace of three years per cell. The airspace utilisation rates will be between 150 000 tpa and 250 000 tpa, providing the GSL with an approximate life of 22 to 37 years depending on the airspace utilisation rate used. The GSL construction is to be carried out in stages, with Cell 1 and the ancillary infrastructure being constructed first. This engineering design report provides the design for Cell 1, Cell 2, Subsurface drainage system, Leachate collection system, Leachate Pond, Retention Pond, Stormwater Dam, Sediment Management Structure and Stormwater Management Structures.

AH is submitting a Works Approval Application (WAA) to the Department of Water and Environment Regulation (DWER) for the construction and operation of the GSL classified as a Class II landfill, which is designed to accept putrescible wastes, based on the DWER description set out on the document titled '*Landfill Waste Classification and Waste Definitions 1996*' published by the Chief Executive Officer of the DWER (Ref. [1]). As no specific guideline is provided by the DWER in relation to the landfill and associated structure's design, the EPA Victoria Publication 788.3 (Vic BPEM) dated August 2015 (Ref. [2]) is considered to present the most applicable best practice guideline to manage the potential risks at the site and has therefore been adopted for general guidance at GSL.

This engineering design report is intended to form part of the documentation to be submitted with the WAA and shall be read in conjunction with the Technical Specifications (Ref. [3]), Construction Quality Assurance Plan (Ref. [4]) and design Drawings (Ref. [5]). This report has been updated following correspondence from DWER dated 9 October 2017 requesting additional information related to stability assessment and leachate management and recirculation risks. These issues have been addressed in the relevant sections of this report.

This Design Report presents specific information related to the design of Cell 1, Cell 2 and ancillary structures.

2.0 BACKGROUND

Golder Associates originally submitted a Works Approval Application on behalf of SUEZ in March 2015. The SUEZ proposal for this property received then-DER approvals on 17 March 2016 after approximately four years of work to demonstrate that the facility could be constructed and operated in an environmentally acceptable manner. Subsequent to the approval, SUEZ acquired Perth Waste and a landfill site at North Bannister and decided not to progress the Allawuna Farm Landfill project on economic grounds.

A Shire of York local government planning approval remains valid and AH has commenced negotiations with the private landholder for the property to pursue a similar, but lower volume, landfill project on the same site. The SUEZ works approval and supporting technical studies remain in the public domain and provide a benchmark for the standards/expectations of regulators to approve such a proposal. AH has elected to call the project the Great Southern Landfill (GSL) – following a common naming convention for WA landfills, which are named after the road where they are located.

AH has decided to submit a WAA following the same principles and philosophies developed for the Allawuna Farm landfill. As part of the submission Golder conducted due diligence assessments of all the previous studies carried out for Allawuna and re-assessed the landfill design. In Golder's opinion the original principles and philosophies in general still hold true. Some minor amendments were however necessary to the design to suit AH operational practices and subsequent developments in the regulatory approach to WAAs.



3.0 REFERENCE STUDIES AND CONSTRUCTION DOCUMENTS

The studies and other documents used in the preparation of this report are listed in Table 1. The reports listed in Table 1 are not included in this report as it forms part of the overall Works Approval Application submission. Please note that these documents are referred to by its designated acronym or by reference number.

Table 1: Reference studies and construction documents

Name/Acronym	Full Name	Reference Number
Studies		
Geotechnical Investigation	<i>"Allawuna Farm Landfill, Geotechnical Investigations for Landfill Development"</i> , (Ref. 147645033-008-R-Rev0) March 2015 (Appendix A)	[6]
Hydrology Assessment	<i>"Great Southern Landfill site – desktop review – Surface Water Management"</i> (Ref.1777197-007-M) 23 June 2017, with referenced document <i>"Allawuna Farm Landfill, Surface Water, Groundwater and Leachate Management Plan"</i> (Ref. 14765033-015-R-Rev0) March 2015	[7]
Hydrogeology Assessment	<i>"Allawuna Landfill Hydrogeological Site Characterisation Studies"</i> (Ref. 14765033-009-R-Rev0), March 2015	[8]
Stability Assessment	<i>"Stability Analysis and Liner System Integrity Assessment for Landfill Development"</i> (ref 14765033-012-R-Rev0), March 2015	[9]
Construction Documents		
Technical Specification	<i>"Technical Specifications for Construction of Cell 1, Cell 2 and Ancillary Works"</i> (Ref. 1777197-012-R) dated July 2017	[3]
Construction QA	<i>"Construction Quality Assurance Plan for the Construction of Cell 1, Cell 2 and Ancillary Works"</i> (Ref. 1777197-13-R) dated July 2017	[4]
Construction Drawings		
Drawing D101	Cover Sheet	[5]
Drawing D102	Works Approval Area	
Drawing D103	General Arrangement	
Drawing D104	Cell 1 Top of Prepared Subgrade and Setout Plan and Subsurface Drainage System	
Drawing D105	Cell 2 Top of Prepared Subgrade and Setout Plan	
Drawing D106	Cell 1A & 1B Earthworks Plan (Isopachytes)	
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Drawing D114	Cell 1 Leachate Collection Pipes and Setout Plan	
Drawing D115	Cell 2 Leachate Collection Pipes and Setout Plan	
Drawing D116	Cell 1 Sump Layout Plan and Setout	
Drawing D117	Cell 2 Sump Layout Plan and Setout	
Drawing D118	Sump Outlet Pipes	
Drawing D119	Leachate Collection Pipe Details	
Drawing D120	Leachate Pond Plan and Sections	



Name/Acronym	Full Name	Reference Number
Drawing D121	Leachate Pond Details	
Drawing D122	Retention Pond Plan and Sections	
Drawing D123	Retention Pond Details	
Drawing D124	Stormwater Dam Plan and Sections	
Drawing D125	Stormwater Dam Spillway Plan and Sections	
Drawing D126	Stormwater Discharge Channel Plan and Sections	
Drawing D127	Sediment Management Structure Plan and Sections	

4.0 ABBREVIATIONS AND ACRONYMS

The acronyms and abbreviations used in this document are defined in Table 2.

Table 2: Abbreviations and acronyms

Name/Acronym	Definition
AEP	Annual exceedance probability
ARI	Average return interval
AS	Australian Standard
BGL	Below ground level
BOM	Bureau of Meteorology
Vic BPEM	Victorian EPA Best Practice Environmental Management
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DWER	Western Australia Government Department of Water and Environment Regulation
EC	Electrical conductivity
EPA	Environmental Protection Authority
FSL	Final Subgrade Level
Golder	Golder Associates Pty Ltd
GoldSim	Not an acronym – A graphical object-oriented modelling environment
GCL	Geosynthetic Clay Liner
HDPE	High density polyethylene
HELP	Hydrologic Evaluation of Landfill Performance (HELP) computer program
IECA	International Erosion Control Association
LCP	Leachate Collection Pond
LCS	Leachate Collection System
MB	Monitoring Bore
Mt	Million tonnes
OMC	Optimum Moisture Content
SILO	Not an acronym – Refers to the name of a climate information database
SMDD	Standard Maximum Dry Density
V:H	Vertical : Horizontal
tpa	tonnes per annum
XPSWMLCP	Not an acronym – An integrated software package capable of simulating rainfall-runoff processes and the hydraulic performance of constructed/natural drainage systems



5.0 DESIGN COMPARISON

For ease of reference a comparison was done between the original design carried out for the Allawuna Farm Landfill (Refer Section 2.0) and the design carried out for Great Southern Landfill. The comparison summary is provided in Table 3.

Table 3: Comparison between Allawuna Farm Landfill design and Great Southern Landfill design components

Design Component	Great Southern Landfill	Notes
Overall design philosophy	No change	
Cell Floor and Embankment Configuration	<ul style="list-style-type: none">■ Cell floor elevations increased■ Embankment configuration amended minimally to suit new floor elevation.	<ul style="list-style-type: none">■ Cell floor levels have been amended to allow a separation distance of 2.0 m from the invert level of the sump to the maximum estimated winter groundwater elevation.■ Overall waste footprint has not changed.
Cell configuration	Increased number of cells	Number of cells increased from 6 to 7 due to lower anticipated waste tonnage used for modelling
Final landform	No change	
Total airspace	No change	
Liner system	No change	
Subsurface drainage system	No change	
Retention pond	No change	
Leachate collection system	Minimal change	Inclusion of additional leachate collection pipe due to addition of one more cell
Leachate collection pond	No change	
Stormwater dam	No change	
Sediment management structure	No change	
Sediment management and stormwater management infrastructure	No change	
Conceptual capping	No change	
Borrow areas	No change	

6.0 LOCATION

The GSL is located south of the Great Southern Highway, approximately 20 km west of the town of York, on Lot 4869 of Plan 224502 in Western Australia. The site is located in the upper reaches of the Thirteen Mile Brook catchment, with the landfill footprint located to the northern side of the un-named tributary and approximately 400 m north-east of the Thirteen Mile Brook.

7.0 SITE LAYOUT

The GSL is to be comprised of a total of seven (7) cells operating in stages. The total footprint of the GSL cells is 36 ha. The layout of the proposed cells and ancillary works are shown in Figure 1.



DESIGN REPORT – GREAT SOUTHERN LANDFILL

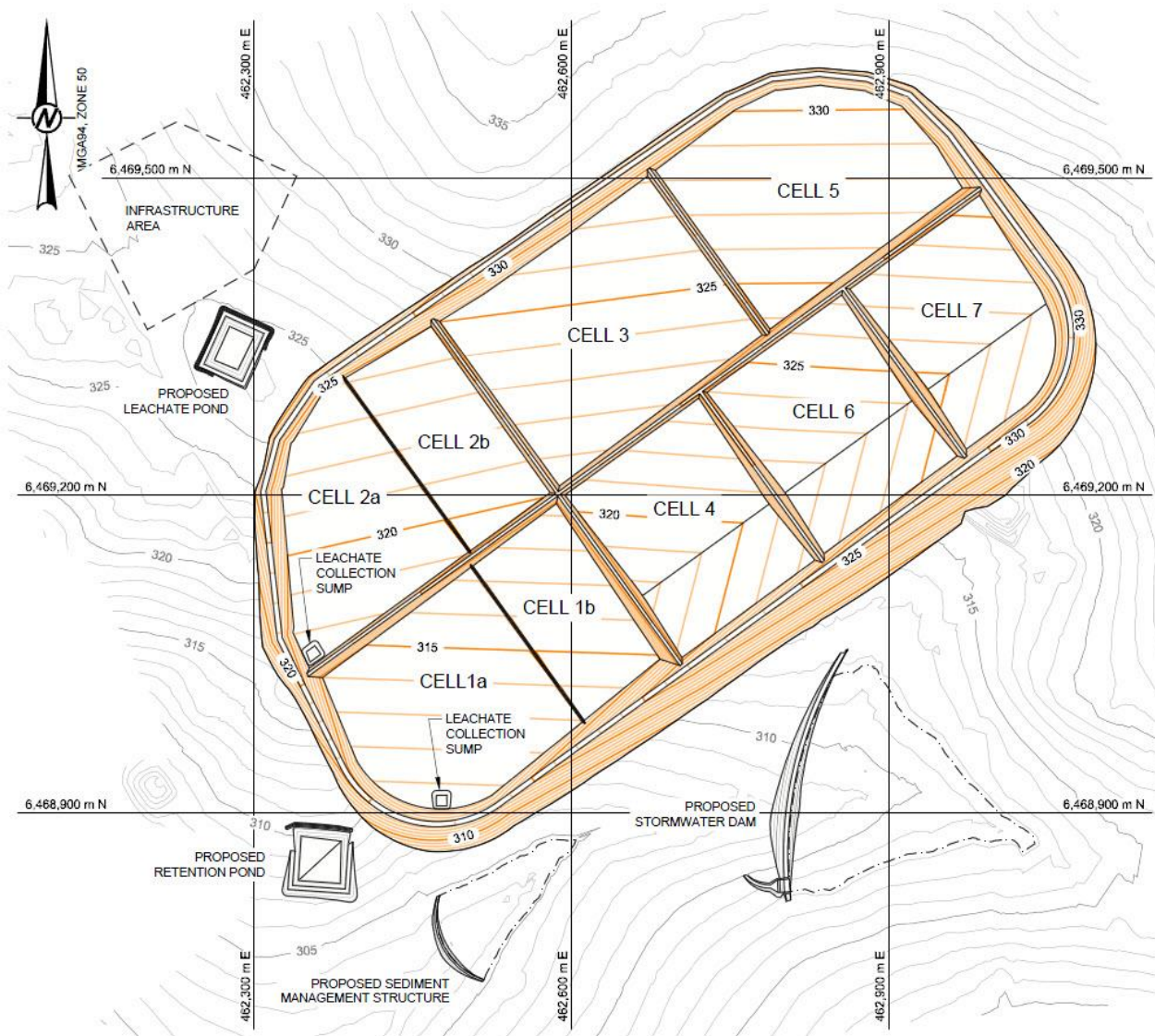


Figure 1: Layout of GSL cells and ancillary works

The GSL cells and structures that are part of the design presented in this Design Report are presented and highlighted in Figure 2 with further details presented in the Drawings [7].

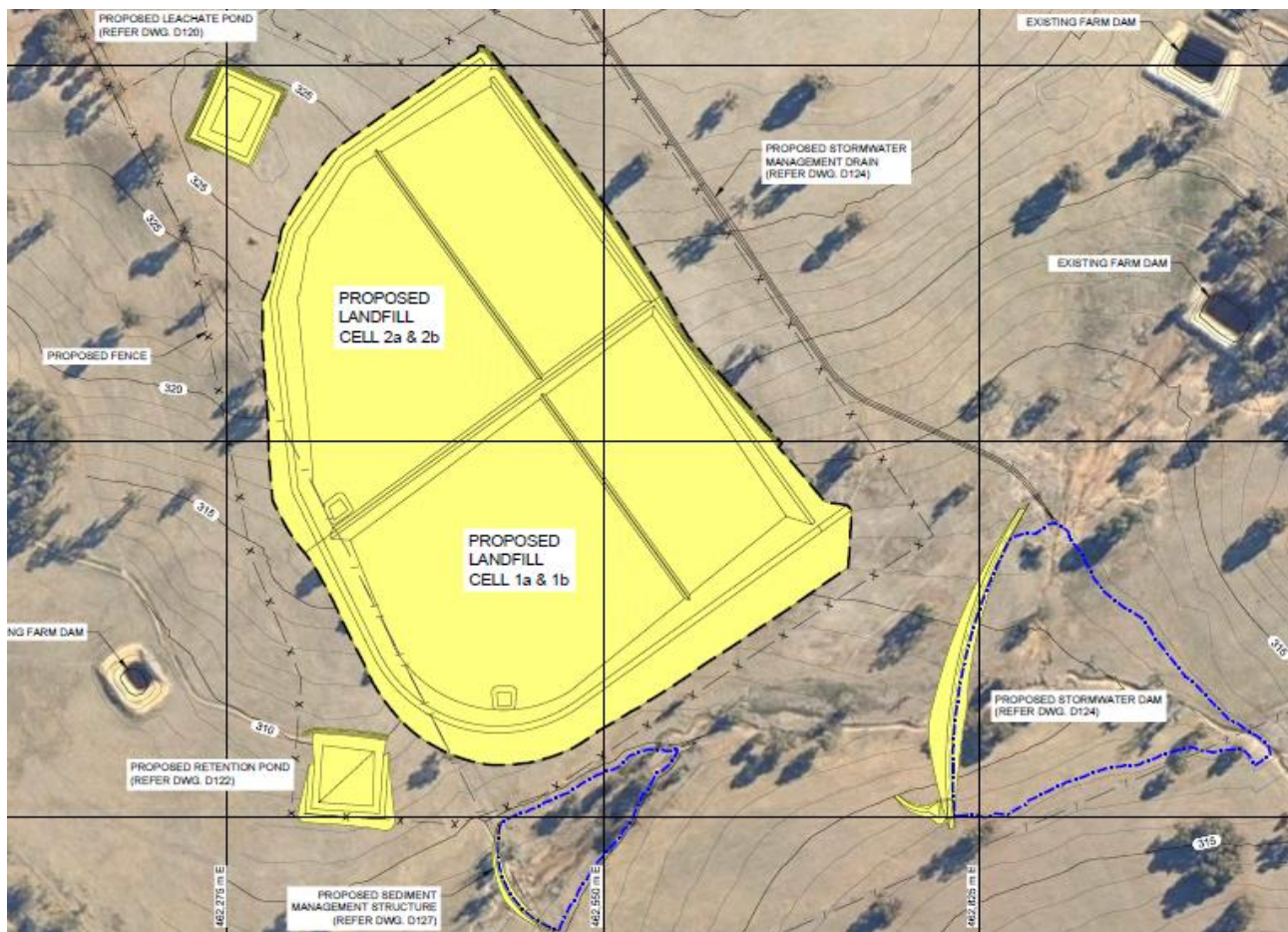


Figure 2: Site layout – Cell 1, Cell 2 and ancillary works

The footprint area for Cell 1 and Cell 2 is approximately 7.9 and 6.1 ha respectively, combined approximately 39% of the final GSL footprint. The footprint areas for the Leachate and Retention pond is approximately 0.34 ha and 0.43 ha respectively. The Stormwater Dam has an embankment footprint of 0.36 ha, with a maximum pond footprint that could cover a surface area of 2.6 ha. The Sediment Management structure has an embankment footprint of 0.06 ha, with a potential maximum pond surface area of 0.8 ha.

8.0 DESIGN OVERVIEW

The final GSL incorporates the design and construction of seven primary cells, which are progressively constructed and its associated structures. This design report cover the design of Cell 1 and 2 and its associated structures. The notable components and features of the design are described below:

- Cells 1 and 2 will be receiving Class II putrescible waste. Its components are:
 - Subgrade: a compacted 500 mm subgrade base that is to be constructed with a final surface slope of approximately 3% towards the leachate sump and lined with a geosynthetic liner system.
 - Geosynthetic liner system: the liner system consists of a geosynthetic clay liner (GCL) to be placed over the compacted subgrade, followed by a 2 mm thick HDPE geomembrane and then a Cushion Geotextile. The leachate drainage layer is formed by aggregate and covered by a separation geotextile.



■ Leachate Collection System:

- Side Wall Drainage layer: a leachate collection layer installed 2.0 m up the landfill side-walls to direct lateral leachate seepage towards the cell base leachate collection system comprising of a 300 mm thick leachate drainage aggregate layer.
- Base Drainage layer: A 300 mm thick leachate drainage aggregate layer installed over the base of the landfill cell. The landfill base is designed with a surface slope of 3% towards a leachate collection sump and riser pipe.
- Leachate collection pipes: a network of perforated leachate collection pipes is to be installed over the base liner, covered by the base drainage layer.
- Leachate collection sump: the leachate collection pipe network directs leachate into a leachate collection sump and is located at the lowest elevation point within Cell and Cell 2.
- In addition solid leachate pipes are installed with the intent of connecting it to the drainage systems for the future cells. Note that future cells will have an operational extraction point (sump) as well as a long term extraction point (connection to Cell 1 and 2 sumps)

■ Cell embankments:

- Cell division bunds, to be constructed with side slopes 1:2 (V:H) and nominal crest width of 5 m.
- Perimeter embankment, to be constructed as part of the perimeter of the final GSL with side slopes of 1:3 (V:H) and minimum embankment crest width of 5 m.
- Cell stormwater management bund to divert clean stormwater runoff away from the areas of operation within the cell, with a nominal height of approximately 500 mm.

■ Leachate Pond: A lined pond to be constructed upstream of the landfill and downstream from the proposed infrastructure area, to store the leachate collected and pumped from the leachate collection sumps.

■ Subsurface Drainage System:

- Subsurface Drain Trenches: these groundwater interception trenches are to be excavated below the base of the perimeter embankment to reduce the impacts of the phreatic surface mounding beneath the cell floor.
- Subsurface Drain Pipes and drainage materials: a network of perforated drainage pipes is to be installed in the trenches with the drainage materials.
- Subsurface Drain Sump: the subsurface drain pipe network directs all subsurface flows into the drain sump at the lowest elevation point within this system. The collected flows are pumped from this sump into the Retention pond.

■ Retention Pond: A lined pond to be constructed in close proximity to the south corner of the GSL cells. This pond has been designed to store the subsurface water from the subsurface drainage system.

■ Stormwater and Sediment Management:

- Stormwater Dam: is to be constructed on a creek line to store the stormwater runoff from the GSL upstream catchments areas. Clean stormwater runoff will be diverted to this pond during the operation of the landfill. The stormwater dam consist of an engineered fill for the key-in trench and main embankment, plus a designed spillway.
- Sediment Management Structure: is to be constructed downstream of the Stormwater dam and GSL, with free draining materials to collect sediments carried with the stormwater runoff from the site.



- Stormwater Diversion Bunds: these are to be constructed with compacted general fill, to nominal heights of 500 mm and 1:2 (V:H) side slopes, to divert clean stormwater runoff away from possible sources of contamination. These are to be located around Cell 1 and 2, Leachate Pond, Retention Pond, Borrow Pits and any other structures that might require them during construction and operations. There are also stormwater diversion bunds used within the cells during operations.
- Stormwater Management Drain: is to be constructed as cut to fill trench to divert the stormwater surface runoff from the GSL upstream catchment areas away from the operational areas and into the Stormwater dam.

9.0 HAZARD CATEGORY

To assess the Hazard Category for the structures associated with the GSL, namely Cell 1 and 2, Stormwater Pond, Leachate Pond and Retention Pond, the ANCOLD “Guidelines on Assessment of the Consequences of Dam Failure” dated May 2000 was referenced.

The assessment was based on the consequences of pond failure at the GSL comprised a review of contour elevations, the proximity of residential dwellings in relation to the pond and severity of damage and loss. Table 3 Hazard Categories of the ANCOLD “Guidelines on Assessment of the Consequences of Dam Failure” was assessed with a selected ‘Population at Risk’ at 0. This selection was based on the location of existing structures and the location of the site offices in relation to the structures. The ‘Severity of Damage and Loss’ was selected as minor based on guidelines provided in Appendix D of the ANCOLD “Guidelines on Assessment of the Consequences of Dam Failure”.

Based on this assessment the Hazard Category for the GSL structures in a failure scenario would be ‘very low’. This Hazard Category has been considered in preparing the design of these structures and in particular when designing the number of redundancies for the dam spill and outlet, particularly during peak storm events. The Hazard Category was also considered when setting the maximum operating depth and freeboard of the leachate pond, retention pond and stormwater dam.

10.0 BASIS OF DESIGN

10.1 Design codes, standards and guidelines

10.1.1 Order of precedence

The most recent revisions of applicable design codes, regulations, standards and guidelines has been used in the design of the GSL. These documents include, but are not necessarily limited to the standards, codes and guidelines listed in Section 10.1.2 below. The order of precedence applied to the design of the GSL is the following:

- 1) Australian regulatory requirements
- 2) Australian industry codes, standards and guidelines
- 3) International industry codes, standards and guidelines.

10.1.2 Regulatory requirements

The statutory authority having jurisdiction over the site is the Western Australian Government’s Department of Water and Environment Regulations (DWER). The design and construction of the GSL shall comply with all relevant government acts, by-laws and regulations, both state and federal, including but not limited to the following:

- *Aboriginal Heritage Act 1972 (WA)*
- *Environmental Protection Act 1986 (WA) (EP Act)*
- *Environmental Protection Act Regulations 1987 (WA)*
- *Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (WA)*



- *Occupational Safety and Health Act, 1984 (WA)*
- *Occupational Safety and Health Regulations, 1996 (WA).*

10.1.3 Applicable codes, standards and guidelines

The GSL has been designed in recognition of the following pertinent Australian codes and guidelines:

- EPA Victoria – *Best Practice Environmental Management – Siting, Design, Operation and Rehabilitation of Landfills*, August 2015. (Vic BPEM (Ref. [8])
- International Erosion Control Association (IECA) – *Best Practice Erosion and Sediment Control*, 2008
- ANCOLD “Guidelines on Assessment of the Consequences of Dam Failure” dated May 2000.

10.1.4 Units of measurement

The units of measurement used on the design of the GSL is consistent with the International System (SI) in accordance with AS ISO 1000.

10.2 Environmental considerations

The design of the GSL accounts for the following environmental considerations:

- Adverse impacts on the abundance, species diversity, geographic distribution and productivity of fauna and flora will be minimised during the construction works and operation of the facility.
- Controls will be implemented so that dust emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.
- Waste management strategies will be implemented so that waste does not adversely affect the health, welfare and amenity of people, the environment and the land uses.
- Impacts on the surface water systems will be limited to the extent that the values of the existing environment are maintained and the quantity and quality of the water released does not result in significant changes to the environment.
- Impacts on groundwater quality and quantity will be limited to the extent that the values of the existing environment are maintained and the quality of the water released does not result in significant changes to the environment or existing users.
- The short and long term safety and stability of the embankments and surrounding area will be maintained.

The GSL will be constructed, operated and rehabilitated so that, as far as practicable, it is a safe and stable landform which is consistent with the identified post closure use.

10.3 Environmental management

The design, operation and performance of the GSL will be influenced by the environmental management activities that need to take place at the site. A short summary of the environmental factors, impacts and proposed control measures is presented in Table 4.



Table 4: Summary of environmental factors, impacts and controls

Environmental Factor	Potential Impacts	Environmental Controls
Groundwater	Impacts to local groundwater from seepage	<ul style="list-style-type: none">■ Subsurface Drainage System under GSL cells.■ Leachate Collection System within Cell 1 and Cell 2.■ Ongoing monitoring of groundwater levels and quality.
Surface water	Discharge over Leachate and Retention ponds	<ul style="list-style-type: none">■ Maintain a minimum freeboard to help prevent overtopping■ Development of an operating strategy prior to the start of operations to provide framework for data collection and reporting■ Routine inspection to monitor water level.

The design approach has sought to minimise the impact on the environment through the following means:

- Construction of a liner system to reduce the impact on the environment.
- Limiting the extent of clearing required for the required infrastructure as far as is practicable.
- Diverting clean stormwater runoff from the active landfill cell.
- Capturing rainwater falling on to the landfill cells for re-using in the landfill construction.

10.4 Design assumptions

The general assumptions that form the basis for the design for the GSL are listed below:

- The landfill is classified as a Class II (Ref. [1])
- The landfill utilisation rates are between 150 000 tpa to 250 000 tpa.
- The average landfill *in situ* density = 1.0 t/m³.
- The minimum cell life assumed to be three years.
- The GSL cell's sump inverts, are to be at least 2.0 m above the maximum estimated winter groundwater level.
- The base of the Leachate Collection Pond (LCP) is to be at least of 2.0 m above the maximum estimated winter groundwater level.

10.5 Design parameters

The key parameters that form the design basis for the GSL are listed in Table 5.

Table 5: Key design input parameters for GSL

Parameter	Design Input	Parameter Requirement	Design Basis
Facility Design Parameters			
Design life	22 to 37 years	Golder assessment	
Landfill utilisation rates expected	150 000 to 250 000 tpa	Alkina Holdings	
Landfill utilisation rate used in the design	200 000 tpa	Alkina Holdings	
Method of landfill waste placement	In stages, in lifts within the cells. Cells are subdivided during operations.	Golder assessment	



DESIGN REPORT – GREAT SOUTHERN LANDFILL

Parameter	Design Input	Parameter Requirement	Design Basis
Foundation materials	Gravel/sand layer between 0.5 to 1 m overlying a silty/clay layer up to 5.5 m below ground overlying hard rock (either Saprolite, Saprock or fresh Granite)	Golder assessment	Golder Geotechnical Field Investigation (Appendix A)
Interpreted depth of Soil for Cell base design	0.7 m to 4.2 m	Golder assessment	Golder Geotechnical Field Investigation (Appendix A)
FSL elevations	Cell 1: RL 310 m to RL 319 m Cell 2: RL 317 m to RL 325 m	Golder assessment	
GSL waste elevation at closure	RL 350.5 m	Golder assessment	
GSL Footprints	Cell 1 = 7.9 ha (approx.) Cell 2 = 6.1 ha (approx.) All cells = 36 ha (approx.)	Golder assessment	
Stormwater Dam Design Parameters			
Contributing catchment area	200 ha	Golder assessment	Hydrology Assessment (Ref. [7])
Seepage losses	1×10^{-8} m/s	Golder assessment	
Spillway design	peak 100 year ARI	Golder assessment	
Design storm event	1:100-year, 72-hour	Vic BPEM	Ref. [2]
Design wind wave run-up	1:10 AEP	Golder assessment	
Minimum freeboard	0.5 m after design storm	DWER guidelines	Ref. [1]
Yearly evaporation	1 415 mm	BoM	Hydrology Assessment (Ref. [7])
Median annual rainfall	589	BoM	Hydrology Assessment (Ref. [7])
Landfill Design Parameters			
<i>In situ</i> waste density	1.0 t/m ³	Golder assessment	Golder assessment
LCS Sump minimum depth to estimated maximum winter groundwater elevation	2.0 m	Vic BPEM – interpreted	
Subsurface System Parameters			
Extent of seepage	Assessment of extent required, based on observed seepage extent during winter	Golder assessment	Golder assessment
Leachate Collection System Parameters			
90 th percentile annual rainfall	736 mm (1995)	Golder assessment	Golder assessment



11.0 CELL 1 AND CELL 2

Cell 1 and 2 has been design to receive Class II putrescible waste. Cell 1 has been designed for an operational design life of 4 years at a landfill utilisation rates of 200 000 tpa. The operational design life for Cell 2 has been estimated to be 5 years based on the same utilisation rates. Cell 1 has a footprint of 7.9 ha and Cell 2 has a footprint of 6.1 ha. The layout of Cell 1 and Cell 2 are shown in Drawings D104 and D105.

The main components of Cell 1 and 2 design are the:

- Subsurface drainage system.
- Subgrade.
- Geosynthetic lining system.
- Leachate collection system and
- Embankments: Perimeter embankments and cell division bunds.

These main components of the Cell 1 and 2 design are described in the following sections.

11.1 Site preparation

Site preparation works for Cell 1 and Cell 2 consist of the following:

- Decommissioning of monitoring bores MB12 and MB13 within Cell 1 and GMB06 within Cell 2.
- Clear and grubbing of the entire footprints, including embankments, bunds and cell base.
- Removal of the topsoil layer to a nominal depth of 300 mm from the entire footprint, including embankments, bunds and cell base.
- Excavation of all unsuitable materials, within the base of the cells, to a minimum depth of 500 mm, to a firm suitable subgrade.
- Replacement of the excavated unsuitable materials with engineered clay material. Moisture condition, place and compact to a minimum Standard Maximum Dry Density (SMDD) ratio of 95% and Optimum Moisture Content (OMC) of -0% to +3%, to a maximum elevation of -250 mm from FSL for the cell.
- Proof Roll of the entire footprint area, including cell base and embankments.

The site preparation has to be in accordance with the Technical Specifications (Ref. [3]) and Drawings (Ref. [5]). The preparation required for Cell 1 and 2 also applies to the Retention pond, Leachate pond and Water Dam.

11.2 Subsurface drainage system

The subsurface drainage system has been designed to:

- Reduce the impacts of phreatic surface mounding beneath the cell floor
- Prevent the pressurisation of the basal liner system from below
- Reduce the accumulation of pore pressures in the embankment fill.

The subsurface drainage system will consist of a network of perforated pipes within a free draining seepage interception trench, located below the embankment toe. The trench and pipe network will be located on the south-east section of the GSL, falling at a grade of between 1% and 3% towards the perimeter embankment toe. The subsurface drainage pipe network connects and slopes towards a common collection sump. This subsurface drain sump is located at the lowest ground surface elevation on the south-east perimeter embankment. The water collected in this sump is to be pumped and directed into the Retention pond.



The area to be serviced by the subsurface drainage system is based on the area of intersection between the potentiometric groundwater contours (consistent with hydrogeological studies completed by Golder in 2017 [10]) and the pre-construction topography and confirmed by visual observation in the field during winter. This equates to an area of approximately 271 600 m² across Cells 1, Cell 4, Cell 6 and Cell 7, representing the portions of the subgrade which may be subject to periodic groundwater seepage.

The subsurface drain system is proposed to be progressively extended at the start of the construction of Cell 4, Cell 6 and Cell 7. To allow for the future extension of the subsurface drainage system, the connecting subsurface drain trench and network connecting pipe daylights into the surface at the far north-east end of the south-east perimeter embankment.

The approach taken for the design of the subsurface drainage system was to prepare a seepage model using the finite element code SEEP/W¹ to estimate the required spacing for trenches to intercept the groundwater seepage and maintain a minimum distance of 2.0 m between the Cell sump invert and the phreatic surface mound between these drainage trenches. The trench and pipe minimum spacing required was found to be 40 m. The details of this assessment is presented in the Hydrology report (Ref. [7]).

The layout of the Subsurface Drainage system is presented in Drawings D104 with details presented in Drawing D113, in accordance with the Technical Specifications (Ref. [3]).

No subsurface drainage system is proposed for Cell 2, or the future Cell 3 and Cell 5, since the groundwater is significantly lower than 2.0 m below the sump invert levels.

The design details for the subsurface drainage system are presented in the Technical Specifications (Ref. [3]) and Drawings. Once the subgrade drainage system in Cell 1 has been constructed the construction of the liner system is to be constructed.

11.3 Subgrade and liner system

The liner system for Cell 1 and 2 is based on the Vic BPEM [5] guidance document and from base to top comprises of the following components as shown in Figure 3:

- A compacted engineered subgrade.
- A Geosynthetic Clay Liner (GCL) (including 2 layers of GCL at the locations of the leachate collection sumps).
- A 2 mm thick HDPE geomembrane liner.
- Cushion Geotextile.

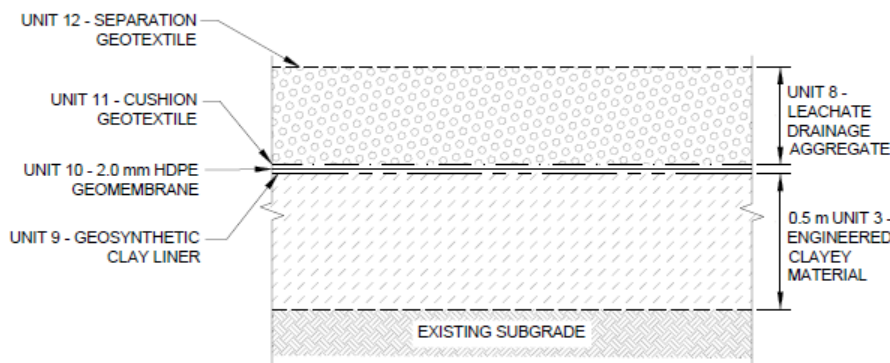


Figure 3: Typical liner system section

¹ Geostudio 2007 Version 7.23 Copyright © 1991-2013 Geo-Slope International, Ltd.



Figure 3 also presents the leachate drainage aggregate and separation geotextile that forms part of the Leachate Collection system presented in Section 11.5.

The Cell 1 and Cell 2 lining systems is to be placed over the cell base and extend up the side slopes of the embankments. The Liners are required to be anchored in place prior to the construction of the Leachate Collection system.

Each component of the liner system is discussed in the following sections. The components are also shown in detail in the Drawing D110 (Ref. [7]) with additional information included in the Technical Specification (Ref. [3]).

11.3.1 Compacted subgrade

The subgrade is to be formed by a combination of cut and fill of the existing surface within the Cell 1 and 2 footprint to achieve a general grade of nominally 3% to the western perimeter of the cells. The required construction outcomes of the subgrade are detailed in the Technical Specification.

As required in the Technical Specification the upper surface of the subgrade on the base of Cell 1 and 2 is to be proof rolled and observed for deflection prior to the placement of the overlying liner system.

A geotechnical assessment of the GSL subgrade conditions was undertaken by Golder, with the outcomes presented in the Geotechnical Assessment (Appendix A). Based on the results of the geotechnical assessment the site is characterised by a loose to medium density layer of clayey GRAVEL or clayey SAND material overlying a layer of stiff to very stiff sandy/gravelly CLAY or SILT of generally medium plasticity. The gravel/sand layer extends to between 0.5 m to 1 m below ground, underlain by a variable thickness silt/clay layer up to 5.5 m below ground.

There is hard rock strength material at variable depth between 0.7 m and 4.2 m, generally identified as Saprolite, Saprock or fresh Granite. The depths of refusal has been used to estimate a 3D model of depth to rock, for use in landfill design. The very stiff fine grained material and underlying rock strength materials are considered to form a competent foundation for the construction of the proposed landfill. The foundation is not expected to significantly consolidate once loaded with waste and compacted fill material.

11.3.2 Geosynthetic clay liner

In accordance with the Technical Specification the Subgrade layer below the GCL is to be moisture conditioned to near or wet of optimum moisture content before being covered with GCL providing sufficient moisture to hydrate the GCL with water and keep the GCL hydrated under the expected loading conditions.

The Technical Specification includes independent testing for the measurement of the mass of bentonite of the GCL at a required frequency of 1 test per 2500 m². This provides an effective means for conformance testing of one of the key performance components of the GCL, being the mass of bentonite.

The GCL is specified to be supplied with additional bentonite applied to the overlaps and independent testing is required to be undertaken on the product supplied to verify the presence of this additional bentonite.

The material property requirements for the GCL are provided in the Technical Specification. The Technical Specification includes requirements relating to Fluid Loss of the bentonite used in GCL manufacture. Requirements related to Swell Index have not been included. Based on Industry experience (comms with Prof A Bouazza², and TRI Environmental laboratory³), Fluid Loss tests have been found to be a more reliable indicator of the hydraulic conductivity of the bentonite in the GCL. The Fluid Loss test method is subject to less operator sensitivity and variability than the Swell Index test.

² Professor Abdelmalek Bouazza is from the Department of Engineering at Monash University.

³ TRI Australasia is a Geosynthetics Testing, Research, Consulting and Field Services Facility located at Burleigh Heads in Queensland.



The design therefore proposes to use the results of Fluid Loss testing in conjunction with the GCL hydraulic conductivity test results to assess compliance of the proposed GCL with the requirements of the Technical Specification. On this basis we propose a testing frequency of the GCL rolls for Fluid Loss of test per 300 m². Swell Index testing would not be used to assess compliance of material proposed for use as GCL.

The internal batters of the Cell 1 and 2 are specified to be 1:3 (V:H) for the perimeter embankment and 1:2 (V:H) for the Cell Division Bunds. An anchor trench has been included in the design for construction and placement of the GCL.

11.3.3 HDPE geomembrane

As specified on the Drawings and the Technical Specification, a 2 mm thick HDPE geomembrane is to be placed over the entire internal footprint base area of the Cell 1 and 2 and embankment slopes, overlaying the GCL. HDPE geomembrane is generally adopted in the industry as suitable for use in landfill liner systems due to its resistance to chemical degradation as supported by numerous studies and guidance documents (Vic BPEM (Ref. [2])). Aspects that are specifically addressed in the Technical Specification (Ref. [3]) to ensure a suitable liner system is provided in regards to long term performance, include:

- Confirmation of resin source and manufacturer
- Thickness requirements
- Standard Oxidative Induction Time (Std-OIT) – provides an indication of the amount of antioxidants included to protect the liner against high temperatures (i.e. installation conditions)
- High Pressure Oxidative Induction Time (HP-OIT) – provides an indication of the amount of anti-oxidants included in the resin mix to protect the liner against operational temperatures.
- Environmental Stress Crack Resistance.

The geomembrane layer is to be placed in the anchor trench with the GCL.

11.3.4 Cushion geotextile

The cushion geotextile is to be placed overlaying the HDPE geomembrane as specified on the Drawings and the Technical Specifications. Over this layer the Leachate Collection system will be placed.

The cushion geotextile is the last layer of the three layers in this lining system that is required to be anchored at the anchor trenches.

To assess the performance of the cushion geotextile (identified during the tender process) compression testing of the proposed cushion geotextile will be undertaken. The compression testing will be undertaken in accordance with a Modified Hydrostatic Puncture Test (ASTM D5514) to assess the geotextiles capacity to limit potential deformations and strain in the geomembrane liner.

11.3.5 Anchor trenches

The anchor trench for the Cell 1 and 2 has been designed with a set-back of 1 m from the crest of the perimeter embankment and a set-back of 2 m from the crest of the cell division bunds. The trench is to have a nominal width of 0.6 m and depth of 0.7 m. Experience with geosynthetic installation has shown the specified anchor trenches are effective and constructible

The anchor trench backfill is specified to be engineered fill, with the following geosynthetic materials permanently secured in the trenches as per the Drawings D110 and D112:

- GCL
- HDPE Geomembrane
- Cushion Geotextile.



The anchor trench is to be backfilled whilst the liner materials are in a relaxed state (i.e. not in a state of tension), in full contact with the subgrade without the presence of wrinkles or folds. Temporary anchorage such as sandbags can be used to hold the material in place until a relaxed state is achieved.

11.3.6 Separation geotextile

The separation geotextile is to be placed over the leachate drainage aggregate (that forms part of the Leachate Collection System described in following sections) on the base and side slopes of the cells, to reduce the likelihood of clogging the leachate aggregate. It will be kept in place by sand bags in accordance with the Technical Specifications (Ref. [3]) and Drawing D110 (Ref. [5]).

11.4 Perimeter embankment and cell division bund

The perimeter embankment and cell division bunds design has been based on the Stability Assessment (Ref. [9]) that was reviewed by Golder as part of the design of the GSL at the different stages of operations. In the stability analysis report it was recommended that embankment slopes should not be steeper than:

- 1:2 (V:H) for short-term conditions or embankments that may be present for less than 20 years and
- 1:3 (V:H) for long-term conditions or embankments that will be present for 20 years or more.

Based on these findings the GSL embankment design includes two types of embankments, the internal embankments referred to as Cell Division Bunds and the external embankments referred to as Perimeter embankments.

The following are the design characteristics specific to each embankment:

- Cell Division Bunds:
 - Side slopes 1:2 (V:H)
 - Nominal crest width of 5 m, with an anchor trench excavated 2 m from the crest, to facilitation future tie-in of adjacent cell liners.
 - 3 m to 5 m height for Cell 1 and 2 to 3 m for Cell 2.
- Perimeter embankment:
 - Side slopes 1:3 (V:H)
 - Crest width of 5 m, with an anchor trench excavated 1 m from the crest.
 - Cell 1 embankment slopes from RL 320.3 m on the north-west end to RL to 313.5 m at the lowest point in the south-east side, to RL 321.9 m at the north-east corner, with embankment heights ranging from 3 to 11 m.
 - Cell 2 embankment slopes from RL 330.4 m on the north corner to RL 320.3 at the north end where it connects with Cell 1. The embankment heights range from 3 to 5 m.

The cell division bunds will be constructed with general fill. These bunds will also divert stormwater away from the active waste disposal area to reduce leachate generation.



11.5 Leachate collection system

The leachate collection system (LCS) forms part of the leachate management system for the GSL. The Leachate Collection System (LCS) extends across the base of the cells and along the toe of the side walls to be collected at the Leachate Collection Sump. This system will intercept vertical and lateral leachate seepage occurring through the waste. The LCS has been designed in accordance with the guidance provided in the Vic BPEM (Ref. [2]). The assessment and calculations that form the basis for the design are presented in the Hydrology Assessment (Ref. [7]). The Hydrological Assessment has taken into consideration the recirculation of the leachate although this is not going to be the general practice. It has also taken into consideration the diversion of surface water away from the waste mass and the progressive capping of the waste. The general management practice for leachate will involve evaporation from the leachate dam. Where excess leachate generation occurs, above the design capacity of the leachate management system, the collected leachate will generally re-circulated into the landfill. Leachate will only be transferred offsite for treatment at a licensed treatment facility in the case of an emergency. Recirculation will take place at the working face where the leachate will be irrigated onto the working face as recommended in the Vic BPEM¹.

The amount and quality of the leachate will vary, as it depends on a range of different variables, for example:

- Timing – if a cell is commissioned or operational during the summer or winter
- Size and area of exposed landfill and liner
- Quantity of landfill waste within the landfill
- Shape of waste mass (slope angle)
- Operation of the landfill
- Type of waste
- Type of cover material.

All of the above variables have a significant influence on the quantity of leachate being generated on site. For this reason, Alkina will carry out ongoing leachate monitoring during the operational phase as part of its commitments and, if deemed necessary, will construct an additional leachate pond to contain any unaccounted leachate.

The LCS presented in this design report consist of the following components:

- **Leachate Collection Pipes network:** These are to be placed over the cushion geotextile within the cell base. The network of leachate collection pipes consist of perforated pipes located at 20 m spacing across the floor of the landfill that connects with the perforated leachate header pipes. The landfill subgrade is to have a slope of approximately 3% to promote drainage towards the leachate collection pipes and sump. The leachate header pipes direct the leachate towards the leachate collection sumps at a grade of at least 1%.

The leachate collection system for Cell 1 has three (3) solid leachate header pipes that penetrate the cell division bund on the north-east to allow for the extension of the leachate collection system during the construction of the proposed Cell 4, Cell 6 and Cell 7. Cell 2 has two (2) solid leachate header pipes, to later connect with Cell 3 and Cell 5.
- **Leachate Drainage Aggregate:** A 300 mm thick leachate drainage aggregate layer is to be placed over the cushion geotextile and is to cover the leachate collection pipes with a minimum thickness of 300 mm over the pipes.



- **Leachate Collection Sump:** This is located at the lowest elevation point within Cell 1 and Cell 2. The leachate collected at this sump will be emptied via pumping to the Leachate Pond. The leachate collection sumps assist with the requirement of maintaining the leachate levels within the landfill base to a maximum of 300 mm above the landfill liner, in accordance with the Vic BPEM (Ref. [2]) recommendation.
- **Leachate Pond:** This is located outside the landfill footprint. It collects the leachate from the GSL. The design for this structure is presented in Section 12.0.

Details of the LCS components mentioned above are presented in Drawings D111 to D 119, and in the Technical Specifications (Ref. [5]).

11.6 GSL stability assessment

Golder (2015) undertook a stability assessment for the previously approved Allawuna Farm Landfill (AFL) (Ref [9]) included in Appendix B. Golder reviewed the 2015 Allawuna Farm landfill design and stability assessment in relation to the design of the GSL. The only significant amendment between the two designs is the number of cells into which the landfill has been divided. This design amendment has no implication on the stability of the GSL. Therefore the stability assessment carried for the AFL is still relevant for the GSL design. The following components have not been amended:

- Location, footprint and foundations materials
- Cross-sectional embankment and bund design (including slopes, embankment elevation, crest widths and lengths), and construction materials
- Waste slopes and waste type
- Basal liner system
- Capping system.

Note that Alkina has integrated all the recommended changes to the initial design geometry for Allawuna, based on the Stability Assessment and Liner interface assessment carried out for Allawuna. The assessments carried out are summarised below and are relevant to the new GSL facility.

11.6.1 Objectives of stability assessment

The objective of the assessment carried out in 2015 was to:

- Assess the proposed final landfill slopes and potential cover materials
- Assess the stability of the liner system and waste landform during operational stages and after closure
- Assess the impact of a possible malfunction of leachate pumps on the stability of the landfill during operational stages
- Assess the stability of embankments and foundation throughout the life of the facility and after closure
- Assess the impact of a seismic event on the stability of the landfill during operational stages and after closure
- Assess the integrity of the proposed liner system prior, during and subsequent to waste placement
- Propose suitable materials for the construction of the basal liner system and capping system.

11.6.2 Stability analysis

Taking into consideration the above objectives the stability analysis was carried out for:

- 1) Liner interface stability, comprising of:
 - a) Assessment of the capping system stability (i.e. veneer stability)



- b) Analyses of the basal liner system interface stability
- c) Assessment of the basal liner system integrity
- 2) Waste stability
- 3) Embankment and foundation stability.

The scenarios and assumptions used are described in detail in Appendix B.

11.6.3 Outcomes of stability assessment

The complete set of results for the stability analysis and veneer stability assessment carried out is presented in Appendix B. The results of these assessment are summarised as follow:

- The stability analyses undertaken for the basal liner system interface has shown acceptable factors of safety for five out of six scenarios. Although the result for one scenario was lower than the minimum Factor of Safety (FoS), the estimated permanent deformation due to earthquake action (MCE) was well below acceptable values.
- The stability analyses undertaken for the waste landform has shown acceptable factors of safety for five out of six scenarios. Although the result for one was lower than the minimum FoS, the estimated permanent deformation due to earthquake action (MCE) was well below acceptable values.
- The stability analyses undertaken for the foundation and embankment has shown acceptable factors of safety for the landfill design prior to and post waste deposition.

Summary of recommendations based on the outcomes of the analysis:

- The minimum friction angle of the liner component at the side slopes and base of the landfill shall be no less than 16°. This friction angle should be achieved using a double-textured HDPE instead of single textured.
- The critical interface of the basal liner system should be located between the upper side of the HDPE geomembrane and the lower side of the cushion geotextile.
- Embankment slopes should not be steeper than 1V:2H for short term conditions (embankments that may be present for less than 20 years; i.e. internal embankments and cell division bunds), and not steeper than 1V:3H for long term conditions (embankments that may be present for 20 years or more; i.e. external perimeter bunds).
- Waste slopes should not be steeper than 1V:3H for the operational landform, and not steeper than 1V:5H for the final landform (post closure).
- Closure capping:
 - Laboratory testing of proposed materials should be undertaken prior to construction of the capping system to verify the veneer stability assessment.
 - The HDPE and LLDPE geomembranes should be textured on both sides in order to achieve the required post-peak friction angle at both interfaces.
 - The overall slope length exceeds the average length of a geosynthetic roll. Best practice for lining on slopes typically prevents the use of cross-slope joins. In view of that, intermediate anchoring of geosynthetic panels should be provided.
 - Placement of the cap soil should be carried out from the bottom of the slope upwards, retaining a large buttress at the toe to reduce the likelihood of slippage during construction. Construction vehicles should exert a low-ground pressure (e.g. tracked) and an assessment of the operational stability of the slope during construction should be undertaken once the proposed materials and equipment are confirmed.



The basal liner system integrity assessment undertaken prior to waste placement, during waste deposition (operations) and post-waste placement indicates the following:

- The integrity of the lining system during waste placement is satisfactory
- The settlement of the subgrade and embankment fill due to the loading imposed by the waste will not detrimentally impact the integrity of the lining system, and
- The post-waste deposition settlement will not affect the integrity of the lining system.

A flood risk assessment, presented in Section 14.3 (Ref. [7]), was carried out to identify the potential risk of flooding of the landfill infrastructure. Based on the assessment, flooding is not expected to impact on the stability of the GSL.

12.0 LEACHATE POND

The leachate from the leachate collection sump will be directed by pumping to the leachate pond to be located to the north of the landfill, as indicated in the Drawings D120 and D121. The leachate pond is to be constructed prior to the initial operation of Cell 1.

To size the leachate pond a water balance analysis was undertaken, which included the assessment of leachate generation within the landfill, resulting from:

- Rainfall infiltration through uncapped waste.
- Rainfall seepage through the interim cap and
- Rainfall seepage through the final landfill cap areas.

These different scenarios were assessed for the maximum storage required for the number of closed, interim capped and operational cells. The initial leachate generation simulations were carried out using the Hydrologic Evaluation of Landfill Performance (HELP) computer program. The results from this simulation were then used as inputs for the leachate pond water balance assessment carried out using the GoldSim modelling software.

12.1 Leachate pond design

The water balance carried out concluded that a storage of 2500 m³ was required. Table 6 provides the summary of the leachate pond design details.

Table 6: Leachate pond details

Leachate Pond	Top of Crest Dimensions (m)	Top of Crest Area (m ²)	Maximum Storage Depth (excl. 500 mm Freeboard)	Maximum Storage Volume (excl. 500 mm Freeboard)
Leachate Pond	40 x 50	2000	2.0	2580

Note: Ongoing monitoring of leachate generation rates will be carried out as the site develops in order to ensure that sufficient leachate storage capacity is available and that the leachate management strategy remains robust and effective over the life of the landfill.

The Leachate Pond has been designed for an operational design life of 30 years, although additional ponds will be required over the life of the landfill site.

The estimated maximum winter groundwater elevation is at a minimum of 18 m below the pond base.

The leachate pond base is to be sloped at 1% towards the southern corner of the facility. The maximum operational water level is proposed to be at RL 324 m, with the base at approximately RL 322 m. The pond is designed to be formed by a cut/fill exercise, having side slopes of 1:3 (H:V) and embankment crest of 4 m width.



Stormwater diversion bunds will be constructed around the perimeter of the pond, as shown in Drawing D120, to provide the target storage capacity, with stormwater diversion bunds on the upstream of the pond to minimise the amount of clean stormwater entering the pond.

12.1.1 Leachate pond liner system

The proposed liner system for the leachate pond is to the same standard as the liner system for Cell 1 and Cell 2 and consists of:

- 500 mm thick compacted subgrade of engineered clayey fill material, extending from the base to the embankment side (refer Section 11.3.1)
- GCL liner (refer Section 11.3.2)
- 2.0 mm smooth HDPE geomembrane liner (refer Section 11.3.3), anchored in place using an anchor trench (refer Section 11.3.5)
- A system of permanent ballast to protect the pond liner.

Details of the design for the retention pond are provided in detail in the Technical Specifications and in Drawings D120 and D121.

12.1.2 Permanent floor ballast

As shown on Drawing D120, the floor area is to be covered with permanent ballast at the internal pond toe. As the Leachate Pond is expected to be empty on occasion, the liner system of the pond may be exposed to the elements for short time periods. Therefore, a nominal ballast permanent ballast system has been included in the design to reduce the risk of wind uplift. The ballast requirements are provided in the Technical Specification.

The geomembrane liner within the Leachate Pond is specified to comprise double textured geomembrane. Placement of a double-textured geomembrane will resist movement related to expansion and contraction due to the heat/cool cycles between the GCL of the pond and the textured geomembrane thereby, reducing the tensile loading on the geomembrane. Low tensile loading on the geomembrane will reduce the likelihood of stress crack formation in the geomembrane. In addition it provides a safety feature in addition with egress buoys and ropes, as the textured membrane is easier to walk on.

12.1.3 Leachate conveyance

The long-term objective for leachate management on site is to manage leachate levels via a number of different processes. A leachate management plan will be produced for the leachate pond prior to operation to capture the management strategy for the ponds. This will include the adoption of the following methods or a combination of the following methods:

- Dust suppression across the active landfill surface
- Evaporation from the ponds
- Recirculation of leachate into the landfill
- Trucking to off-site disposal (as a contingency measure if required).

Should the capacity of the leachate pond be exceeded, the retention pond can be used to contain leachate, for short periods not exceeding two weeks, as the liner systems for both ponds are similar. This would require the temporary placement of a pump and pipe to transfer leachate from the leachate pond to the retention pond.



13.0 RETENTION POND

The retention pond receives water from the subsurface drainage system via pumping. The capacity requirements for the retention pond were assessed in the Hydrology Assessment (Ref. [7]). The sizing of the facility was based on an estimated peak flow rather than an average flow. Subsurface water management and storage requirements are to be monitored and reviewed throughout the operational life of the GSL.

13.1 Retention pond design

The assessment recommended an initial retention pond size of 2000 m³, assuming that the water stored within the retention pond is to be managed and controlled primarily through direct evaporation losses with alternative water management options, such as use for dust suppression, to be implemented if there is an ongoing accumulation of stored water.

The maximum storage for the retention pond presented in this design is 2800 m³. Table 7 provides the summary of the retention pond design details.

Table 7: Retention pond details

Retention Storage Pond	Top of Crest Dimensions (m)	Top of Crest Area (m ²)	Maximum Storage Depth (excl. 500 mm Freeboard)	Maximum Storage Volume (excl. 500 mm Freeboard)
Retention Pond	50 x 40	2000	1.5	2800

The retention pond base is to be sloped at 1% towards the north-east corner. The maximum operational water level is at RL 308.8 m, with the lowest pond floor elevation at RL 307.3 m. The estimated groundwater surface is at a minimum of 2.7 m below the pond base.

13.2 Retention pond liner system

The water quality on the retention pond is generally expected to be suitable for release to the environment, with the extent of contamination, should it occur, expected to be minimal. For this reason the proposed liner system for the retention pond consists of:

- 500 mm thick compacted subgrade of engineered clayey fill material, extending from the base to the embankment side (refer Section 11.3.1)
- 2.0 mm smooth HDPE liner, anchored in place in an anchor trench. (refer Section 11.3.3 and 11.3.5)
- A system of permanent ballasts to protect the pond liner.

Details of the design for the retention pond are provided in detail in the Technical Specifications and in Drawing D122 and D123.

Note that water should not be discharged if suspected or found to be contaminated (EPA, 2014 Ref. [2]). The testing and stormwater discharge procedure should be defined based on the operational strategy for the landfill and will be dependent upon the nature of material being disposed of in the landfill cells. Where discharge from the retention pond is permitted, this should be carried out through pumping of water from the pond. It is recommended that uncontaminated stormwater from this pond be utilised for dust suppression, when possible, or pumped to the stormwater dam prior to release to the downstream environment over the spillway.



14.0 STORMWATER DAM

An assessment of the site water balance for the GSL has been carried out in order to develop an improved understanding of the water management requirements relating to the proposed stormwater dam. The water balance model was constructed using GoldSim, a graphical object-oriented modelling environment with a capacity to incorporate dynamic probabilistic simulations. For the purpose of the assessment of the potential stormwater dam yield and reliability, the simulation period is based on the 25-year period from January 1990 to December 2014. This includes the drier climate period from 2000 onwards and also includes the second (2010), fourth (1994) and fifth (2001) driest years of the 115 year SILO rainfall record, thereby allowing the potential yield of the storage to be assessed for drought years. The Hydrology Assessment describes in detail the structure, inputs and assumptions applied in the water balance assessment.

14.1 Stormwater dam and spillway design

The Stormwater dam has been designed to store the stormwater runoff from an upstream catchment area of 200 ha, it has an embankment footprint area of 0.363 ha and a pond surface area of 2.6 ha at maximum water level. The typical design details for the Stormwater dam are presented in Drawings D124, D125 and D126 (Ref. [5]). The following are some of the main characteristics of the design:

- Stormwater dam key-in and base are to be proof roll. All unsuitable materials (such as sand) are to be excavated, removed and replaced with engineered clay materials.
- Key-in trench:
 - Side trench slopes of 1:2 (V:H)
 - Depth to refuse (bedrock).
 - Fill of compacted engineered clay as per Technical Specifications.
- Embankment:
 - Upstream side slopes of 1:2 (V:H)
 - Downstream side slopes of 1:3 (V:H)
 - Crest width = 4.0 m
 - Fill of compacted engineered clay as per Technical Specifications
 - Embankment crest elevation = RL 312.5 m
 - Freeboard = 0.25 m (providing for a 1 :100 ARI over the maximum operation level for flood storage depth of 0.5 m)
 - Maximum water elevation = RL 311.75 m
 - Maximum storage volume = 36 000 m³
- Spillway sizing based on 100 year ARI:
 - Concrete base, broad-crested weir type spillway width.= 10 m
 - Spillway elevation = 311.75 m
 - Maximum flood depth = 0.5 m
 - Peak inflow = 7.7 m³/s
 - Peak outflow = 6.2 m³/s



As part of the engineering design of the Stormwater dam, the storage capacity was modelled and assessed. This is presented in the following section. The consequences of flooding of the downstream water course was also assessed and is presented in Section 14.3.

14.2 Stormwater dam storage assessment

The water balance for the Stormwater Dam was assessed with the proposed location and dimensions for the dam (Ref. [7]). The maximum storage volume ($36\,000\text{ m}^3$) was assessed against the demand requirements, potential losses and catchment runoff yield to assess the reliability of the Stormwater Dam over the life of the landfill site. The variation in modelled storage over the 25-year period is presented in Figure 4.

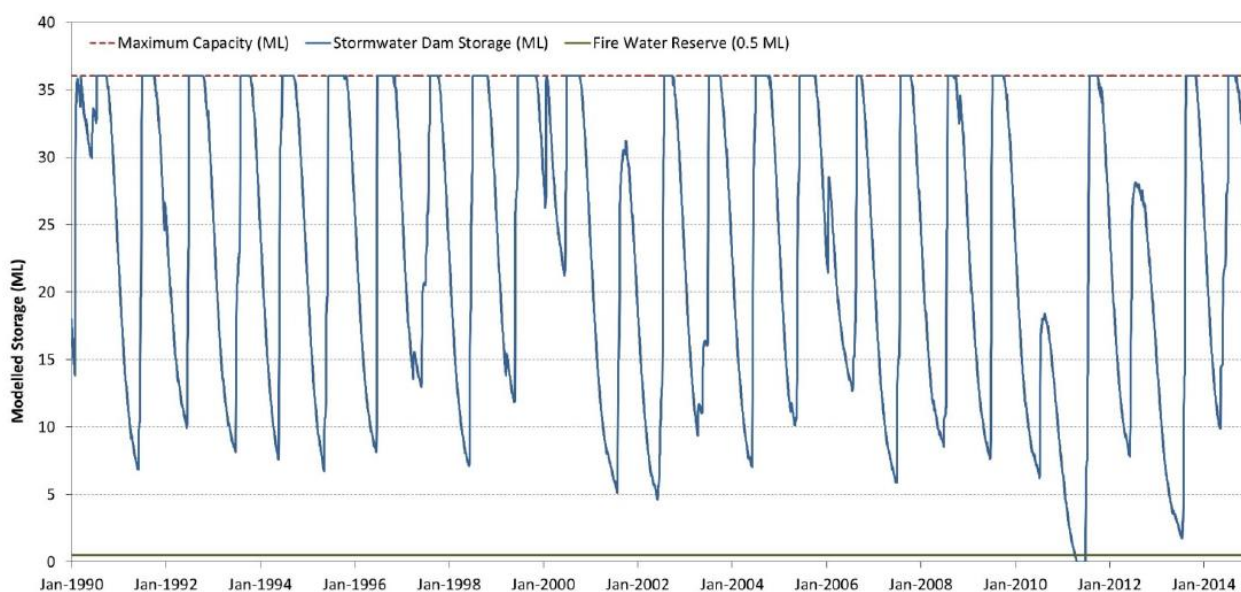


Figure 4: Modelled stormwater dam storage (Jan 1990 to Dec 2014)

The storage water balance assessment indicated that based on the current estimates of upstream catchment runoff, water demand and storage losses, the stormwater dam only fails to provide sufficient water supply in one year (2011) out of the 25-year simulation period. This failure, due to the emptying of the storage during the summer of 2011 is a result of the very limited surface water runoff during the preceding winter period which did not allow the storage dam to fill sufficiently to maintain water supply for the following summer. Over the 25-year period the stormwater dam was predicted to not fill during the particularly dry winters of 2001, 2010 and 2012, highlighting the sensitivity of the water supply to winter period rainfall and runoff.

Excluding 2011 and 2013, the water balance model indicated that approximately 5000 m^3 of storage may be expected to be the minimum storage level during 'normal' operation. This unused water volume may be utilised and/or allocated as an emergency water supply, i.e. for fire water and construction water.

Construction water use from the stormwater dam should be utilised during the winter months when excess surface water yield is highest. Water availability for construction water requirements may be constrained during particularly dry years, i.e. during winter periods when the dam does not reach full storage capacity. Alternative water sources should be utilised where construction water is required during an extended dry period and these may include groundwater supplies or obtaining water from external sources.

The management and operation of the stormwater dam as a water supply will need to be assessed in more detail in order to identify potential operational rules and restrictions in order to maximise the reliability of the water supply over the operational life of the landfill.



14.3 Local flood risk assessment

In addition to the assessment of the potential impact on average flows, a flood risk assessment was carried out for the creek reach downstream of the stormwater dam to the confluence with the Thirteen Mile Brook (Ref. [7]). The estimated 100-year ARI design condition adopted for the design of the dam spillway was used to identify the potential risk of flooding of landfill infrastructure and impacts on operation, i.e. road alignments. It should be noted that the sediment control structure to be located downstream of the stormwater dam is not proposed to be a permanent water retaining structure and has been designed to allow the bypass of extreme flood events.

Site-specific 2-dimensional (2D) hydraulic modelling of the study reach was undertaken using XPSWMM⁴. The existing topographic survey data were adopted to generate a digital terrain model (DTM) of the study reach and adjacent floodplain extents required to define the 2D hydraulic modelling domain.

The estimated peak design flood discharge of 6.2 m³/s, estimated as the 100-year ARI peak flood discharge from the stormwater dam spillway (Section 14.1), has been defined as the steady-state inflow to the hydraulic model at the upstream boundary. In the absence of flood levels for the downstream model boundary at the confluence of the local creek with Thirteen Mile Brook an assumed constant water level of approximately 3 m above creek invert level has been adopted. The application of this conservative downstream boundary condition has been reviewed and does not have a significant influence on the upstream flood levels.

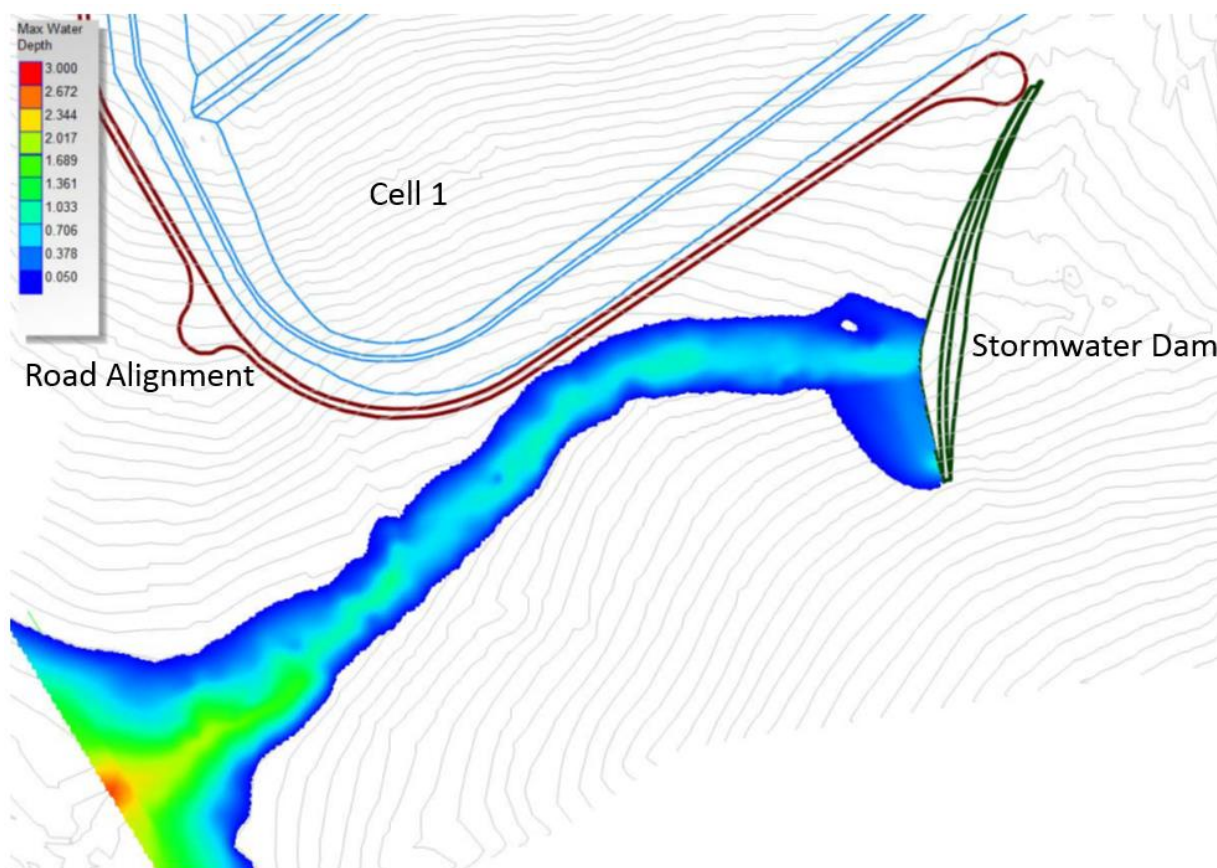


Figure 5: Modelled 100-year ARI flood extent and depth below stormwater dam

⁴ (XP Solutions, 2014), an integrated software package capable of simulating rainfall-runoff processes and the hydraulic performance of constructed/natural drainage systems.



The modelled 100-year ARI flood extent and depths are presented in Figure 5 relative to landfill infrastructure developments, i.e. stormwater dam (green), proposed road alignment (red) and landfill extent (light blue). Based on the existing topographic survey and road alignment it appears that the maximum flood extent for the 100-year ARI event is not expected to directly impact the proposed road alignment. Directly adjacent to the road alignment modelled flow depths and velocities are low, i.e. less than 0.5 m/s.

However, it would be recommended that additional profiling, stabilisation and/or raising of the road profile along the potentially most-at-risk section be considered in order to increase the stability, integrity and serviceability of the road through the life of the landfill.

15.0 SEDIMENT MANAGEMENT STRUCTURES

Sediment from the site will be managed through a combination of sediment management options. Sediment management requirements, specifications and designs have been based on the approaches recommended by the International Erosion Control Association (IECA, 2008) [11]. The sediment control measures include:

- Sediment fences.
- Rock or sandbag check dams.
- Sediment Structure.

The sediment fences and sandbag check dams are not permanent structures and are to be constructed during construction or operations as required.

Sediment structure design

The sediment structure is intended to capture sediments that escape from the other sediment capturing systems on the site and to prevent sediment from entering the Thirteen Mile Brook. It is proposed to be constructed downstream of the stormwater dam and upstream of the inflow confluence to Thirteen Mile Brook to minimise the release of sediment eroding from the landfill site to the downstream environment. The location and design details of the sediment structure are shown in Drawing D103 and D127 respectively. The sediment impacted runoff from the landfill cells will discharge south through the culverts under the access road.

The primary function of the sediment structure is to retain sediment conveyed in the inflowing surface runoff above a defined particle size, not simply to retain a defined volume of water relating to a given ARI storm. Therefore the sediment structure has been design for the controlled release of retained water prior to the inflow of a later event. This allows the settling zone within the pond to be restored to its full capacity within the required period.

If the capacity of the storage is not exceeded following a storm event, conveyed sediment would be retained, while inflow will be allowed to gradually drain through the embankment. Should multiple storms occur within a short period, the inflow volume exceeding retention capacity would discharge over the rock embankment, which acts as a broad crested weir. The inflowing sediment above the recommended particle size would, however, still be deposited within the sediment storage zone of the pond.

The sediment structure design has the following characteristics:

- Key-in cut to bedrock with 1:2 (V:H) side slopes.
- Proof roll of the structure footprint. All unsuitable materials (such as sand) are to be excavated, removed and replaced with engineered clay materials. The proof-rolled surface is to be covered by a separation geotextile and anchored in place.
- A rock filter embankment and key-in constructed of aggregate with a particle size varying between 250 mm and 500 mm.
- Rock embankment side slopes 1:2 (V:H).
- Crest elevation = RL 304.80 m.



Design details are presented in the Technical Specifications and Drawing D127.

The sediment structure is a rock filter that will provide passive drainage of water retained in the pond over a period of hours. The design therefore allows for the controlled release of inflows to ensure the maximum available storage capacity can be maintained within the sediment structure.

16.0 STORMWATER DIVERSION BUNDS AND DRAINS

Stormwater diversion drains have been designed to serve as the principal stormwater conveyance and surface runoff management system for the landfill site. The diversion drain aim to maximise the contributing catchment area for the stormwater dam as well as minimising the risk of uncontrolled stormwater runoff entering the operational landfill site from upslope catchment areas. The upstream catchment is small and surface runoff responses are likely to be sheet-flow runoff during significant storm events. Therefore the nominal diversion infrastructure consists of 0.5 m bunds with a diversion drain aligned with the upslope edge of the bund to control and divert runoff to the stormwater dam. Details of the basis for this design are provided in the Hydrology Assessment (Ref. [7]).

The stormwater management drain features are:

- Constructed by cut and fill methods, if cut materials are suitable for general fill.
- To nominal depths of 0.5 m.
- Sides slopes of the drain not steeper than 1:3 (V:H).
- Bund of nominal height of 0.5 m constructed with general fill.

In addition the Stormwater Diversion Bunds have been designed to divert clean stormwater runoff away from the Cells, Leachate Pond and Retention Ponds. These are to be constructed with the following features:

- To nominal height of 0.5 m, constructed from general fill.
- Side slopes not exceeding 1:2 (V:H).

17.0 CLOSURE AND REHABILITATION

The final landform at the top of waste for the site is shown in Figure 6. As landfill cells are completed it will be progressively capped to reduce infiltration and hence generation of leachate.

The objectives of the capping are as follows:

- Minimising infiltration of water into the waste, ensuring that the infiltration rate does not exceed the seepage rate through base of the landfill.
- Providing a long-term stable barrier between waste and the environment in order to protect human health and the environment.
- Preventing the uncontrolled escape of landfill gas.
- Providing land suitable for its intended after use.

The final capping design will be developed prior to commencing capping, but a conceptual capping system has been developed for the site, with the intent to achieve the above objectives. The conceptual capping detail is shown in Figure 7.



DESIGN REPORT – GREAT SOUTHERN LANDFILL

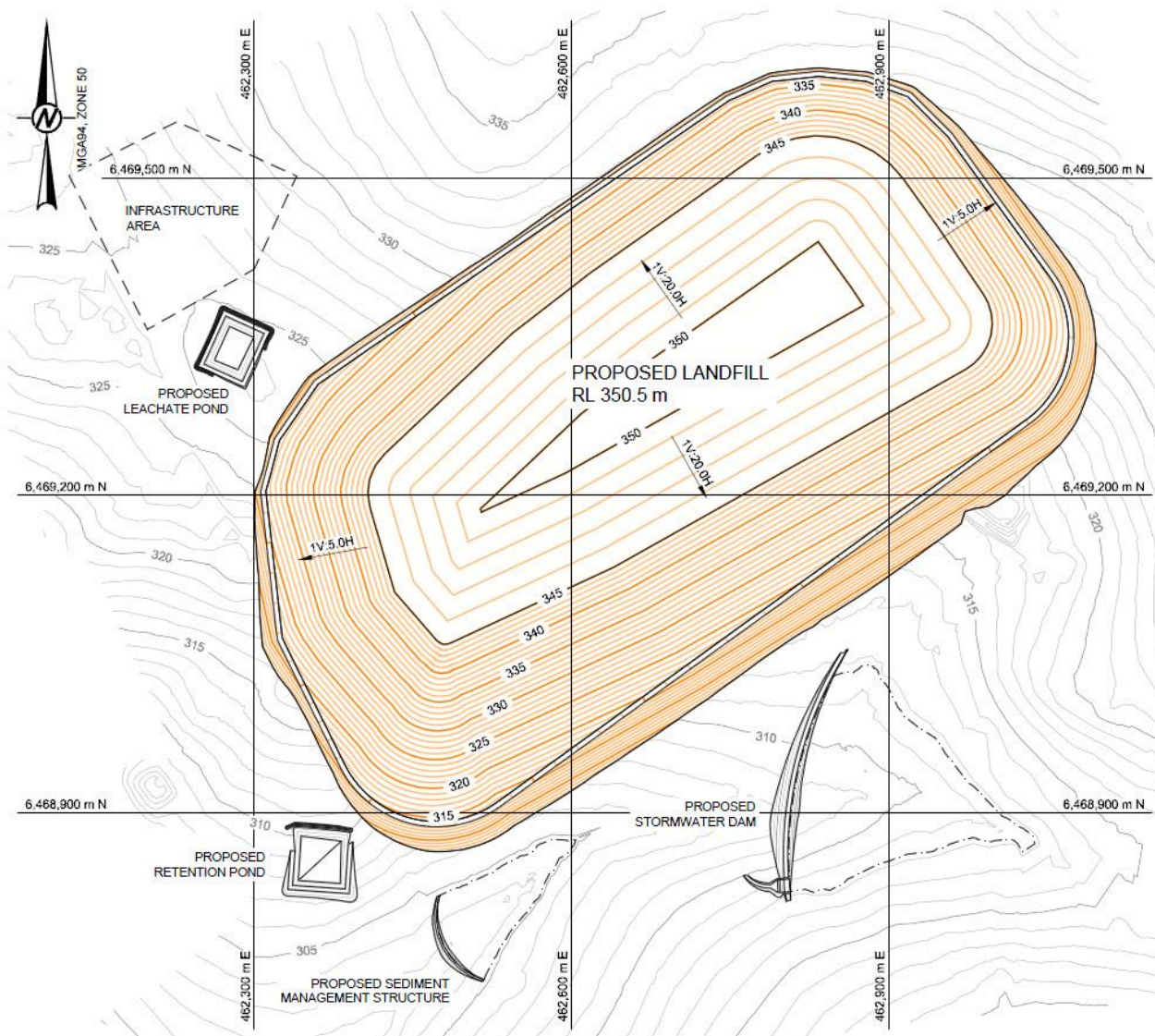


Figure 6: Final waste landform

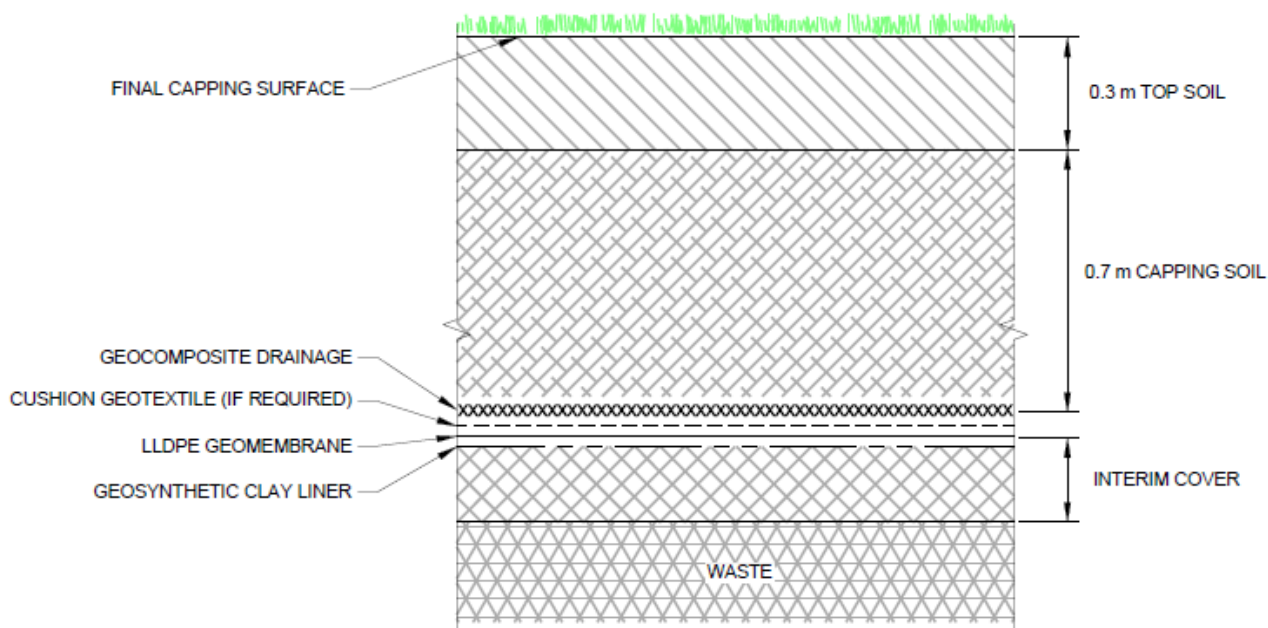


Figure 7: Conceptual final capping

18.0 DESIGN SUMMARY

Based on the engineering designs presented in this document, the following infrastructure are required at the GSL site:

- The subsurface drainage system has been designed at 40 m spacing to reduce the impact of the phreatic surface mounding beneath the cell floor and maintain the minimum distance of 2.5 m between the cell floor and the phreatic surface.
- The leachate collection system has been designed to intercept vertical and lateral leachate seepage occurring through the landfill waste.
- The Cell 1 and Cell 2 embankment has been designed based on the Stability Analysis, with side slopes of 1:3 (V:H) and crest widths of 5 m for the perimeter embankments and 1:2 (V:H) side slopes and crest widths of 5 m for the Cell Division bunds.
- A Leachate Pond with a minimum operational storage capacity of at least 2500 m³ (a minimum 0.5 m freeboard above the operational capacity), suitable for the operation of Cell 1 and Cell 2.
- A Retention Pond with storage capacity of at 2800 m³ (a minimum 0.5 m freeboard above the operational capacity).

Retention pond capacity requirements for the storage and management of subsoil drainage will be monitored and assessed continuously during the operation and further development of the landfill.
- A Stormwater Dam with a storage capacity of approximately 36 000 m³ to provide water supply requirements.
- Stormwater diversion bunds and interception drains have been designed to control surface water runoff from surrounding areas and ensure that clean stormwater runoff remains separated from potentially impacted runoff within the landfill site.
- A stormwater diversion drain has been designed to divert and control stormwater runoff along the eastern edge the landfill site and discharge to the stormwater dam.



- A sediment structure has been designed downstream of the stormwater dam and upstream of the inflow confluence to Thirteen Mile Brook to minimise the release of sediment eroding from the landfill site to the downstream environment.

It should be noted that stormwater management and conveyance systems associated with road alignments and other landfill infrastructure developments, excluding the landfill cells, are not covered in this document.

19.0 RECOMMENDATIONS

The following recommendations are provided for consideration by AH in regards to future development works:

- The requirement for additional leachate storage capacity associated with the development of future cells should be assessed prior to future cell construction.
- AH may want to consider developing a water resource operation and management plan in order to minimise the risk and impact of water deficits during dry years based on surface water flow and level data collected during site development and operation.
- The alignment of diversion bunds and drains should be reviewed and adapted in a staged manner as the landfill site and operational cells develop. The external diversion bund alignments should be located in areas to maximise stormwater runoff to the stormwater dam and minimise runoff entering operational areas.

20.0 IMPORTANT INFORMATION

Your attention is drawn to the document titled – “Important Information Relating to this Report”, which is included in Appendix C of this report. The statements presented in that document are intended to inform a reader of the report about its proper use. There are important limitations as to who can use the report and how it can be used. It is important that a reader of the report understands and has realistic expectations about those matters. The Important Information document does not alter the obligations Golder Associates has under the contract between it and its client.



Report Signature Page

GOLDER ASSOCIATES PTY LTD

Pamela Soto
Project Engineer

Liza Du Preez
Associate/Principal Landfill Engineer

JEJ_PS/LDP/hn

A.B.N. 64 006 107 857

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REFERENCES

- [1] Department of Water and Environment Regulation, Landfill Waste Classification and Waste Definitions 1996, 1996.
- [2] EPA Victoria, Best Practice Environmental Management – Siting, Design, Operation and Rehabilitation of Landfills', Publication 788.2, October 2015.
- [3] Golder Associates Pty Ltd, "Technical Specifications for Construction of Cell 1, Cell 2 and Ancillary Works," July 2017.
- [4] Golder Associates Pty Ltd, "Construction Quality Assurance Plan for the Construction of Cell 1, Cell 2 and Ancillary Works," July 2015.
- [5] Golder Associates Pty Ltd, "Alkina Holdings Pty Ltd, Great Southern Landfill Cell 1 and 2 Works Approval Drawings, Rev. B," July 2017.
- [6] Golder Associates Pty Ltd, "Allawuna Farm Landfill, Geotechnical Investigation for Landfill Development," March 2015.
- [7] Golder Associates Pty Ltd, "Allawuna Farm Landfill, Surface Water, Groundwater and Leachate Management Plan," March 2015.
- [8] Golder Associates Pty Ltd, "Allawuna Landfill Hydrogeological Site Characterisation Studies," March 2015.
- [9] Golder Associates Pty Ltd, "Stability Analysis and Liner System Integrity Assessment for Landfill Development," March 2015.
- [10] Golder Associates Pty Ltd, "Hydrological Site Characterisation Great Southern Landfill," Ref. 1777197-007-M-Rev0, July 2017.
- [11] International Erosion Control Association (IECA) Australasia, "Best Practice Erosion and Sediment Control," 2008.

Design Report – Great Southern Landfill (# 1777197-019-R-Rev3) includes two appendices.

Appendix A: Geotechnical Investigation

This document is available in Appendix 1.1

Appendix B: Stability Assessment

This document is available in Appendix 1.5